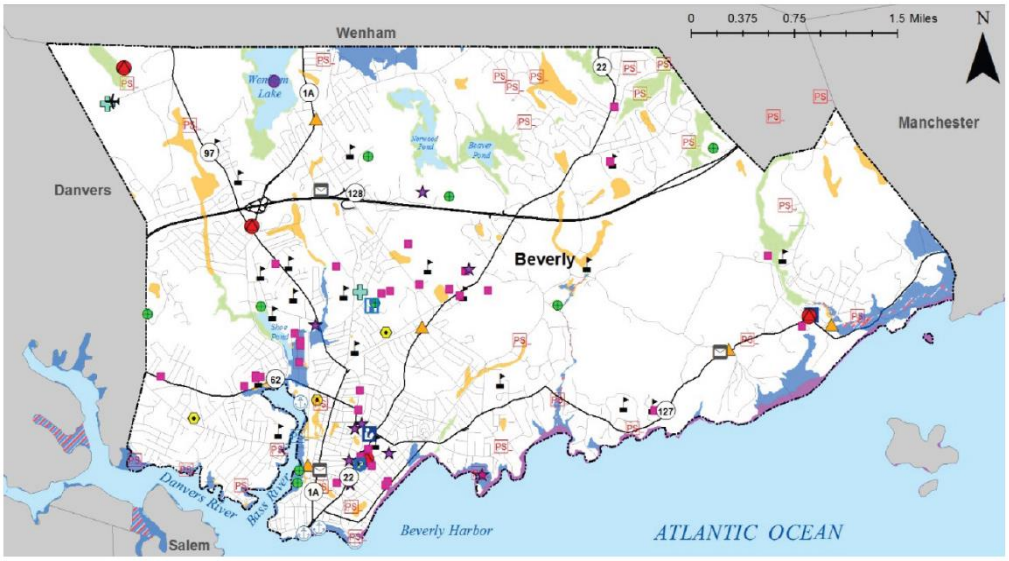
Dewberry



Natural Hazards Mitigation Plan

City of Beverly 2018 Update

City of Beverly, Massachusetts

Funded by a grant from the Federal Emergency Management Agency, Region I,
Administered by the Massachusetts Emergency Management Agency

PREPARED WITH ASSISTANCE FROM:

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SUBMITTED TO:

City of Beverly
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A RESOLUTION TO ALLOW THE CITY OF BEVERLY TO ADOPT THE BEVERLY 2018 HAZARD MITIGATION PLAN UPDATE AS THE CITY'S OFFICIAL HAZARD MITIGATION PLAN

WHEREAS the City of Beverly has experienced past flooding and other natural hazard events that pose risks to public health and safety and which may cause serious property damage; and

WHEREAS the planning process fostered by the Massachusetts Emergency Management Agency and set forth by the Federal Emergency Management Agency offers the opportunity to consider natural hazards and risks, and to identify mitigation actions to reduce future impacts of such hazards; and

WHEREAS the Commonwealth of Massachusetts provided federal Hazard Mitigation Assistance program funds to the City of Beverly to support development of an updated hazard mitigation plan; and

WHEREAS a Hazard Mitigation Plan has been developed by the Local Hazard Mitigation Planning Committee and staff from the City and other entities; and

WHEREAS the Hazard Mitigation Plan recommends several mitigation actions that will help minimize and reduce safety threats and damage to private and public property; and

WHEREAS a public meeting was held on Monday, 3 December 2018, to solicit questions and comments and to present the plan and the proposed mitigation actions.

NOW THEREFORE BE IT RESOLVED by the City Council of the City of Beverly that:

1. The Hazard Mitigation Plan is hereby adopted as an official plan of the City of Beverly.
2. The City offices identified in the Plan are hereby directed to pursue implementation of the recommended priority actions that are assigned to their agencies.
3. Any action proposed in the Plan shall be subject to and contingent upon budget approval, if funding is required, and this resolution shall not be interpreted so as to mandate any such appropriations.
4. The Department of Public Services and Engineering is designated to coordinate with other City offices and stakeholders and shall periodically report on the activities, accomplishments, and progress, and shall prepare a progress report as required by the Massachusetts Emergency Management Agency.

AND BE IT FURTHER RESOLVED, that this Resolution shall take effect on its passage:

PASSED this 17th day of December, 2018

Adoption Resolution

Paul M. Guanci, President

John P. Frates, Jr., Vice President

Timothy P. Flaherty

Julie R. Flowers

David J. Lang

Estelle M. Rand

James F. Latter

Scott D. Houseman

Donald G. Martin, Dean

A TRUE COPY
ATTEST:
City Clerk

DEC 17 2018

Executive Summary

Executive Summary

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.

A local mitigation plan is the physical representation of a jurisdiction's commitment to reduce risks from natural hazards. Local officials can refer to the plan in their day-to-day activities and in decisions regarding regulations and ordinances, granting permits, and funding of capital improvements and other community initiatives.

The City of Beverly Hazard Mitigation Plan will continue to be a useful tool for all community stakeholders by increasing public awareness about local hazards and risks, and providing information about options and resources available to reduce those risks.

Authority

On October 30, 2000, President Clinton signed into law the Disaster Mitigation Act of 2000 (DMA2K), which required state and local mitigation plans that would help to reduce loss of life and property, human suffering, economic disruption, and disaster assistance costs resulting from natural disasters.

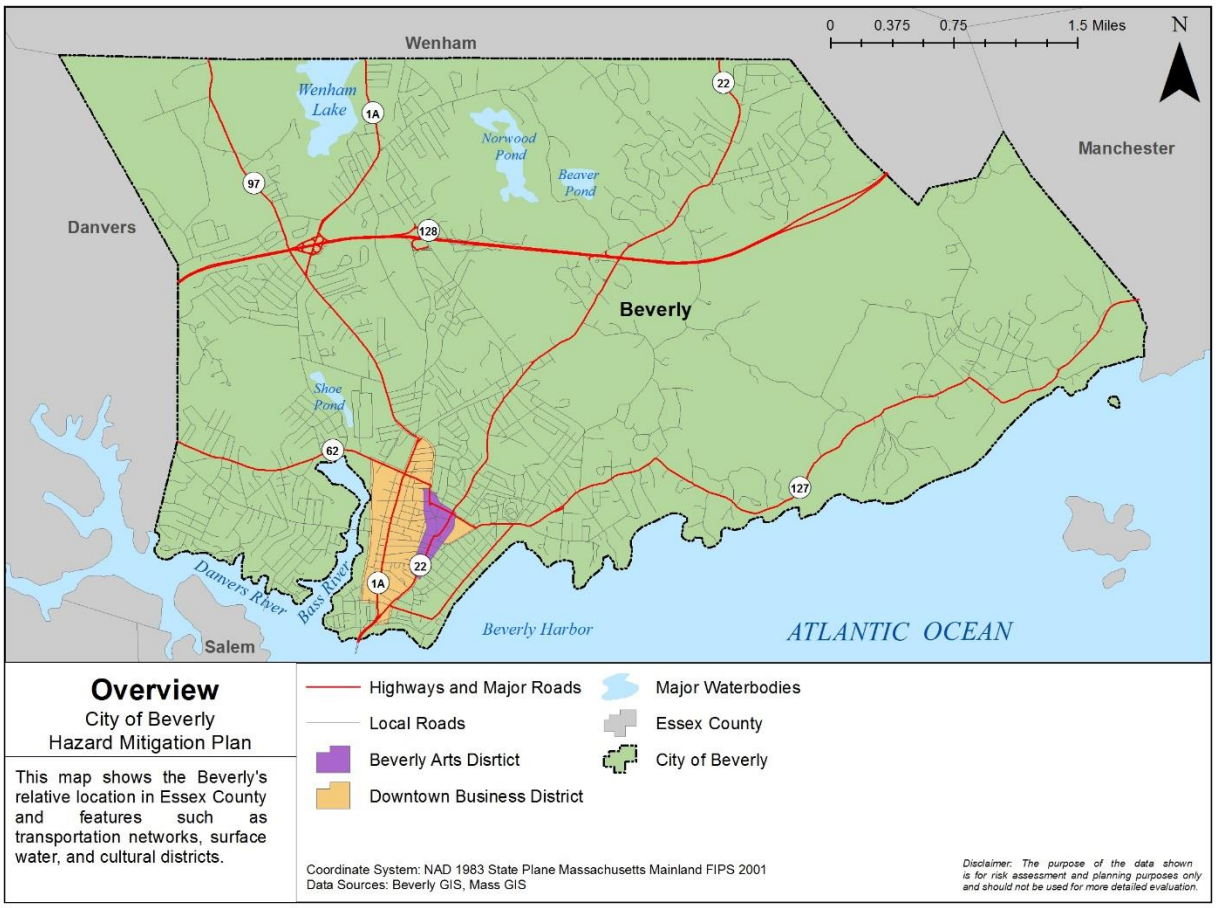
The law amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act and added a new section to the law, Section 322, Mitigation Planning. Section 322 requires local governments to prepare and adopt jurisdiction-wide hazard mitigation plans for disasters declared after November 1, 2004, as a condition of receiving Hazard Mitigation Grant Program (HMGP) project grants and other non-disaster related mitigation grant assistance programs. Local governments must review and update their mitigation plans every five years in order to continue Hazard Mitigation Assistance (HMA) program eligibility.

The Plan was prepared pursuant to the federal Hazard Mitigation and Pre-Disaster Mitigation Programs (44 CFR Parts 201 and 206).

Planning Area

The City of Beverly is located in Essex County along the Atlantic Ocean. The city is a part of greater Boston metropolitan region. Figure ES-1 shows the geographic extent of Beverly. The plan addresses all areas of the City.

Figure ES-1. Map of the City of Beverly



Planning Committee Membership

The City of Beverly established a Local Hazard Mitigation Planning Committee (LHMPC) for the 2012 Hazard Mitigation Plan update that has been subsequently expanded to include a broader range of stakeholders for the 2018 plan update. The 2018 planning committee is comprised of the following community members, arranged into a Core Team, LHMPC, and an expanded Stakeholder Advisory Committee (Table ES-1).

Table ES-2. Planning Committee Members

Title	Name
Core Team – From Coastal Resiliency Team	
Director of Planning and Community Development	Aaron Clausen
Director of Public Service and Engineering	Mike Collins
City Engineer	Greg St. Louis
Conservation Agent	Amy Maxner
GIS Manager	Roland Adams
Local Hazard Mitigation Planning Committee (Core Team + Additional Members)	
Director of Emergency Management	Mark Foster
Fire Chief	Paul Cotter
Police Chief	John LeLacheur

Title	Name
Harbor Master	Daniel McPherson
Director/ Building Commissioner	Steve Frederickson
Assistant Planning Director – Planning Board	Darlene Wynne
Chief of Staff – Mayor's Office	Kevin Harutunian
Dewberry Engineers Inc. (Planning Consultant)	Scott Choquette
Dewberry Engineers Inc. (Planning Consultant)	Peter Garvey
Dewberry Engineers Inc. (Planning Consultant)	Sydney Delmar
Stakeholder Advisory Committee (LHMPC plus Stakeholders)	
Resident – Coastal Resiliency Team (CRT)	David Gardner
Salem Sound Coastwatch	Barbara Warren
Endicott College	Chris Tripler
Endicott College	Man Butler
Beverly High School - Teacher – CRT	Nancy Schalch
VP General Manager Cummings	Steve Drohosky
Executive Director of Greater Beverly Chamber of Commerce	John Somes
Endicott College – Director of Physical Plant	Dennis Monaco
Metropolitan Area Planning Council	S. Cleves
Neighboring Communities – Salem	Tom Daniel
Neighboring Communities – Danvers	Karen Nelson
Neighboring Communities – Manchester	Sue Brown

Hazard Identification and Risk Assessment

A solid fact base is a key component of any plan. The Hazard Identification and Risk Assessment (HIRA) serves as the fact base for the hazard mitigation plan. The risks identified therein were used to inform and prioritize the strategies. The HIRA consists of three components. Its purpose is to:

1. Identify which hazards could affect the City of Beverly,
2. Profile hazard events and determine what areas and community assets are the most vulnerable to damage from these hazards, and
3. Estimate losses and prioritize the potential risks to the community.

For this plan update, certain hazards were not addressed due to the infrequency of occurrence and/or limited impact, several were combined and some added. Table ES-2 summarizes the results of the hazard identification, which are explained fully in Section 4.0, Hazard Identification and Risk Assessment. Table ES-3, provides an overview of annualized occurrences and annualized damages, also explained in detail in Section 4.0.

Table ES-2. Hazard Identification and Ranking

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary impacts		
Winter Storms	Highly Likely	Large	Negligible	Moderate	High	Significant
Flood	Highly Likely	Small	Critical	High	Medium-High	Significant
Severe Weather (Thunderstorms)	Highly Likely	Large	Negligible	Moderate	High	Significant
Extreme Temperatures	Likely	Isolated	Catastrophic	Negligible	Medium-High	Moderate
Hurricanes	Somewhat Likely	Large	Critical	Moderate	Medium-High	Moderate
Tornadoes	Somewhat Likely	Isolated	Catastrophic	Limited	Medium-Low	Limited
Earthquakes	Unlikely	Small	Catastrophic	High	Medium-Low	Limited
Drought	Somewhat Likely	Medium	Negligible	Negligible	Medium-High	Limited
Wildfire	Somewhat Likely	Medium	Negligible	Negligible	Medium-High	Limited

Table ES-3. Estimated Annualized Occurrences and Losses

Hazard	Annualized Occurrence	Annualized Damages (2017$)	Annualized Deaths Reported	Annualized Injuries Reported
Drought	0.23	$0.00	0.00	0.00
Extreme Temperature	0.18	$0.00	0.00	0.00
Flood	4.05	$2,525,255	0.09	0.14
Hurricane	0.05	$106,154	0.00	0.00
Severe Weather (Strong Wind, High Wind, Lightening)	11.55	$258,669	0.18	0.41
Sever Weather (Hail)	3.11	$2,914	0.00	0.00
Severe Weather (Thunderstorm Wind)	0.22	$172,339	0.02	0.11
Tornados	5.14	$39,279	0.00	0.06
Winter Storm	0.23	$655,169	0.00	0.00

Mitigation Goals, Objectives and Strategies

The LHMPC reviewed the previous plan's goals and objectives and made revisions to better reflect resiliency which, in the face of climate change and sea level rise, has emerged as a major societal concern. The goals and objectives are centered on three basic areas of mitigation: the existing built environment, future development, and public and stakeholder engagement. The 2018 to 2023 plan goals and objectives are:

Goal A: Protect people and property by reducing damages to the existing built environment from the impacts of natural hazards.

Objectives:

I. Ensure that critical infrastructure sites are protected from natural hazards;
II. Maintain existing mitigation infrastructure in good condition;
III. Protect existing residential and business areas from flooding, by strengthening regulations for improvements and structures in Special Flood Hazard Areas;
IV. Ensure that non-conforming uses going through a permit process incorporate mitigation best practices;
V. Continue budgeting for and completing public works projects that reduce damages from natural hazards;
VI. When feasible, increase resilience along the shoreline to protect against current flood risk future conditions, including sea level rise.

Goal B: Protect future development from damages associated with natural hazards.

Objectives:

I. Continue to enforce existing zoning and building regulations when evaluating possible changes to address the risks of climate change and sea level rise;
II. Encourage future development to be resilient and less prone to natural hazards;
III. Make efficient use of public funds for hazard mitigation;
IV. Ensure that the City remains resilient and able to respond to various natural hazard events.

Goal C: Educate the public and stakeholders on how to become more resilient to .natural hazards

Objectives:

I. Educate the public about zoning and building regulations, particularly with regard to changes in regulations that may affect tear-downs and new construction;

II. Work with surrounding communities to ensure regional cooperation and solutions for hazards affecting multiple communities such as coastal erosion;
III. Educate the public about natural hazards and mitigation measures;
IV. Promote increased purchase of flood insurance.

A comprehensive table of 30 strategies is included in Table 6.1 in Section 6: Hazard Mitigation Strategy for 2018-2023, and in Appendix E. The strategies address all of the hazards identified in the plan and are prioritized around risk and vulnerability and to address all of the above stated goals and objective. The strategies range from policies and regulation, to increased public awareness, to physical projects. In the same section of the plan, as well as in Appendix D, the status of the strategies from the 2012 Hazard Mitigation Plan is provided. Beverly is proud of the significant achievements it made in implementing its 2012 strategy.

Acknowledgements

The 2018 Plan update was supported by a Federal Emergency Management Agency Hazard Mitigation Grant Program (HMGP) planning grant administered by the Massachusetts Emergency Management Agency. The Beverly Hazard Mitigation Plan 2018 Update was led by the City of Beverly's Local Hazard Mitigation Planning Committee. Development of the plan including the generous contribution of time by various local and regional stakeholders and the public. The Plan (2018 Update) was facilitated by Dewberry Engineers Inc.

Conclusion

This City of Beverly Hazard Mitigation Plan 2018 Update embodies the continued commitment and dedication of the local government and community members of the City to enhance the safety of residents and businesses by taking actions before a disaster strikes. While nothing can be done to prevent natural hazard events from occurring, the City is poised to minimize the disruption and devastation that so often accompanies these disasters.

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1. Introduction

1 Introduction

1.1 Mitigation

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.

A local mitigation plan is the physical representation of a jurisdiction's commitment to reduce risks from natural hazards. Local officials can refer to the plan in their day-to-day activities and in decisions regarding regulations and ordinances, granting permits, and funding of capital improvements and other community initiatives. Additionally, local plans serve as the basis for states to prioritize future grant funding as it becomes available.

The City of Beverly Hazard Mitigation Plan will continue to be a useful tool for all community stakeholders by increasing public awareness about local hazards and risks, and providing information about options and resources available to reduce those risks. Educating the public about potential hazards will help Beverly protect itself against the effects of future hazards, and will enable informed decision-making regarding where to live, purchase property, or locate businesses.

1.2 Impetus for Local Mitigation Planning

On October 30, 2000, President Clinton signed into law the Disaster Mitigation Act of 2000 (DMA2K), which required state and local mitigation plans that would help to reduce loss of life and property, human suffering, economic disruption, and disaster assistance costs resulting from natural disasters.

The law amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act and added a new section to the law, Section 322, Mitigation Planning. Section 322 requires local governments to prepare and adopt jurisdiction-wide hazard mitigation plans for disasters declared after November 1, 2004, as a condition of receiving Hazard Mitigation Grant Program (HMGP) project grants and other non-disaster related mitigation grant assistance programs. Local governments must review and, if necessary, update their mitigation plans every five years from the original date of the plans in order to continue Hazard Mitigation Assistance (HMA) program eligibility.

The requirements for local mitigation plans are found in Section 44 Code of Federal Regulations Part 201.6. FEMA's "Local Multi-Hazard Mitigation Planning Guidance" issued on October 1, 2011 provides updated FEMA interpretation and explanation of local plan mitigation regulations and FEMA's expectations for mitigation plan updates. In addition, FEMA now uses the 2013 Local Mitigation Plan Review Tool to ensure that a plan meets FEMA's regulatory requirements.

1.3 City of Beverly Local Hazard Mitigation Plan 2018 Update Sections

Executive Summary provides a high level overview of the plan update process for the City of Beverly, and the key findings of the hazard identification and risk assessment and resulting mitigation strategy.

Section 1.0 – Introduction summarizes the nearly two-decade of mitigation planning history, established by the Disaster Mitigation Act of 2000, its regulatory requirements, and the plan document organization.

Section 2.0 – Planning Process defines the processes followed throughout the update of this plan including a description of stakeholder involvement and outreach.

Section 3.0 – Community Profile provides a physical and demographic profile of the City of Beverly, examining characteristics such as geography, hydrography, development, people, and land uses.

Section 4.0 – Hazard Identification and Risk Assessment evaluates the natural hazards likely to impact the City of Beverly, and quantifies whom, what, where, and how the region might be affected by natural hazards. This section also addresses critical facilities and quantifies potential losses based on best available data.

Section 5.0 Capability Assessment describes the available programs and resources currently in place to support plan implementation.

Section 6.0 – Multiple Hazard Mitigation Strategy addresses the City of Beverly hazard-related issues and concerns by establishing a revised framework and goals for mitigation activities and policies. The strategy includes a revised goals and a range of updated mitigation strategies, actions, and projects to support achievement of the goals to reduce hazard exposure to area citizens and to increase community resiliency. The mitigation strategy is developed specifically to address the risks and vulnerabilities identified in Sections 4.0 and 5.0. Status on the 2012 mitigation strategies may be found in Appendix D and new 2018 – 2023 strategies, organized by six major mitigation project types, may be found in Appendix E.

Section 7.0 – Plan Adoption, Implementation, Monitoring and Maintenance Procedures describes how the plan will be implemented, monitored, evaluated, and updated. This section also includes a process for continuing stakeholder involvement after the plan is completed.

Appendices are included at the end of the plan and contain supplemental reference materials and more detailed calculations and methodologies used throughout the planning process. Complete meeting and outreach support materials, history of federal disaster declarations in the region, additional HIRA data, and 2012 mitigation strategy status updates may all be found in the Appendices, along with a detailed summary of updated information in the 2018 plan.

Appendix A – Committee meeting materials and outreach

Appendix B – Public Survey Results

Appendix C – Hazard Identification and Risk Assessment supplemental materials

Appendix D – 2012 Mitigation Strategies Status

Appendix E – 2018 – 2023 Detailed Strategy Update

Appendix F – Record of Changes

Appendix G – Sample Adoption Resolutions

Appendix H – List of Abbreviated Terms

2. Planning Process

2 Planning Process

Mitigation planning is the process of organizing community resources, identifying and assessing hazard risks, and determining how to best minimize those risks. Its purposes include the protection of life and property, the reduction of disaster-related costs, the speeding of the recovery process, and a demonstration of commitment to the continual improvement of the quality of life in the City of Beverly.

While protection of life and property is the primary purpose of this planning document, the benefits of mitigation are not limited to risk reduction. Mitigation, when incorporated with other planning efforts, can have the additional benefit of achieving multiple community goals. Such goals might include the preservation of open space, the protection of environmental health, and enhancing recreational opportunities. In order to accomplish these additional goals, the planning process should also incorporate the City's vision for growth.

2.1 Local Hazard Mitigation Planning Committee (LHMPC)

The City of Beverly established a Local Hazard Mitigation Planning Committee (LHMPC) for the 2012 Hazard Mitigation Plan update that has been subsequently expanded to include a broader range of stakeholders for the 2018 plan update. The 2018 planning committee is comprised of the following community members, arranged into a Core Team, LHMPC, and an expanded Stakeholder Advisory Committee (Table 1-1):

Table 2-1. Planning Committee Members

Title	Name
Core Team – From Coastal Resiliency Team	
Director of Planning and Community Development	Aaron Clausen
Director of Public Service and Engineering	Mike Collins
City Engineer	Greg St. Louis
Conservation Agent	Amy Maxner
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Endicott College – Director of Physical Plant	Dennis Monaco
Metropolitan Area Planning Council	S. Cleves
Neighboring Communities – Salem	Tom Daniel
Neighboring Communities – Danvers	Karen Nelson
Neighboring Communities – Manchester	Sue Brown

2.2 Meetings, Public Participation, Stakeholder Engagement

The preparation of this Plan required a series of meetings and webinars (Table 2-2) for facilitating discussion, gaining consensus and initiating data collection efforts with local government staff, community officials and other identified stakeholders. More importantly, the meetings and workshops prompted continuous input and feedback from relevant participants throughout the drafting stages of the Plan. Below is a summary of key meetings and community workshops held during the development of the updated plan. In many cases, routine discussions and additional meetings were held by local staff to accomplish planning tasks specific to their department or agency, such as the approval of specific mitigation actions for their jurisdiction, department, or agency to undertake and include in the Mitigation Action Plan. Detailed meeting documentation from the planning process is available in Appendix A.

Table 2-2. Hazard Mitigation Planning Process and Meetings

Date	Meeting	Action	Attendance
1/10/17	Coastal Resilience Plan Kick-Off Meeting	Attended to addressing the similarities and overlap of this effort with the HMP update in an effort to expand stakeholders on the LHMPC.	15
1/18/17 2:00 PM – 3:30 PM	LHMPC Kick-Off Milestone Meeting #1	Reconvened LHMPC, completed hazard identification, facility review, and provided an overview of planning process.	13
1/30/17	On-Line HMP Update Page	Established a page on the Beverly Website to provide information as the plan is updated.	N/A
2/7/17	Stakeholder Presentation to Coastal Resiliency Plan Advisory Committee	Overview of the Hazard Mitigation Planning Process, and discussion of opportunities for	13

Date	Meeting	Action	Attendance
		coordination between groups.	
2/23/17 – 3/31/17	Online Public Survey	To introduce the plan update and initiate public engagement in the hazard mitigation planning process	86
2/23/17	Twitter and Email distribution of Online Public Survey		
5/21/17 10:00 AM – 1:00 PM	Touch-A-Truck Public Event Exhibit	Interactive one day outdoor event held during National Public Works Week. Staffed a 2018 Hazard Mitigation Plan Update booth and discussed plan update with members of the public.	100+
6/7/17	LHMPC Milestone Meeting #2	Meeting to discuss the results of the Hazard Identification and Risk Assessment (HIRA).	5
6/10/17 11:00 AM – 1:00 PM	Coastal Resilience Plan Public Workshop	Staffed exhibit booth including public survey results and hazard ranking data for the 2018 HMP update at the 3rd Coastal Resilience Plan public workshop	5
6/10/17	Public Meeting Notice	Notice to inform public of meeting to update communities on the progress of the plan update.	N/A
6/22/17	Public Meeting #1	First public meeting to update communities on the progress of the plan update and provide initial results of the HIRA.	12
9/7/17	LHMPC Milestone Meeting #3	Meeting to discuss Mitigation Actions and Strategies.	5
11/8/2017 2:00 PM – 4:00 PM	Core Groups Meeting #4	Review full draft of plan, refine mitigation strategy list and evaluation	6
5/24/2018 2:00 – 4:00	LHMPC Milestone Meeting #5	Full committee review and ranking of mitigation strategies, including STAPLE-E	6

Date	Meeting	Action	Attendance
		evaluation and priority ranking	
6/18/2018 – 7/26/2018	Stakeholder an Public Review Period	Final Draft Plan posted to Public Works Website and announcement sent to Stakeholder Committee soliciting review comments.	A total of 140 views were recorded on the website, with 28 being multiple views. No comments were received.
12/3/2018	Public Meeting of City Council to Solicit Comments	Requested edits Received from on Council Member	N/A
12/17/2017	City Council Meeting	Plan Adopted by full Council and Attested by Clerk	N/A

2.3 Online Public Survey

An online public survey was created and shared with community members to obtain feedback on the hazards that are perceived to be the greatest threat to the City. The survey was created through SurveyMonkey and was open to the public for input from February 23rd 2017 to March 31st 2017. The results of the survey were consolidated and shared during a three public outreach events on May 21, June 10, and June 22, 2017 (see Table 2-2). Survey results were also used to inform the Hazard ID and Risk Assessment (Section 4) and Mitigation Strategy (Section 6). A copy of the survey and the results can be found in Appendix B.

2.4 Public Website

The Beverly Local Hazard Mitigation Planning Committee established a website that explains the purpose of the 2018 Hazard Mitigation Plan update, communicates milestones of the project, and shares meeting presentations and worksheets with the public. This website was also used to publicize the online public survey, and to post of completed sections of the plan for review and comment. The website can be accessed here: http://www.beverlyma.gov/departments/engineering/hazard-mitigation-plan/#

2.5 Public Meetings

A variety of public outreach opportunities were included in the planning process. Results of the public survey and initial hazard ranking were exhibited during the City of Beverly touch-a-truck event on May 21, 1017. On June 10, 2017, the same results and input were exhibited at a public forum for the Coastal Resilience Plan. A formal public meeting was held on June 22, 2017 at the Beverly Public Library to present the full findings of the Hazard Identification and Risk Assessment and to solicit input on mitigation goals, objectives and actions. The meeting provided an introduction to the hazard mitigation planning process, including public participation, hazard identification and risk assessment, hazard profiles, and mitigation strategies. After the final LHMPC meeting

on May 24, 2018, a full draft of the plan was distributed to all stakeholders and posted on the Beverly website for a stakeholder/public review comment period. A public adoption hearing was held on December 3, 2018 to present the final plan and for adoption by the Beverly City Council. After receiving one requested modification, the plan was adopted by the Council at a meeting on December 17, 2018.

2.6 Beverly Coastal Resiliency Plan Coordination

Members of the LHMPC, including the planning consultant, attended meetings for the Coastal Resiliency Planning Process, with the goal of coordinating efforts and streamlining the planning process to improve the quality of both plans. As listed in Table 2-2, the details of the Hazard Mitigation Planning Process were presented to members of the Coastal Resilience Plan Advisory Committee on February 7th, 2017. Committee members Greg St. Louis and Roland Adams tabled at the Beverly Coastal Resiliency Plan's 2nd Community Workshop on March 30th, 2017. LHMPC members also attended the Coastal Resiliency Plan's 2nd Advisory Meeting on January 10th, 2017, and 3rd Advisory Meeting on February 7th, 2017.

Figure 2-3. CR Plan Stakeholder Meeting

2.7 Incorporation of Existing Plans and Studies

The *2018 City of Beverly Hazard Mitigation Plan* update incorporates information from a number of other plans, studies, and reports. These documents include:

- City of Beverly Master Plan
- City of Beverly Open Space and Recreation Plan
- City of Beverly Housing Needs Assessment
- City of Beverly Coastal Resiliency Plan
- County and municipal codes and ordinances, including floodplain ordinances
- State and local mitigation planning guidance
- 2012 FEMA Crosswalk Comments
- 2013 Commonwealth of Massachusetts State Hazard Mitigation Plan

Additional information on relevant content of many of these documents can be found in **Section 5, Capabilities Assessment**. This plan update coincided with the development of the City of Beverly's first Coastal Resiliency Plan. The results of the coastal resiliency study were incorporated into the vulnerability and risk assessment section of the coastal flooding hazard profile as well as the discussions of sea level rise and climate change impacts on the City.

3. Community Profile

3 Community Profile

3.1 History

Founded in 1626, the City of Beverly is one of the oldest communities in the Commonwealth. Residents describe their City as the birthplace of the United States Navy, noting that the first ship commissioned by the Navy first sailed from Beverly Harbor. The City was the location of the first cotton mill and the first Sunday school in the country, and has one of its neighborhoods, the Fish Flake District, on the National Register of Historic Places. While its history is rich, it is the present and future that engross the energies of the community. Beverly residents have watched an interesting shift over the past 50 years, as the City changed from an industrial site with large manufacturers like the United Shoe Machine Corporation, to a bedroom community that is 85% residential and emphasizes its academic and cultural facilities more than the industrial parks that house mixed computer and other high technology firms.

Beverly is the home of Endicott College, a private institution, and a campus of the public North Shore Community College. It is also the site of the North Shore Music Theatre, which brings in large numbers of visitors to Broadway-type productions. Intact in Beverly is the spacious echo of the past since the City is still the home of some of the most historic families in America on gracious estates in the northern portion of the community. Residents note the first-rate hospital, the miles of beautiful beach, and the diverse sections of the community that offer everything from rural to urban lifestyles in saying that the City offers everything that anyone could want in a home town. (MA DHCD profile)

Additional information can be found on the City's website at http://www.beverlyma.gov/.

3.1.1 Historic and Cultural Areas

The LHMPC identified several historic sites of cultural importance to the City, including the Balch House, the Cabot House/Beverly Historical Society, Fish Flake Hill, the Cabot Street Theatre, Hale Farm and the North Shore Music Theatre. These buildings and sites are located outside of the most significant hazard areas, away from the coast and floodplain areas.

3.2 Geography

The City of Beverly is located in Essex County along the North Shore of Massachusetts, approximately 26 miles northwest of the City of Boston. According to the 2010 U.S. Census, the city encompasses approximately 15 square miles, which includes two islands, the Great and Little Misery Islands, and nine miles of coastline. The community is bordered by Manchester and Wenham to the North, Danvers to the West, Salem to the South, and the Atlantic Ocean to the East. It is within the jurisdiction of Boston's Metropolitan Area Planning Council (MAPC) and also the North Shore Task Force

(NSTF), a sub region of the MAPC. *Figure 3-1* provides an overview of the City and surrounding areas.

The Danvers River runs from the west and the Bass River runs from the North through downtown Beverly. The two rivers meet together at Salters Point in downtown Beverly, where they become the Danvers River that empties to the Atlantic Ocean. A large portion of Wenham Lake is within the City of Beverly, in addition to a number of smaller ponds and streams.

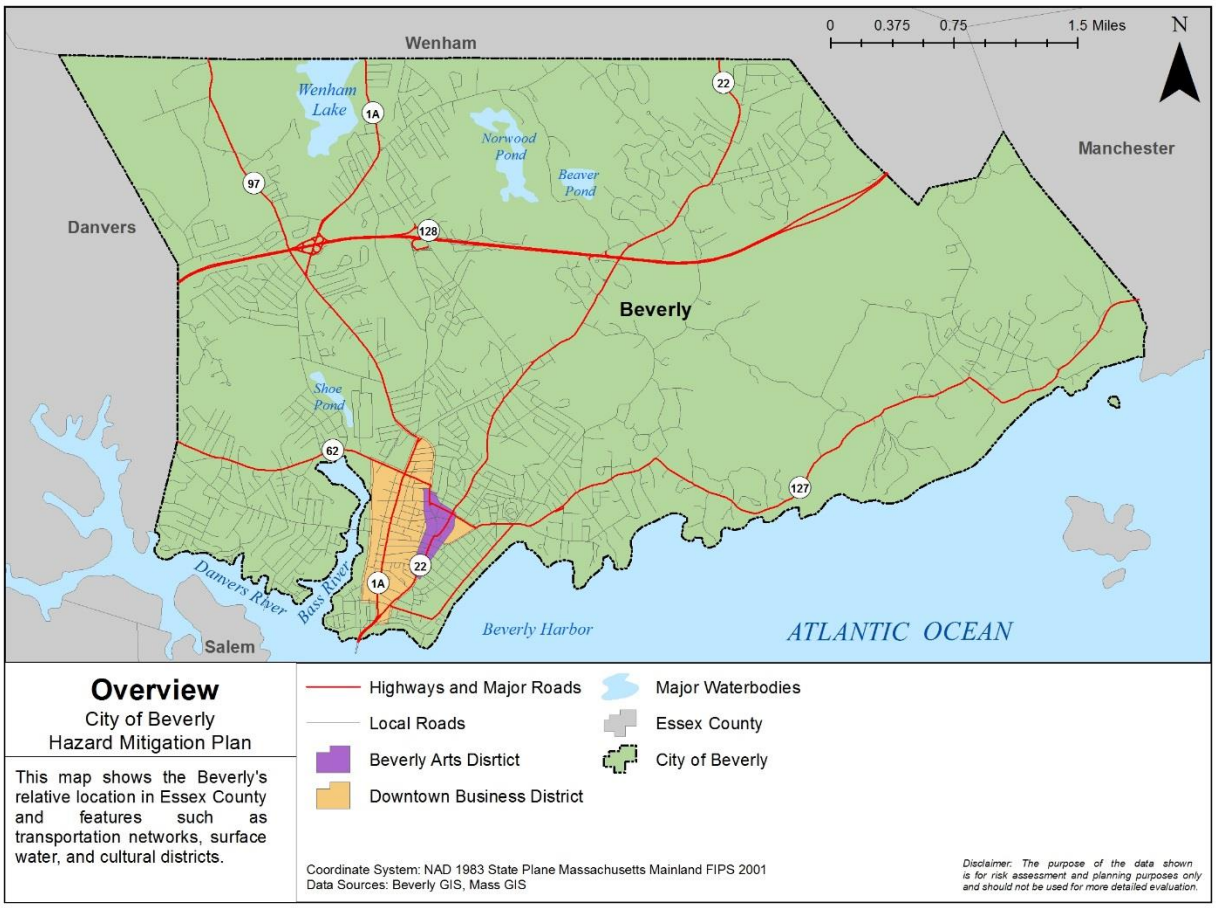

Figure 3-1. Overview of City of Beverly

3.2.1 Water Resources

According to the City of Beverly's 2015 Open Space Plan, Beverly is located within two watershed basins as delineated by the Commonwealth of Massachusetts: the North Coastal Watershed Basin and the Ipswich River Watershed Basin. Approximately 60% of Beverly's landmass is located within the North Coastal Watershed. The remaining 40% of the city's landmass is located in the more northerly sections of the city and contribute to the Ipswich River Watershed; this watershed envelops all of the major fresh water

bodies located in Beverly, namely the Wenham Lake Reservoir, Norwood Pond and Beaver Pond.

The Wenham Lake Reservoir, a publicly owned water supply, provides drinking water to Beverly, Salem and parts of Wenham. Water for the Reservoir is drawn from the Ipswich River through a canal from December through May, as regulated by state permit. The Ipswich River has been classified as one of the countries most threatened riverine ecosystems, due to water withdrawals by the many communities within its watershed. The permitted water withdrawal from the river to Wenham Lake Reservoir corresponds to winter and spring when the river is at high levels. The Reservoir is also augmented by water stored at Longham and Putnamville Reservoirs in Wenham and Topsfield respectively.

According to the Massachusetts DEP Priority Resource (21E) Map on MassGIS, Beverly contains two Medium Yield Aquifers, all or portions of which are non-potable drinking water sources. One non-potable, medium yield aquifer is located within the North Coastal Drainage Basin, south of Wenham Lake in the North Beverly neighborhood. This aquifer is roughly bounded by the Newburyport MBTA line to the east, Balch Street to the south and the Raymond Farms neighborhood to the west. The second medium yield aquifer is within the Ipswich River Drainage Basin. It is bounded on the east by Wenham Lake, on the west by Whirling Drive and shares the Town of Wenham corporate boundary to the north. Portions of this aquifer are considered a non-potable drinking water source.

In addition to reservoirs and ponds, Beverly has a large number of freshwater wetland habitats. Wooded swamps dominated by red maples and wetlands shrubs such as winterberry, sweet pepperbush, withered, and buttonbush are a common habitat type within the Beverly Commons, Norwood Pond area, other forests and even some residential areas. A number of cattail marshes occur in the Centerville neighborhood.

There are several salt marshes within the City. The Bass River, which is tidal, supports a number of fringing salt marshes within close proximity to the downtown area. Chubb's Brook Salt Marsh located on the Beverly-Manchester boundary line is the largest salt marsh area within the City. Twenty-nine of the forty-four acres that comprise Chubb's Brook Salt Marsh are located in Beverly. A small salt marsh is located behind Patch Beach.

A significant wetland restoration project was completed in 2006 on the western shore and up gradient of the Wenham Lake Reservoir. This project included the removal of 40,000 cubic yards of fly ash from the drinking water reservoir, an active stream course named "Airport Brook," and sixteen acres of associated wetlands. Fly ash, a byproduct of coal-burning power plants, typically contains elevated levels of heavy metals associated with the parent coal material.[1]

[1] July 2015 City of Beverly Open Space Plan http://www.beverlyma.gov/wp-content/uploads/2013/10/REVISED-OSRP-2016.pdf

3.3 Land Use and Development Trends

Hazard mitigation is not focused only on protecting people and the built environment that are already in harm's way. Developing thoughtful and sound land use policy and regulations that ensure that future land use and development are not increasing the City's vulnerability to natural disasters is equally important. A majority of the City consists or developed land. The subsections below provide a summary of current conditions in Beverly.

3.3.1 Existing Land Use

A majority of the city is developed land, however the Beverly Conservation Commission has ownership of 423 acres, much of it in the Beverly Commons woodlands in Beverly farms. The City of Beverly owns 418 acres of parkland and playgrounds: 98 acres that are under the care and custody of the Parks and Recreation Department, 160 acres of the Beverly Golf and Tennis Club, and 160 acres under the general ownership of the City.[2]

The most recent land cover statistics available from the Commonwealth are from aerial photography done in 2005. Table 3-1 shows the acreage and percentage of land in 21 categories. If the five residential categories are aggregated, residential uses make up 33.28 % of the area of the City (9,852.83) acres). The highest percentage is forested lands which comprises 34.78 % which is 3,426 acres. Although this analysis is dated, overall changes in percentages are thought to be very minimal as of 2018.

Table 3-1. 2005 Land Use in Beverly, MA

Land Type	Acres	Percent
Cropland	64.42	0.65%
Pasture	42.82	0.43%
Forest	3426	34.78%
Wetland	276.56	2.80%
Mining	0	0.00%
Open Land	185.89	1.80%
Participation Recreation	149	1.50%
Spectator Recreation	0	0.00%
Water-based Recreation	9.98	0.10%
Multifamily Residential	392.23	3.98%
High Density Residential	1109.88	11.26%
Medium Density Residential	1288.7	13.08%
Low Density Residential	488.83	4.96%
Very Low Density Residential	227.98	2.33%

[2] July 2015 City of Beverly Open Space Plan (http://www.beverlyma.gov/wp-content/uploads/2013/10/REVISED-OSRP-2016.pdf)

Land Type	Acres	Percent
Saltwater Wetland	37.66	0.38%
Commercial	369	3.74%
Industrial	196.1	2.00%
Urban Open	16.01	0.16%
Transportation	299.82	3.04%
Waste Disposal	32.2	0.33%
Water	156.57	1.59%
Cranberry Bog	0	0.00%
Power line	4.17	0.04%
Saltwater Beach	56.5	0.58%
Golf Course	107.98	1.09%
Marina	13.9	0.14%
Urban Public	296.82	3.01%
Cemetery	70.61	0.72%
Orchard	1.37	0.01%
Nursery	16.16	0.16%
Forested Wetland	492.03	4.99%
Junkyards	0	0.00%
Brush land/Succession	23.64	0.24%
Total	9852.83	100

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

3.3.2 Development Trends

The decline of the economy around 2008 saw a corresponding decline in construction with only 31 building permits issued for single-family homes between 2009 and 2011. As the overall economy continues to improve, Beverly has seen a rise in the development of both residential and commercial properties.

MAPC projects that Beverly will essentially reach its maximum build out under existing zoning by 2020. The growth rate is projected to be about 1 percent per year between 2001 and 2020, adding about 19 percent to the housing stock and projecting an additional population increase of 6,335 persons by the year 2020. The City anticipates further new commercial and industrial development primarily from land located near Beverly Airport and land in central Beverly located adjacent to Route 128. Commercial redevelopment is expected to occur in the downtown areas bordering Cabot and Rantoul Streets and along the waterfront in the Ferry Landing and Ventron sites.

3.3.3 Recent and Potential Future Development

According to the Beverly Open Space Plan (updated April 2016), the commercial/industrial sector has seen several large-scale industrial projects undertaken

or completed in recent years in the City of Beverly. The Cummings Center, which occupies the former USMC complex and contains two million square feet of office and research and development, continues to thrive and attract businesses. A recent addition to Cummings Center is the corporate offices of American Renal who operate over a 100 clinics providing outpatient dialysis services. Recent commercial projects include a new business campus on Dunham Road, fronting Route 128, and includes a new 5-story office building at 50 Dunham Road comprising 100,00 square feet, 85,000 of which is already occupied. As of May 2017, under construction was 48 Dunham Road, which will consist of a 1,000 square-foot office/R&D building with attached garage. In the licensing phase is a 56,000 square-foot skilled nursing/traditional care facility on Sohier Road. Smaller projects include the construction of a 13,555 square-foot Walgreens on Dodge Street and a CVS at the corner of Rantoul and Elliot Streets with 13,000 square feet and a 70-car parking lot.

The City's Planning Department was consulted for a list of areas that are currently in development or likely to be developed in the future. As of May 9, 2017, there were 33 projects in various phases of permitting, design or development.

Properties under development that are found to be in the 100 year flood zone (0.1% annual chance of flooding in any given year) include:

1. Nelson Ave Extension
2. Harbor Front
3. Bass River (46 River Street)
4. 201 Elliott Street

These sites are all being developed to NFIP standards.

3.4 Population

At-risk populations are especially vulnerable to the impacts of disasters. Characteristics of these populations include: elderly, poor health, disabled, low wealth and ethnicity. By identifying socially vulnerable populations, the City of Beverly will further assist in the response and recovery to disasters. Several mitigation actions address socially vulnerable population through education initiatives.

After a major growth spurt between 1940 and 1970, Beverly's population has remained relatively stable with some limited declines.[3] During the 10-year period between 2000 and 2010, Beverly's population went from 39,862 to 39,502, a decrease of 360 people or .903%. The average population density for the city is 2,450 people per square mile. The most populated clusters include areas in Gloucester Crossing, Prospect Hill, Goat Hill, downtown, and Endicott College.

[3] Beverly Housing Needs Assessment (September 2016) http://www.beverlyma.gov/wp-content/uploads/2016/06/Beverly-Housing-Needs-Assessment.pdf

The Metropolitan Area Planning Council (MAPC) has provided population projections into the year 2030, which show a continued slight decrease in population by 2020, but an increase by 2030 (*Table 3-2*). While the City of Beverly's population has remained relatively stable at about 40,000 residents, significant demographic shifts are projected, with fewer children and more elderly adults anticipated. There is an anticipated increase in those residents older than 60 from 20% in 2010 to 29% by 2030.

*Table 3-3*3 summarizes the cultural demographics for Beverly based on 2010 Census data.

Table 3-2. Beverly Population by Age Group

Age Group	% of total population			
	2000	2010	2020	2030
0-19	24%	23%	21%	21%
20-34	19%	20%	22%	19%
35-59	36%	35%	30%	31%
60-85+	19%	20%	26%	29%

Source: MAPC Population Projection Data

Table 3-3. Cultural Demographics of Beverly

Race	Population	% of Population
White	36,105	91.4%
Black or African American	632	1.6%
Hispanic or Latino	1,383	3.5%
Asian	672	1.7%
American Indian	79	0.2%
Native Hawaiian and Other Pacific Islander	40	0.1%
Two or More Races	632	1.6%

Source: 2010 US Census Quick Facts

3.4.1 Race

Table 3-4 presents data on the racial composition of the population in Beverly. The community has had very little racial diversity: about 98% of the population described themselves as White in 1990, decreasing to 94.2% by 2014. Asian and Black residents have more than doubled in number during this period with the Latino or Hispanic population more than tripling.

Table 3-4. Racial Composition, 1990 to 2014

Population Characteristics	1990		2000		2010		2014	
	#	%	#	%	#	%	#	%
Population*	37,289	97.6	38,257	96.0	36,868	93.3	38,011	94.2
Asian Population*	388	1.0	511	1.3	686	1.7	858	2.1
Black Population*	328	0.9	413	1.0	647	1.6	705	1.7

Population Characteristics	1990		2000		2010		2014	
	#	%	#	%	#	%	#	%
Those of 2 or more races	-	-	392	1.0	632	1.6	504	1.2
Latino/Hispanic of any race**	439	1.1	720	1.8	1,397	3.5	1,405	3.5

Source: U.S. Census Bureau, Census 1990, 2000 and 2010 Summary File 3; 2014 American Community Survey 5-Year Estimates, 2010-2014
* Includes only those of that race
** Latino or Hispanic of any race.

3.5 Education

The percentage of those having a high school diploma is higher in Beverly, at 94.4%, compared to county and state levels of about 89%. Likewise 45.4% had completed a bachelor's degree as of 2014, higher than 37.2% and 40.0% with a bachelor's degree or higher for the county and state, respectively. Educational attainment has also been increasing, up considerably from 2000 values of 90.8% and 36.5% with at least a bachelor's degree.

Beverly has relatively high education attainment and has experienced increasing school enrollment recently. School officials indicate that some of the increase in enrollments is a result of new residential building activity that has provided opportunities for older homeowners to downsize, thus making their homes available to families with children. The Beverly Public School District reported a student enrollment of 4,523 students for the 2015-2016 school year, up from 4,219 students in 2008-2009 and down from 4,736 students in 1999-2000. While the numbers and percentages of children enrolled in Beverly's school system have declined since 2000, it is likely that the recent growth in enrollment is at least partially driven by shifts from the area's private schools to local ones.

3.6 Income

Table 3-5 presents income data based on Census estimates over the past several decades.

Table 3-5. Household Income Distribution, 1989 - 2014

Income Range	1989		1999		2010		2014	
	#	%	#	%	#	%	#	%
Under $10,000	1,850	12.5	1,104	7	1,061	6.9	840	5.3
10,000-24,999	2,664	18	2,135	13.6	1,875	12.1	2,151	13.5
25,000-34,999	1,986	13.4	1,418	9	1,145	7.4	1,203	7.6
35,000-49,999	2,812	19	2,517	16	1,533	9.9	1,349	8.5

Income Range	1989		1999		2010		2014	
	#	%	#	%	#	%	#	%
50,000-74,999	3,134	21.2	3,403	21.6	2,892	18.7	2,528	15.9
75,000-99,999	1,280	8.7	2,261	14.4	1,840	11.9	2,131	13.4
100,000-149,999	1,048	7.1	1,887	12	2,749	17.8	2,950	18.5
150,000 +			1,011	6.4	2,374	15.3	2,773	17.4
Total	14,774	100	15,736	100	15,469	100	15,925	100
Median HH* Income	$39,603		$53,984		$66,671		$73,980	

Source: U.S. Census Bureau, Census 1990, 2000 and 2010 Summary File 3; 2014 American Community Survey 5-Year Estimates, 2010-2014. *Household

Incomes have increased significantly over the years, with the median household income level increasing by 87% since 1999 for example, from $39,603 to $73,980, which is somewhat lower than the rate of inflation during this period of 91%. In comparison, the median household income for the state as a whole, while somewhat lower, increased by 81%, from $36,952 to $67,846 during this same period.

The growing prosperity of Beverly's residents is also reflected in the increasing proportion and numbers of those earning more than $100,000, going from 7.1% of all households in 1989 to 35.9% by 2014, compared to about 33% for the state and Essex County. While many in the community continue to prosper, there are some who are struggling financially. For example, based on 2014 census estimates, 2,991 households earned less than $25,000, representing almost one-fifth of all households.

3.7 Housing

According to the 2010 U.S. Census, the City of Beverly has 15,850 housing units within its jurisdictional boundaries. Of those units, 60.60% are owner occupied (2011 – 2015). MAPC projections indicate that the number of households will increase by another 12.4% between 2010 and 2030, more than double the projected 5.8% population increase. This is due to projected increases in smaller families and nonfamily households, largely driven by an aging population.

The City of Beverly hired a consulting team to help prepare a Community Housing Plan in order to help the city better understand their current and future housing needs. While the plan is still in progress, a housing needs assessment was completed in September 2016, which analyzes housing affordability in the city to identify housing needs a strategies to address those needs.

According to the assessment, the lowest internet rental listing for a two-bedroom apartment was $1,300 in May 2016. This rent would require an income of about $59,000, assuming $175 in monthly utility bills and housing expenses of no more than 30% of household income. This means that the median income earning renter household ($37,872), who can afford a rent of about $772, faces a monthly affordability gap of more than $800. In total, about 1,200 homeowners in Beverly are spending more than half their income on housing, including 400 seniors, 475 families and 325 non-elderly single individuals.

Table 3-6 is a table from the Beverly Housing Needs Assessment that summarizes housing data from the U.S. Census Bureau and American Community Survey from 1990 to 2014. Census data indicates that owner-occupied units grew by 11.5% between 1990 and 2014, from 8,717 to 9,720 units, while total housing growth was only 7.3%. The number of rental units showed a slight loss since 2000, from 6,292 to 6,205 units or from 40% to 39% of all units. Significant recent and planned development of rental housing will boost this percentage beyond 40% in the near future however.

Table 3-6: Housing Occupancy, 1990 to 2014

Housing Characteristics	1990		2000		2010		2014	
	#	%	#	%	#	%	#	%
Total # Housing Units	15,652	100.0	16,275	100.0	16,641	100.0	16,787	100.0
Occupied Units*	14,796	94.5	15,750	96.8	15,850	95,2	15,925	94.9
Total Vacant Units/ Seasonal, Rec. or Occasional Use*	856/ 63	5.5/ 0.4	525/ 125	3.2/ 0.8	791/ 119	4.8/ 0.7	862/ 107	5.1/ 0.6
Occupied Owner Units**	8,717	58.9	9,457	60.0	9,619	60.7	9,720	61.0
Occupied Rental Units**	6,079	41.1	6,293	40.0	6,231	39.3	6,205	39.0
Average Household Size/ Owner-occupied Units	2.79 persons		2.70 persons		2.60 persons		2.63 persons	
Average Household Size/ Renter-occupied Units	2.04 persons		1.93 persons		1.93 persons		1.90 persons	

Source: U.S. Census Bureau, Census 1990, 2000 and 2010 Summary File 1 and American Community Survey 5-Year

Estimates, 2010-2014 * Percentage of all housing units ** Percentage of occupied housing units

3.8 Economic Profile

Over the past 50 years or more, Beverly's economy has shifted from one relying predominantly on manufacturing, including huge companies such as the United Shoe Machine Corporation, to more mixed employment opportunities including life sciences, computer and high technology firms, and a major medical center. The City is also home to significant academic and cultural facilities including Endicott College, Montserrat

College of Art, as well as the North Shore Music Theater, Larcom Theater and Cabot Theater that in addition to Beverly's beaches attract thousands of visitors annually.[4]

There are 33,831 Beverly residents over the age of 16 in 2014, of which 23,114 or approximately two-thirds were in the labor market or about 60% were employed in 2014 according to the Census Bureau's American Community Survey estimates. The unemployment rate for the city's residents is about 7% which is higher than the 5.4% rate reported by the state's Executive Office of Labor and Workforce Development.

The 2014 Census Bureau's American Community Survey data also reports the concentration of Beverly workers by industry. The largest category of workers, 47%, is involved in management and professional occupations. In addition, about 24% are involved in sales and office occupations, 16% are in service occupations, 7.0% work in production, transportation, and moving, and the remaining 6.2% work in natural resources, construction, and maintenance.

3.8.1 Major Employers

Some of the major employers in the City of Beverly are Axcelis Technologies, Microsoft, Orchard Brands, Zipcar, and Crane Aerospace. Table 3-7 summarizes the average employment and wages by industry in 2015 for the City of Beverly. The industries are reported based on the 2-digit North American Industry Classification System (NAICS) codes. The industries have been sorted by those with the highest average monthly employment. The health care and social assistance industry is the largest with an average of 6,292 employees, the highest total wages ($352,632,605), and highest number of establishments (263). The management of companies is one of the smallest industries in size but yields the highest average weekly wage of $5,868. The average weekly wages for Beverly across industries, $1,475, is about 87% of Boston's average weekly wage of $1,703 but considerably higher than $913 for Salem, $932 for Peabody, and $1,000 for Danvers for example.

Table 3-7. Average Employment and Wages by Industry, 2015

Industry (2-digit NAICS code)	No. of Establishments	Total Wages	Average Monthly Employment	Average Weekly Wages
62 - Health Care and Social Assistance	263	$352,632,605	6,292	$1,078
61 - Educational Services	37	$142,712,135	2,892	$949
31-33 - Manufacturing	53	$162,825,609	2,001	$1,565
54 - Professional and Technical Services	214	$152,471,401	1,869	$1,569
44-45 - Retail Trade	143	$76,214,084	1,826	$803

[4] Beverly Housing Needs Assessment (2016) http://www.beverlyma.gov/wp-content/uploads/2016/06/Beverly-Housing-Needs-Assessment.pdf

Industry (2-digit NAICS code)	No. of Establishments	Total Wages	Average Monthly Employment	Average Weekly Wages
72 - Accommodation and Food Services	110	$33,011,853	1,557	$408
81 - Other Services, Ex. Public Admin	145	$27,947,949	1,158	$464
56 - Administrative and Waste Services	85	$66,163,712	1,138	$1,118
52 - Finance and Insurance	73	$100,955,459	1,068	$1,818
42 - Wholesale Trade	82	$64,584,505	756	$1,643
23 - Construction	103	$34,157,926	498	$1,319
51 - Information	35	$41,408,659	478	$1,666
71 - Arts, Entertainment, and Recreation	31	$7,961,667	371	$413
55 - Management of Companies and Enterprises	13	$79,943,283	262	$5,868
53 - Real Estate and Rental and Leasing	49	$16,963,488	250	$1,305
22 - Utilities	5	$25,252,896	233	$2,084
48-49 - Transportation and Warehousing	23	$13,686,845	205	$1,284
11 - Agriculture, Forestry, Fishing & Hunting	10	$1,429,244	23	$1,195
Total	1474	$1,400,323,320	1271	$1,475

Source: Massachusetts Executive Office of Labor and Workforce Development, 2015 Annual Employment and Wages Report (ES-202)

4. Hazard Identification and Risk Assessment

4 Hazard Identification and Risk Assessment

4.1 Introduction

The risk assessment analyzes the potential natural hazards that may occur within the City of Beverly 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.

Identifying the risk and vulnerability for a community is critical when determining how to allocate finite resources to carry out feasible and appropriate mitigation actions. The hazard analysis involves identifying all of the hazards that potentially threaten the City of Beverly, and then analyzing them individually to determine the degree of threat posed by each hazard. Addressing risk and vulnerability through hazard mitigation measures will reduce societal, economic, and environmental exposure to natural hazard impacts.

4.1.1 2018 HIRA Update

In order to update Beverly's risk assessment, the most recently available hazard and land use data was gathered and City staff met to identify changes in local hazard areas and development trends. City staff reviewed critical infrastructure in order to create an up-to-date list. The most recently available version of HAZUS (described below) was used to assess the potential impacts of flooding and hurricane wind on the city's infrastructure using the best available data.

The 2018 plan update expands the hazard specific profiles, and consolidates, updates, and streamlines content from the 2010 hazard identification. As part of the update, the following hazards were added to the hazard identification and risk assessment section:

- Severe Weather (Thunderstorms); and
- Extreme Temperatures.

The 2018 analysis included, but was not limited to: 1) determining annualized number of hazard events and losses using the National Centers for Environmental Information (NCEI), which was formally known as the National Climatic Data Center (NCDC) and other data sources where available; 2) updating the assessment of vulnerability and risk based on new data; 3) new analysis with updated critical facilities data; 4) creation of hazard maps specific to the city; and 5) providing overall hazard comparisons (presented at the end of this section).

In addition, each section of the plan was also reformatted to improve clarity, and new maps and imagery were included. The 2013 Commonwealth of Massachusetts Hazard Mitigation Plan, was reviewed as part of this update and, when applicable, information from the plan has been cited.

4.2 Hazard Identification

The City of Beverly is exposed to a range of hazards that threaten both human life and property. The natural hazards profiled in the Massachusetts State Hazard Mitigation Plan (HMP) of 2013 are compared in Table 4-1 to the hazards selected by the City of Beverly for inclusion in this plan update.

Table 4-1. Hazards of Concern

Hazards Identified in Massachusetts Hazard Mitigation Plan 2013	Hazard of Concern in City of Beverly	Justification
Coastal Erosion	Yes	Incorporated into the "Flooding" hazard profile
Dam Failure	No	This hazard was not included due to its low frequency of occurrence. There are no dams in Beverly that pose a concern.
Earthquake	Yes	
Fire	Yes	Incorporated into the "Wildfire" hazard profile
Flood	Yes	
Hurricane	Yes	
Landslide	No	This hazard was not included due to its low frequency of occurrence. Was included in 2012, committee made decision in 2017 to remove from list of hazards based on lack of historic occurrences.
Nor'easters	Yes	Incorporated into the "Severe Winter Weather" hazard profile
Severe Weather (High Wind, Thunderstorms, Tornados, Extreme Temperatures, Drought)	Yes	Organized this hazard into multiple individual hazards: Severe Winter Weather (thunderstorms, severe wind, lightening, and hail), Tornados, Extreme Temperatures, and Drought
Severe Winter Weather	Yes	
Tsunami	No	This hazard was not included due to its low frequency of occurrence and low probability.

Some of these hazards are considered to be interrelated or cascading (i.e., hurricanes can cause flooding, high wind, and tornadoes). For preliminary hazard identification

purposes these distinct hazards are broken out separately. It should also be noted that some hazards, such as winter storms, may impact a large area yet cause little damage, while other hazards, such as a tornado, may impact a small area yet cause extensive damage.

The hazards listed below were not included in the Commonwealth's plan as they are not considered significant threats in Massachusetts. For the same reason, they are not included in this plan.

- Avalanche
- Expansive Soils
- Land Subsidence
- Volcano

4.2.1 Federal Disaster Declarations

An important source for identifying hazards that can affect a locality is the record of presidential disaster declarations and historic storm data. According to FEMA, since 1962 there have been 201 major disaster declarations for Massachusetts, of which 22 have been declared for Essex County. Federal disaster declarations, and much of the recording of damages from disasters are at the county level. There have been 9 federal disaster declarations related to severe storms, 7 related to snow, 7 related to flood, 6 related to hurricanes and 2 related to coastal storms, as detailed in Table 4-2.

Table 4-2. Presidential Declared Disasters for Essex County (as of February 2017)

Disaster Number	Disaster Type	Incident Type	Incident Begin Date	Programs Declared			
				IH	IA	PA	HM
325	DR	Flood	3/6/1972		X	X	X
357	DR	Fishing Losses	9/28/1972		X		
546	DR	Blizzard	2/6/1978		X	X	X
650	DR	Fire	12/3/1981		X	X	X
751	DR	Hurricane	9/27/1985			X	X
790	DR	Flood	3/30/1987		X	X	X
914	DR	Hurricane	8/19/1991		X	X	X
920	DR	Coastal Storm	10/30/1991		X	X	X
975	DR	Coastal Storm	12/11/1992		X	X	X
1090	DR	Snow	1/7/1996			X	X
1142	DR	Flood	10/20/1996		X	X	X
1224	DR	Flood	6/13/1998		X		
1364	DR	Severe Storm(s)	3/5/2001		X		X
1512	DR	Flood	4/1/2004	X	X		X
1614	DR	Severe Storm(s)	10/7/2005	X	X	X	X
1642	DR	Severe Storm(s)	5/12/2006	X	X	X	X
1701	DR	Severe Storm(s)	4/15/2007			X	X
1813	DR	Severe Ice Storm	12/11/2008			X	X
1895	DR	Severe Storm(s)	3/12/2010	X		X	X
1959	DR	Snow	1/11/2011			X	X
4110	DR	Severe Storm(s)	2/8/2013			X	X
4214	DR	Severe Storm(s)	1/26/2015			X	X

4.2.2 NCEI Storm Events Data

The National Center for Environmental Information (NCEI) Storm Events Database is published by the National Oceanic and Atmospheric Administration (NOAA)'s National Weather Service (NWS). The storm events database contains information on storms and weather phenomena that have caused loss of life, injuries, significant property damage, and/or disruption to commerce. The NCEI data currently provides information about events from January 1950 to January 2017. Records for the majority of weather events (48 types) were reported starting in 1996, as defined in NWS Directive 10-1605. The exception is tornado events that were recorded from 1950 through 1954 and tornado, thunderstorm and hail events that were recorded starting in 1955.

The NCEI Storm Events Database publishes data by county, therefore the storm event summary tables in each section of the HIRA will report totals for Essex County. The NCEI database is organized by episode ID and event ID. The episode ID is the overall storm system (ex. Thunderstorm) that affects an area and can include several associated events ID's, such as hail, lightening, and high wind. There have been 481 total hazard episodes reported in Essex County from January 1950 to January 2017 as summarized in Table 4-3.

The total property damages from all reported hazard episodes exceeds $91.7 million (inflated to 2017 dollars). Property damages are reported for each event associated with an episode. There was no reported crop damage for any of the noted hazards. There were seven reported deaths and 23 reported injuries due to these hazard episodes, which are also reported for each event. The hazards specific sections in this report profile the historic events and include, when applicable, narratives from this dataset.

Table 4-3. Hazard Episodes Reported in Essex County, MA (January 2017)

Hazard	Episodes	Property Damage (2017)	Deaths	Injuries
Drought	5	$0	0	0
Extreme Temperature	4	$0	0	0
Flood	89	$55,555,602	2	3
Hurricane	1	$2,335,390	0	0
Severe Weather	254	$16,731,680	5	16
Tornados	15	$2,670,955	0	4
Winter Storm	113	$14,413,710	0	0
Total	**481**	**$91,707,338**	**7**	**23**

These estimates are believed to be an underrepresentation of the actual losses experienced as some hazard losses go unreported or are difficult to accurately quantify. Table 4-3 only summarizes the NCEI database hazards and does not include other hazards that will be discussed in this HIRA, such as earthquake and wildfire. Other best available national and local datasets will be used in these hazard sections to quantify losses. Although these losses are for all of Essex County, they give a sense of which hazard have historically posed the most significant threat.

4.2.3 Hazard-Specific Datasets

The level and type of analysis that can be completed is dependent on the type and quality of data available for analysis. Critical facility, infrastructure, and building footprint data are described in the following section. The majority of the hazards impacting the City of Beverly do not have definitive impact boundaries, and, as a result, past occurrences were used to try to identify probable locations where these events may happen in the future. Table 4-4 provides a breakdown, by hazard, of the datasets used for analysis and mapping in the hazard-specific sections that follow. The available datasets illustrate the difficult nature of quantitatively assessing vulnerability and risk within the City. This assessment has been compiled using the best available data.

Table 4-4. Hazard Specific Data Utilized for Analysis and Mapping

Hazard	Dataset	Source
Winter Storms and Freezing Rain	Snowfall statistics	National Weather Service (NWC)
	NCEI Storm Events Database	NOAA National Center for Environmental Information (NCEI)
Flooding	Digital Flood Insurance Rate Maps (DFIRMs)	FEMA
	NFIP Policy & Claims	FEMA
	Repetitive & Severe Repetitive Loss Properties	FEMA
	NCEI Storm Events Database	NOAA NCEI
	FEMA HAZUS-MH	FEMA
Hurricanes/Tropical Storms	NCEI Storm Events Database	NOAA NCEI
	FEMA HAZUS-MH	FEMA

Hazard	Dataset	Source
Severe Weather (thunderstorms, high wind, hail, and lightening)	Significant Storm Events for thunderstorms, high wind, hail, and lightening	SVRGIS
	NCEI Storm Events Database	NOAA NCEI
Earthquake	Significant US Earthquakes 1568 – 2009	USGS Earthquake Hazard Program via National Atlas
	Peak Ground Acceleration	FEMA HAZUS-MH
	Annualized Loss Estimates	
Extreme Temperature	NCEI Storm Events Database	NOAA NCEI
Drought	NCEI Storm Events Database	NOAA NCEI
Wildfires	Wildland Urban Interface (WUI) geospatial dataset	SILVIS Lab, University of Wisconsin - Madison

4.3 Risk Assessment

4.3.1 Hazard Ranking

The purpose of the hazard identification and risk assessment is to provide a factual basis for developing mitigation strategies by prioritizing areas most threatened and vulnerable to natural hazards. During the kickoff meeting for the plan held on January 18, 2017, the natural hazards applicable to the City were discussed in terms of frequency and historical damages.

A standardized methodology, which allows for greater flexibility and room for subject matter expertise, was developed to compare different hazards' risk for the 2018 update. This method prioritizes hazard risk based on a blend of quantitative factors extracted from NCEI and other available data sources. Many of the hazards assessed in this HIRA did not have quantifiable probability or impact data, thus a semi-quantitative ranking system was used to compare all of the hazards of interest instead. These include:

- Likelihood of occurrence (probability)
- Range of impact
    - Affected Area
    - Primary Impact
    - Secondary Impact
- Community Survey Ranking

The probability of each hazard is determined by assigning a level, from unlikely to highly likely, based on the likelihood of occurrence from historical data. The range impact value includes the affected area, primary impact and secondary impact levels of each hazard. Input received from the Community Survey was used as parameter in the ranking and reflects community perceived risk in terms of hazards impacting the survey responders' home and neighborhood. The total score for each hazard is the probability score multiplied by its importance factor times the sum of the impact level scores multiplied by their importance factors. Based on this total score, the hazards are separated into three categories based on the hazard level they pose to the communities: Significant, Moderate, and Limited. Table 4-5 provides a summary of the categories used to rank the hazards and their weighted values for the Composite Hazard Index. The overall hazard rankings are provided at the end of the Hazard Identification and Risk Assessment sections (see Table 4-49. Overall Hazard Priority Summary).

Table 4-5. Hazard Ranking Parameters

Probability	Affected Area	Primary Impact	Secondary Impact	Community Survey Rating
Weighting: 2	*Weighting: 0.5*	*Weighting: 0.8*	*Weighting: 0.7*	*Weighting: 1.0*
Unlikely *Less than 1% probability in next 100 years or has a recurrence interval of greater than every 100 years.*	**Isolated** *Less than 1% of area affected*	**Negligible** *Less than 10% damage*	**Negligible** *No loss of function, downtime, and/or evacuations*	**Low** *No perceived threat to neighborhood or home*
Somewhat Likely *Between 1 and 10% probability in next year or has a recurrence interval of 11 to 100 years.*	**Small** *Between 1 and 10% of area affected*	**Limited** *Between 10% and 25% damage*	**Limited** *Minimal loss of function, downtime, and/or evacuations*	**Medium-Low** *Minimal perceived threat to neighborhood or home*

Probability	Affected Area	Primary Impact	Secondary Impact	Community Survey Rating
Weighting: 2	*Weighting: 0.5*	*Weighting: 0.8*	*Weighting: 0.7*	*Weighting: 1.0*
Likely *Between 10 and 100% probability in next year or has a recurrence interval of 10 years or less.*	**Medium** *Between 10 and 50% of area affected*	**Critical** *Between 25% and 50% damage*	**Moderate** *Some loss of function, downtime, and/or evacuations*	**Medium-High** *Some perceived threat to neighborhood or home*
Highly Likely *Near 100% probability in next year or happens every year.*	**Large** *Between 50 and 100% of area affected*	**Catastrophic** *More than 50% damage*	**High** *Major loss of function, downtime, and/or evacuations*	**High** *Major perceived threat to neighborhood or home*

The hazard ranking generated from this exercise, along with consideration of available date, was used to prioritize the level of effort assigned to further analysis of each hazard in the vulnerability analysis and lost estimation sections.

4.4 Vulnerability Analysis

The purpose of the vulnerability assessment is to estimate the extent of potential damages from natural hazards of varying types and intensities. The vulnerability and risk assessment builds upon the information by identifying and characterizing an inventory of assets in the City of Beverly, and then assessing the potential impact and amount of damages that can be expected to be caused by each identified hazard event. The primary objective of the vulnerability assessment is to quantify exposure and the potential loss estimates for each hazard. In so doing, the City of Beverly and partners may better understand their unique risks to identified hazards and be better prepared to evaluate and prioritize specific hazard mitigation actions.

4.4.1 Critical Facility Analysis

To assess Beverly's vulnerability, an inventory of its structures and critical facilities was performed. Critical facilities are those that warrant special attention in preparing for a disaster and that are vital in maintaining community function. Beverly has prepared an inventory of critical facilities that includes emergency response facilities such as: law enforcement, fire, and emergency medical services (EMS) stations; hospitals, nursing homes, and care facilities; schools; local government buildings; and important transportation facilities, including airports, parks, water treatment plants, and waste water treatment plants.

Table 4-6. Summarizes the total number of critical facilities in Beverly by facility type. The most common critical facility in Beverly is sewer pump stations with 29 total facilities. Day cares and schools are the second and third most common critical facility types in Beverly. Figure 4-2 shows the location of the different critical facilities throughout Beverly.

Table 4-6. Critical Facilities (Source: City of Beverly GIS)

Facility Type	Number of Facilities
Adult Day Care	2
Assisted Living	4
Bridge	3
Cell Tower	3
Children Residence	3
Church	15
College	2
Cultural Resource	9
Dam	1
Day Care	20
Government	12
Hazmat	13
Heliport	2
Landing Strips	1
Library	2
Marina	4
Mortuary	1
Nursing Home	3
Pharmacies	6
Reservoir	1
School	18
Sewer Pump Station	29
Storm Pump Station	1
Supermarket	4
Train Station	5
Utility	6
Total:	**170**

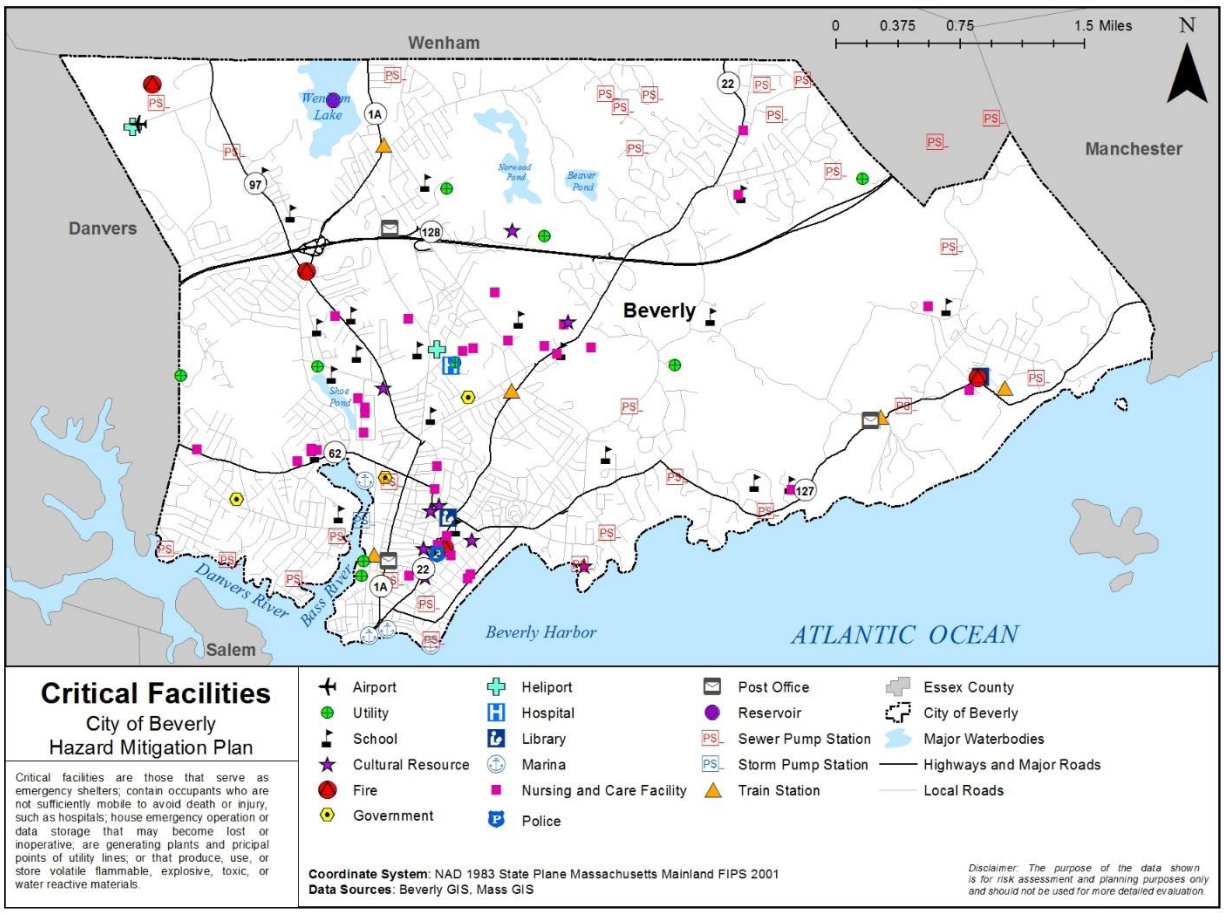

Figure 4-2. City of Beverly Critical Facilities

4.4.2 Building Data

The geospatial tax parcel data for the City of Beverly includes details on the number of buildings on each parcel and the total assessed value of the buildings, among other features. This geospatial tax parcel data was overlaid with the city's neighborhoods in order to summarize the total number of buildings and their assessed value for each neighborhood, as shown in Table 4-7. This tax parcel data was used in the risk assessment to determine the exposure of the City of Beverly's building stock to the different hazards.

Table 4-7. Total Buildings and Property Value

Neighborhood	Total Assessed Building Value	Total Building Count
Beverly Farms	$302,182,100.00	766
Centerville	$382,768,800.00	1323
Cove	$419,104,750.00	1583

Neighborhood	Total Assessed Building Value	Total Building Count
Downtown	$591,276,090.00	2070
Fish Flake	$23,190,100.00	104
Folly Hill	$49,724,500.00	97
Gloucester Crossing	$31,074,000.00	128
Goat Hill	$51,448,100.00	262
Kittridge Crossing	$415,161,600.00	1060
Monteserrat	$217,271,160.00	572
North Beverly-East	$173,557,800.00	735
North Beverly-West	$303,022,090.00	677
Prides Crossing	$211,764,100.00	240
Prospect Hill	$105,299,700.00	473
Raymond Farms/The Colleges	$76,722,900.00	434
Ryal Side-North	$149,676,200.00	777
Ryal Side-South	$181,208,400.00	978
Shingleville	$59,781,800.00	290
Beverly Golf & Tennis Club	$1,030,900.00	3
Grand Total	**$3,745,265,090.00**	**12572**

4.4.3 Hazus-HM

Hazus-MH (multiple-hazards) is a computer model 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, earthquake, and flooding. For this plan update, Hazus-MH Version 3.2 was run for hurricane wind and flooding. There are also three levels at which Hazus-MH can be run. Level 1 relies upon default data on building types, utilities, transportation, etc. from national databases as well as census data. The hurricane wind analysis results that follow in Section 4.5.5 was completed using Level 1 data. Level 2 uses a combination of local and default hazard, building, and damage data. The flood analysis was completed using a Level 2 analysis, the results of which are explained in Section4.5.2. Based on limited resources and low probability of occurrence a new Hazus run was not completed for the earthquake hazard. The Commonwealth of Massachusetts included an updated earthquake run in its 2013 hazard mitigation plan which is referenced in the Section 4.5.7 Earthquake hazard profile.

A more detailed explanation of the methodology used to run Hazus for flood and wind can be found in Appendix C, including a description of the inventory development, model setup, and a summary of issues and challenges encountered.
.

4.5 Hazard Specific Analysis

The hazard identification highlights the types of hazards the City of Beverly is most vulnerable to and ranks them based on specific parameters. A vulnerability and risk assessment are then completed for each of the hazards to measure the potential loss of life, personal injury, economic injury, and property damage resulting from hazards. Each of the hazards are presented as sub-sections of this report with the following primary components:

1. Hazard Profile
    a. Description
    b. Location and Extent
    c. Previous Occurrence
    d. Probability of Future Events
2. Vulnerability and Risk Assessment
    a. Hazard Ranking
    b. Vulnerability and Impact to People and Property

The level of analysis for the vulnerability and risk assessment varies based on the designated hazard ranking. The hazard assessment also examines the impact of hazards on existing and future land uses and development trends, within the identified hazard areas. Current conditions were evaluated in terms of what is already developed, and in terms of people and property types. The City has comprehensive plans, zoning ordinances, capital improvement plans, and other documents, which were used as indicators of potential future risks to undeveloped properties, services, and infrastructure. New development and areas targeted for re-development often present the best opportunities for incorporating new

methods of development or retrofitting development so that it will be able to withstand the effects of hazards.

4.5.1 Severe Winter Weather

4.5.1.1 Description

Winter storms can vary in size and strength and include heavy snow, blizzards, ice, rain, sleet, and blowing and drifting snow. Extremely cold temperatures often accompany winter storms, made worse by strong winds that result in cold temperatures that cause frostbite and even death. The following are the National Weather Service's descriptions of various components of a winter storm:

- **Heavy snowfall** - the accumulation of six or more inches of snow in a 12 hour period or eight or more inches in a 24 hour period.
- **Blizzard** - the occurrence of sustained wind speeds over 35 mph accompanied by heavy snowfall or large amounts of blowing or drifting snow for more than three hours.
- **Freezing drizzle/freezing rain** - precipitation that falls as liquid, but freezes on contact with roads, trees, power lines and other surface structures that are below 32 degrees F, forming a dangerous glaze of ice.
- **Ice storm** - a type of winter storm characterized by freezing rain which results in a dangerous coating of ice on trees, power lines, and road surfaces.
- **Sleet** - solid grains or pellets of ice formed by the freezing of raindrops or the refreezing of largely melted snowflakes. Sleet does not cling to surfaces.
- **Wind chill** – a calculated temperature index that describes the combined effect of wind and low air temperatures on exposed skin.

Storm systems powerful enough to cause blizzards usually form when the jet stream dips far to the south, allowing cold air from the north to clash with warm air from the south. Blizzard conditions often develop on the northwest side of an intense storm system. The difference between the lower pressure in the storm and the higher pressure to the west creates a tight pressure gradient, resulting in strong winds and extreme conditions due to the blowing snow.[5]

Beverly's worst winter storms are Nor'easters, which are a type of winter storm with counter-clockwise wind circulation around a low-pressure center that results in heavy snow, high wind, and rain. According to the National Weather Service, the U.S. East Coast provides an ideal breeding ground for Nor'easters. During winter, the polar jet stream transports cold Arctic air southward across the plains of Canada and the United States, then eastward toward the Atlantic Ocean where

[5] 2013 Massachusetts State Hazard Mitigation Plan.

warm air from the Gulf of Mexico and the Atlantic tries to move northward. The warm waters of the Gulf Stream help keep the coastal waters relatively mild during the winter, which in turn helps warm the cold winter air over the water. This difference in temperature between the warm air over the water and cold Arctic air over the land is the fuel that feeds Nor'easters. In Massachusetts, Nor'easters occur one to two times per year, typically during the late fall and early winter.[6] These storms typically have sustained wind speeds of 20-40 mph and gusts up to 50-60 mph, resulting in storm surge equal to or greater than 2.0 feet. Due to the stationary nature of Nor'easters, these storms can result in considerable coastal erosion and flooding.

NOAA's National Centers for Environmental Information (NCEI) produced the Regional Snowfall Index (RSI), a regional snowfall impact scale that uses the area of snowfall, the amount of snowfall, and the number of people living within a snowstorm. The RSI ranking categories are similar to the Northeast Snowfall Impact Scale (NESIS), which was developed for storms that had a major impact on the Northeast but also included the impact of snow on other regions. The NESIS was considered a quasi-national index that was calibrated to Northeast storms, whereas the RSI is a regional index that is produced for six NCEI climate regions in the eastern two-thirds of the United States.

Since the index uses population information, it attempts to quantify the societal impacts of a snowstorm. NCEI has analyzed and assigned RSI values to over 500 storms going back as far as 1900, therefore the index puts a particular event into a century scale historical perspective. Table 4-8 shows the RSI ranking categories.[7]

Table 4-8. NCEI Regional Snowfall Index

Category	Description	RSI Value
1	Notable	1 - 3
2	Significant	3 - 6
3	Major	6 - 10
4	Crippling	10 - 18
5	Extreme	18.0+

Source: NOAA-NCDC, 2011 (http://www.ncdc.noaa.gov/snow-and-ice/rsi/)

4.5.1.2 Location and Extent

Winter storms and extreme cold events occur annually in Beverly. The coastal areas of Beverly are especially susceptible to the damaging effects of Nor'easters that can cause storm surge, high winds, and flooding along the coastline. All parts

[6] 2013 Massachusetts State Hazard Mitigation Plan.

[7] https://www.ncdc.noaa.gov/snow-and-ice/rsi/

of Beverly are considered to be equally likely to be impacted by heavy snow, ice, and sleet.

Figure 4-3 shows the normal annual snowfall totals from 1981 to 2010 based on data collected by the Northeast Regional Climate Center. Essex County is circled in blue on the figure. Beverly is located in an area where normal snow totals average between 40 and 60 inches per year.

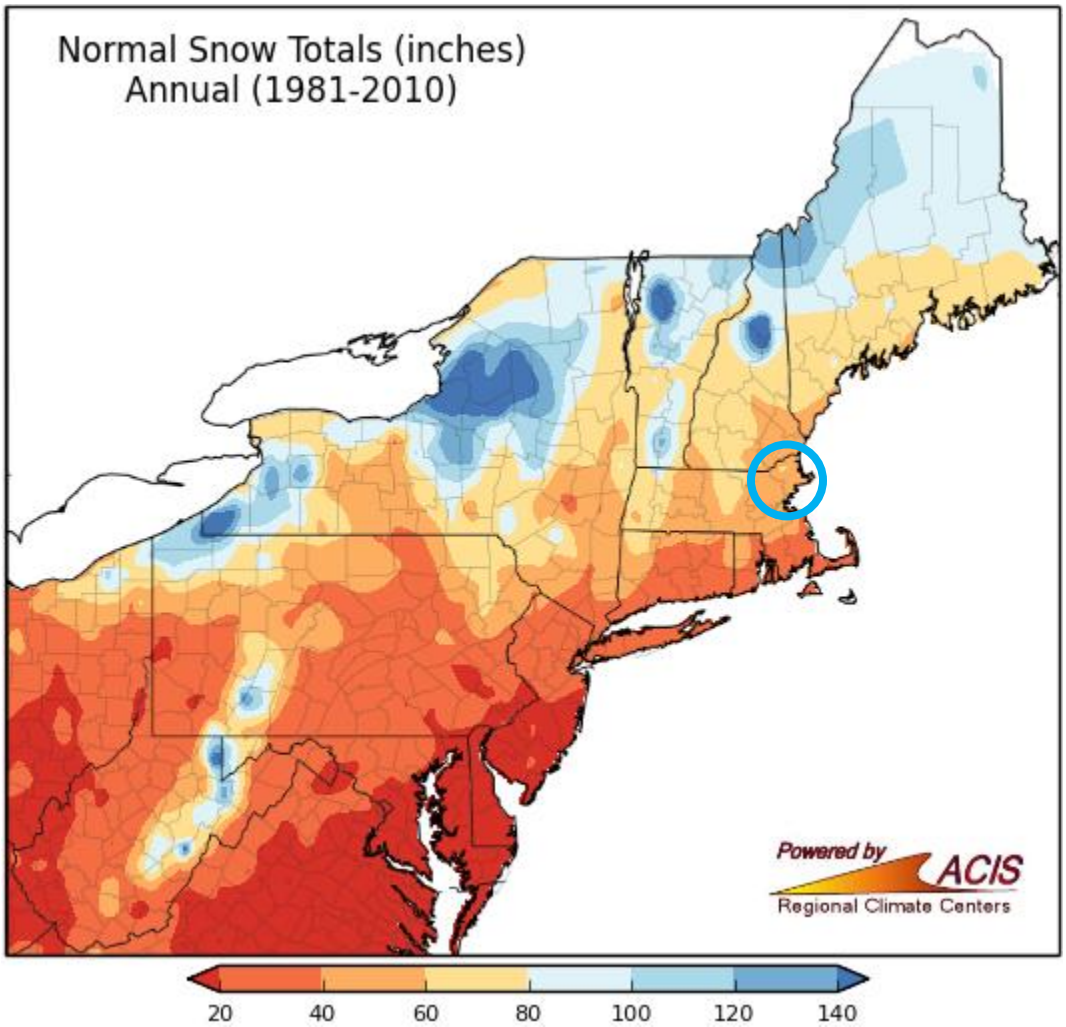

Figure 4-3. Normal Annual Snow Totals from 1981 to 2010[8]

4.5.1.3 Previous Occurrences

Winter storms, including heavy snow and winter weather, occur frequently in Essex County. According to the NOAA NCEI Storm Events Database, there are 113 severe winter weather events (see Table 4-3) documented in Essex County since 1996.

[8] Northeast Regional Climate Center

These severe winter weather events have resulted in a total of $14.4 million in property damage. Heavy snow has been the costliest winter hazard resulting in $11 million of total property damage. It should be noted that these numbers reflect reported damages. Often with this database, if damages are reported on a statewide or multiple county level, damages are spread evenly across the counties in the area. Data is not parsed by municipality. The data does, however, demonstrate the overall magnitude of the risk in the planning area.

According to the 2013 Massachusetts State Hazard Mitigation Plan, Essex County has experienced 20 ice events from 1971 to 2012. These events primarily occurred in late December and early January.

In Essex County, Massachusetts, there have been 13 FEMA disaster declarations related to severe winter weather from 1978 to 2017, as summarized in Table 4-9.

Table 4-9. FEMA Winter Storm-Related Disaster Declarations (1954 to 2017) in Essex County, MA

Disaster Number	Disaster Type	Incident Type	Incident Begin Date	Declaration Date	IH	IA	PA	HM
546	DR	Coastal Storms, Flood, Ice & Snow	2/6/1978	2/10/1978	N	Y	Y	Y
975	DR	Winter Coastal Storm	12/11/1992	12/21/1992	N	Y	Y	Y
3103	EM	Blizzards, High Winds & Record Snowfall	3/13/1993	3/16/1993	N	N	Y	Y
1090	DR	Blizzard Of 96	1/7/1996	1/24/1996	N	N	Y	Y
3165	EM	Snow	3/5/2001	3/28/2001	N	N	Y	N
3175	EM	Snow	2/17/2003	3/11/2003	N	N	Y	N
3191	EM	Snow	12/6/2003	1/15/2004	N	N	Y	N
3201	EM	Record And/or Near Record Snow	1/22/2005	2/17/2005	N	N	Y	N
1813	DR	Severe Winter Storm And Flooding	12/11/2008	1/5/2009	N	N	Y	Y
3296	EM	Severe Winter Storm	12/11/2008	12/13/2008	N	N	Y	N
1959	DR	Severe Winter Storm And Snowstorm	1/11/2011	3/7/2011	N	N	Y	Y
4110	DR	Severe Winter Storm, Snowstorm, And Flooding	2/8/2013	4/19/2013	N	N	Y	Y
4214	DR	Severe Winter Storm, Snowstorm, And Flooding	1/26/2015	4/13/2015	N	N	Y	Y

Figure 4 shows the 3-day snowfall extremes by county in Massachusetts.[9] The snowfall totals are reported in inches on a scale from 23" to 43.9". Essex County, circled in red, experienced an extreme snowfall event that started on February 8th, 1978, when 43.9" fell over a 3-day period. This event was the most snow recorded over a 3-day period in Massachusetts and further reinforces the historic nature of the Blizzard of 1978.

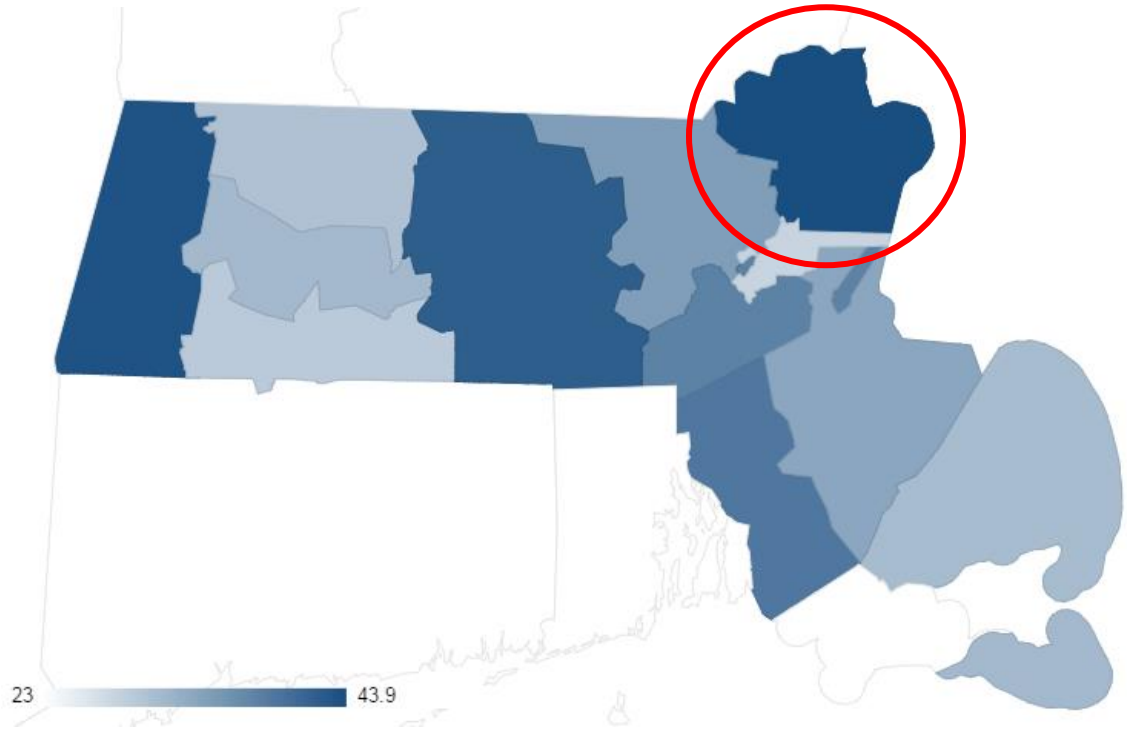

Figure 4. Massachusetts 3-Day Snowfall Extremes by County.

4.5.1.4 Probability of Future Events

Based on the occurrence of winter weather in Essex County as documented in the NOAA NCEI Storm Events Database, the City of Beverly should expect to see between five and six related events per year, including instances of ice, heavy snow, and blizzards.

4.5.1.5 Vulnerability and Risk Assessment

Hazard Ranking

The priority hazard ranking process for the 2018 HIRA determined Severe Winter Weather to be a high priority hazard in the City of Beverly. As described in the profile above, winter weather events within the City are frequent events with

[9] NOAA NCEI Snowfall Extremes https://www.ncdc.noaa.gov/snow-and-ice/snowfall-extremes/

multiple reported events each year. Impacts are estimated to be large, as 50 to 100 percent of the City is impacted, usually with negligible damage to facilities and moderate loss of function, downtown, and/or evacuations. The community survey results indicate that citizens of Beverly perceive the hazard to be a high threat to their neighborhood or home. Table 4-10 outlines the hazard ranking for each of the hazard priority criteria related to Severe Winter Weather.

Table 4-10. Severe Winter Weather Hazard Priority

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Severe Winter Weather	**Highly Likely** *Near 100% probability in next year or happens every year*	**Large** *Between 50 and 100% of area affected*	**Negligible** *Less than 10% damage*	**Moderate** *Some loss of function, downtime, and/or evacuations*	**High** *Major perceived threat to neighborhood or home*	**Significant**

Vulnerability and Impact to People and Property

The NCEI Storm Events data was annualized by taking the total number of winter storm events and dividing by the length of record. The annualized values should only be utilized as an estimate of what can be expected in a given year. Using historical records at the county level, it can be estimated that Essex County will experience between five and six events every year. Damages from these events can be expected in the magnitude of $655,169 for property. These costs reflect only reported damage to property at the county level and would likely be less in the City of Beverly. There are no reported deaths or injuries from these events, however future deaths and injuries still remain a risk. Table 4-11 summarizes these annualized results for winter weather events in Essex County. These numbers do not take into account expenditures on public safety and snow removal on an annual basis.

Table 4-11. Annualized Damages from Winter Weather Events.

Annualized Occurrence	Annualized Property Damage
5.14	$655,169

All critical facilities in Beverly are considered vulnerable to the effects of severe winter storms due to the potential disruption of services and transportation systems as well as possible structure failure due to heavy snow loads. The level of vulnerability of a building depends on the age of the building (and the building codes in effect at the time of construction), type of construction, and condition of the structure (i.e., how well it has been maintained, materials used, etc.).

FEMA Risk Management has published a Snow Load Safety Guide[10]. The guide states:

> "Most buildings are not at risk of snow induced failure More often than not, attempting to remove snow from a roof is more hazardous than beneficial, posing a risk to both personnel and the roofing structure. However, snow accumulation in excess of building design conditions can result in more than a temporary loss of electrical power and inaccessible roads. Buildings may be vulnerable to structural failure and possible collapse if basic preventative steps are not taken in advance of a snow event. Knowledge of the building roof framing system and proper preparation in advance of a snow event is instrumental in reducing risk to the structure."

Using the FEMA Snow Load Safety Guide, it can be assumed that certain roof types and materials are more susceptible to snow-induced collapse. Buildings vulnerable to increased snow accumulation and unbalanced loads include:

- Gable/multi-span gable roof
- Mono-slope roof
- Flat or low-slope roof with or without roof drains
- Stepped roof
- Saw-tooth roof

Based on the available building information in Beverly's tax maps, the following types of building roofs are summarized in Table 4-12. Based on the list above of vulnerable roof types, 86% of Beverly's building stock has a gable or hip style roof. Both roof styles can cause unbalanced snow loads when the roof acts as an aerodynamic shade, blocking wind from blowing snow on the leeward side of the roof ridge, causing unbalanced build up. In general, the steeper the pitch of a gable or hip style roof, the more effectively it will shed snow. Flat roofs and low slope roofs

Table 4-12. Building Roof Type

Roof Type	Number of Buildings
Bow	2
Flat	963
Gable	8955
Gambrel	509
Hip	1881
Mansard	115

[10] FEMA Risk Management Series: Snow Load Safety Guide. FEMA P-957 January 2013. https://www.fema.gov/media-library-data/7d8c55d1c4f815edf3d7e7d1c120383f/FEMA957_Snowload_508.pdf

Roof Type	Number of Buildings
Saltbox	11
Sawtooth	2
Shed	4
(blank)	129
Grand Total	12571

In addition to roof types, framing materials can also be a factor in determining a structure's vulnerability to snow loads and failure. Wood-framed structures are more susceptible to excess snow loads. Wood-framed structure failure could include joint failures, member fracture, and lateral buckling from improper or inadequate installation. There are 11,440 wood-framed structures in Beverly, of which 9013 were constructed prior to 1975.[11]

Even small accumulations of ice can cause a significant hazard, especially on power lines and trees. An ice storm occurs when freezing rain falls and freezes immediately upon impact. Communications and power can be disrupted for days, and even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Extended power outages from ice storms would require residents to look for supplemental heat sources; improper use of these sources could result in house fires. Injuries could result from slipping on ice if residents, especially elderly, were to leave their home.

Injuries and death during winter storms are usually caused from transportation accidents and hypothermia. Snow and ice can cause disruptions in transportation lines and utilities resulting in emergency response delays. Secondary effects of winter storms include carbon monoxide poisoning and house fires from increased and improper use of alternative heating sources.

Socially vulnerable populations and rural communities are especially at-risk to winter storms; these include children under five (5.3% of Beverly's population) and people over the age of 65 (14.6% of Beverly's population).[12]

Figure 4-5 and Figure 4-6 provide a visual understanding of where the hot spots of vulnerable populations are located in Beverly. The area in and around the Downtown Beverly District has a particularly high concentration of these vulnerable populations.

[11] Drifting loads were first incorporated into BOCA in 1975. Unbalanced roof snow loads were introduced in UBC in 1988.

[12] U.S. Census Bureau QuickFacts, Beverly, MA, https://www.census.gov/quickfacts/table/PST045216/00

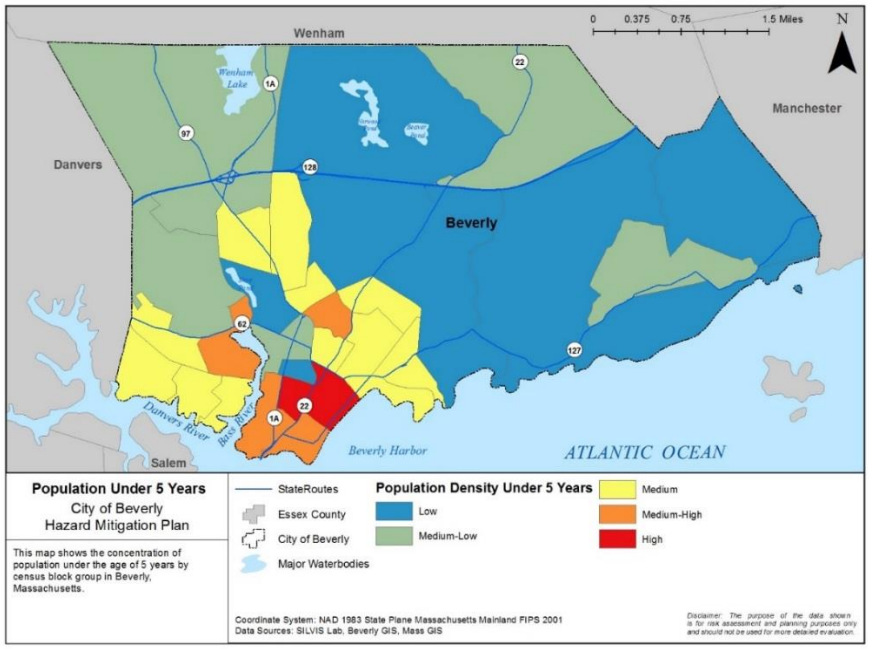

Figure 4-5. Population Density Under 5 Years of Age

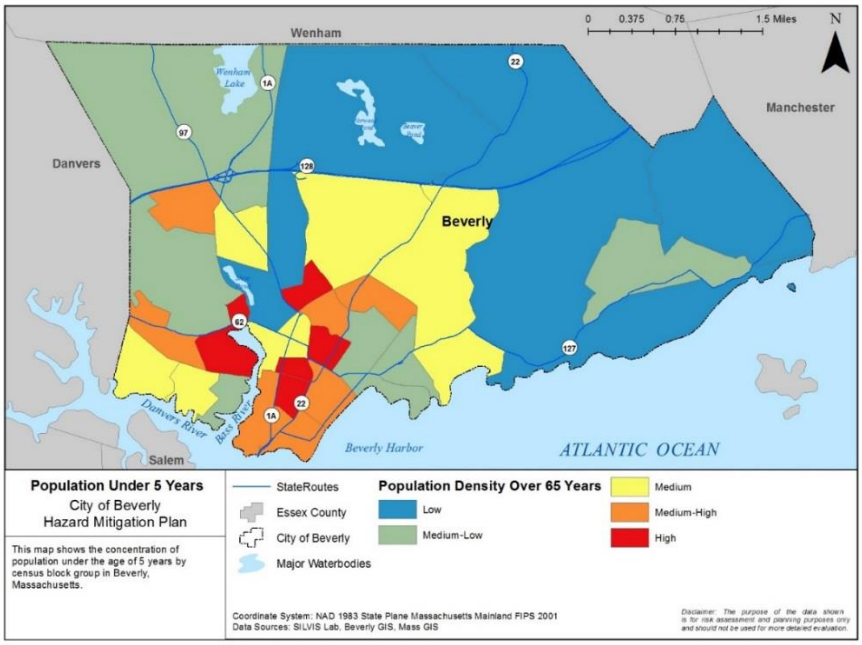

Figure 4-6. Population Density over 65 Years of Age

4.5.2 Flooding

4.5.2.1 Description

Floods are among the most frequent and costly natural disasters in terms of human hardship and economic loss—75 percent of federal disaster declarations are related to flooding. Property damage from flooding totals over $5 billion in the United States each year. Flooding can often coincide with spring snowmelt and can also be a direct result of other frequent weather events, which in Massachusetts include Nor'easters, heavy rainstorms, tropical storms, and hurricanes.[13]

The severity of a flooding event is typically determined by a combination of several major factors, including: stream and river basin topography and physiography; precipitation and weather patterns; recent soil moisture conditions; and the degree of vegetative clearing and impervious surface. There are several different types of floods. The flood-related hazards most likely to affect Beverly are riverine (inland) flooding, urban flooding, and coastal flooding.

Riverine (inland) Flooding

Riverine flooding occurs when a channel, for example a stream, receives more water than it can hold and the excess water overflows the channel banks flooding the surrounding area. Heavy rain and large amounts of snow melt can cause riverine flooding. In Beverly, nor'easters and tropical storms have been known to cause severe riverine flooding due to high rainfall rates. Nor'easters are very slow moving storms that can also generate high runoff when soil infiltration rates are exceeded. Large snowfalls can also lead to inland flooding when snow melts in early spring.

Urban Drainage Flooding

Urban drainage flooding can occur when there is increased water runoff due to urban development and drainage systems. Drainage systems are designed to remove surface water from developed areas as quickly as possible to prevent localized flooding on streets and other urban areas. They make use of a closed conveyance system that channels water away from an urban area to surrounding streams, bypassing natural processes of water infiltration into the ground, groundwater storage, and evapotranspiration (plant water uptake and respiration). Since drainage systems reduce the amount of time the surface water takes to reach surrounding streams, flooding can occur more quickly and reach greater depths than if there were no urban development at all.[14]

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[13] 2013 Massachusetts State Hazard Mitigation Plan

[14] Wright, James M. Chapter 2: Types of Floods and Floodplains. Floodplain Management: Principles and Current Practices. Emergency Management Institute, Federal Emergency Management Agency. (2008). Available online at: http://training.fema.gov/EMIWeb/edu/docs/fmpcp/Chapter%202%20-%20Types%20of%20Floods%20adn%20Floodplains.pdf

Coastal Flooding

Coastal flooding is the inundation of land areas along the coasts of oceans, bays, estuaries, coastal rivers, and large lakes, by seawater that is over and above normal tide action. Coastal flooding is the result of storm surge caused by winds and forward motion associated with a storm that piles water up in front of it as it moves toward shore. This advancing surge combines with the normal tides to create the hurricane storm tide that can increase the mean water level 15 feet or more. Severe storm surge is also frequently associated with Nor'easters that impact Beverly and the surrounding coastal areas of Massachusetts.

Storm surge heights, wind speed, fetch length, pressure and associated waves are dependent upon the configuration of the continental shelf (narrow or wide) and the depth of the ocean bottom (bathymetry). These as well as other factors can impact storm surge height and wave height. A narrow shelf, or one that drops steeply from the shoreline and subsequently produces deep water in close proximity to the shoreline, tends to produce a lower surge but higher and more powerful storm waves. Table 4-13 highlights the general impacts of storm surge hazards.

Table 4-13. Storm Surge Impacts

Extent of Storm Surge	Impacts:
High: 4-10 feet	Major Structural Flooding, loss of life, and major beach erosion
Medium: 3-4 feet	Flood damage to homes
Low: 0-3 feet	Damage to sea turtle nests, minor beach erosion

Sea Level Rise (SLR)

Sea level is the sea level related to the level of the continental crust. Relative sea level changes can thus be caused by absolute changes of the sea level and/or by absolute movements of the continental crust. SLR presents a hazard that should be considered in long-term land use, development, and critical infrastructure planning. Beverly has exposure to the potential impacts of SLR, with approximately 5.13 miles of harbor/riverine shoreline, from Tucks Point to Danvers and 6.15 miles of ocean shoreline from Tucks Point to the Manchester line. Climate change, including the continued increase in global temperature, is projected to result in an acceleration of observed rates of SLR. Projections in global increases in sea level by 2100 due to climate change range from one (1) to two (2) feet[15] up to 6.6 feet.[16]

[15] IPCC, 2007: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E.Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp.

[16] Pfeffer, W.T. et al, 2008: Kinematic Constraints on Glacier Contributions to 21st-Century Sea-Level Rise. Science 321, 1340.

Although SLR is a gradual process, impacts may be experienced in the short term. Some examples include increased frequency of low-level inundation, exacerbated flood elevations during storm events, increased rates of coastal erosion, and increased saltwater intrusion into groundwater.

The City of Beverly was the recipient of a $89,981 grant from the Massachusetts Office of Coastal Zone Management (CZM) to identify potential impacts of sea level rise due to climate change and develop a resiliency strategy to begin address these potential impacts. In an on-going effort to address the present and future risks of climate change and sea level rise to critical infrastructure, public facilities and residential and commercial uses, the City undertook an assessment of critical infrastructure most vulnerable to coastal flooding.

4.5.2.2 Location and Extent

Strong on-shore winds associated with Nor'easters and tropical storms can generate damaging storm surge that inundates the coastal areas of Beverly. Not all storms that pass close to Beverly cause extremely high storm surges. Similarly, storms which produce extreme conditions in one area may not necessarily produce critical conditions in other areas. As noted in the effective countywide Flood Insurance Study (FIS) for Essex County, coastal flooding in Beverly has been particularly evident in the low-lying areas on the north end of Dane Street Beach and Chubbs Brook Area.

Riverine and urban flooding also occurs in Beverly, primarily as a result of the high rate of precipitation associated with slow moving storms. The resulting large volume of water can overwhelm the capacity of natural and structured drainage systems that convey water, causing it to overflow the system. The effective FIS for Essex County notes that riverine flooding has not generally been a serious problem in Beverly. The FIS also reports frequent flooding occurs at Cabot Street / Herrick Street because of capacity constraints south of Cabot Street. This was corrected by an additional 66" Reinforced Concrete Pipe (RCP) from Cabot Street across a playground, discharging at the lower Shoe Pond. Additional improvements were made as part of the North Beverly Brook project in 2009 by cleaning the 66" and 48" culverts across the playground and cleaning downstream culverts at the Cummings Center.

The extent of a floodplain, whether in a coastal or riverine area, is designated by the frequency of the flood that is large enough to cover them. For example, the 10-year floodplain will be covered by the 10-year flood and the 100-year floodplain by the 100-year flood. Flood frequencies such as the 100-year flood are determined by plotting a graph of the size of all known floods for an area and determining how often floods of a particular size occur. Another way of expressing the flood frequency is the chance of occurrence in a given year, which is the percentage of the probability of flooding each year. For example, the 100-year flood has a 1 percent chance of occurring in any given year. The 500-year flood has a 0.2 percent chance of occurring in any given year. Digital Flood Insurance Maps (DFIRM) are developed as part of the FEMA Flood Insurance Study (FIS) to

delineate the areas that are at risk of being flooded during a 100-year flood event. These areas are also referred to as the Special Flood Hazard Area (SFHA).

The SFHA on a DFIRM is typically labeled as Zones A/AE/AO/AH (areas subject to inundation by the 1-percent-annual-chance, or 100 year flood event) and Zone VE (areas subject to inundation by the 1-percent-annual-chance flood event with additional hazards due to storm-induced velocity wave action). DFIRMs also delineate the 500-year flood event or one that has a 0.2-percent-annual-chance of being equaled or exceeded. The 500-year flood event is labeled as Zone X (shaded). Areas of minimal flood hazard, outside the SFHA and higher in elevation than the 500-year flood zone, are labeled Zone X (unshaded).[17] It is important to note that while FEMA digital flood data is recognized as best available data for planning purposes, it does not always reflect the most accurate and up-to-date flood risk. Flooding and flood-related losses often do occur outside of delineated special flood hazard areas.

Figure 4-7 illustrates the location and extent of the currently mapped flood zones in Beverly based on the Essex County FIS with an effective date of July 16, 2014. There are three effective Letters of Map Revision (LOMR) that have been approved on 4/17/2015 and 5/5/2017, since the last hazard mitigation plan update. The revisions from these LOMRs are not visible at the map scale of Figure 4-7, however details about each LOMR can be found on the FEMA Map Service Center website. Some general background about each of these LOMRs is as follows:

- The LOMR effective 4/17/2015, 15-01-1016A, is a Coastal High Hazard Area determination document that removed an individual structure from the V zone.
- LOMR 16-01-2010P, effective 5/5/2017, updates flood elevations and extents along the Atlantic Ocean via Manchester Bay and Salem Sound, as well as from the confluence of Chubbs Brook with Chubb Creek to the upstream crossing of the railroad.
- 17-01-0046P LOMR, also effective 5/5/2017, updates flood zones and flood extents along the Atlantic Ocean via Beverly Harbor.

[17] https://www.fema.gov/flood-zones

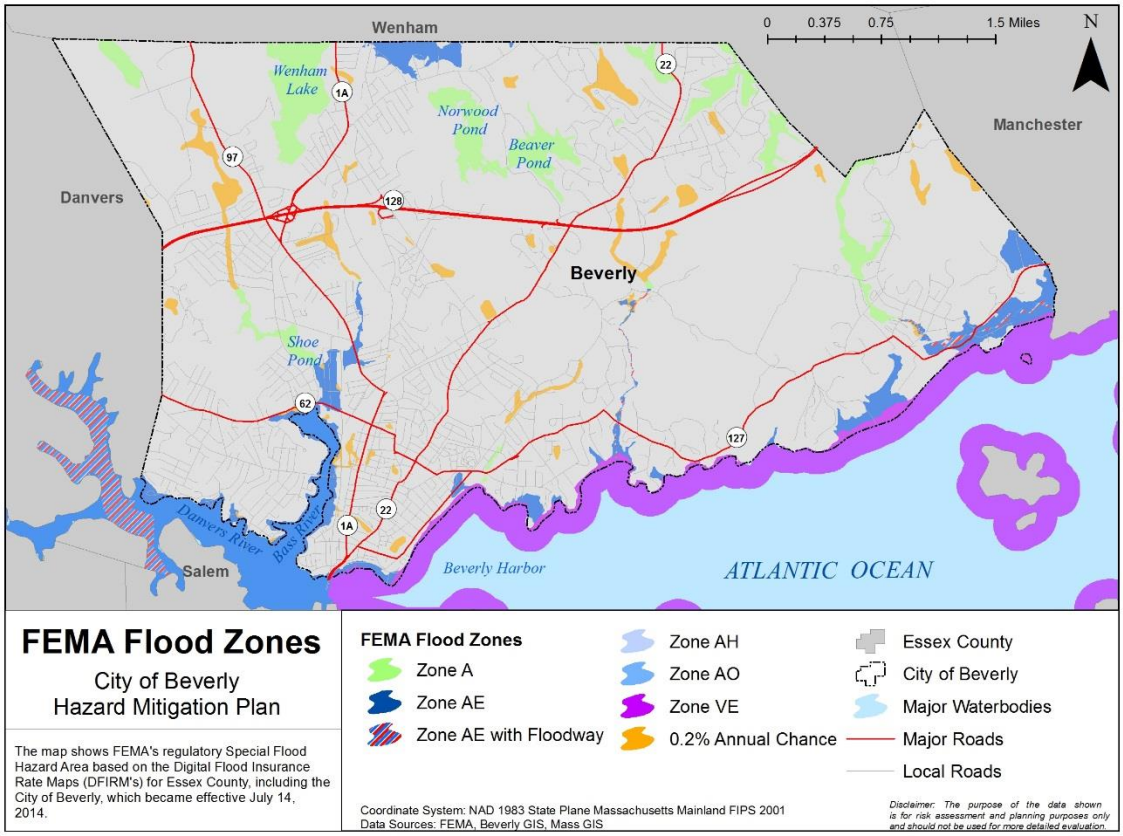


Figure 4-7. FEMA Flood Zones in Beverly

The Locally Identified Areas of Flooding described below were identified by City staff as areas in Beverly where flooding is known to occur. These areas do not necessarily coincide with the flood zones from the FIRM's. They may be areas that flood due to inadequate drainage systems or other local conditions rather than location within a flood zone. The numbers do not reflect priority order.

1. North Beverly Brook (Flooding): This mitigation project has been completed. The North Beverly Brook is about a 1000 acre drainage area that drains to the "Lower Shoe Pond" at the Cummings Center.
2. Lawrence Street Brook (Flooding): This mitigation project has been completed with the final sub project to provide flood storage at Kellehers Pond.
3. Chubbs Creek (Flooding): This mitigation project was completed in two phases. The second phase has been completed.
4. Water Street (Coastal Flooding):
5. Millbrook Road (Flooding):
6. Bayview Seawall (Coastal Flooding/Storms):
7. Tide gate at head of Bass River: coastal flooding/storms in the engineering phase, pending FEMA Grant decision.

4.5.2.3 Previous Occurrences

Since 1972, seventeen flood related events have resulted in Federal disaster declarations in Essex County. These events are summarized in Table 4-14.

Table 4-14. Flood-Related Federal Disaster Declarations for Essex County, Massachusetts

Disaster Number	Disaster Type	Incident Type	Incident Begin Date	Incident End Date
325	DR	Severe Storms & Flooding	3/6/1972	3/6/1972
546	DR	Coastal Storms, Flood, Ice & Snow	2/6/1978	2/8/1978
751	DR	Hurricane Gloria	9/27/1985	9/27/1985
790	DR	Severe Storms & Flooding	3/30/1987	4/13/1987
914	DR	Hurricane Bob	8/19/1991	8/19/1991
920	DR	Coastal Storm	10/30/1991	11/2/1991
975	DR	Winter Coastal Storm	12/11/1992	12/13/1992
1142	DR	Extreme Weather Conditions And Flooding	10/20/1996	10/25/1996
1224	DR	Heavy Rains And Flooding	6/13/1998	7/6/1998
1364	DR	Severe Storms And Flooding	3/5/2001	4/16/2001
1512	DR	Flooding	4/1/2004	4/30/2004
1614	DR	Severe Storms And Flooding	10/7/2005	10/16/2005
1642	DR	Severe Storms And Flooding	5/12/2006	5/23/2006
1701	DR	Severe Storms And Inland And Coastal Flooding	4/15/2007	4/25/2007
1895	DR	Severe Storms And Flooding	3/12/2010	4/26/2010
4110	DR	Severe Winter Storm, Snowstorm, And Flooding	2/8/2013	2/9/2013
4214	DR	Severe Winter Storm, Snowstorm, And Flooding	1/26/2015	1/28/2015

The NOAA NCEI Storm Events Database reports 89 flood related events in Essex County from 1996 to 2017 (see Table 4-3), which includes reports of coastal flooding, flash flood, heavy rain, storm surge, and riverine flooding. The most significant flood events, defined as those with over $500,000 in reported property damage, are reported in Table 4-15 in chronological order. One of the most significant flood events in terms of quantity of rain was the Mothers' Day floods of 2006, in which communities in northeaster Massachusetts, including the City of Beverly, received as much as 15 inches of rain in a 100-hour period.

Table 4-15. Significant Historic Flood Events

Date	Location	Property Damage	Description
6/13/1998 - 6/18/1998	Lynnfield, Georgetown, Peabody, Methuen, Ipswich, Essex County	$3,340,018	On June 12th through the 14th, a slow moving complex storm system moved through New England. The combination of its slow movement and the presence of tropical moisture across the region produced rainfall of 6 to 12 inches over much of eastern Massachusetts, which led to widespread urban, small stream, and river flooding. During the period from June 15th through the 20th, the slow moving upper level system continued to set off afternoon thunderstorms which moved very slowly in the weak upper level wind flow. Several flash flood events occurred. The flooding resulted in a Presidential Disaster Declaration in the following Massachusetts counties: Essex, Middlesex, Norfolk, Suffolk, and Bristol. Dollar damage has been established at $13,000,000.
5/13/2006	Essex County	$8,291,042	Heavy rainfall, most of it falling over a 100 hour period, caused widespread flooding across much of eastern Massachusetts of small streams and main stem rivers, resulting in State of Emergency and subsequent disaster declaration. Rainfall totaled 8 to 12 inches with some parts of Essex County exceeding 12 inches. Several roads and schools were closed, in addition to evacuations of thousands of people. Two fatalities (adult males) were attributed to flooding from the storm. Both occurred in Topsfield in the vicinity of the Ipswich River.
3/15/2010	Eastern and Southern Essex County	$10,731,480	A stacked low pressure system moved southeast of Nantucket, spreading rain across Southern New England. Rainfall totals were on the order of six to ten inches, resulting in major flooding along small streams, and in urban areas especially with poor drainage. A state of emergency was declare and a federal disaster declaration was made. Strong winds downed numerous trees and wires and caused some minor structural damage to a few buildings.

Date	Location	Property Damage	Description
3/30/2010	Newbury	$3,580,810	Three to seven inches of rain fell across Essex County resulting in several rivers going into minor flood, including the Spicket River at Methuen and the Merrimack River at Lawrence and at Haverhill. In addition, several small streams rose above flood stage across Essex County, including the Parker River at Byfield and the Ipswich River at Ipswich and South Middleton. Several streets were closed due to flooding in Peabody, Methuen, Andover, Danvers, Saugus, Gloucester, and Topsfield. Many basements were also flooded. There were 4 reported injuries as a direct result of this storm.
7/10/2010	West Peabody	$547,524	Two to four inches of rain fell within an hour's time and produced significant urban flash flooding in and around the city of Boston. In Lynn, Alley and Commercial streets experienced significant flooding. A car was stranded on Chatham Street. In Peabody, a car was stranded near Foster and Spring Streets. Shaws Lane and Oak Streets were flooded.
10/4/2011	North Salem, Marblehead, Beverly, Devereux, Topsfield, Salem Maritime NHS, South Lawrence, Hawthorne	$7,329,941	Low pressure southeast of Nantucket produced widespread showers across southern New England. These showers trained over an area known as the North Shore in Massachusetts, including the towns of Peabody, Swampscott, and Salem. In all, these showers produced four to six inches of rain in these towns in one to two hours, resulting in substantial urban flash flooding. Numerous roads were closed due to flooding and hundreds of houses and businesses sustained flood damage as a result of this storm.
2/9/2013	Eastern Essex County	$5,945,027	An historic winter storm deposited heavy snow across southern New England, including an average of one to two feet of snow over the southeastern Massachusetts coast. Blizzard conditions were experienced were experienced along the Massachusetts coast, where gusts exceeded hurricane force (74 mph) at a few locations. Coastal flooding occurred as a result of the high wind, causing damage to coastal structures and roads, flooding of homes and businesses, and significant beach erosion.

Date	Location	Property Damage	Description
3/7/2013	Eastern Essex County	$1,025,005	This storm brought heavy snow and significant coastal flooding to the forecast area. This was an unusual synoptic set-up, with low pressure lingering off the coast of southern New England for several days. Snowfall was difficult to forecast due to concerns about precipitation type and boundary layer temperature. In the end, precipitation type turned out to be all snow for much of the area, with most locations receiving 1 to 2 feet of snow. In addition, the Massachusetts east coast was hit by widespread moderate and pockets of major coastal flooding for two high tide cycles and beach erosion for at least 5 high tide cycles.

4.5.2.4 Historical Summary of Insured Flood Losses

The National Flood Insurance Program (NFIP) is a federal program that enables property owners in participating communities to purchase insurance for flood losses. For a community to participate in the NFIP they must adopt floodplain management regulations that reduce future flood damages. This insurance is designed to provide an alternative to disaster assistance to reduce the high costs associated with repairing damage to buildings and their contents caused by floods (FEMA).

In addition to providing flood insurance and reducing flood damages through floodplain management regulations, the NFIP identifies and maps the Nation's floodplains. Mapping flood hazards creates broad-based awareness of the flood hazards and provides the data needed for floodplain management programs and to actuarially rate new construction for flood insurance.

Communities that participate in the NFIP are required to adopt and enforce the minimum federal NFIP floodplain management regulations. These regulations apply to all types of floodplain development and ensure that development activities will not cause an increase in future flood damages. Buildings are required to be reasonably safe from flooding which usually requires the finished floor elevation to be elevated at or above the corresponding Base Flood Elevation (BFE). The BFE is determined based on modeling and mapping identified within a community's Flood Insurance Study (FIS). The FIS and its corresponding Flood Insurance Rate Maps (FIRMs) provide information on areas of flood risk per the NFIP standards. These maps identify areas that have a 1%-annual chance of flooding as well as those areas with a 0.2%-annual chance of flooding.

If the finished grade elevation for a structure is below the corresponding BFE, and there is a federally insured loan on the structure, then there is a mandatory requirement to purchase a flood insurance policy. The requirement for high risk structures to carry a flood insurance policy is one method used by the NFIP to offset the escalating costs of flood disasters.

The City of Beverly participates in the NFIP. Table 4-16 summarizes Beverly's participation history, including dates of when the Flood Hazard Boundary Maps (FHBM) were issued, when the first Flood Insurance Rate Maps became effective, the date of the effective FIRMs used for flood insurance purposes, and the date the community entered into the NFIP (Reg-Emer Date).

Table 4-16. Beverly NFIP Participation

Community Name	Status	Initial FHBM /Identified	Initial FIRM Identified	Current Effective Map Date	Reg-Emer Date
City of Beverly	Participating	8/16/1974	3/18/1986	7/16/2014	3/18/86

There are 358 flood insurance policies in Beverly, of which 209 policies are for properties in the A zone and 2 are policies for properties in the V zone. Total coverage of these policies is equal to $91.4 million. As of February 2017, 145 NFIP claims with $1.55 million in total payments were filed for properties within the city.

Table 4-17 summarizes the NFIP policy and claim statistics for the county with Essex County totals for comparison. These losses include both inland and coastal flooding events. It should be emphasized that these numbers include only those losses to structures that were insured through the NFIP policies, and for losses in which claims were sought and received. It is likely that many additional instances of flood losses in Essex County were either uninsured, denied claims payment, or not reported.

Table 4-17. Beverly NFIP Policies and Claims

Community Name	Number of Policies	Total Coverage	Total Premium	Total Claims Since 1978	Total Paid since 1978
City of Beverly	358	$91,416,800	$ 277,974	145	$1,552,558
Essex County	9,931	$2,550,466,700	$ 10,964,803	4,709	$73,398,477

Community Rating System (CRS)

The National Flood Insurance Program's (NFIP) Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risks. There are ten CRS classes: Class 1 requires the most credit points and gives the largest flood insurance premium reduction; Class 10 receives no premium reduction. These discounts are applied per each CRS community and apply to all flood insurance policyholders. For CRS participating communities, flood insurance premium rates are discounted in increments of 5%; i.e., a Class 1 community would receive a 45% premium discount, while a Class 9 community would receive a 5% discount. If a community does not apply or fails to receive at least 500 points, it's in Class 10, and property owners get no discount. [18]

Although the City of Beverly conducts activities that may be eligible for points, it has made an informed decision not to participate in the CRS. It is believed that with the relatively low number of policies and the discounts it could achieve based on current activities, the cost of managing the program would exceed the financial benefits. The City is, however, committed to a sound floodplain management program, as discussed in Section 6, Capabilities Assessment.

FEMA Repetitive Flood Claims

A NFIP repetitive loss (RL) property is defined as a facility or structure that has experienced two or more insurance claims of $1,000 or more in any given 10 year period

[18] FEMA Community Rating System https://www.fema.gov/national-flood-insurance-program-community-rating-system

since 1978. A RL property may or may not be currently insured by the NFIP. Currently there are over 122,000 RL properties nationwide.

According to FEMA repetitive loss property records (as of December 2016), there are 17 “non-mitigated” repetitive loss properties located in Beverly, an increase from the 15 structures identified in the 2012 plan . These properties include fourteen single-family residential structures, two 2-4 family structures and one non-residential structure. Eight of these properties are currently insured. These 17 RL properties account for a total of 42 losses and more than $313,500.00 in claims payments under the NFIP (Table 4-18). Due to privacy concerns, it is not appropriate to include the addresses of these properties in a public plan. Figure 4-8 shows the general areas in the City where there are concentrations of RL properties. The Beverly Farms neighborhood of Beverly contains the highest number.

Table 4-18. Repetitive Loss Properties Summary (as of December 2016)

Occupancy	FEMA Flood Zone	Losses	Total Paid
Single-Family	AE (floodway)	2	$31,301.01
Single-Family	AE (floodway)	2	$27,119.79
Single-Family	AE	2	$20,048.95
Single-Family	AE	4	$22,602.73
Single-Family	AE	2	$7,472.99
Single-Family	A	4	$34,453.94
Single-Family	VE	4	$49,296.56
Single-Family	AE	2	$3,292.25
Single-Family	X-unshaded	2	$6,777.38
Single-Family	X-unshaded	2	$3,770.44
Single-Family	X-Shaded	3	$4,216.96
Single-Family	X-unshaded	2	$12,162.88
2 to 4 Family	X-unshaded	2	$6,266.34
Single-Family	A	2	$29,178.61
Single-Family	AE	2	$6,362.80
2 to 4 Family	X-unshaded	3	$34,812.98
Other Non-Residential	X-unshaded	2	$14,414.50

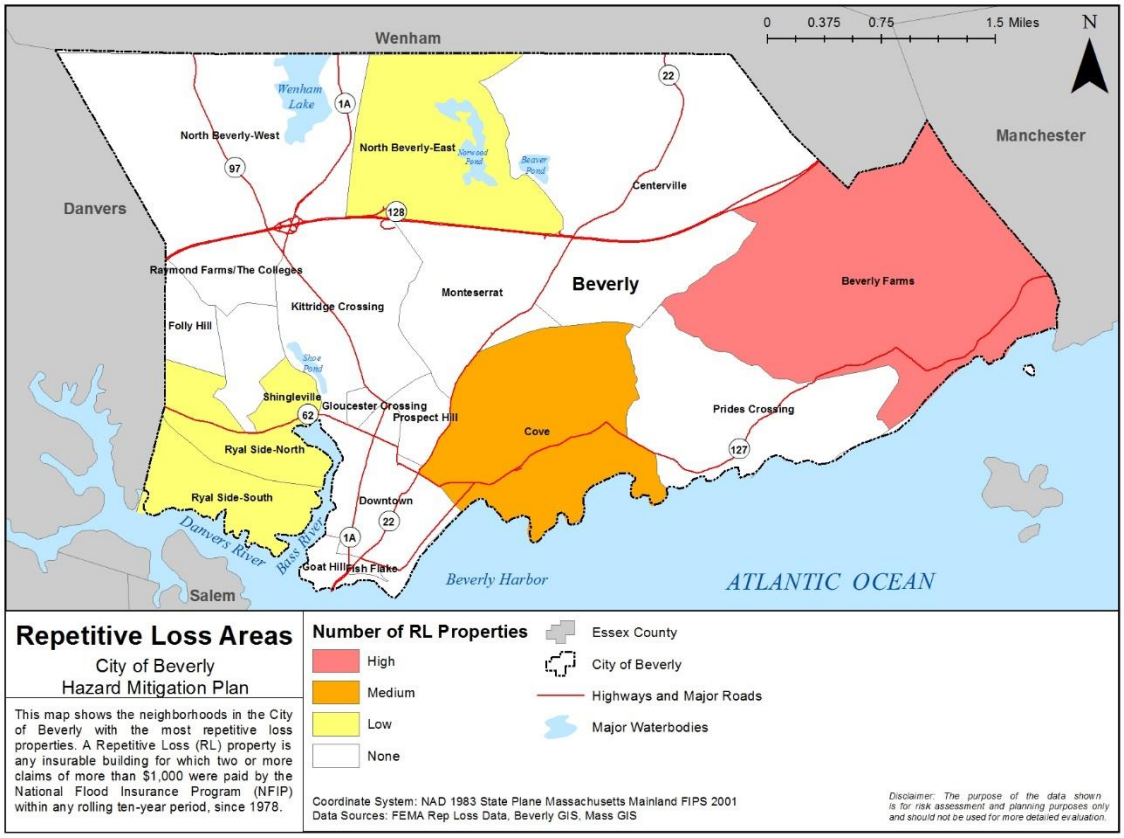


Figure 4-8. Repetitive Loss Properties in Beverly, MA

4.5.2.5 Probability of Future Events

Flood events will continue to have a high frequency of occurrence in the City of Beverly. The probability of future flood events is based on the magnitude and according to best available data. Further, it is highly likely that Beverly will continue to experience inland and coastal flooding as a result of large Nor'easters, tropical storms and hurricanes that pass through the area.

It should also be noted that anticipated sea level rise will increase the probability and intensity of future tidal flooding events in years to come. Increases in short and long duration high intensity rainfall events are also increasing in New England. While annual rainfall has not increased dramatically in the last decade, the intensity of storms has. Rising sea level over time will shorten the return period (increasing the frequency) of significant flood events. For example; sea level rise of 1 foot over a typical project analysis period (50 years) may cause a flood event currently of annual probability 2 percent (50-year flood) to become an event of 10 percent annual probability (10-year flood).

4.5.2.6 Vulnerability and Risk Assessment

Hazard Ranking

The priority hazard ranking process for the 2018 HIRA confirmed flooding to be a significant priority hazard in Beverly. As described in the profile above, flood events within the City are highly likely events that happen nearly every year. Impacts are estimated to be small, one to 10 percent of the city, with critical damage to facilities and high loss of function, downtown, and/or evacuations. The community survey results indicate that citizens of Beverly perceive the hazard to be a medium-high threat to their neighborhood or home. Table 4-19 outlines the hazard rankings for each of the hazard priority criteria related to Flooding.

Table 4-19. Flooding Hazard Priority

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Flood	**Highly Likely** *Near 100%* **probability** *in next year or happens every year*	**Small** *Between 1 and 10% of area affected*	**Critical** *Between 25% and 50% damage*	**High** *Major loss of function, downtime, and/or evacuations*	**Medium-High** *Some perceived threat to neighborhood or home*	**Significant**

Vulnerability and Impact to People and Property

Flood losses to properties can be caused by storm tides from hurricanes and tropical storms or from storm water flooding caused by stream/canal overflow or sheet flow. Historical flood damages from tropical storms and hurricanes include foundation and wall damage to structures, contents damage, loss of utilities, infrastructure damage to roads, and beach erosion. Damages from storm water runoff events also include wall damage due to “wicking”, mildew damage, damages to contents, minor foundation damage, damage to water distribution systems, and potable water contamination. Public related costs include debris clearance; equipment, material and labor expenses related to emergency response; and building or facility damage (county parks, utilities, communications).

Consideration should be given to the location of critical facilities in Beverly to flood hazards. Figure 4-9 maps the location of Beverly’s critical facilities in relation to the FEMA mapped special flood hazard areas (SFHA) (1% annual chance flood) and the 500 year flood zone (0.2% annual chance flood). There are 22 critical facilities that intersect the SFHA, seven of which are sewer pump stations and three are care facilities.

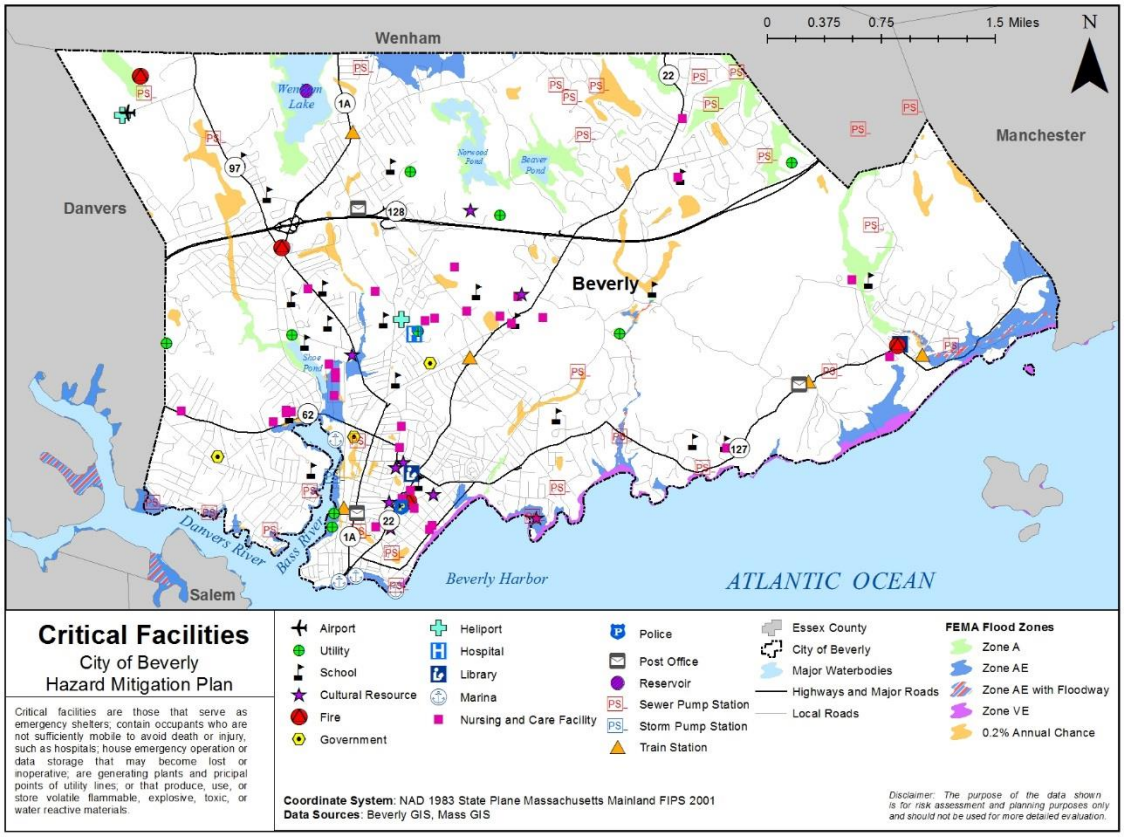


Figure 4-9. Critical Facilities near Special Flood Hazard Areas

The NCEI Storm Events data was annualized by taking the total number of damaging flood events and dividing by the length of record. The annualized values should only be utilized as an estimate of what can be expected in a given year. Using historical records at the county level, it can be estimated that Essex County will experience about four flood related events every year. Property damage from these events is expected to reach nearly $2.5 million annually. While a low probability, deaths and injuries due to flood events are possible on an infrequent basis. Table 4-20 summarizes these annualized damages for flood events in Essex County, though the City of Beverly is expected to experience a smaller but similar magnitude of annualized occurrences and damages.

Table 4-20. Annualized Damages from Flood Events in Essex County

Annualized Occurrences	Annualized Property Damage	Annualized Deaths	Annualized Injuries
4.05	$2,525,255	0.09	0.14

Loss Estimation

Hazus-MH Flood model was run at the building level for Beverly. User-defined Facilities (UDF) were created for this project based on tax parcel and roof footprint data from the

City. This Hazus flood scenario model includes five multi-frequency return period events; the 10-, 25-, 50-, 100- and 500-year frequency events. These return periods are also expressed as annual-chance events represented by 10%, 4%, 2%, 1% and 0.2%. Estimated loss values from each annual chance event are annualized to determine the weighted average loss or the expected loss in any given year across the range of years analyzed (500 years).

Buildings that experienced damage in the Hazus flood scenario model represent those individual structures that intersected the flood depth grids and experienced estimated building and/or content losses. Table 4-21 compares the 100-year return period estimated losses due to flood to the average annual losses.

Table 4-21. UDF 100-Year and Average Annual Losses from Flood

Return Period	Building Losses	Content Losses	Inventory Losses	Total Losses
100-Year	$6,887,700	$7,211,391	$2,921,438	$17,020,530
Average Annual	$876,629	$1,056,143	$132,632	$2,065,404

Table 4-22. UDF Average Annual Total Losses by General Occupancy Type from Flood

Occupancy Type	Exposure/Value	Total Losses	Percent Damage
Commercial	$566,649,029	$1,534,841	0.27%
Government	$655,356	$2,528	0.39%
Industrial	$6,006,307	$28,875	0.48%
Residential	$54,900,509	$499,159	0.91%
Total	$628,211,203	$2,065,404	0.33%

The annualized UDF results were then used to develop a building loss ratio: total annualized damage (structure, contents and inventory) versus total building value (structure and contents). This individual building loss ratio was then aggregated to the census block level and the level of damage was ranked from very low (small loss ratio) to very high (large loss ratio) as displayed in Figure 4- 10. Figure 4-11 displays points for the individual buildings that would experience damage in the annualized UDF results, ranked based on the building loss ratio. These buildings generally coincide with the location of the higher risk FEMA flood zones. Additional details about methodologies used to run the Hazus flood module and additional results from this analysis can be found in Appendix C.

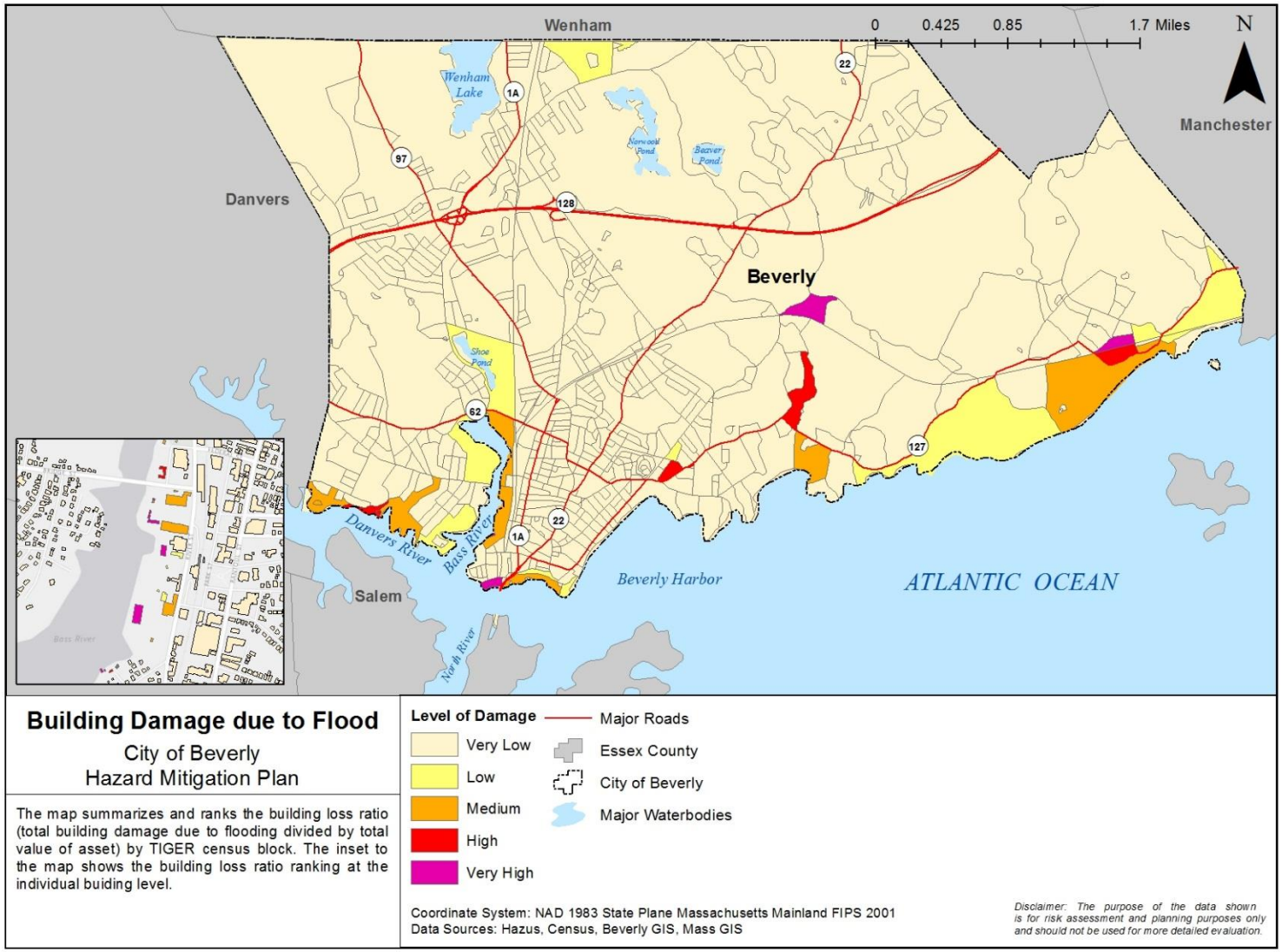


Figure 4- 10. UDF Average Annual Building Loss due to Flood by Census Block

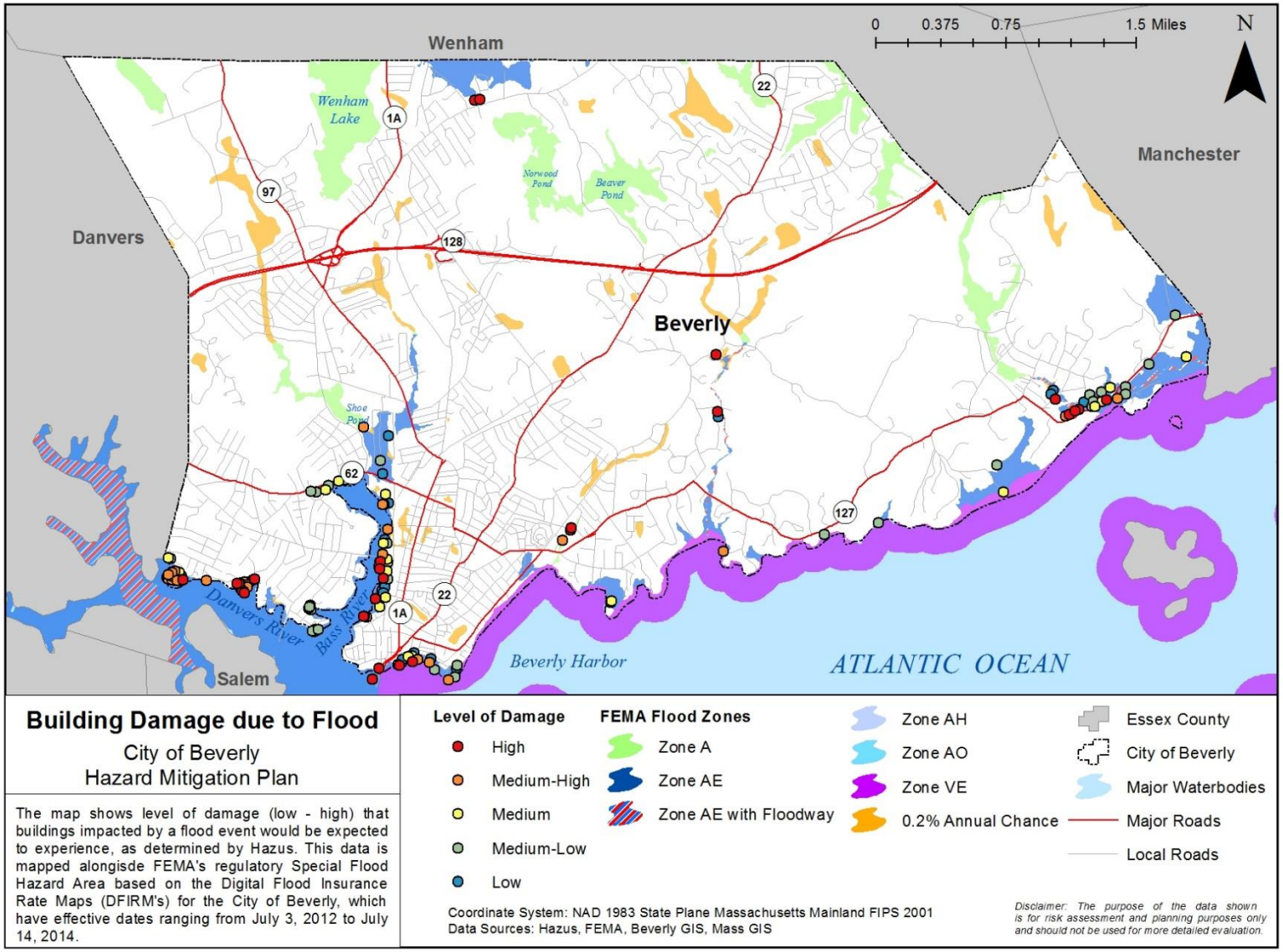


Figure 4-11. UDF Annualized Damages by Building

4.5.3 Severe Weather (Thunderstorms, Severe Wind, Lighting, and Hail)

4.5.3.1 Description

For the purposes of this plan, severe weather includes thunderstorms, severe wind, lightning, and hail events. The National Weather Service defines a thunderstorm as a localized storm produced by a cumulonimbus cloud and accompanied by lightning and thunder. Thunderstorms are typically the result of warm, moist air that is pushed upwards into the atmosphere where it cools and forms into cumulonimbus clouds. As the air continues to cool, it starts to form water droplets or ice. As these droplets or ice start to fall, they may collide and combine many times into larger forms before reaching the Earth's surface. These severe storms are associated with the presence of strong winds, thunder, and lightning. It is also possible to experience a thunderstorm with no precipitation which can cause wildfires to occur. Thunderstorms can form in any geographic region, and are sometimes the cause of other natural phenomena such as downburst winds, heavy rain, flash floods, large hailstones, tornadoes, and waterspouts.

A severe thunderstorm includes damaging winds greater than 58 mph (50 knots) or greater and hail 1 inch or larger in diameter. Severe winds have been further broken down into three categories by the NWS Storm Events database:

- **High Wind:** Sustained non-convective winds of 35 knots (40 mph) or greater lasting for 1 hour or longer or winds (sustained or gusts) of 50 knots (58 mph) for any duration (or otherwise locally/regionally defined), on a widespread or localized basis. In some mountainous areas, the above numerical values are 43 knots (50 mph) and 65 knots (75 mph), respectively.
- **Strong Wind:** Non-convective winds gusting less than 50 knots (58 mph), or sustained winds less than 35 knots (40 mph) resulting in a fatality, injury, or damage.
- **Thunderstorm Wind:** Winds, arising from convection (occurring within 30 minutes of lightning being observed or detected), with speeds of at least 50 knots (58 mph), or winds of any speed (non-severe thunderstorm winds below 50 knots) producing a fatality, injury, or damage. Events with maximum sustained winds or wind gusts less than 50 knots (58 mph) should be entered as a Storm Data event only if they result in fatalities, injuries, or serious property damage.

Hail is precipitation in the form of ice pellets larger than 5 mm that forms in thunderstorms between currents of rising air (updrafts) and currents of descending air (downdrafts) as shown in Figure 4- 12. These events typically occur in late spring and early summer. One criteria for severe thunderstorms, as defined by the NWS, is hail that is 1 inch in diameter (quarter-size) or larger.

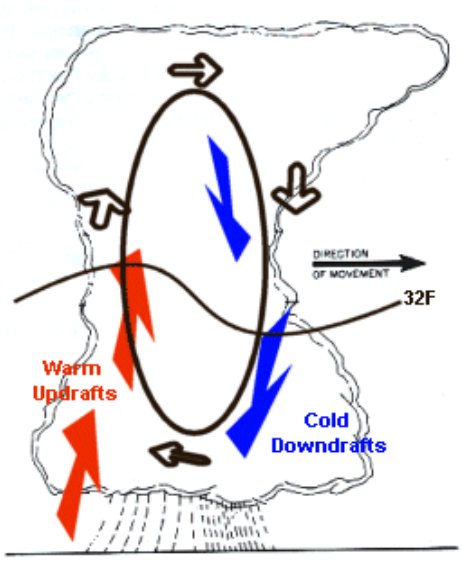


Figure 4- 12. Formation of Hail (Source: NOAA)

Lightning is defined by the NWS as a visible electrical discharge (i.e. lightning bolt) produced by a thunderstorm. The discharge may occur within or between clouds, between the cloud and air, between a cloud and the ground or between the ground and a cloud. A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit. Lightning rapidly heats the sky as it flashes, but the surrounding air cools following the bolt. This rapid heating and cooling of the surrounding air causes thunder.

4.5.3.2 Location and Extent

All of Beverly has the potential to be impacted by a thunderstorm that causes severe wind, lightening, and hail. All structures and assets in Beverly should be considered vulnerable to these hazards.

Using the NWS definition for a severe thunderstorm, dime-sized hail is considered a minimum hazard and quarter-sized hail is considered a major hazard. Quarter-sized hail can cause significant damage to agricultural crops and livestock, as well as property such as automobiles, aircraft, and roofs. Although rare, large hailstones may even cause injury or death. The amount of cover obtained during a hail storm can greatly reduce the risk to human health during these events.

While there is no established index for lightning, a lightning strike is considered to be of minimum severity when it has limited impacts on infrastructure (ex. tree limbs) and major severity when it causes extensive damage (ex. Loss of life, fire, structural damage). The potential damages resulting from lightning strikes are primarily loss of life, business interruption, fire and minor structural damage. A false sense of security often leads people to believe that they are safe from a lightning strike because it may not appear to be near their location. However, lightning can strike 10 miles away from a rain column, which puts people that are still in clear weather at risk.

Using the NWS severe wind categories listed above, sustained non-convective winds of 40 mph or greater lasting for 1 hour or longer or winds (sustained or gusts) of 58 mph for any duration, on a widespread or localized basis are considered a minimum severity event. A major severity event would be wind events of greater than 58 mph or wind events resulting in death, injury or significant damage.

4.5.3.3 Previous Occurrences

From the NCEI Storm Events Database, the most significant severe weather events in Essex County were extracted and summarized in Table 4-23. Significant events include any event that caused a death or injury, as well as the top 5 most costly events in terms of property damage.

Table 4-23. Significant Severe Weather Events

Location	Event Date	Event Type	Magnitude (mph)	Deaths	Injuries	Property Damage ($ 2017)
Essex County	8/8/1986	Thunderstorm Wind	0	0	2	$0.00
Essex County	6/16/1988	Thunderstorm Wind	70	0	2	$0.00
Essex County	7/7/1989	Thunderstorm Wind	60	1	1	$0.00
Beverly	8/13/1994	Thunderstorm Wind	62	0	0	$8,056,072.87
Essex County	7/20/1996	Strong Wind	40	1	0	$0.00
Essex County	10/15/2003	High Wind	50	0	2	$32,443.21
Andover	5/24/2004	Lightning		0	0	$252,813.13
Essex County	2/17/2006	High Wind	58	0	2	$592,217.26
Peabody	7/11/2006	Thunderstorm Wind	78	0	0	$592,217.26
Essex County	10/28/2006	High Wind	50	0	0	$532,995.54
Peabody	7/28/2007	Lightning	N/A	0	1	$0.00
Essex County	3/21/2008	Strong Wind	42	0	1	$27,726.27
Haverhill Airport	6/20/2008	Lightning	N/A	1	1	$0.00
Prides Crossing	7/2/2008	Thunderstorm Wind	50	0	1	$11,090.51
Hawthorne	7/3/2008	Thunderstorm Wind	50	0	1	$3,327.15
Essex County	2/25/2010	High Wind	58	0	0	$438,019.59
Forest River	6/3/2010	Lightning	N/A	0	1	$0.00
Shawsheen Village	9/6/2014	Lightning	N/A	0	1	$0.00

Location	Event Date	Event Type	Magnitude (mph)	Deaths	Injuries	Property Damage ($ 2017)
Conomo Point	9/6/2014	Lightning	N/A	2	0	$0.00

The likelihood and potential severity of thunderstorm wind/lightning/hail events can be assessed by reviewing the number and severity of thunderstorm events that have occurred in the period of history available for Essex County. There have been 254 episodes of severe weather reported in Essex County according to the NCEI Storm Events Database. These episodes reflect the overall storm system that affects the area and can include several associated events, such as hail, lightening, and high wind.

For the 254 reported severe weather episodes in Essex County, there were 418 associated wind events reported, of which 121 did not have a recorded magnitude or had a magnitude of 0. Of the remaining 297 recorded wind gusts, the recorded wind speeds varied from 28 to 100 miles per hour (mph). Table 4-24 shows the distribution of events by recorded wind speed, where the maximum wind speeds for an average thunderstorm range from 50 to 55 mph. Similarly, Table 4-25 shows the distribution of reported hail events by recorded hail size.

Table 4-24. Frequency of Wind Events

Wind Speed (mph)	Number of Events
Not Recorded	121
25-30	1
31-35	4
36-40	22
41-45	9
46-50	201
51-55	20
56-60	24
61-65	3
66-70	9
71-75	1
76-80	1
81-85	1
86-90	0
91-95	0
96-100	1
Total:	**418**

Table 4-25. Frequency of Hail Events

Hail Size (in.)	Object Analog Reported	Count of Events
0.5	Marble, moth ball	1
0.75	Penny	28
0.88	Nickel	13
1	Quarter	20
1.25	Half dollar	5
1.5	Walnut, ping pong	6
1.75	Golf ball	3
2	Hen egg	4
2.5	Tennis ball	0
2.75	Baseball	1
3	Tea cup	1
4	Softball	1
4.5	Grapefruit	0
	Total:	**83**

4.5.3.4 Probability of Future Events

The chance of future occurrences of thunderstorms that cause high wind, hail and lightening within Essex County is high (8.57 events per year). Since Beverly is a small portion of the County, probability is expected to be less, but still significant. Since it is difficult to determine the probability of future occurrences in a specific area with any degree of accuracy, all areas within Beverly are assumed to be equally at risk to the damaging effects of thunderstorms. Based on the frequency tables above, the average hail event in Beverly is expected to produce hail sizes ranging from 0.75" and 1". Future severe wind events will cause 50 to 55 mph gusts and sustained winds.

4.5.3.5 Vulnerability and Risk Assessment

Hazard Ranking

The priority hazard ranking process for the 2018 HIRA determined Severe Weather to be a significant priority hazard in the City of Beverly. As described in the profile above, thunderstorm-related events within the city are frequent with multiple events each year. Impacts are estimated to be large, 50 to 100 percent of the City, with negligible damage to facilities and moderate loss of function, downtown, and/or evacuations. The community survey results indicate that citizens of Beverly perceive the hazard to be a high threat to their neighborhood or home. Table 4-26 outlines the hazard rankings for each of the hazard priority criteria related to Severe Weather.

Table 4-26. Severe Weather Hazard Priority

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Severe Weather	**Highly Likely** *Near 100% probability in next year or happens every year*	**Large** *Between 50 and 100% of area affected*	**Negligible** *Less than 10% damage*	**Moderate** *Some loss of function, downtime, and/or evacuations*	**High** *Major perceived threat to neighborhood or home*	**Significant**

Vulnerability and Impact to People and Property

The impact of various severe weather events (including thunderstorms with high wind, lightning, and hail) can be measured in financial terms, as well as fatalities and injuries. The NCEI Storm Events data was annualized by taking the total number of damaging several weather events and dividing by the length of record. The annualized values should only be utilized as an estimate of what can be expected in a given year. The NCEI Storm Events database recorded the Severe Weather sub hazards for different periods of time. Hail and Thunderstorm Wind have 63 years of record, and Strong Wind, High Wind, and Lightening have 22 years of record. Annualized damages from Severe Weather events are reported in two groups to account for these different periods of record, as shown in Table 4-27. Strong Wind, High Wind, and Lightening have a high annual occurrence of between 11 and 12 events. Hail and Thunderstorm Wind have a lower annual occurrence of between three and four events. Annual property damages from these events can be expected between $175,253 and $258,669, depending on the hazard types. Severe weather events involving Strong Wind, High Wind, and Lightening have a low but measureable probability of causing death and injury.

Table 4-27. Annualized Damages from Severe Weather Events

Included Hazards	Annualized Occurrences	Annualized Property Damage	Annualized Deaths	Annualized Injuries
Strong Wind, High Wind, Lightning	11.55	$258,669	0.18	0.41
Hail, Thunderstorm Wind	3.11	$175,253	0.00	0.00

As evidence in property loss figures, severe weather events, especially the wind associated with a thunderstorm, have the potential to be very destructive. The NCEI estimates are believed to be an underrepresentation of the actual losses experienced due to hazards, as losses from events that go unreported or that are difficult to quantify are not likely to appear in the NCEI database.

The primary hazard caused by thunderstorm winds is the transport of debris, which can cause casualties and property loss or even the dislodging of mobile homes from their

structures or vehicles. High winds may also cause damage to poles and lines carrying electric, telephone, and cable television service. Older structures built before 1940 could be more susceptible to wind damage.

Older critical facilities are vulnerable to wind damage due to the age of construction and possible poor condition. It is important to identify specific critical facilities and assets that are most vulnerable to the hazard. Evaluation criteria include the age of the building (and what building codes may have been in effect at the time of construction), type of construction, and condition of the structure (i.e., how well the structure has been maintained).

4.5.4 Extreme Temperatures

4.5.4.1 Description

Extreme Heat

Extreme heat is typically a summer phenomenon that involves substantially hotter temperatures and/or more humid than average weather for a location at that time of year. The NWS can issue heat-related messages to inform citizens of forecasted extreme heat conditions. These messages are based on projected or observed heat index values and include:

- **Excessive Heat Outlook**: When there is a potential for an excessive heat event within three to seven days;
- **Excessive Heat Watch**: When conditions are favorable for an excessive heat event within 12 to 48 hours but some uncertainty exists in regards to occurrence and timing; and
- **Excessive Heat Warning / Advisory:** When an excessive heat event is expected within 36 hours. These messages are usually issued when confidence is high that the event will occur. A warning implies that conditions could pose a threat to life or property, while an advisory is issued for less serious conditions that may cause discomfort or inconvenience, but could still lead to threat to life and property if caution is not taken.

Extreme Cold

Extreme cold events occur when temperatures drop well below normal in an area for a period of time. Extremely cold air comes every winter in at least part of the country and affect millions of people across the United States. This arctic air, together with brisk winds, can lead to dangerously cold wind chill values. People exposed to extreme cold are susceptible to frostbite in a matter of minutes. Areas of the body most prone to frostbite are uncovered skin and the extremities, such as hands and feet. Hypothermia is another threat during extreme cold. Hypothermia occurs when the body loses heat faster than it can produce.

Cold weather can also affects crops. In late spring or early fall, cold air outbreaks can damage or kill produce for farmers, as well as residential plants and flowers. A freeze

occurs when the temperature drops below 32°F. Freezes and their effects are significant during the growing season. Frost develops on clear, calm nights and can occur when the air temperature is in the mid-30s. Each plant species has a different tolerance to cold temperatures.[19]

4.5.4.2 Location and Extent

The entire City of Beverly has the potential to be impacted by extreme temperatures. The "heat index" or "apparent temperature" is often used to measure how hot the air "feels" based on temperature and humidity. The index can be used as an indicator of potential health effects (Figure 4- 13). Risks from exposure to extreme heat include sunburn, heat cramps, heat exhaustion, heat stroke, and death. Extreme heat is also hazardous to livestock, agriculture, and structures such as roads and bridges, and may diminish water and energy supplies, which may increase the risk to human health.

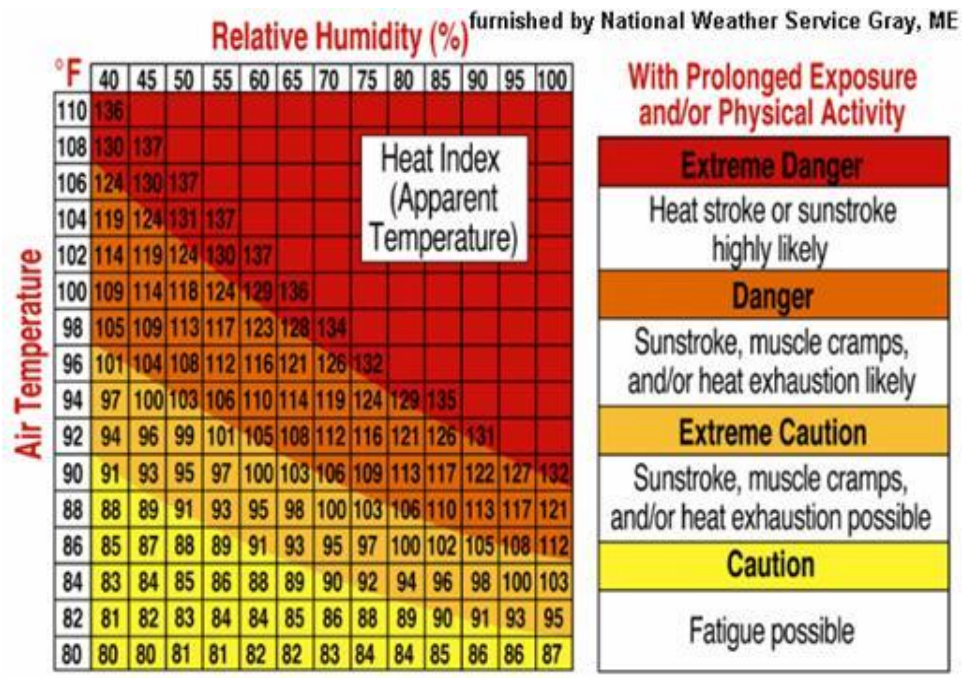


Figure 4- 13. NWS Heat Index Chart

The NWS Wind Chill Temperature (WCT) index uses advances in science, technology, and computer modeling to provide an accurate, understandable, and useful formula for calculating the dangers from winter winds and freezing temperatures. The index (Figure 4-14) does the following:

- Calculates wind speed at an average height of 5 feet, the typical height of an adult human face, based on readings from the national standard height of 33 feet, typical height of an anemometer

[19] http://www.nws.noaa.gov/om/cold/

- Is based on a human face model
- Incorporates heat transfer theory based on heat loss from the body to its surroundings, during cold and breezy/windy days
- Lowers the calm wind threshold to 3 mph
- Uses a consistent standard for skin tissue resistance
- Assumes no impact from the sun, i.e., clear night sky.

Wind Chill Chart

Wind (mph)	Temperature (°F)																	
Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Figure 4-14. NWS Wind Chill Chart

4.5.4.3 Previous Occurrences

Extreme heat events have normally occurred in early summer. The impact of these events can affect the local population, tourism industry, and agricultural industry. The NOAA NCEI Storm Events Database has recorded one occurrence of high heat event and one excessive heat event in Beverly since 1998, both of which occurred in July:

- From July 6th to 7th, 2010, a strong ridge built in Southern New England resulting in temperatures nearing 100 with high humidity. The heat index values at the Beverly Municipal Airport (KBVY) Automated Surface Observing System were 100 to 104 degrees.

- On July 22nd, 2011, a strong upper level ridge brought extremely hot temperatures to Southern New England. Coupled with a moist southwest low level flow, humidity levels brought heat index values above 105 degrees over the course of a few hours. The Automated Weather Observation System at Beverly Municipal Airport (KBVY), recorded heat indexes of 105 to 107 over a three hour period.

Extreme cold events typically occur during the late fall, winter, and early spring months in Beverly. The NOAA NCEI Storm Events Database recorded two extreme cold/wind chill events in Essex County:

- On February 15th, 2015, the Automated Surface Observing System at Beverly Municipal Airport (KBVY) recorded wind chills as low as 27 degrees below zero. This extreme cold was associated with a low pressure system off the Delmarva Peninsula that rapidly intensified and moved northeastward towards Boston and eastern Massachusetts. This storm brought additional heavy snow to the region, adding up to nearly 60 inches of snow in less than three weeks. The large amount of snow, combined with wintry, frigid temperatures resulted in snow piling up on roofs and numerous (250) roof collapses were reported to emergency management and to the National Weather Service in the days after this snowstorm.
- On February 16th, 2016, wind chills as low as 35 below zero were reported in Beverly. These extremely low temperatures were associated with an arctic high pressure that brought strong northwest winds and extremely cold wind chills to southern New England.

4.5.4.4 Probability of Future Events

Extreme temperatures are often unpredictable and may be localized, which makes it difficult to assess the probability. Using historical records it can be estimated that Beverly will experience an extreme temperature event once every five years.

Extreme temperature events can occur simultaneously with drought and winter storms, but either can occur without the other. While extreme temperature events can cause death to any person of any age, the elderly, very young, and mobility restricted are considered the most at risk.

4.5.4.5 Vulnerability and Risk Assessment

Hazard Ranking

The priority hazard ranking process for the 2018 HIRA determined Extreme Temperatures to be a moderate priority hazard in the City of Beverly. As described in the profile above, extreme temperature events within the city are likely with a 10 to 100 percent annual probability. Impacts are estimated to be isolated, less than one percent of the city affected, with catastrophic damage to facilities and negligible loss of function, downtown, and/or evacuations. The community survey results indicate that citizens of Beverly perceive the hazard to be a medium-high threat to their neighborhood or home. Table 4-28 outlines the hazard rankings for each of the hazard priority criteria related to Extreme Temperatures.

Table 4-28. Extreme Temperature Hazard Priority

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Extreme Temperatures	**Likely** *Between 10 and 100% probability in next year or has a recurrence interval of 10 years or less*	**Isolated** *Less than 1% of area affected*	**Catastrophic** *More than 50% damage*	**Negligible** *No loss of function, downtime, and/or evacuations*	**Medium-High** *Some perceived threat to neighborhood or home*	**Moderate**

Vulnerability and Impact to People and Property

The NCEI Storm Events data was annualized by taking the total number of extreme temperature events and dividing by the length of record. The annualized values should only be utilized as an estimate of what can be expected in a given year. Using historical records at the county level, it can be estimated that the Essex County will experience an extreme weather event about every five years. There are no expected damages to property from these events. Table 4-29 shows the annualized results for Extreme Temperature events in Essex County.

Table 4-29. Annualized Damages from Extreme Temperature Events

Hazard	Annualized Occurrence	Annualized Property Damage
Extreme Temperatures	0.18	$0.00

Severe winter weather has the ability to knock out heat, power and communications services to a home or office, sometimes for days at a time. The extreme cold temperatures often associated with these kinds of events can put entire regions at risk. The National Weather Service refers to winter storms as the "Deceptive Killers" because most deaths are indirectly related to the storm. Instead, people die in traffic accidents on icy roads or of hypothermia from prolonged exposure to cold. The elderly populations are particularly susceptible due to increased risk of injury and death from falls and overexertion and/or hypothermia from attempts to clear snow and ice, or related power failures. Younger populations are similarly at higher risk to developing hypothermia due to exposure to extreme cold temperatures.

Extreme heat can similarly impact large regions and populations in a variety of ways. The most common result of prolonged periods of extreme heat is a drought that can damage local vegetation and agriculture. A drought is a meteorological event that usually occurs for an extended period of time (six or more months) in which an area experiences less than 75% of its normal precipitation. Extreme heat events coupled with droughts can increase the chance of a wildfire occurring. Wildfires can be particularly problematic

during a drought as there may not be enough water available for firefights to use to fight them.

Extreme heat is also hazardous to livestock, agriculture, and structures such as roads and bridges, and may diminish water and energy supplies, which may increase the risk to human health. The people living in these areas exposed to extreme heat may experience increased instances of sunburn, heat cramps, heat exhaustion, heat stroke, and death.

The youngest and oldest sectors of the population are most at risk of experiencing damaging health effects when exposed to extreme heat and cold. In Beverly, 5.3% of the population is children under the age of five and 14.6% is people over the age of 65.[20]

Figure 4-5 and Figure 4-6 in the Severe Winter Weather section show the areas in the City of Beverly with higher population concentrations under the age of 5 and over the age of 65. The areas in and around the Downtown Beverly District have a particularly high concentration of these vulnerable populations. Precautions should be taken to limit exposure to the sun on days of extreme heat.

4.5.5 Hurricanes/Tropical Storms

4.5.5.1 Description

A tropical cyclone is defined by the NOAA's National Hurricane Center as a warm-core non-frontal synoptic-scale cyclone, originating over tropical or subtropical waters, with organized deep convection and a closed surface wind circulation about a well-defined center. Once formed, a tropical cyclone is maintained by the extraction of heat energy from the ocean at high temperature and heat export at the low temperatures of the upper troposphere. In this they differ from extratropical cyclones, which derive their energy from horizontal temperature contrasts in the atmosphere (baroclinic effects). Hurricanes and other tropical cyclones that impact the east coast of the United States originate in the Atlantic basin, which includes the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico.

A hurricane is a type of tropical cyclone in which the maximum sustained surface wind is 74 mph or more. Table 4-30 shows the Saffir-Simpson Hurricane Wind Scale that is used to classify tropical storms and hurricanes based on the potential wind damage.

[20] U.S. Census Bureau QuickFacts, Beverly, MA, https://www.census.gov/quickfacts/table/PST045216/00

Table 4-30. Saffir-Simpson Hurricane Wind Scale and Typical Damages[21]

Category	Sustained Wind Speeds (mph)	Surge (ft)	Pressure (mb)	Typical Damage
Tropical Depression	<39	--	--	
Tropical Storm	39-73	--	--	
Hurricane 1	74-95	4-5	> 980	*Minimal* – Damage primarily to shrubbery and trees, unanchored manufactured homes damaged, some signs damaged, no real damage to structures on permanent foundations.
Hurricane 2	96-110	6-8	965-980	*Moderate* – Some trees toppled, some roof coverings damaged, major damage to manufactured homes.
Hurricane 3	111-130	9-12	945-965	*Extensive Damage* – Large trees toppled, some structural damage to roofs, manufactured homes destroyed, structural damage to small homes and utility buildings.
Hurricane 4	131-155	13-18	920-945	*Extreme Damage* – Extensive damage to roofs, windows, and doors; roof systems on small buildings completely fail; some curtain walls fail.
Hurricane 5	> 155	> 18	< 920	*Catastrophic Damage* – Roof damage considerable and widespread, window and door damage severe, extensive glass failures, some buildings fail completely.

4.5.5.2 Location and Extent

A hurricane or storm track is the line that delineates the path of the eye of a hurricane or tropical storm. The average diameter of hurricane force winds is 100 miles, with tropical storm force winds extending out 300 – 400 miles. While there have been no recorded hurricane or tropical storm tracks directly through Beverly, hurricane and tropical force winds are felt throughout the city as storms pass. Figure 4-15 shows the distribution of the four wind zones in the United States that reflect the number and strength of extreme windstorms. Beverly is located in a “Hurricane-Susceptible Region” of Zone II where damaging wind speeds of up to 160 mph can be experienced. Buildings should be built to withstand this “design” wind event.

[21] The Saffir-Simpson Hurricane Wind Scale uses wind speed, central pressure, and damage potential to create storm classifications. This scale is the standard describing an event’s disaster potential. The Scale is 1 to 5 categorization based on the hurricane's intensity at the indicated time. The scale provides examples of the type of damage and impacts in the United States associated with winds of the indicated intensity. In general, damage rises by about a factor of four for every category increase.

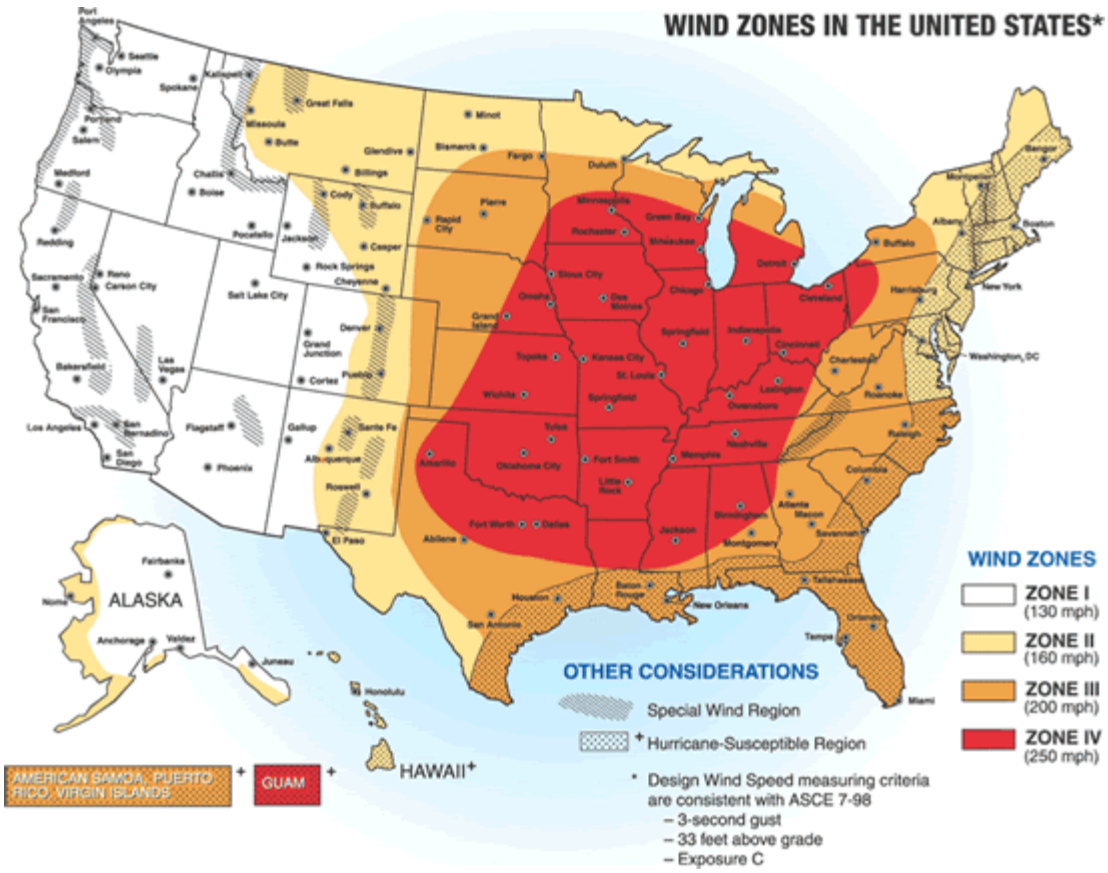


Figure 4-15. Wind Zones in the United States

4.5.5.3 Previous Occurrences

According to the NOAA NCEI database, Tropical Storm Irene is the only tropical storm event reported to have directly impacted the City of Beverly in the last 50 years, passing through on August 29th, 2011. The City has been indirectly impacted by a variety of other tropical storms and hurricanes over the years, including Hurricane Sandy. Table 4-31 summarizes the hurricanes and tropical storms that have impacted the greater Commonwealth of Massachusetts since 1938.

Table 4-31. History of Hurricanes and Tropical Storms in Massachusetts

Date	Name	Magnitude	Landfall
Sep-1938	New England Hurricane of 1938	3	Yes
Sep-1944	Great Atlantic Hurricane	4	Yes
1945	Unnamed	N/A	
1949	Unnamed	N/A	
Sep-1954	Edna	3	Yes
Oct-1954	Hazel	3	
Aug-1954	Carol	2-3	

Date	Name	Magnitude	Landfall
Aug-1955	Diane	3	
Sep-1959	Gracie	3	
Sep-1960	Donna	5	Yes
Sep-1985	Gloria	4	
Aug-1991	Bob	3	Yes
Jul-1996	Bertha	3	
Sep-1999	Floyd	4	Yes
Jul-2006	Beryl	Tropical Storm	
Sep-2008	Hanna	1	
Aug-2009	Bill	Tropical Storm	
Sep-2010	Earl	4	
Aug-2011	Irene	2	
Oct-2012	Sandy	Tropical Storm	Yes
Jul-2014	Arthur	Tropical Storm	
Sep-2016	Hermine	Tropical Storm	

Source: 2013 Massachusetts State Hazard Mitigation Plan (updated for storms since 2013)

4.5.5.4 Probability of Future Events

Based on past hurricanes and tropical storms, the number of tropical systems impacting the Massachusetts coastline has increased over the course of the last six years, with six events occurring since 2006, including Hurricane Sandy. Prior to 2006, seven years had passed since the last tropical event. Utilizing simple averaging calculations, the Commonwealth, in its State Hazard Mitigation Plan averaged a tropical storm event approximately every 1.75 years. It should be noted that this is not the recurrence interval, which requires a much more detailed analysis based on event type, category, and time.

4.5.5.5 Vulnerability and Risk Assessment

Hazard Ranking

The priority hazard ranking process for the 2018 HIRA determined Hurricanes to be a moderate priority hazard in the City of Beverly. As described in the profile above, hurricane and tropical storm events within the city are somewhat likely with a one to 10 percent annual probability. Impacts are estimated to be large, 25 to 50 percent of the city affected, with critical damage to facilities and moderate loss of function, downtown, and/or evacuations. The community survey results indicate that citizens of Beverly perceive the hazard to be a medium-high threat to their neighborhood or home. Table 4-32 outlines the hazard rankings for each of the hazard priority criteria related to Hurricane Wind Damage.

Table 4-32. Hurricane Wind Damage Hazard Priority

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Hurricanes	**Somewhat Likely** *Between 1 and 10% probability in next year or has a recurrence interval of 11 to 100 years*	**Large** *Between 50 and 100% of area affected*	**Critical** *Between 25% and 50% damage*	**Moderate** *Some loss of function, downtime, and/or evacuations*	**Medium-High** *Some perceived threat to neighborhood or home*	**Moderate**

Vulnerability and Impact to People and Property

Hurricane force winds can easily destroy poorly constructed buildings and mobile homes. Debris such as signs, roofing material, and small items left outside become flying missiles in hurricanes. Extensive damage to trees, towers, water, above and underground utility lines (from uprooted trees), and fallen poles cause considerable disruption.

High-rise buildings are also vulnerable to hurricane force winds, particularly at the higher levels since wind speed tends to increase with height. Recent research suggests you should stay below the tenth floor but still above any floors at risk for flooding. It is not uncommon for high-rise buildings to suffer a great deal of damage due to windows being blown out. Consequently, the areas around these buildings can be very dangerous.

The NCEI Storm Events data was annualized by taking the total number of damaging hurricane events and dividing by the length of record (Table 4-33). The annualized values should only be utilized as an estimate of what can be expected in a given year. Using historical records at the county level, it can be estimated that the Essex County will experience about one hurricane or tropical storm every 20 years. This frequency is much different from what was captured in the Massachusetts Hazard Mitigation Plan and reflects the limitations of the NCEI database. Damages from these events can be expected in the magnitude of $106,154 for property damages annually. There are no expected deaths or injuries based on the historic records, however deaths and injuries are still likely to occur as a result of a hurricane or tropical storm. It is important to note that these are estimates of frequency and expected damages based on data available for Essex County. If a hurricane or tropical were to impact the City of Beverly, property damages would likely be much higher than estimated.

Table 4-33. Annualized Damages from Hurricane/Tropical Storm Events

Annualized Occurrence	Annualized Property Damage
0.05	$106,154

Loss Estimation

The Hazus-MH Level 1 Hurricane (wind) module from FEMA's loss estimation software was used to estimate building stock losses in Beverly from a hurricane that made landfall on the East Coast. This scenario was run at the census tract level, not census block. Since there are only 7 census tracts in Beverly, much of the Hurricane Wind loss results are not as refined as the UDF results when mapped therefore the results have been summarized in a series of tables.

Table 4-34 summarizes the number of buildings estimated to be damaged by the 10, 20, 50, 100, 200, 500, and 1000 year return period wind events. The table shows that up to 4,077 buildings could be damaged by the 1000-year storm, which accounts for about 35.7% of the 11,424 valid UDF buildings found within the City of Beverly. In terms of economic loss due to hurricane wind damage, the property damage and business interruption for each return period was estimated in Table 4-35. The total annualized projected economic losses due to high wind events, which includes total property damage and business interruption, is $96,235,209 which accounts for only 1.57% of the total economic value of Beverly. It's important to note that this is a projected loss value based on imperfect data.

Table 4-34. Hurricane Probabilistic Number of Buildings Damaged

Return Period	Minor	Moderate	Severe	Destruction	Total
10	0	0	0	0	0
20	8	0	0	0	9
50	99	6	0	0	105
100	455	40	1	0	495
200	1170	149	4	2	1325
500	2281	463	27	19	2789
1000	3094	845	83	55	4077

Table 4-35. Hurricane Probabilistic Economic Loss

Return Period	Residential Property Damage	Total Property Damage	Business Interruption (income loss)
10	-	-	-
20	$1,842,568	$1,842,568	$356,940
50	$16,232,411	$16,827,455	$99,623,167
100	$37,622,916	$42,175,913	$982,115,720
200	$70,192,455	$91,494,537	$2,599,326,698
500	$137,129,136	$234,229,917	$9,402,798,933
1000	$223,895,063	$440,249,656	$19,097,637,311

Return Period	Residential Property Damage	Total Property Damage	Business Interruption (income loss)
Annualized	$1,673,000	$2,710,000	$93,525,000

Additional details about methodologies used to run the Hazus wind module and additional results from this analysis can be found in Appendix C.

4.5.6 Tornado

4.5.6.1 Description

The formation of a tornado begins with a funnel cloud, a rapidly rotating column of air. As the funnel cloud increases in intensity, a tornado is formed when the rotating column of air extends from the thunderhead cloud to the ground. The path width of a tornado is generally less than half of a mile, but the path length can vary from a few hundred yards to dozens of miles. A tornado moves at speeds from 30 to 125 mph, but can generate winds exceeding 300 mph.

In the United States, tornadoes are classified using the Fujita Scale, which assigns numeric scores from zero to five (or higher) based on the severity of observed damages. The traditional Fujita scale, introduced in 1971, was used to rate the intensity of tornadoes thereafter, and was also applied to previously documented tornadoes. Starting in February of 2007, an “enhanced” Fujita scale was implemented, with somewhat lower wind speeds at the higher F-numbers, and more thoroughly-refined structural damage indicator definitions. Table 4-36 shows the differences between the old and new tornado intensity scales, wind speeds, typical damages, and frequency.

Table 4-36. Tornado Damage Scale (Source: NOAA Storm Prediction Center)

Derived EF Scale		Fujita Scale		Damage	Frequency
EF Number	3 Second Gust (mph)	F Number	3 Second Gust (mph)		
EF0	65 to 85	F0	40 to 72	Light Damage. Some damage to chimneys, TV antennas, roof shingles, trees, and windows	29%
EF1	86 to 110	F1	73 to 112	Moderate Damage. Automobiles overturned, carports destroyed, trees uprooted	40%
EF2	111 to 135	F2	113 to 157	Considerable Damage. Roofs blown off homes, sheds and outbuildings demolished, mobile homes overturned	24%

Derived EF Scale		Fujita Scale		Damage	Frequency
EF Number	3 Second Gust (mph)	F Number	3 Second Gust (mph)		
EF3	136 to 165	F3	158 to 206	Severe Damage. Exterior walls and roofs blown off homes. Metal buildings collapsed or severely damaged. Forests and farmland flattened.	6%
EF4	166 to 200	F4	207 to 260	Devastating Damage. Few walls, if any, standing in well-built homes. Large steel and concrete missiles thrown far distances.	2%
EF5	Over 200	F5	261 to 318	Incredible Damage. Homes leveled with all debris removed. Schools, motels, and other larger structures have considerable damage with exterior walls and roofs gone. Top stories demolished.	Less than 1%

Source: NOAA Storm Prediction Center http://www.spc.noaa.gov/efscale/ef-scale.html

Tornadoes are one of nature's most violent storms. In an average year, about 1,000 tornadoes are reported across the United States, resulting in 80 deaths and over 1,500 injuries. Tornadoes have the potential of creating total destruction of homes, especially mobile homes, businesses, and cars, causing many deaths; extensive tree damage along roadways, which may inhibit or block access; extensive damage to electric and telephone lines; utility line breaks; damaged or destroyed radio and television towers.

4.5.6.2 Location and Extent

Despite tornados being an infrequent occurrence in Massachusetts, the entire City is considered equally at risk of experiencing the damaging effects of a tornado. Figure 4-16 summarizes tornado activity in the United States based on the number of recorded tornadoes per 1,000 square miles. This figure comes from the American Society of Civil Engineers and is based on NOAA's Storm Prediction Center statistics. Beverly is located in an area where there are 1-5 recorded tornados per 1,000 square miles.

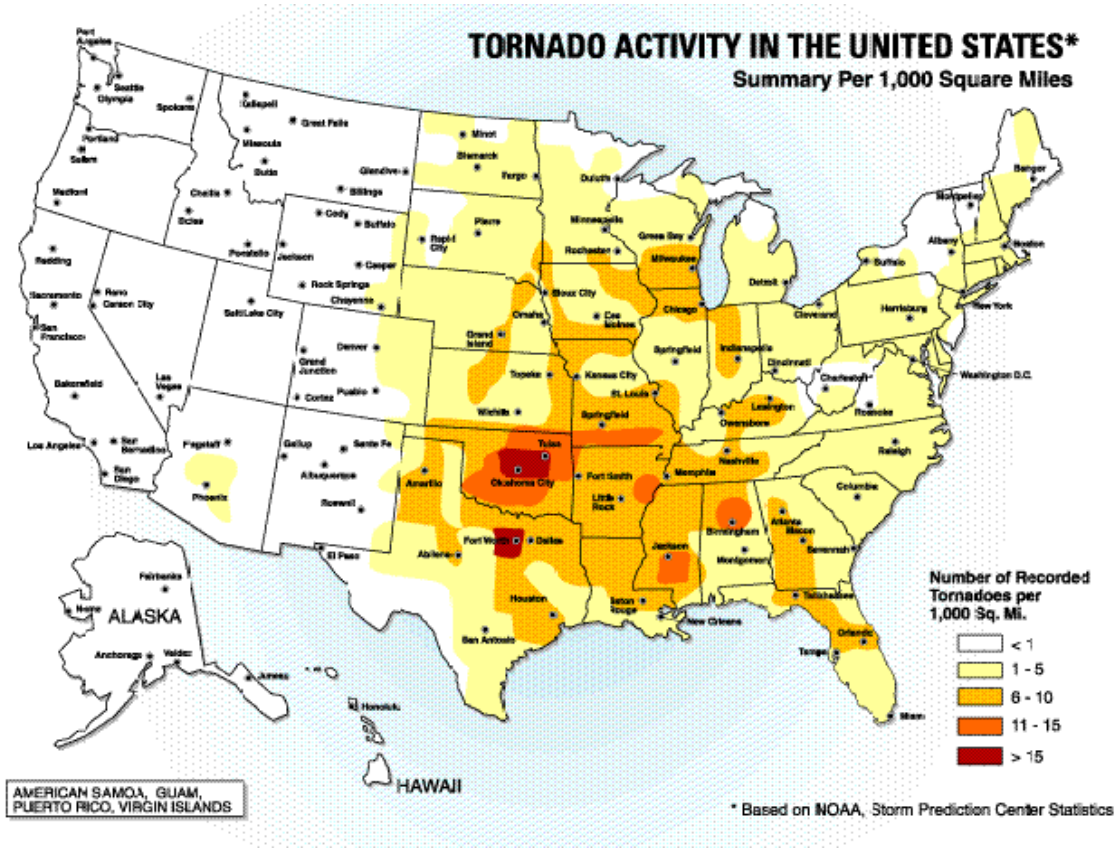


Figure 4-16. Tornado activity in the United States

Buildings must be designed to withstand both external and internal wind pressures on the structural framing and exterior elements. The level to which these structures are designed, as expected, directly correlates with its ability to resist damages due to high winds. A community's building code dictates the design wind speed to which a structure must be designed. Beverly has adopted the State Building Code, which adopts the International Building Code, and the applicable Code of Massachusetts Regulations to govern the construction, alteration, repair, maintenance, removal and demolition of buildings and structures in the City.

4.5.6.3 Previous Occurrences

There have been no recorded tornados within the City of Beverly. Within the greater Essex County, there have been a total of 12 tornadoes, 2 funnel clouds and 1 waterspout reported since 1950 according to the NOAA NCEI Storm Events Database (Table 4-37). There is no recorded history of a tornado with a classification greater than F2 occurring in Essex County. Of the tornado events that have occurred in Essex County, 17% of them were F0 tornadoes, 67% of them were classified as F1 tornadoes, and 17% were classified as F2 tornadoes. The majority of the tornado events that occur in Essex County are events that are likely to cause only moderate damage. The last significantly damaging tornado (F-3) in Massachusetts was in June of 2011 in the western part of the state. It

destroyed more than 100 homes in the Springfield metro area before losing strength around Sturbridge.

Table 4-37. NCEI Tornado Events (1950 – 2016)

Tornado Category	Classification	Number of Events
F0	Gale Tornado (40 – 72 mph)	2
F1	Moderate Tornado (73 – 112 mph)	8
F2	Significant Tornado (113 – 157 mph)	2
F3	Severe Tornado (158 – 206 mph)	0
F4	Devastating Tornado (207 – 260 mph)	0
F5	Incredible Tornado (261 – 318 mph)	0
Waterspout	Weak tornado that forms over water	1
Funnel Cloud	Rotating funnel-shaped cloud forming the core of a tornado or waterspout	2
	Total:	**15**

4.5.6.4 Probability of Future Events

Typically, there are one to three tornadoes somewhere in southern New England per year. Most occur in the late afternoon and evening hours, when the heating is the greatest. The most common months are June, July, and August. The NWS advises that tornadoes strike randomly, so all areas within Beverly are considered equally at risk.

According to the NCEI Storm Events Database, most tornadoes (around 77%) in the United States are considered weak (EF-0 or EF-1) and about 95% of all United States tornadoes are below EF-3 intensity. The remaining small percentage of tornadoes are categorized as violent (EF-3 and above). Of these violent twisters, only a few (0.1% of all tornadoes) achieve EF-5 status, with estimated winds over 200 mph and nearly complete destruction. However, given that on average over 1,000 tornadoes hit the United States each year, that means that 20 can be expected to be violent and possibly one might be incredible (EF-5). With a lack of history of tornadoes in Beverly, it is not possible to quantify probability with any degree of certainty.

4.5.6.5 Vulnerability and Risk Assessment

Hazard Ranking

The priority hazard ranking process for the 2018 HIRA determined Tornadoes to be a limited priority hazard in the City of Beverly. As described in the profile above, tornado events within the city are somewhat likely with a one to 10 percent annual probability. Impacts are estimated to be isolated, with less than one percent of the city affected, with catastrophic damage to facilities and limited loss of function, downtown, and/or evacuations. The community survey results indicate that citizens of Beverly perceive the hazard to be a medium-low threat to their neighborhood or home. Table 4-38 outlines the hazard rankings for each of the hazard priority criteria related to Tornado events.

Table 4-38. Tornado Hazard Priority

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Tornadoes	**Somewhat Likely** *Between 1 and 10% probability in next year or has a recurrence interval of 11 to 100 years*	**Isolated** *Less than 1% of area affected*	**Catastrophic** *More than 50% damage*	**Limited** *Minimal loss of function, downtime, and/or evacuations*	**Medium-Low** *Minimal perceived threat to neighborhood or home*	**Limited**

Vulnerability and Impact to People and Property

Tornadoes are high-impact, low-probability hazards whose effect is dependent on its intensity and the vulnerability of development in its path. Tornado vulnerability is based on building construction and standards, the availability of shelters or safe rooms, and advanced warning capabilities. Even well-constructed buildings are vulnerable to the effects of a stronger (generally EF-2 or higher) tornado. Quantifying assets at risk for tornado damage is virtually impossible since tornadoes are so unpredictable. With that being said, it can be assumed that every structure has an equal chance of exposure to a tornado event. Therefore, all of the assets of Beverley County should be included.

Vulnerability to tornadoes is dependent on the geographic extent and magnitude of the event. Damages from lower intensity tornadoes (EF0) can range from chimney damage to uprooted shallow trees. A significant tornado (EF2) would cause considerable damage to roofs on frame houses, complete destruction of mobile homes and large trees and utility lines snapping. A devastating tornado (EF4) would result in well-constructed houses being leveled, weak foundations blown to a distance and cars thrown.

Buildings must be designed to withstand both external and internal wind pressures on the structural framing and exterior elements. The level to which these structures are designed, as expected, directly correlates with its ability to resist damages due to high winds. The community's building code dictates the design wind speed to which a structure must be designed. For some building types, the structures constructed subsequent to the adoption of the building code are likely to be the most resistant to damages from wind. Beverly has a large number of historic homes that were built to lower design wind speeds and are considered at heightened risk of experiencing damage as a result of a tornado. Damage to these homes will displace homeowners and cause temporary relocation as the home is rebuilt to current standards. If commercial buildings and infrastructure are damaged, employees may need to search elsewhere for employment, possibly outside of Beverly.

A generalized loss estimate for the county was derived from NCEI Storm Events data and is shown in

Table 4-39. The data was annualized by taking the total number of damaging tornado events in Essex County and dividing by the length of record. The annualized values should only be utilized as an estimate of what can be expected in a given year. Using historical records at the county level, it can be estimated that the Essex County will experience a tornado every 4 to 5 years. Annual property damages from these events can be expected to be about $39,279. There are no expected deaths or injuries based on historical records.

Table 4-39. Annualized Damages from Tornado Events

Annualized Occurrence	Annualized Property Damage
0.22	$39,279

As evidence in property loss figures, tornadoes have the potential to be very destructive. The NCEI estimates are believed to be an underrepresentation of the actual losses experienced due to hazards, as losses from events that go unreported or that are difficult to quantify are not likely to appear in the NCEI database. At the same time, since Beverly is a small portion of Essex County, these numbers could be considered to be high.

4.5.7 Earthquake

4.5.7.1 Description

An earthquake is defined by the United States Geological Survey as the sudden slip on a fault, and the resulting ground shaking and radiated seismic energy caused by the slip, or by volcanic or magmatic activity, or other sudden stress changes in the earth. A fault is a fracture along which blocks of earth's crust on either side have moved relative to one another parallel to the fracture. There are three types of faults: strike-slip, normal, and thrust (Figure 4-17).

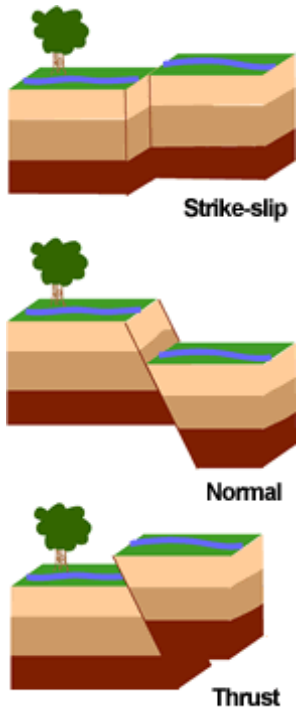


Figure 4-17. Fault types (USGS)

Normal faults occur in response to pulling or tension: the overlying block moves down the inclined dip of the fault plane. Thrust (reverse) faults occur in response to squeezing or compression: the overlying block moves up the inclined dip of the fault plane. Strike-slip (lateral) faults occur in response to either type of stress; the blocks move horizontally along a vertical fault past one another. Most faulting along spreading zones is the normal type, along subduction zones is thrust type, and along transform faults is strike-slip.

4.5.7.2 Location and Extent

Earthquakes in eastern North America are caused by forces moving the tectonic plates over the surface of the Earth. New England is located in the middle of the North American plate. One edge of the North American plate is along the west coast where the plate is pushing against the Pacific Ocean plate. The eastern edge of the North American plate is at the middle of the Atlantic Ocean, where the plate is spreading away from the European and African plates. New England's earthquakes appear to be the result of the cracking of the crustal rocks due to compression as the North American plate is being very slowly squeezed by the global plate movements.22

The severity of an earthquake can be expressed in terms of both *magnitude* and *intensity*. The *magnitude* measures the amount of energy released at the source of the earthquake

[22] Massachusetts State Hazard Mitigation Plan (2013)

and is measured using a seismograph. *Intensity* measures the strength of the shaking produced by an earthquake at a certain location.23

Table 4-40 summarizes the intensities typically observed at locations near the epicenter of earthquakes of different magnitudes and defines the intensity scale based on the effects on people, human structures, and the natural environment. Table 4-41 displays the Modified Mercalli Scale and peak ground acceleration equivalent.

Table 4-40. Richter Magnitude Scale and Modified Mercalli Intensity Scale Comparison

Richter Magnitude Scale	Modified Mercalli Intensity Scale	Effects
1.0 to 3.0	I	Not felt except by a very few under especially favorable conditions
3.0 to 3.9	II	Felt only by a few persons at rest, especially on upper floors of buildings
	III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck.
4.0 to 4.9	IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors, disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
	V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
5.0 to 5.9	VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
	VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken
6.0 to 6.9	VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned
	IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
7.0 and Higher	X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
	XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
	XII	Total damage. Lines of sight and level are distorted. Objects thrown into the air.

[23] USGS "Magnitude/Intensity Comparison" https://earthquake.usgs.gov/learn/topics/mag_vs_int.php

Table 4-41. Modified Mercalli Intensity (MMI) and PGA Equivalents

MMI	Acceleration (%g) (PGA)	Perceived Shaking	Potential Damage
I	<.17	No Felt	None
II	.17 - 1.4	Weak	None
III	.17 - 1.4	Weak	None
IV	1.4 - 3.9	Light	None
V	3.9 - 9.2	Moderate	Very Light
VI	9.2 - 18	Strong	Light
VII	18 - 34	Very Strong	Moderate
VIII	34 - 65	Severe	Moderate to Heavy
IX	65 - 124	Violent	Heavy
X	> 124	Extreme	Very Heavy
XI	> 124	Extreme	Very Heavy
XII	> 124	Extreme	Very Heavy

Source: Massachusetts State Hazard Mitigation Plan, 2013

The Peak Ground Acceleration (PGA) is a measurement of the change in speed for a particle at ground level that is moving horizontally due to an earthquake.[24] A PGA measurement expresses the severity of an earthquake and is a measure of how hard the earth shakes (or accelerates) in a given geographic area for a given event.

4.5.7.3 Previous Occurrences

While there have been no recorded earthquake epicenters in Beverly, the northeastern U.S. (NEUS) is one of the most seismically active areas east of the Rocky Mountain.[25] This area has a long and continuous history of earthquake activity that dates back to the colonial times, with the most notable damaging earthquakes occurring in 1638, 1663, 1727, 1737, 1755, 1884, 1904, 1940 and 1944. According to the Massachusetts State Hazard Mitigation Plan, New England experiences an average of five earthquakes per year. From 1638 to 2013, 366 earthquakes were recorded to have epicenters in Massachusetts.[26] Most have originated from the La Malbaie fault in Quebec or from the Cape Anne fault located off the coast of Rockport. For example, the 1755 Cape Ann

[24] Petersen, M.D., Moschetti, M.P., Powers, P.M., Mueller, C.S., Haller, K.M., Frankel, A.D., Zeng, Yuehua, Rezaeian, Sanaz, Harmsen, S.C., Boyd, O.S., Field, Ned, Chen, Rui, Rukstales, K.S., Luco, Nico, Wheeler, R.L., Williams, R.A., and Olsen, A.H., 2014, Documentation for the 2014 update of the United States national seismic hazard maps: U.S. Geological Survey Open-File Report 2014–1091, 243 p., *http://dx.doi.org/10.3133/ofr20141091*.

[25] New England Seismic Network (2012) http://earthquake.usgs.gov/research/external/reports/G10AC00086.pdf

[26] Weston Observatory Northeast Earthquake Catalog

earthquake had a magnitude 6.0 – 6.2 and caused significant damage to masonry structures in Boston.[27]

Table 4-42 summarize the notable historic earthquakes that have occurred in Massachusetts from 1727 to present.[28]

Table 4-42: Notable Historic Earthquakes in Massachusetts

Location	Date	Intensity (MMI)	Magnitude
MA – Off Cape Ann	11/18/1755	8	6
MA – Offshore	1/2/1785	7	5.4
MA – Cape Ann	11/10/1727	7	5
MA – Cape Ann	12/29/1727	6	–
MA – Off Cape Cod	2/2/1766	6	–
MA – Cape Ann	6/14/1744	6	4.7
MA – Newbury	11/7/1907	5	–
MA – Wareham	4/25/1924	5	–
MA – Cape Ann	1/7/1925	5	4
MA – Nantucket	10/25/1965	5	–
MA – Woburn	10/5/1817	5	4.3
MA – Cape Ann	11/18/1727	5	–
MA – Off Cape Cod	11/23/1755	5	–
MA – Wareham/Taunton	12/25/1800	5	–
MA – Cape Ann	12/9/1729	5	–
MA – Cape Ann	2/10/1728	5	–
MA – Cape Ann	2/20/1730	5	–
MA – Cape Ann	2/20/1730	5	–
MA – Boston	3/12/1761	5	4.6
MA – Cape Ann	3/30/1729	5	–
MA – Cape Ann	3/9/1730	5	–
MA – Boxford	5/12/1880	5	–
MA – Boston	6/24/1741	5	–
MA – Salem	7/1/1744	5	–
MA – Marblehead	8/25/1846	5	4.3
MA – Brewster	8/8/1847	5	4.2

[27] Ebel, 2006a (http://earthquake.usgs.gov/research/external/reports/G10AC00086.pdf)

[28] The Northeast States Emergency Consortium, "Massachusetts Earthquakes", http://nesec.org/massachusetts-earthquakes/

4.5.7.4 Probability of Future Events

Seismologists and geologists agree that earthquakes are impossible to predict with any degree of accuracy. PGA maps are used as tools to determine the likelihood an earthquake of a given intensity may be exceeded over a period of time. Figure 4- 18 overlays historic earthquake event locations with the PGA values for the Commonwealth that have a 2-percent chance of being exceeded in 50 years. Beverly, highlighted in the red circle, is within an area with a PGA rank of 12%g to 16%g. If this earthquake occurred it would likely have a strong perceived shaking and light potential damage (refer to Table 4-41 for details).

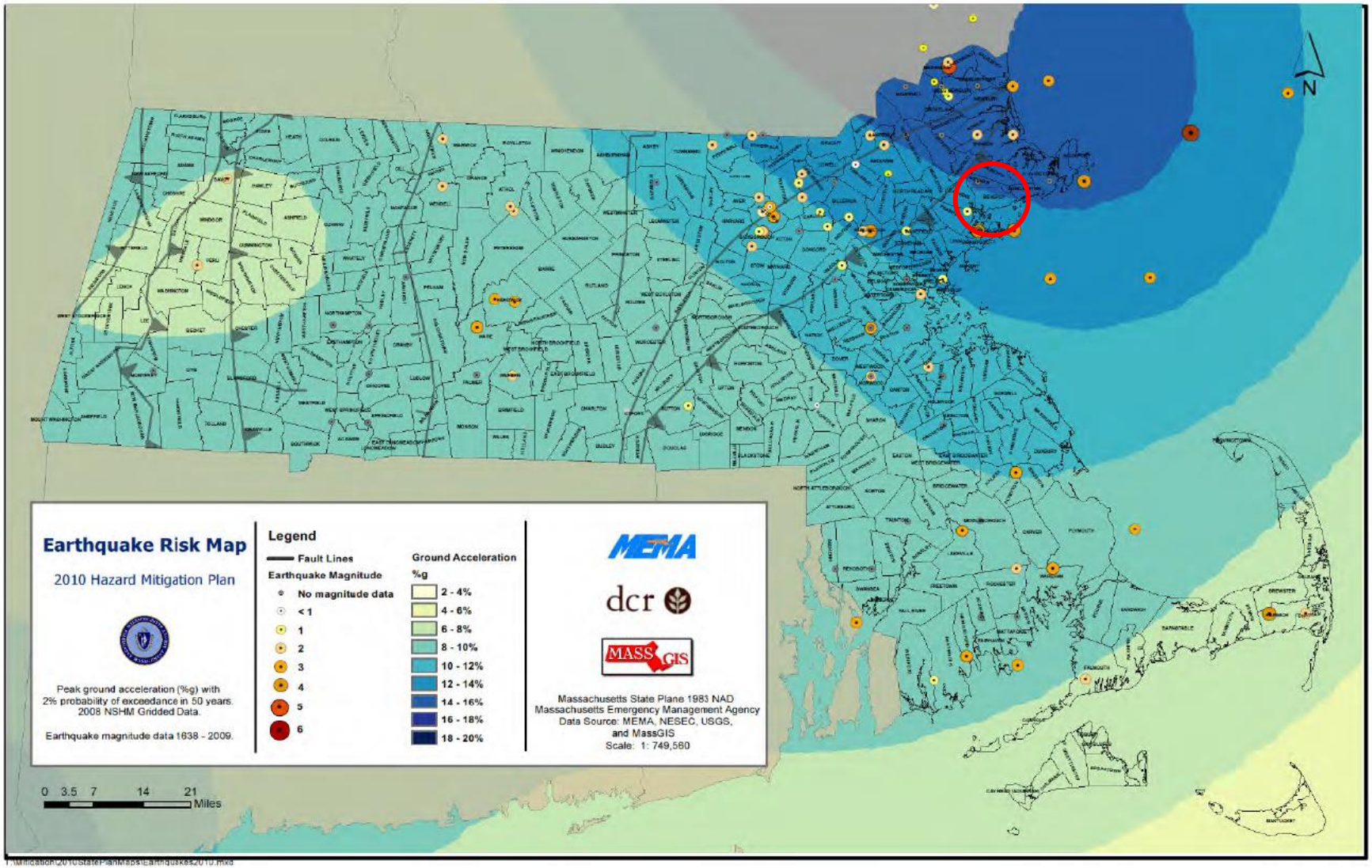


Figure 4- 18. Earthquake Risk Map of the Commonwealth of Massachusetts

4.5.7.5 Vulnerability and Risk Assessment

Hazard Ranking

The priority hazard ranking process for the 2018 HIRA determined Earthquakes to be a limited priority hazard in the City of Beverly. As described in the profile above, earthquake events within the city are unlikely with less than one percent annual probability. Impacts are estimated to be small, with one to 10 percent of the city affected, with catastrophic damage to facilities and high loss of function, downtown, and/or evacuations. The community survey results indicate that citizens of Beverly perceive the hazard to be a medium-low threat to their neighborhood or home. Table 4-43 outlines the hazard rankings for each of the hazard priority criteria related to Earthquake.

Table 4-43. Earthquake Hazard Priority

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Earthquakes	**Unlikely** *Less than 1% probability in next 100 years or has a recurrence interval of greater than every 100 years*	**Small** *Between 1 and 10% of area affected*	**Catastrophic** *More than 50% damage*	**High** *Major loss of function, downtime, and/or evacuations*	**Medium-Low** *Minimal perceived threat to neighborhood or home*	**Limited**

Vulnerability and Impact to People and Property

Earthquakes are low probability, high-consequence events. Although earthquakes may occur infrequently they can have devastating impacts that affect entire communities and regions. The destructiveness of an earthquake depends on a number of factors, including the magnitude of the tremor, direction of the fault, distance from the epicenter, regional geology, and the design characteristics of buildings and infrastructure. Moderate and even very large earthquakes are inevitable; consequently, buildings in these regions are seldom designed to deal with an earthquake threat; therefore, they are extremely vulnerable.

Ground shaking from an earthquake primarily causes structural damage and collapse of buildings and bridges, as well as the disruption of gas, electricity, and phone services. Some secondary impacts caused by earthquakes may include fire, hazardous material release, landslides, flash flooding, avalanches, tsunamis, and dam failure. Injuries, deaths and extensive property damage can result from both the primary and secondary impacts of this hazard.

Another potential vulnerability to this hazard is the 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.

FEMA has developed a software suite, Hazards US Multi-Hazard (Hazus-MH), that is a good tool for estimating potential losses to natural disasters. The Hazus-MH earthquake model was utilized to estimate damages and losses to buildings, lifelines, and essential facilities from deterministic (scenario-based) and probabilistic earthquakes.

The Hazus earthquake module allows users to define a number of different types of earthquakes and to input a number of different parameters. The module is more useful where there is a great deal of data available on earthquakes. In New England, defining the parameters of a potential earthquake is much more difficult because there is little historical data. The earthquake module does offer the user the opportunity to select a number of historical earthquakes that occurred in Massachusetts. In the 2012 Beverly Hazard Mitigation plan, two earthquakes were selected to run Hazus analysis on: (1) 1963 earthquake with a magnitude of 5.0 and (2) probabilistic earthquake with a magnitude of 7.0. Results of these analyses are captured in Table 4-44. Nearly one third of Beverly's building stock would sustain moderate damage in the event of a magnitude 7.0 earthquake. In addition, an estimated 391 buildings would be completely damaged from a 7.0 magnitude event and would have a total replacement value of about $123 million.

Because earthquake was identified as a limited hazard in the community, and due to limited changes to the Hazus software and no new significant earthquakes in Massachusetts since 2012, a new Hazus analysis was not run for this hazard mitigation plan update.

Table 4-44. Hazus Estimated Damages from Earthquakes

Analysis Parameters	Historic Event 1963 Magnitude 5.0	Probabilistic Event Magnitude 7.0
Estimated total number of buildings	11,054	11,054
Estimated total building replacement value (Year 2002 $) (Millions of dollars)	$3,478	$3,478
# of buildings sustaining slight damage	415	3,691
# of buildings sustaining moderate damage	82	3,319
# of buildings sustaining extensive damage	10	1,153
# of buildings completely damaged	1	391
# of households displaced	16	1,811
# of people seeking public shelter	3	406
Building debris generated (tons)	Not available	Not available
Total property damage (Millions of dollars)	$55.95	$961.05
Total losses due to business interruption (Millions of dollars)	$2.80	$170.80

In addition to the two scenarios above, the 2013 Commonwealth of Massachusetts State Hazard Mitigation Plan ran an assessment for the 100-, 500-, 1,000-, and 2,500- year mean return periods (MRP) through a Level 2 analysis in Hazus-MH 2.1 to analyze the earthquake hazard for the Commonwealth. In Essex County, of which Beverly is a part of, losses were estimated to buildings (structure and contents) for the different MRP's. There was $0 in estimated potential losses for the 100-year MRP, $166,341,965 in losses for the 500-year MRP, $563,000,060 for the 1,000-year MRP, and for the 2,500-year MRP losses were over $2 billion.

4.5.8 Drought

4.5.8.1 Description

A ***drought*** is a period in which an unusual scarcity of rain causes a serious hydrological imbalance in which water supply reservoirs empty, water wells dry up, and crop damage ensues. A prolonged period of drought may or may not accompany the periods of extreme heat. Drought is a complex physical and social process that can vary on a regional basis. Unlike floods, droughts are not a distinct event and typically do not have a well-defined start or end date.

There are four main classifications of droughts based on meteorological, agricultural, hydrological, and socioeconomic effects:

- Meteorological droughts are typically defined by the level of "dryness" when compared to an average, or normal, amount of precipitation over a given period of time.
- Agricultural droughts relate common characteristics of drought to their specific agricultural-related impacts. Emphasis tends to be placed on factors such as soil/water deficits, water needs based on differing stages of crop development, and water reservoir levels.
- Hydrological drought is directly related to the effect of precipitation shortfalls on surface and groundwater supplies. Human factors, particularly changes in land use, can alter the hydrologic characteristics of a basin.
- Socio-economic drought is the result of water shortages that limit the ability to supply water-dependent products in the marketplace.

4.5.8.2 Location and Extent

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. A Drought Management Plan was developed by the Commonwealth in 2001 as a working document that has been activated several times in the past (last updated May 2013). This plan is updated in consultation with the Drought Management Task Force to reflect the lessons of past experience and to ensure a thorough and responsive approach to managing drought conditions in the future. The Drought Management Task Force assesses drought conditions on a regional basis, rather than using a single, statewide assessment, allowing for a more fine-tuned approach to drought actions and conservation measures to address specific situations in each region.

Beverly and the rest of Essex County is located in the Northeast Drought Region, as shown in Figure 4-19.

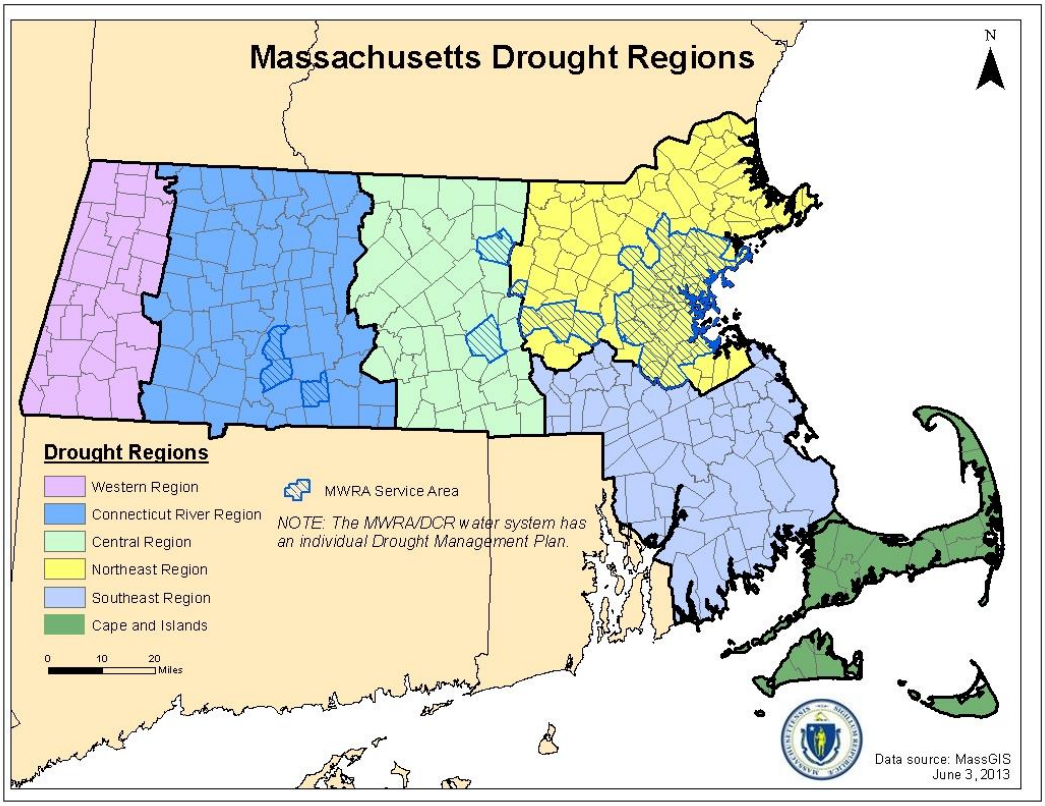


Figure 4-19. Massachusetts Drought Regions

Five levels of drought have been developed as part of the Massachusetts Drought Management Plan to categorize drought severity:

- Normal
- Advisory
- Watch
- Warning
- 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.[29]

There are several drought indices available to assess the impacts of dry conditions. The Commonwealth uses a multi-index system to determine the severity of a drought or extended period of dry conditions. The determination of drought level is based on these seven indices: Standardized Precipitation Index, Crop Moisture Index, Keetch-Byram Drought Index (KBDI), Precipitation, Groundwater levels, Stream flow levels, and Index Reservoir levels. Details about each index can be referenced in the 2013 Massachusetts Drought Management Plan.[30]

4.5.8.3 Previous Occurrences

According to the NCEI Storm Events Database, there have been 5 episode ID's related to drought events. Due to the difficulty in estimating the start and end of a drought, these episodes can summarized into two drought periods:

- April 2012 – May 2012
- July 2016 – September 2016

4.5.8.4 Probability of Future Events

Droughts are often unpredictable and may be localized, which makes it difficult to assess the probability. Historical analysis of precipitation shows that drought is a frequent occurrence in Massachusetts. However, severe, widespread multiyear droughts are much less common.

4.5.8.5 Vulnerability and Risk Assessment

Hazard Ranking

The priority hazard ranking process for the 2018 HIRA determined Drought to be a limited priority hazard in the City of Beverly. As described in the profile above, drought events within the city are somewhat likely with one to 10 percent annual probability. Impacts are estimated to be medium, with 10 to 50 percent of the city affected, with negligible damage to facilities and negligible loss of function, downtown, and/or evacuations. The community survey results indicate that citizens of Beverly perceive the hazard to be a medium-high threat to their neighborhood or home. Table 4-43 outlines the hazard rankings for each of the hazard priority criteria related to Drought.

[29] Massachusetts Drought Management Plan. http://www.mass.gov/eea/docs/eea/wrc/droughtplan.pdf

[30] Ibid.

Table 4-45. Drought Hazard Priority

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Drought	**Somewhat Likely** *Between 1 and 10% probability in next year or has a recurrence interval of 11 to 100 years*	**Medium** *Between 10 and 50% of area affected*	**Negligible** *Less than 10% damage*	**Negligible** *No loss of function, downtime, and/or evacuations*	**Medium-High** *Some perceived threat to neighborhood or home*	Limited

Vulnerability and Impact to People and Property

The drought events from the NOAA NCEI Storm Events Database were annualized by taking the total number of damaging drought events and dividing by the length of record. The annualized values should only be utilized as an estimate of what can be expected in a given year. Using countywide historical records, it can be estimated that the Essex County will experience about one drought episode every four to five years. Periods of drought are likely to be even less frequent. No damages from historic events have been documented. Table 4-46 shows the annualized results for drought events. Probability for Beverly should be roughly the same as the rest of Essex County.

Table 4-46. Annualized Damages from Drought Events

Annualized Occurrence	Annualized Property Damage	Annualized Crop Damages
0.23	$0	$0

Droughts can last a few months to several years and are often times very difficult to predict. The severity of a drought may be gauged by the size of the area affected, the duration, and the degree of moisture deficiency. Risk to critical facilities, infrastructure, buildings and people cannot be easily quantified for drought as it can be for hazards with well-defined recurrence intervals and intensity-damage models, such as flooding. The board draws excess water from the Ipswich River during the winter flood stage and stores it in 3 reservoirs, Putnamville and Longham Reservoirs and the largest is Wenham Lake. A prolonged drought will likely have a significant impact on these municipal water sources. The City of Beverly is supplied with drinking water by the Salem Beverly Water Supply Board.

Drought conditions can also cause soil to compact, decreasing its ability to absorb water, making an area more susceptible to flash flooding and erosion. A longer drought may also increase the speed at which dead and fallen trees dry out and become more potent fuel sources for wildfires, especially in the wildland urban interface zone. Drought may

also weaken trees in areas already affected by plant or bug infestations, causing more extensive damage to trees and increasing wildfire risk, at least temporarily.

4.5.9 Wildfire

4.5.9.1 Description

Fires within forested areas that are ignited by natural causes such as lightning or as part of a controlled burn process are part of the natural fire cycle and an important contributor to forest health. A ***wildfire*** is an uncontrolled and undesirable fire that spreads through vegetative fuels, exposing and possibly consuming structures for areas greater than one acre.

Three main factors influence wildfire behavior – topography, fuel, and weather. Other hazards can contribute to the potential for wildfires or can influence wildfire behavior: high winds can down power lines; earthquakes can rupture gas lines; lightning can spark fires. Lightning is also a major cause of structural fires and wildfires.

4.5.9.2 Location and Extent

The Wildland Urban Interface (WUI) is the line, area or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuel. [31] The three types of communities that occur in or around the WUI are:

- Interface Community - The Interface Community exists where structures directly abut wildland fuels. There is a clear line of demarcation between residential, business, and public structures and wildland fuels. The development density for an interface community is usually 3 or more structures per acre or a population density of 250 or more people per square mile, with shared municipal services.
- Intermix Community - The Intermix Community exists where structures are scattered throughout a wildland area. There is no clear line of demarcation; wildland fuels are continuous outside of and within the developed area. The development density in the intermix ranges from structures very close together to one structure per 40 acres or a population density in between 28-250 people per square mile.
- Occluded Community - The Occluded Community generally exists in a situation, often within a city, where structures abut an island of wildland fuels (e.g., park or open space). There is a clear line of demarcation between structures and wildland fuels. The development density for an occluded community is usually similar to those found in the interface community, but the occluded area is usually less than 1,000 acres in size.

Beverly's wildfires tend to occur in the more remote wooded areas. The most common cause of these fires has been unattended children playing with matches and campfires.

[31] Radeloff, V. C., R. B. Hammer, S. I Stewart, J. S. Fried, S. S. Holcomb, and J. F. McKeefry. 2005. The Wildland Urban Interface in the United States. Ecological Applications 15:799-805.

The following areas of the City were identified as having the highest potential for brush fires.

1. Land near Endicott College
2. Sally Mulligan Park area
3. Branch Lane area
4. Greenwood Avenue area

The areas where these forested lands meet with urban areas (WUI) are considered most at risk to sustaining damages to property and structures as well as injuries and loss of life. Drought or near-drought conditions can significantly increase the potential for wildfires to spread. Figure 4-20 shows the location of the wildland-urban interface and intermix zones in the City.

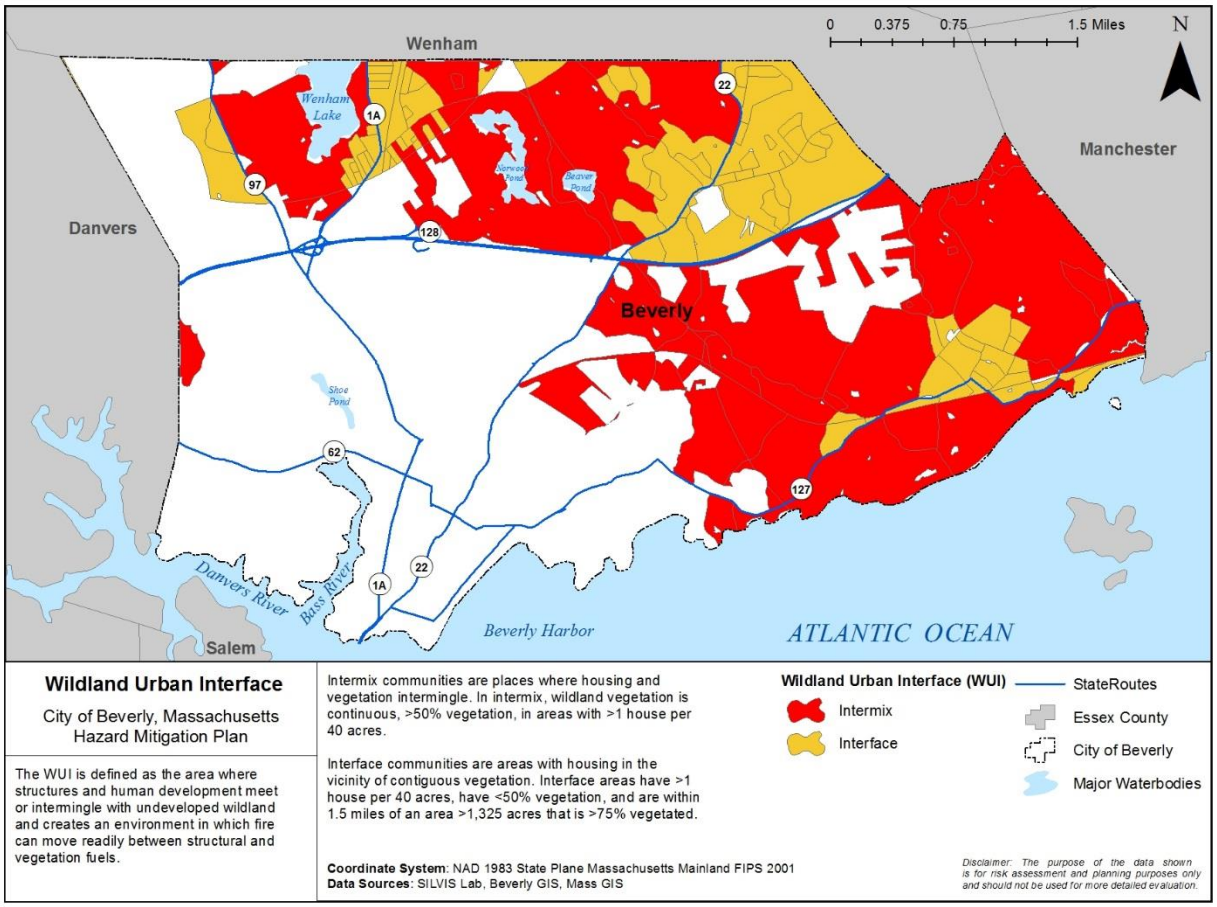


Figure 4-20. Wildland-Urban Interface (WUI) Areas in Beverly

4.5.9.3 Previous Occurrences

Wildfires pose a great threat to life and property, particularly when they move from forest or rangeland into developed areas. An average of 5 million acres burn every year in the U.S. as a result of wildfires, causing millions of dollars in damage. Each year more than

100,000 wildfires occur in the U.S., almost 90% of which are started by humans; the rest are caused by lightning. Weather is one of the most significant factors in determining the severity of wildfires.

The Beverly Fire Department has not responded to any recent wildfires that have resulted in property damage.

4.5.9.4 Probability of Future Events

The wildfire season in Massachusetts usually begins in late March and typically culminates in early June, corresponding with the driest live fuel moisture periods of the year. April is historically the month in which wildfire danger is the highest. However, wildfires can occur every month of the year. Drought, snow pack, and local weather conditions can expand the length of the fire season. The early and late shoulders of the fire season usually are associated with human-caused fires.

Insect and disease infestations, years of fire suppression, and growth in the wildland-urban interface (WUI) can also increase wildfire risk and the potential for catastrophic wildland fires. Forest insect epidemics and forest parasites contribute to wildfire potential by increasing fuel loading.

For the purpose of this plan, the probability of future occurrences is defined by the number of events over a specified period. The Massachusetts State Hazard Mitigation Plan summarizes the historical record of wildfires and indicates the Commonwealth has experienced four federally declared urban and wildfire events from 1954 to 2012. While this figure greatly underestimates how often fires of various sizes occur and affect the Commonwealth in a given year, it is reflective of the fact that wildfires are not likely to be a frequent annual event in the future.

4.5.9.5 Vulnerability and Risk Assessment

Hazard Ranking

The priority hazard ranking process for the 2018 HIRA determined Wildfire to be a limited priority hazard in the City of Beverly. As described in the profile above, wildfire events within the city are somewhat likely with one to ten percent annual probability. Impacts are estimated to be medium, with 10 to 50 percent of the city affected, with negligible damage to facilities and negligible loss of function, downtown, and/or evacuations. The community survey results indicate that citizens of Beverly perceive the hazard to be a medium-high threat to their neighborhood or home. Table 4-47 outlines the hazard rankings for each of the hazard priority criteria related to Wildfire.

Table 4-47. Wildfire Hazard Priority

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Wildfire	**Somewhat Likely** *Between 1 and 10% probability in next year or has a recurrence interval of 11 to 100 years*	**Medium** *Between 10 and 50% of area affected*	**Negligible** *Less than 10% damage*	**Negligible** *No loss of function, downtime, and/or evacuations*	**Medium-High** *Some perceived threat to neighborhood or home*	Limited

Vulnerability and Impact to People and Property

Wildfires can have disastrous consequences causing damage to residences, commercial buildings, and to timber, grasslands and natural resources. Economic consequences include the cost of suppression, reduced property values, lost sales and business revenues, reduced tourism, and increased water treatment costs. Resources threatened include communities, homes, gas transmission lines, electrical facilities and lines, timber, watershed and recreation areas, and wildlife. Wildfires may create additional environmental concerns well after they are extinguished such as increased erosion and water quality concerns in storm water runoff.

Although rare, deaths and injuries usually occur at the beginning stages of wildfires when sudden flare-ups occur from high wind conditions. In most situations, however, people have the opportunity to evacuate the area and avoid bodily harm. Financial losses related to wildfires include destroyed or damaged houses, barns, private facilities and equipment, loss of commercial timber supplies, and local and state costs for response and recovery.

Environmental short-term loss caused by a wildland fire can include the destruction of wildlife habitat and watersheds. Long-term effects include reduced access to affected recreational areas, destruction of cultural and economic resources and community infrastructure, and vulnerability to flooding due to the destruction of watersheds.

Protecting the WUI is the nation's fastest-growing firefighting expense. While there is no definitive measure of the current extent or grown rate of the WUI, one group of researcher estimated in 2013 that 16 percent of the WUI is developed and 84 percent is undeveloped but is available for development.[32] Thus, as development continues in the WUI, fire risk will increase as well as firefighting costs.

[32] Headwaters Economics, *As Wildland Urban Interface (WUI) Develops, Firefighting Costs Will Soar*, at http://headwaterseconomics.org/interactive/wui-development-and-wildfire-costs on April 27, 2017. This site contains an interactive map showing in graphs and tables the undeveloped WUI land in each county in the 11 coterminous western states.

4.6 Climate Change as an Amplifier of Natural Hazards

Climate change is both a present threat and a slow-onset disaster. It acts as an amplifier of existing natural hazards. Extreme weather events have become more frequent over the past 40 to 50 years, and this trend is projected to continue. [33] Climate change is expected to have a significant impact on communities, including those in Massachusetts. For instance, more frequent intense precipitation events may translate into more frequent flash flooding episodes.

The National Climate Assessment and Development Committee has documented average temperature across the United States has increased 1.5°F since 1895 with the majority of the increase since 1980. Weather events have and will continue to become more intense and frequent, and will result in health and livelihood related impacts such as water supply, agriculture, transpiration and energy. The impact of dynamic storm events include but are not limited to more frequent and intense heat waves, increases in ocean and freshwater temperatures, frost-free-days, heavy downpours, floods, sea level rising, droughts and wildfires.[34]

According to the American Planning Association, new conditions and certain extreme experiences in recent years have brought the issue of climate change into the forefront for planners, lawmakers, and the public. Clear evidence exists of climate change leading to specific, measurable effects ranging from Arctic melting and sea level rise to heightened storm and drought frequency and/or severity. These conditions make it imperative that planners and policymakers work immediately to implement new policies to address climate change.[35]

The effects of climate change may be felt through any of the hazards detailed within this hazard mitigation plan. It can increase the hazards that currently exist and introduce new hazards not previously experienced in the city. As such, it is imperative that Beverly continue to be proactive by including climate change as an amplifier that may exacerbate natural hazards.

4.6.1 Observed Trends

In 2013, NOAA produced a technical report entitled *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment,* a series of nine climate documents (one for the contiguous United States and eight for each region) which include

[33] IPCC, 2012 - Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (Eds.) Available from Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 8RU ENGLAND, 582 pp.

[34] National Climate Assessment and Development Advisory Committee (NCADAC) January 2013 Draft Climate Assessment Report. http://ncadac.globalchange.gov/

[35] American Planning Association. *Policy Guide on Planning and Climate Change*. April 27, 2008.

descriptions of observed historical climate trends, as well as future predictions and scenarios. In this context, Massachusetts is included as part of the Northeast Region (also includes ME, NH, VT, MA, RI, CT, NY, NJ, PA, DE, WV, and Washington DC). According to the report, temperatures across the region increased on average 0.16 degrees Fahrenheit per decade between 1895 and 2011. Increases were observed in every season, although the most significant upward trend has been during the winter months. Precipitation across the region has also been on the rise, particularly since 1970, and during the fall months. The frequency of extreme precipitation (heavy downpours) has also increased significantly over this time period. Given this regional trend, the City of Beverly should continue to strongly consider climate change and its associated effects on future planning.

4.6.1.1 Future Trends

According to *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment,* average temperatures in the City of Beverly region are expected to be anywhere from 2.5 - 4.5 degrees Fahrenheit warmer by the middle of the century (2041-2070) and 3.5 - 7.5 degrees Fahrenheit warmer by the latter part of the century (2071-2099), depending on the emissions scenario (or continued rate of greenhouse gas emissions into the future). These values are compared to average temperatures during the period from 1970-1999 (Figure 4-21).The high emissions scenario (A2) is displayed on the left and the low emission scenario (B1) is displayed on the right. The City is also expected to experience more extreme heat, with an average of 15-18 more days annually above 95 degrees Fahrenheit by the middle of the 21st Century (2041-2070) as compared to the latter part of the 20th Century (1981-2000).

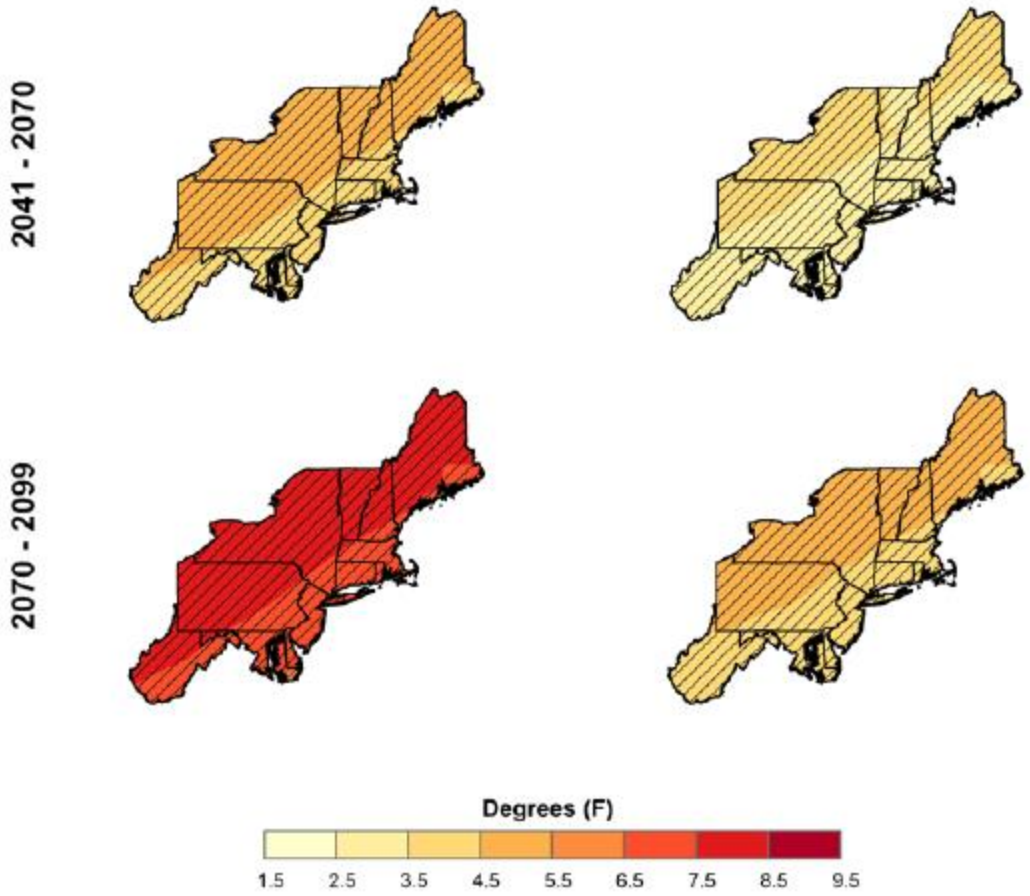


Figure 4-21. Projected Temperature Increase Across the Northeastern United States. Source: NOAA, 2013.

According to *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment,* average annual precipitation is expected to increase 0 to 3 percent by the middle of the century (2041-2070) and 3 to 6 percent by the latter part of the century (2070-2099), relative to the 1971-1999 average. However, more of this precipitation is expected to fall as extreme, high intensity events. The red arrow on the map marks the approximate location of the City of Beverly, where there is an expected 15 to 18 percent increase in the annual number of days with greater than 1 inch of precipitation by the middle of the century (2041-2070), relative to the 1980-2000 average (Figure 4-22). Precipitation may also be less consistent throughout the year, with both more extended wet and dry periods. Such changes in precipitation patterns could lead to more frequent flash flooding, as well as more frequent and extended droughts.

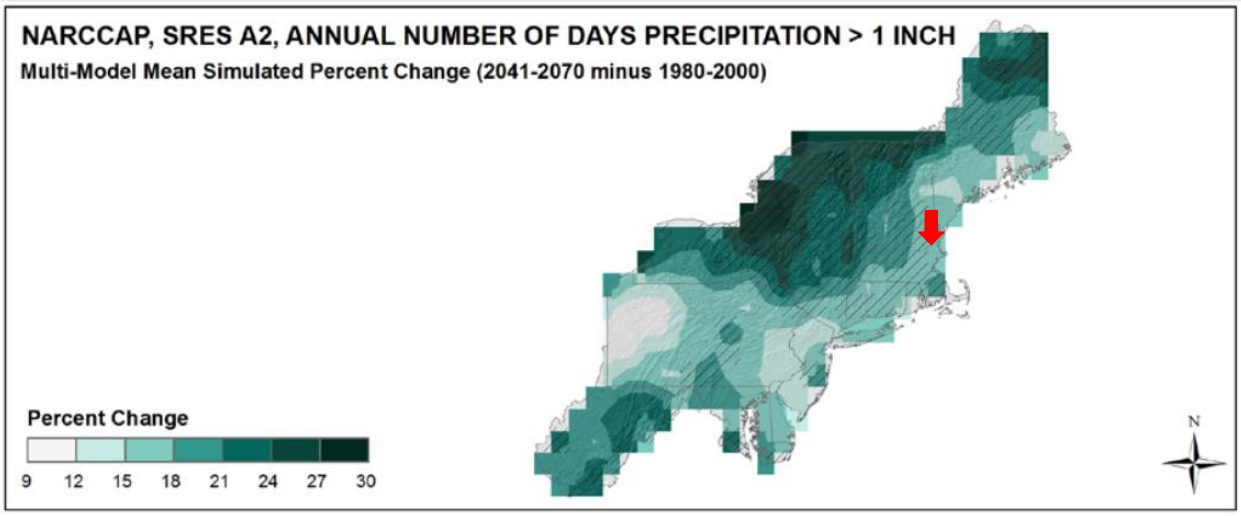


Figure 4-22. Percent Change in Annual Number of Days with Precipitation > 1 inch for the Northeast Region by 2041-2070, relative to 1980-2000. Source: NOAA, 2013.

The projected change in the climate has significant global effects as well. Some concerns are:

- The risk of drought and the frequency, intensity, and duration of heat waves are expected to increase.
- More extreme precipitation is likely, increasing the risk of flooding.
- If the world's average temperature warms only an additional 2.7 to 4.5 degrees Fahrenheit above pre-industrial levels, an estimated 20 to 30 percent of known plant and animal species would be at increasingly high risk of extinction[36].
- Sea level rise has the potential to increase coastal flooding during storm events and even permanently inundate low-lying areas in many coastal and inland areas. Given the City Beverly's location, impacts from sea level rise could be substantial.

4.6.2 Regional Initiatives

Both the City of Beverly and the Commonwealth of Massachusetts have been engaged in climate change initiatives. In 2008, the Massachusetts Legislature passed and signed Section 9 of The Global Warming Solutions Act, which directed the Secretary of Energy and Environmental Affairs (EEA) to convene an advisory committee to develop a report that analyzes strategies for adapting to the predicted changes in climate.

According to the Massachusetts Climate Change Adaptation Report (September 2011), sea level rise in Massachusetts is caused by a combination of rising water temperatures, changing water currents, and melting ice on land (such as Greenland), and is further

[36] Center for Science in the Earth System (The Climate Impacts Group). *Preparing for Climate Change. A Guidebook for Local, Regional, and State Governments*. September 2007.

amplified by local subsidence of land. Relative sea level rise in Massachusetts from 1921 to 2006 was 2.6 millimeters annually (0.10 inches/year)—an increase of approximately 26 centimeters or 10.2 inches per century (NOAA, 2009).[37] Current rates of sea level rise and projections for accelerated trends are all significant threats to the coastal communities of the state. Sea level rise would increase the height of storm surges and associated coastal flooding frequencies, permanently inundate low-lying coastal areas, and amplify shoreline erosion. Extensive development and infrastructure, both public and private, would be affected in these expanding vulnerable areas.

4.6.3 Climate Change Adaptation Measures in the City of Beverly

4.6.3.1 Beverly Coastal Resiliency Plan, June 2017

The City of Beverly was the recipient of a $89,981 grant from the Massachusetts Office of Coastal Zone Management (CZM) to identify potential impacts of sea level rise due to climate change and develop a resiliency strategy to begin address these potential impacts. In an on-going effort to address the present and future risks of climate change and sea level rise to critical infrastructure, public facilities and residential and commercial uses, the City undertook an assessment of critical infrastructure most vulnerable to coastal flooding. The Beverly Coastal Resiliency Plan was in progress during the update of this hazard mitigation plan and is now complete.

As described in the Plan's introduction, the overall objective of the project was to ensure; a broad understanding by the City and its residents on how climate change can affect the City, to minimize current and future impacts associated with climate change, and to provide a vehicle to integrate these considerations into all planning and development efforts. Using this grant, Beverly sought to define the present and future risks of climate change and sea level rise to critical transportation and utility infrastructure, public facilities, and residential and commercial uses, the City of Beverly and its resiliency consultant, BSC Group, first organized a Core Resiliency Team (CRT) to conduct public outreach and education, identify programmatic and policy themes to address Beverly's vulnerabilities to coastal storm surge, and begin to develop resiliency projects and strategies. BSC Group worked in collaboration with the CRT, which was comprised of the City's Project Manager (the Planning Director), and City staff , including the City Engineer, Assistant Planning Director, the City GIS Coordinator, and the Environmental Planner. The City of Beverly partnered with BSC Group for their expertise in resiliency planning and infrastructure evaluation on this project. BSC Group was responsible for developing the vulnerability assessment, scenario creation (along with their subconsultant, Woods Hole Group (WHG), guiding stakeholder input through community workshops and a community survey), assessing the vulnerabilities, and developing resiliency themes. In addition to BSC, the City included input and buy-in from many other local, regional and state-wide stakeholders, including, but not limited to, Salem Sound Coastwatch, Mass Audubon, Endicott College, MEMA Task Force 1, Beverly High School, Beverly Planning

[37] NOAA. http://tidesandcurrents.noaa.gov/sltrends/ sltrends_station.shtml?stnid=8443970

Board, Beverly Conservation Commission, Beverly Harbor Management Authority, Beverly Open Space Committee, Beverly Stormwater Committee and the Mayor's Office.

The resulting plan discusses why Beverly is vulnerable to climate change, the data that was collected in support of the analysis, coastal inundation modeling that was completed by the consultant team, and sea level rise and storm climatology in the context of 2030 and 2070 planning horizons. It then provides an analysis of infrastructure vulnerability for those scenarios, including vulnerability ranking matrix. Lastly, it introduces broad resiliency themes, most of which are consistent with this plan, including:

- Planning;
- Infrastructure;
- Green Space; and
- Community Engagement.

The plan, and its analysis, findings and recommendations is include by reference into this hazard mitigation plan update.

4.7 Conclusions on Vulnerability Assessment

The hazard profiles presented in the above sections were developed using best available data and result in what may be considered principally a qualitative assessment. It relies heavily on historical and anecdotal data, stakeholder input, and professional and experienced judgment regarding observed and/or anticipated hazard impacts. It also carefully considers the findings in other relevant plans, studies and technical reports.

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 4-51 and are shown on Figure 4-9.

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. A summary of the most at risk facilities is found in Table 4-48 based on their exposure to two high hazard zones (flood and wildfire).

Table 4-48. High-Risk Critical Facilities

Facility Name	Type	FEMA Flood Zone	Wildland Urban Interface Area
Salem-Beverly Water Supply Board	Hazmat	A	Medium Density Intermix
Sewer Pump-Beach St	Sewer Pump Station	AE	Medium Density Intermix

4.7.1 Composite Hazard Priorities

The purpose of the hazard ranking is to categorize and prioritize all potential hazards for the City of Beverly based on risk. Combined with the asset inventory and quantitative vulnerability assessment, the summary hazard classifications allows for the prioritization of those high hazard risks for mitigation planning purposes, and more specifically, the identification of hazard mitigation opportunities for Beverly to consider as part of their proposed mitigation strategy. Each hazard was ranked from 1 (limited), 2 (moderate), and 3 (significant) in five categories, which were then weighted and averaged together to develop a Composite Hazard Index. This index was then used to rank the hazards to give the community some sense of how the hazards ranked in comparison to the others. Table 4-5 provides a summary of the categories used to rank the hazards and their weighted values for the Composite Hazard Index.

The overall summary of the different hazards is shown in Table 4-49. The highest priority hazards were winter storms and flooding and were labeled as composite high priority. The composite moderate priority includes severe weather (thunderstorm wind damage), extreme temperatures, and hurricanes.

Table 4-49. Overall Hazard Priority Summary

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Winter Storms	Highly Likely	Large	Negligible	Moderate	High	Significant
Flood	Highly Likely	Small	Critical	High	Medium-High	Significant
Severe Weather (Thunderstorms)	Highly Likely	Large	Negligible	Moderate	High	Significant
Extreme Temperatures	Likely	Isolated	Catastrophic	Negligible	Medium-High	Moderate
Hurricanes	Somewhat Likely	Large	Critical	Moderate	Medium-High	Moderate
Tornadoes	Somewhat Likely	Isolated	Catastrophic	Limited	Medium-Low	Limited
Earthquakes	Unlikely	Small	Catastrophic	High	Medium-Low	Limited
Drought	Somewhat Likely	Medium	Negligible	Negligible	Medium-High	Limited
Wildfire	Somewhat Likely	Medium	Negligible	Negligible	Medium-High	Limited

4.7.2 Summary of Loss Estimates

As described in the hazard-specific estimated loss sections, Essex County has reported 556 hazard events since 1950, as recorded in the NOAA NCEI Storm Events Database. Table 4-50 summarizes the estimated annualized damages for these hazards that was also included in each hazard's profile.

Table 4-50. Summary of Estimated Annualized Damages

Hazard	Annualized Occurrence	Annualized Damages (2017$)	Annualized Deaths Reported	Annualized Injuries Reported
Drought	0.23	$0.00	0.00	0.00
Extreme Temperature	0.18	$0.00	0.00	0.00
Flood	4.05	$2,525,255	0.09	0.14
Hurricane	0.05	$106,154	0.00	0.00
Severe Weather (Strong Wind, High Wind, Lightening)	11.55	$258,669	0.18	0.41
Sever Weather (Hail)	3.11	$2,914	0.00	0.00
Severe Weather (Thunderstorm Wind)	0.22	$172,339	0.02	0.11
Tornados	5.14	$39,279	0.00	0.06
Winter Storm	0.23	$655,169	0.00	0.00

4.7.3 Critical Facilities

As described in each hazard-specific section, hazards with defined spatial extents were intersected with critical facility locations. Table 4-51 summarizes the critical facilities within Beverly that are exposed to flood and wildfire hazards using available geospatial layers. There are 22 critical facilities, of 170 total, that are located in a special flood hazard area (A or AE zone). About 25% of the critical facilities are located either in an interface or intermix zone that has a heightened risk of wildfire exposure. Only two critical facilities, the Salem-Beverly Water Supply Board and the Beach Street Sewer Pump, have exposure to areas of high flood risk and wildfire risk.

Table 4-51. Critical Facility Natural Hazard Exposure

ID	Facility Name	Type	FEMA Flood Zone	Wildland Urban Interface Area
1	Beverly Airport	Heliport	X	Uninhabited_NoVeg
2	Beverly Emergency Management	Government	X	Uninhabited_NoVeg
3	Salem-Beverly Water Supply Board	Hazmat	A	Med_Dens_Intermix
4	Communications & Power Industry	Hazmat	X	Uninhabited_NoVeg
5	North Beverly Fire Station	Government	X	High_Dens_NoVeg
6	Beverly Church Of The Nazarene	Church	X	Med_Dens_NoVeg
8	Axcelis Technologies Inc	Hazmat	X	Uninhabited_NoVeg
9	Herrick House	Assisted Living	X	Med_Dens_NoVeg
10	Henry's Of North Beverly	Supermarket	X	Uninhabited_NoVeg
11	North Shore Nursery	Day Care	X	Low_Dens_Intermix
12	Campbell Funeral Home	Mortuary	X	Med_Dens_NoVeg
13	Creation Station Pre-school	Day Care	X	Med_Dens_Interface
14	Cell Tower	Cell Tower	X	Med_Dens_Intermix
15	North Beverly Rail Station	Train Station	X	Med_Dens_Interface
16	North Shore Community Baptist Church Inc	Church	X	Med_Dens_Interface
17	Essex Park	Nursing Home	X	Med_Dens_NoVeg
18	Beverly Water Tank	Utility	X	Med_Dens_Intermix
19	Beverly Hospital	Heliport	X	High_Dens_NoVeg
20	Ledgewood Rehabilitation	Nursing Home	X	Uninhabited_NoVeg
21	NG-East Beverly No 51	Utility	X	Med_Dens_Intermix
22	Harborlight Montessori	School	X	Med_Dens_NoVeg
23	NG-Balch St No 72	Utility	X	Very_Low_Dens_NoVeg
24	Beverly Farms Branch Library	Library	X	High_Dens_Interface

ID	Facility Name	Type	FEMA Flood Zone	Wildland Urban Interface Area
25	Beverly Farms Fire Station	Government	X	High_Dens_Interface
26	Beverly Historical Society-Balch	Cultural Resource	X	Med_Dens_NoVeg
27	Children Aboard Rainbow Express	Day Care	X	Med_Dens_Interface
28	Beverly Farms Rail Station	Train Station	X	Med_Dens_Interface
29	Montseratt Rail Station	Train Station	X	Med_Dens_NoVeg
30	Senior Center/Board of Health	Government	X	Med_Dens_NoVeg
31	Prides Crossing Rail Station	Train Station	X	Med_Dens_Interface
32	Post Office-Beverly Farms	Government	X	Med_Dens_Interface
33	Rite Aid Pharmacy	Pharmacies	X	Med_Dens_NoVeg
34	Endicott College	College	X	Uninhabited_NoVeg
35	So New Eng Conf. Ass-Seventh Day Advent	Church	X	High_Dens_NoVeg
36	CVS-Downtown	Pharmacies	X	High_Dens_NoVeg
37	Landmark School	School	X	Low_Dens_Intermix
38	DPS Headquarters	Government	X	High_Dens_NoVeg
39	Walgreen Drug Stores	Pharmacies	X	Uninhabited_NoVeg
40	Beverly Housing Authority	Government	X	High_Dens_NoVeg
41	Gar Hall-Building Dept	Cultural Resource	X	Med_Dens_NoVeg
42	Dane Street Church	Church	X	Med_Dens_NoVeg
43	Sewer Pumping Station-Mingo	Sewer Pump Station	X	Uninhabited_NoVeg
44	Beverly Public Library	Library	X	High_Dens_NoVeg
45	Montserrat College Of Art	College	X	Med_Dens_NoVeg
46	First Assembly Of God Church, Of Beverly	Church	X	High_Dens_NoVeg
47	St Mary Catholic Church	Church	X	High_Dens_NoVeg
48	Beverly Historical Society-Hale	Cultural Resource	X	Uninhabited_NoVeg

ID	Facility Name	Type	FEMA Flood Zone	Wildland Urban Interface Area
49	Beverly Rail Station	Train Station	X	Uninhabited_NoVeg
50	First Parish Unitarian Church	Church	X	Uninhabited_NoVeg
51	St Peter's Church	Church	X	High_Dens_NoVeg
52	First Baptist Church In Beverly	Church	X	Med_Dens_NoVeg
53	Lynch Park	Cultural Resource	AE	Uninhabited_NoVeg
54	Beverly Fire Headquarters	Government	X	Med_Dens_NoVeg
55	Christian Science Society	Church	X	High_Dens_NoVeg
56	National Grid Facility	Utility	AE	Med_Dens_NoVeg
57	Main Post Office	Government	X	High_Dens_NoVeg
58	Sewer Pump Station-Marsh	Sewer Pump Station	AE	Med_Dens_NoVeg
60	Beverly Historical Society-Cabot	Cultural Resource	X	High_Dens_NoVeg
61	Hes Homeward Bound-HES	Children Residence	X	High_Dens_NoVeg
62	Girder House (Retire. Home for Ladies)	Assisted Living	X	High_Dens_NoVeg
63	Cell Tower-128	Cell Tower	X	Med_Dens_Interface
64	Beverly Water Tower	Utility	X	Uninhabited_Veg
65	CVS-Beverly Plaza	Pharmacies	X	High_Dens_NoVeg
66	Comcast	Hazmat	X	Med_Dens_NoVeg
68	Blueberry Hill Healthcare	Nursing Home	X	Med_Dens_NoVeg
69	Sewer Pump-Beach St	Sewer Pump Station	AE	Med_Dens_Intermix
70	Bass Haven Yacht Club	Marina	AE	Uninhabited_NoVeg
71	Beverly Port Marina	Marina	AE	Med_Dens_NoVeg
72	Jubilee Yacht Club	Marina	AE	High_Dens_NoVeg
73	Sewer Pump St. SESD	Sewer Pump Station	AE	High_Dens_NoVeg
74	Stop & Shop	Supermarket	X	Med_Dens_Interface
75	Postal Distribution Center	Government	X	Med_Dens_NoVeg

ID	Facility Name	Type	FEMA Flood Zone	Wildland Urban Interface Area
76	Nexus House	Children Residence	X	Uninhabited_NoVeg
77	Stop & Shop	Supermarket	X	Uninhabited_NoVeg
78	First Federated Church of Beverly	Church	X	Med_Dens_NoVeg
79	St. John's Parish	Church	X	Med_Dens_Interface
80	St John the Evangelist Church	Church	X	Med_Dens_NoVeg
81	Beverly Hospital	Cell Tower	X	Uninhabited_NoVeg
82	Shaw's Supermarket	Supermarket	X	High_Dens_NoVeg
83	Beverly Airport	Landing Strips	X	Uninhabited_NoVeg
84	Hall Whitaker Bridge	Bridge	AE	Water
85	Kernwood Bridge	Bridge	X	Med_Dens_NoVeg
86	City of Beverly Harbor Mgmt	Marina	AE	Uninhabited_NoVeg
87	Wenham Lake	Reservoir	A	Water
88	Beverly Hospital	Hazmat	X	Uninhabited_NoVeg
89	Harborlight House	Assisted Living	X	High_Dens_NoVeg
90	Landmark at Ocean View	Assisted Living	X	Med_Dens_NoVeg
91	Second Congregational Church of Beverly	Church	X	Uninhabited_NoVeg
92	Spectrum Adult Day Health Center	Adult Day Care	X	Very_Low_Dens_NoVeg
93	Elder Services Plan of Northshore	Adult Day Care	AE	Very_Low_Dens_NoVeg
94	Hillhouse	Children Residence	X	Uninhabited_NoVeg
95	McKeown School	School	X	Very_Low_Dens_NoVeg
96	Ayers Ryal Side Elementary School	School	X	Uninhabited_NoVeg
97	Centerville Elementary School	School	X	Med_Dens_Interface
98	Cove Elementary School	School	X	Med_Dens_NoVeg
99	Hannah Elementary School	School	X	Med_Dens_NoVeg

ID	Facility Name	Type	FEMA Flood Zone	Wildland Urban Interface Area
100	North Beverly Elementary School	School	X	Med_Dens_Intermix
101	Briscoe Middle School	School	X	High_Dens_NoVeg
102	Beverly High School	School	X	Med_Dens_NoVeg
103	Memorial Methodist Church	Church	X	Med_Dens_NoVeg
104	Cape Ann Waldorf School	School	X	Med_Dens_Intermix
105	Mrs. Alexander's School	Day Care	X	High_Dens_NoVeg
106	Middle School-Construction	School	X	Med_Dens_NoVeg
107	Bright Horizons @ Cummings Center	Day Care	AE	Very_Low_Dens_NoVeg
108	Covenant Christian School	School	X	Med_Dens_Intermix
109	Shoe Pond Dam	Dam	A	Very_Low_Dens_NoVeg
110	Beverly School for the Deaf	School	X	Uninhabited_NoVeg
111	Glenn Urquhart School	School	X	Med_Dens_Intermix
112	Waring School	School	X	Low_Dens_Intermix
113	Shore Country Day School	School	X	Med_Dens_NoVeg
114	Walgreen Drug Stores	Pharmacies	X	Med_Dens_NoVeg
115	Sewer Pump-Prescott	Sewer Pump Station	X	Med_Dens_Interface
116	Sewer Pump-Bailey	Sewer Pump Station	AE	Med_Dens_NoVeg
117	Sewer Pump-Trask	Sewer Pump Station	X	Med_Dens_Interface
118	Sewer Pump-Thaxton	Sewer Pump Station	X	Med_Dens_Interface
119	Sewer Pump-Sherwood	Sewer Pump Station	X	Med_Dens_Interface
120	Sewer Pump-Landers	Sewer Pump Station	X	Med_Dens_Interface
121	Sewer Pump-Grover #2	Sewer Pump Station	X	Med_Dens_Intermix
122	Sewer Pump-Grover #1	Sewer Pump Station	X	Med_Dens_Intermix
123	Sewer Pump-Hobart	Sewer Pump Station	X	Med_Dens_NoVeg
124	Sewer Pump-Bass	Sewer Pump Station	AE	High_Dens_NoVeg

ID	Facility Name	Type	FEMA Flood Zone	Wildland Urban Interface Area
125	Sewer Pump-Roundy	Sewer Pump Station	X	High_Dens_NoVeg
126	Sewer Pump-Chapmans Corner	Sewer Pump Station	X	Med_Dens_NoVeg
127	Sewer Pump-Prides Crossing	Sewer Pump Station	X	Med_Dens_Interface
128	Sewer Pump-Bayview	Sewer Pump Station	X	Med_Dens_NoVeg
129	Sewer Pump-Sourh Hardy	Sewer Pump Station	X	High_Dens_NoVeg
130	Sewer Pump-Wentzell	Sewer Pump Station	X	High_Dens_NoVeg
131	Sewer Pump-Dyer Rd	Sewer Pump Station	X	Med_Dens_Intermix
132	Sewer Pump-Birchwoods	Sewer Pump Station	X	Med_Dens_NoVeg
133	Sewer Pump-Robinson	Sewer Pump Station	X	Med_Dens_Interface
134	Sewer Pump-Kennel Hill	Sewer Pump Station	X	Med_Dens_Interface
135	Sewer Pump-Lynch	Sewer Pump Station	AE	Uninhabited_NoVeg
136	Sewer Pump-Lower Parsons	Sewer Pump Station	X	Med_Dens_Intermix
137	Sewer Pump-Upper Parsons	Sewer Pump Station	X	Med_Dens_Intermix
138	Sewer Pump-Morgan Island	Sewer Pump Station	X	Med_Dens_Interface
139	Sewer Pump-LP Henderson	Sewer Pump Station	X	Uninhabited_NoVeg
140	Beverly Children's Learning Center	Day Care	X	Med_Dens_NoVeg
141	Cabot Children's Enrichment Center	Day Care	X	High_Dens_NoVeg
142	Caterpillar Clubhouse Childcare&Pres.	Day Care	X	Med_Dens_NoVeg
143	Friend-Shipp Preschool	Day Care	X	Med_Dens_NoVeg
144	Futures Behavior Therapy Center	Day Care	X	Med_Dens_NoVeg
145	Harborlight-Stoneridge Montessori	Day Care	X	Med_Dens_NoVeg
146	Harborlight Nursery School	Day Care	X	Med_Dens_NoVeg
147	Learning Zone at Cummings Center	Day Care	AE	Very_Low_Dens_NoVeg
148	Next Generation Children's Center	Day Care	X	Med_Dens_NoVeg
149	Sterling Enrichment & After the Bell	Day Care	X	Med_Dens_NoVeg

ID	Facility Name	Type	FEMA Flood Zone	Wildland Urban Interface Area
150	YMCA Beverly	Cultural Resource	X	Med_Dens_NoVeg
151	Children's Center for Communication	Day Care	X	Uninhabited_NoVeg
152	Garden City Children's Center	Day Care	X	High_Dens_NoVeg
153	Tot-Spot at Landmark	Day Care	X	Low_Dens_Intermix
154	USTC Afterschool Marital Arts	Day Care	X	High_Dens_NoVeg
155	YMCA Centerville	Day Care	X	Med_Dens_Interface
156	St. John the Evangelist School	School	X	Med_Dens_NoVeg
157	City Hall	Government	X	High_Dens_NoVeg
158	Police Headquarters	Government	X	High_Dens_NoVeg
159	Pump Station-Margin St	Storm Pump Station	AE	Uninhabited_NoVeg
160	Medicine Shoppe Pharmacy	Pharmacies	X	High_Dens_NoVeg
161	Music Theater	Cultural Resource	X	Med_Dens_Intermix
162	Cabot Performing Arts Center	Cultural Resource	X	High_Dens_NoVeg
163	Larcom Performing Arts Theatre	Cultural Resource	X	High_Dens_NoVeg
164	Aero Manufacturing Corp.	Hazmat	X	Uninhabited_NoVeg
165	Delta Electronics Manufacturing	Hazmat	X	Med_Dens_NoVeg
166	Endicott College	Hazmat	X	Uninhabited_NoVeg
167	IXYS IC Division Inc.	Hazmat	X	Uninhabited_NoVeg
168	Microsemi Corp	Hazmat	X	Med_Dens_NoVeg
169	Microsemi Corp	Hazmat	X	Uninhabited_NoVeg
170	Osram Sylvania Products	Hazmat	X	Uninhabited_NoVeg
171	Verizon Beverly	Hazmat	X	High_Dens_NoVeg
172	Salem Beverly Bridge	Bridge	AE	Water
173	National Grid	Utility	AE	Med_Dens_NoVeg

5. Capability Assessment and Existing Measures

5 Capability Assessment and Existing Measures

The City of Beverly has a number of resources it can access to implement hazard mitigation initiatives. These resources include both private and public assets at the local, state, and federal levels.

A detailed Hazard Mitigation Capabilities Assessment Questionnaire was prepared and distributed to the city for response. The questionnaire was designed to assess the city's ability to reduce future losses from hazards like floods and winter storms through its various policies and programs. The intent of the capability assessment was to provide an inventory of existing policies, programs, practices, and operational responsibilities that have or may have a major role in supporting the community's mitigation program. The results of the questionnaire are integral to the development of a mitigation strategy, the backbone of the local hazard mitigation plan 2018 revision. The questions presented in the questionnaire covered several agencies in the city. These agencies included the Departments of Engineering, Planning, Community Development, and Public Services. Table 5-1, at the end of this section, summarizes the capabilities of Beverly that will facilitate implementation of the mitigation strategy.

Two important capabilities are the floodplain management ordinance and building code administration and enforcement. Through the administration of its floodplain ordinance, the City can ensure that all new construction or substantial improvements to existing structures located in the SFHA are built with lowest-floor elevations above the Base Flood Elevation (BFE).

Building codes are an important method of ensuring that new construction and significant improvements consider the hazards facing a community. Consequently, structures that are built to applicable codes are inherently resistant to localized strong winds, floods, and earthquakes.

5.1 Existing Multi-Hazard Mitigation Measures

The documents described in the following subsections are deemed by the City to have relevance its overall hazard mitigation program.

5.1.1 Comprehensive Emergency Management Plan (CEMP)

Every community in Massachusetts is required to have a Comprehensive Emergency Management Plan. These plans address mitigation, preparedness, response and recovery from a variety of natural and man-made emergencies. These plans contain important information regarding flooding, hurricanes, tornadoes, dam failures, earthquakes, and winter storms. Therefore, the CEMP is a mitigation measure that is relevant to all of the hazards discussed in this plan. There have been no changes to the CEMP since the 2012 revision of this plan.

5.1.2 Communications Equipment

The City utilizes the Incident Command Unit, a mobile communications center available

to the City through the MA State Police and The MA Department of Fire Services. The City has a Reverse 911 system in place. There have been no changes to these equipment or to the system overall since the last plan update in 2012.

5.1.3 Emergency Power Generators

Emergency power generators can be found in all but one of the City's fire stations, the DPW facility, the Hannah School and the High School.

5.1.4 Massachusetts State Building Code

The Massachusetts State Building Code contains many detailed standards regarding wind loads, earthquake resistant design, flood-proofing, and snow loads. Since the last plan update, Massachusetts Coastal Zone Management has commissioned the update of mapping for areas of Limited to Moderate Wave Action (LiMWA) which is incorporated by reference into the building code. These are areas where the wave action is still present but not to the extent to meet the criteria of a velocity zone. Higher construction standards are required in LiMWA areas. Beverly has identified errors in the LiMWA delineation and is working with FEMA, Region I to have them corrected. There was a large Letter of Map Revision completed in portions of Beverly. It does not address the LiMWA delineation issue. In addition to FEMA Region I, Beverly is coordinating, regarding the possible correction of this issue, with the NFIP State Coordinator.

5.1.5 Public Information & Outreach

The City provides information to residents and business owners relating to a range of potential natural hazards, most especially with regard to flooding, hurricanes, and northeasters. Since the 2012 plan update, public outreach as expanded significantly in Beverly. When FEMA issued revised Flood Insurance Rate Maps in 2014, a direct mailing was sent to all impacted property owners. A series of public meetings were held to review the mapping before its adoption. Public input resulted in the discovery of errors and a subsequent Letter of Map Revision that became effective in the spring of 2017. In addition to the public outreach survey and meetings conducted for this plan update, there were a number of public outreach forums as part of the development of the 2017 Coastal Resilience plan, which resulted in new awareness of the flooding hazard and predicted impacts of climate change and sea level rise.

5.2 Existing Flood Hazard Mitigation Measures

5.2.1 National Flood Insurance Program (NFIP)

FEMA's NFIP maintains a database that contains a NFIP Policy and Claims Report that summarizes flood insurance policies and claims by community. City of Beverly participates in the NFIP with 358 policies in force as of the February 21, 2017. 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.

Additional details about Beverly's NFIP participation can be found in the flooding hazard profile in Section 4.5.2. During this an previous hazard mitigation plan updates, the City of Beverly evaluated the merits of joining the Community Rating System (CRS) and determined that with its relatively low policy count and limited construction in flood prone areas that the program does not provide enough return on investment to be worthwhile.

5.2.2 Public Works Operations/Maintenance Activities

The Public Works Department actively maintains the City's storm drain system. The following specific activities serve to maintain the capability of the drainage system through the reduction of sediment and litter build up and proper maintenance and repair.

- *Street sweeping* – Street sweeping is conducted throughout the City two-three times annually, with downtown area streets swept twice weekly.
- *Catch basin cleaning* –3500 catch basins cleaned annually (some biannually as needed).
- *Roadway treatments* – Calcium Chloride is used for snow/ice treatment.
- *Drainage maintenance*- Approximately 95% of the City's catch basins and drain lines are now digitally mapped.
- *Historical drainage*-Beverly is able to map connectivity between streams, topography and its drainage system by scanning historic aerial photos, starting from the 1940s, into its GIS system.

Beverly is continuing to operate under the 2002 MS4 permit, but is currently conducting an update of its Municipal Separate Storm Sewer System (MS4) permitting and planning.

5.2.3 2002 City of Beverly Master Plan

Given Beverly's coastal location, natural hazard mitigation ideas and strategies are referenced in the plan. These references include investigation to see if current wetland protection rules and regulations are adequate to preserve their critical roles in providing habitat, storm buffering and floodwater storage. The Master Plan also calls for the coordination of open space policies to protect open space, minimize development impacts, allow development of residential areas, protect and improve natural resources, and establish greenways and riparian corridors. Specifically, the Plan calls for the adoption of Open Space Residential Design subdivisions to preserve open space, promote the infiltration of stormwater, reducing runoff, erosion and flooding. Although the Master Plan has not been updated since 2002, many of the recommendation it includes have been implemented or included in other plans, such as its Open Space Plan.

5.2.4 2015 Open Space and Recreation Plan

One of the Plan's top priorities is the protection and acquisition of lands with "high natural, scenic, recreational, agricultural, community and urban gardening, and environmental values. Land of particular interest for protection and acquisition are within the Wenham Lake and Longham

Reservoir watersheds and the City's Water Protection Overlay District. The plan is up to date and certified by the MA Department of Conservation and Recreation.

5.2.5 Floodplain Overlay District

Zoning is intended to protect the public health and safety through the regulation of land use. The Beverly Zoning Ordinance includes a Floodplain District (Sections 29-31). The purposes of this district are:

- To protect the health and safety of residents of lands subject to seasonal or periodic flooding;
- To minimize future flood damage by providing for the maintenance of existing waterways, water bodies, and wetlands through a Flood Plain management program.

The Floodplain Overlay District is an overlay district, defined by the 100-year floodplain as designated by FEMA. Within the District, the following requirements must be met:

- Any uses permitted shall be subject to the provisions of the Commonwealth State Building Code, section 744, entitled "Design Requirements for Floodplains and Coastal High Hazard Areas."
- All encroachments, including fill, new construction, substantial improvements to existing structures, and other developments are prohibited in the floodway as designated on the Flood Boundary and Floodway Map for Beverly
- In zone AO, (areas of 100-year shallow flooding where depths are between one and three feet), for all new construction and substantial improvements, it is required that:
- 1. Residential structures have the lowest floor (including basement) elevated above the crown of the nearest street to or above the depth specified on Beverly's Flood Insurance Rate Maps (FIRMS).
- 2. Non-residential structures have the lowest floor (including basement) elevated above the crown of the nearest street to or above the depth specified on Beverly's FIRM or be flood proofed to or above that level.
- In zones VI - V30, (areas of 100-year coastal flood with wave action), all new construction or substantial improvements must be located landward of the reach of mean high tide.

The only update to the Floodplain Overlay District Regulations since the 2012 Hazard Mitigation Plan update was the adoption by reference of the updated Flood Insurance Rate Maps and subsequent Letter of Map Revision.

5.2.6 Floodplain Management Plan

In 1970, the City commissioned Camp Dresser and McKee (now CDM Smith) to do a study to identify all critical drainage problems and outline a number of capital projects that, if undertaken, would address most of the neighborhood-wide flooding. No action

was taken until 1998 when the City authorized $10 million in bonds to undertake three of the projects. For the 2012 plan, two of the projects had been completed, as well as the first phase of work at Chubb's Brook. For this plan update, all of the major projects identified in the 1970 plan has been completed, including: Lawrence Street Brook, Chubbs Brook (Beverly Farms Brook) and North Beverly Brook.

5.2.7 Subdivision Rules and Regulations

The Beverly Subdivision Rules and Regulations contains provisions intended to reduce the impacts of floods and erosion. Through its design and layout standards, the bylaws contribute to the City's overall efforts to mitigate the risks for damage through flooding. Some of the contributing provisions include the following:

- Open Space Residential Design (OSRD) required for all subdivisions of four lots or greater in some residential districts and three lots or greater in low density residential districts. OSRD encourages the protection and permanent preservation of open space, forestry land, wildlife habitat, other natural resources including public water supplies, aquifers, water bodies and wetlands, and historical resources in a manner that is consistent with Beverly's Master Plan and Open Space and Recreation Action Plan (together, the "Master Plans");
- OSRD subdivisions are encouraged to use non-structural stormwater management techniques such as rain gardens and bio-retention swales and others that do not create impervious surfaces and enable stormwater infiltration;
- At least 50% of the OSRD tract must remain undisturbed land; and
- No increased discharges of stormwater are permitted for new development covered by the regulations.

5.2.8 Wetlands Protection By-Law

The purpose of the Wetlands Protection Regulations is to further protect the City's shores, ponds, rivers, and wetlands for, among other reasons, flood control, erosion and sedimentation control, and public safety. The by-law builds on the State Wetlands Protection Act offering more stringent controls over vernal ponds and isolated vegetated wetlands. There is a 100-foot no-disturb zone for any vernal pond and a 25-foot no-disturb zone for any isolated or bordering vegetated wetland. Any activity that might fill or otherwise alter these resource areas requires a permit from the Beverly Conservation Commission.

5.2.9 Stormwater Management/Construction Site Management Ordinance

Any development or redevelopment that alters more than one acre of land must comply with the City' stormwater management ordinance, whose standards match the MA Stormwater Management Standards, including no increase in post-development peak runoff rates compared to pre-development rates. The ordinance also prohibits illegal stormwater connections, land contours two feet or greater, contains permit requirement for land alteration greater than ¼ acre and implements development standards for erosion control.

5.2.10 DCR dam safety regulations

The state has enacted dam safety regulations mandating inspections and emergency action plans. All new dams are subject to state permitting. There are currently no regulated dams within the corporate limits of Beverly. There have been no new dam construction permits issued since the 2012 plan update.

5.2.11 Seawalls, Jetties and Dikes

There are four miles of coastline in Beverly with a significant number of seawalls. Most of the seawalls are privately owned. Though included in past Capital Improvement Programs, the City has not undertaken a comprehensive study of the condition of all its seawalls. Since the 2012 Hazard Mitigation Plan Update, MA CZM has completed an inventory and classification of these structures.

5.3 Existing Wind Hazard Mitigation Measures

5.3.1 Comprehensive Emergency Plan (CEMP)

The Beverly Comprehensive Emergency Management Plan contains a section on hurricanes. It lists five generic mitigation measures:

- Develop and disseminate emergency public information and instructions concerning hurricane preparedness and safety.
- Community leaders should ensure that Beverly is enrolled in the National Flood Insurance Program.
- Develop and enforce local building codes to enhance structural resistance to high winds and flooding. Build new construction in areas that are not vulnerable to direct hurricane effects.
- Make informed decisions concerning protecting natural attributes such as beaches and dunes with breakwaters and sea walls. Review National Flood Insurance Rate Maps and Hurricane Evacuation Maps for possible impact on the community.
- Maintain plans for managing all hurricane emergency response activities.

The Beverly CEMP outlines three generic mitigation measures for tornadoes.

- Develop and disseminate emergency public information and instructions concerning tornado safety, especially guidance regarding in-home protection and evacuation procedures, and locations of public shelters.
- Strict adherence should be paid to building code regulations for all new construction.
- Maintain plans for managing tornado response activities. Refer to the non-institutionalized, special needs and transportation resources listed in the Resource Manual.

5.3.2 Massachusetts State Building Code

*T*he City enforces the Massachusetts State Building Code. The code's provisions are generally adequate to protect against most wind damage. 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, the potential for severe damages would be extremely high.

5.3.3 Tree-trimming program

The City conducts its own tree maintenance and also uses its own equipment to trim and remove trees as needed and grind stumps. National Grid also maintains its utility line corridors on a rotating, 3-year cycle.

5.4 Existing Winter Hazard Mitigation Measures

5.4.1 Snow disposal

Regular plowing and snow/ice removal. Calcium chloride is used primarily for road treatments. Sand is very rarely used as it creates siltation and clean up problems. Since the last plan update, Beverly has begun treating roads in advance of storms with pre-wet solutions, which also minimizes siltation and clean up requirements, helping the function of stormwater management systems.

5.5 Existing Brush Fire Hazard Mitigation Measures

5.5.1 Burn Permits

The City fire department requires a written permit for outdoor burning, which includes explanation of the related regulations and precautions for the permit-holder to take. The permit-holder must call the fire department on the proposed burn day to confirm weather conditions are suitable for outdoor burning.

5.5.2 Subdivision/Development Review

The Fire Department participates in the review of new subdivisions and development projects.

5.6 Existing Geologic Hazard Mitigation Measures

5.6.1 Massachusetts State Building Code

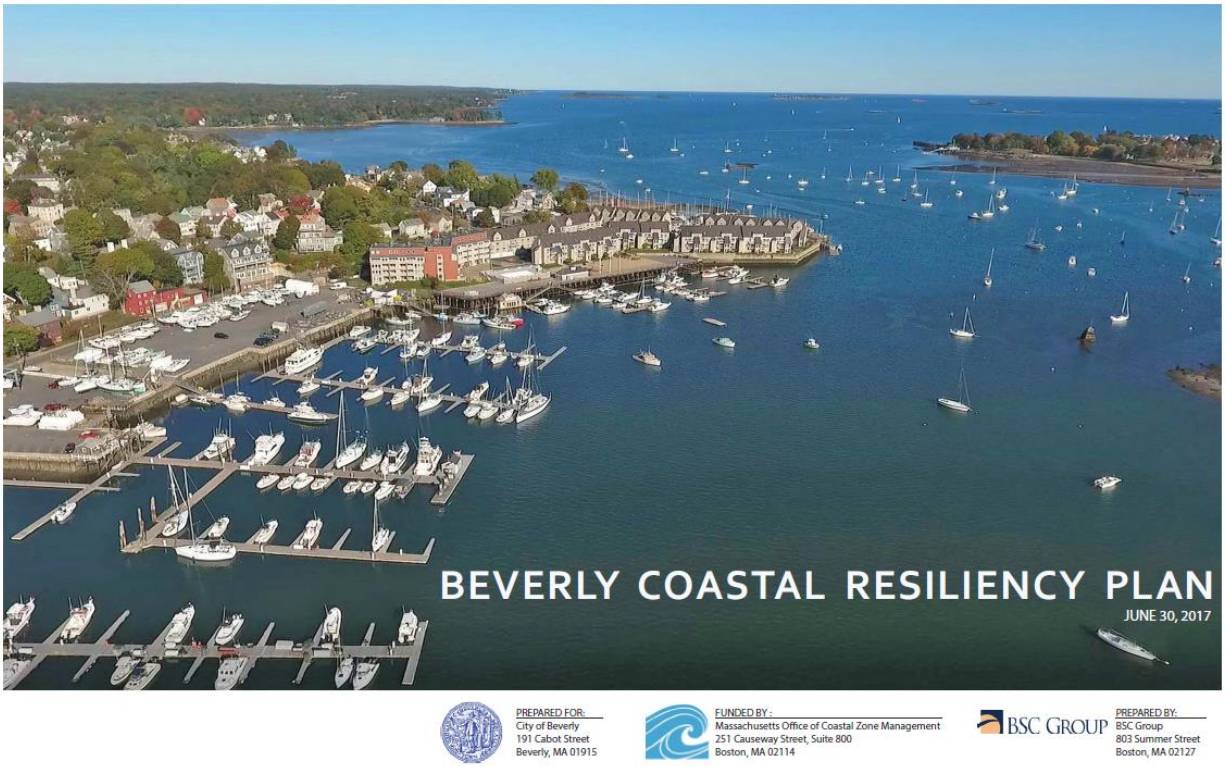
The State Building Code contains a section on designing for earthquake loads (780 CMR 1612.0). Section 1612.1 states that the purpose of these provisions is "to minimize the hazard to life to occupants of all buildings and non-building structures, to increase the

expected performance of higher occupancy structures as compared to ordinary structures, and to improve the capability of essential facilities to function during and after an earthquake". This section goes on to state that due to the complexity of seismic design, the criteria presented are the minimum considered to be "prudent and economically justified" for the protection of life safety. The code also states that absolute safety and prevention of damage, even in an earthquake event with a reasonable probability of occurrence, cannot be achieved economically for most buildings.

5.7 Existing Climate Change Adaptation Measures

5.7.1.1 Beverly Coastal Resiliency Plan, June 2017

The City of Beverly was the recipient of a $89,981 grant from the Massachusetts Office of Coastal Zone Management (CZM) to identify potential impacts of sea level rise due to climate change and develop a resiliency strategy to begin address these potential impacts. In an on-going effort to address the present and future risks of climate change and sea level rise to critical infrastructure, public facilities and residential and commercial uses, the City undertook an assessment of critical infrastructure most vulnerable to coastal flooding. The Beverly Coastal Resiliency Plan was in progress during the update of this hazard mitigation plan and is now complete.



As described in the Plan's introduction, the overall objective of the project was to ensure; a broad understanding by the City and its residents on how climate change can affect the City, to minimize current and future impacts associated with climate change, and to provide a vehicle to integrate these considerations into all planning and development efforts. Using this grant, Beverly sought to define the present and future risks of climate

change and sea level rise to critical transportation and utility infrastructure, public facilities, and residential and commercial uses, the City of Beverly and its resiliency consultant, BSC Group, first organized a Core Resiliency Team (CRT) to conduct public outreach and education, identify programmatic and policy themes to address Beverly's vulnerabilities to coastal storm surge, and begin to develop resiliency projects and strategies. BSC Group worked in collaboration with the CRT, which was comprised of the City's Project Manager (the Planning Director), and City staff , including the City Engineer, Assistant Planning Director, the City GIS Coordinator, and the Environmental Planner. The City of Beverly partnered with BSC Group for their expertise in resiliency planning and infrastructure evaluation on this project. BSC Group was responsible for developing the vulnerability assessment, scenario creation (along with their subconsultant, Woods Hole Group (WHG), guiding stakeholder input through community workshops and a community survey), assessing the vulnerabilities, and developing resiliency themes. In addition to BSC, the City included input and buy-in from many other local, regional and state-wide stakeholders, including, but not limited to, Salem Sound Coastwatch, Mass Audubon, Endicott College, MEMA Task Force 1, Beverly High School, Beverly Planning Board, Beverly Conservation Commission, Beverly Harbor Management Authority, Beverly Open Space Committee, Beverly Stormwater Committee and the Mayor's Office.

The resulting plan discusses why Beverly is vulnerable to climate change, the data that was collected in support of the analysis, coastal inundation modeling that was completed by the consultant team, and sea level rise and storm climatology in the context of 2030 and 2070 planning horizons. It then provides an analysis of infrastructure vulnerability for those scenarios, including vulnerability ranking matrix. Lastly, it introduces broad resiliency themes, most of which are consistent with this plan, including:

- Planning;
- Infrastructure;
- Green Space; and
- Community Engagement.

The 2017 Coastal Resiliency Plan is hereby incorporated by reference into this plan.

5.8 Stakeholder Capabilities

Since the 2012 update, stakeholder involvement in mitigation related activities has increased in Beverly.

5.8.1 Salem Sound Coastwatch

Salem Sound Coastwatch is a non-profit organization with the mission of protecting and improving the environmental quality of Salem Sound and its watershed. To achieve its mission, it engages in activities to increase the public's knowledge and appreciation of natural resources and threats to the ecological health of the watershed. It works with the public and private sectors and other no-profits to foster responsible and sustainable

resource management practices. Additionally, it conducts monitoring and scientific research and shares the results with the public.

Members of Salem Sound Coastwatch participated on both the Coastal Resilience Plan and 2018 Beverly Hazard Mitigation Plan Update teams. Beverly is using the organization to assist with all outreach associated with MS4 permitting and planning. The organization also conducts training program for elementary school kids on sustainability and other environmental initiatives and holds periodic beach cleaning and outfall monitoring activities.

5.8.2 Endicott College

Endicott College, with its campus in Beverly, has recently become active and interested in initiative addressing sustainability and resilience. The college was represented on the Coastal Resilience and Hazard Mitigation Update Committees and has expressed a desire to increase its role in resilience work going forward.

Table 5-1. Beverly Existing Mitigation Measures Effectiveness Evaluation

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, with broad mitigation goals.	None.
Communications Equipment	City-wide.	Effective	None. Since the 2012 update smartphone technology and use has made previous recommendations outdated and no longer needed.
Massachusetts State Building Code	City-wide.	Effective for new construction.	None.
Emergency Power Generators	City-wide.	Effective.	Upgrade generators as needed; provide generators at additional locations; provide alternative fuel sources and generator power source flexibility.
FLOOD HAZARDS			
Participation in the National Flood Insurance Program (NFIP)	Areas identified on the FIRM maps.	There are 358 policies in force.	Encourage all eligible homeowners to obtain insurance.

Type of Existing Mitigation Measures	Area Covered	Effectiveness/ Enforcement	Improvements/ Changes Needed
Public Works Operations/Maintenance	City-wide.	Effective.	None.
Master Plan	City-wide	Needs updating.	Include a new section on Climate Change in the next update.
Open Space Plan	City-wide	Needs updating.	Target acquisition of open space parcels with flood storage capacity.
Zoning – Floodplain District	City-wide.	Effective for new construction.	Evaluate updates that would increase flood resiliency for new construction and substantial improvements.
Subdivision Rules and Regulations	City-wide	Effective.	None.
Wetlands Protection Ordinance	Resource Areas	Effective.	None.
Open Space Residential Design Subdivisions	New subdivisions >4 lots	Effective.	None.
Stormwater Management Ordinance	City-wide	Effective.	None.
DCR Dam Safety Regulations	Dams	Effective.	None.
Seawalls, Jetties, and Dikes	Coastline	Not as effective.	Major improvements needed towards repair and maintenance. Additional funding required.
WIND HAZARDS			
CEMP	City-wide	Effective.	None.
The Massachusetts State Building Code	City-wide.	Effective for most situations except severe storms.	None.
Tree trimming program	City-wide.	Satisfactory.	Continue.
WINTER HAZARDS			
Snow Removal	City-wide.	Effective.	None.
BRUSH FIRE HAZARDS			
Burn Permit	City-wide.	Effective.	None.

Type of Existing Mitigation Measures	Area Covered	Effectiveness/ Enforcement	Improvements/ Changes Needed
Development Review	City-wide.	Effective.	None.
Public Education	City-wide	Effective.	None.
GEOLOGIC HAZARDS			
The Massachusetts State Building Code	City-wide.	Effective.	None.
CLIMATE ADAPTATION			
Beverly Coastal Resiliency Plan, June 2017	Coastal Areas of Beverly	Effective.	None.

6. Hazard Mitigation Strategy for 2018 – 2023

6 Hazard Mitigation Strategy for 2018 - 2023

The City of Beverly is committed to reducing future damage from natural disasters through mitigation. The mission of Beverly's Hazard Mitigation Program and this associated plan is to mitigate the effects of natural hazards by minimizing loss of life and property damage.

The hazard mitigation planning process conducted by the City of Beverly used a typical problem-solving methodology:

- Describe the problem (Hazard Identification).
- Estimate the impacts the problem could cause (Risk Assessment).
- Assess what safeguards exist that might already or could potentially lessen those impacts (Capability Assessment and Existing Measures).
- Using this information to determine what, if anything, can be done, and select those actions that are appropriate for the City (Mitigation Strategy).

During the 2018 plan update process, Beverly's planning team met on multiple occasions to discuss current natural hazard risks as well as the goals, objectives, strategies, and activities required to minimize those risks. This section of the hazard mitigation plan describes the most challenging part of any such planning effort – the development of a mitigation strategy. It is a process of:

- Setting mitigation goals,
- Considering mitigation alternatives,
- Identifying objectives and strategies, and
- Developing a mitigation action plan that addresses both the risk and vulnerabilities identified in Section 4.0 and any gaps in capabilities in Section 5.0.

6.1 Existing Authorities, Policies, Programs, and Resources for Mitigation

Relevant authorities, policies, programs, and resources available to support Beverly's hazard mitigation activities are outlined in Section 5.0 Capabilities and Existing Measures. Beverly has long-established, experienced program administrators and staff who can work with the Local Hazard Mitigation Planning Committee to advance not only the 2018 to 2023 mitigation strategies herein but can also further facilitate a holistic, integrated mitigation program to reduce risk exposure and increase resiliency of the region's population (described in Section 3.0 Community Profile).

6.2 Setting Mitigation Goals and Objectives

When a community decides that certain risks are unacceptable and that certain mitigation actions may be achievable, the development of *goals* and *actions* takes place. *Goals* are

long-term and general statements defining a desired outcome. Objectives are sub-goals with multiple objectives that ladder up to one goal. *Actions, or Strategies,* are detailed and specific methods to meet the goals and objectives.

The LHMPC reviewed the goals from the 2012 Beverly Hazard Mitigation Plan at a meeting on September 7, 2017. The planning team agreed to reaffirm the goal statements from 2012, but decided to make some revisions and additions to the objectives for each goal. Following that meeting, the planning consultant made the revisions to the goals and objectives. At a follow-up core group meeting on November 11, 2017, the Goals and Objectives were finalized and endorsed by the group. These changes were made to better consolidate and eliminate some overlap among strategies, and to help clarify their specific meaning. In some instances they were also expanded to cover possible new mitigation activities under consideration by the planning team. Additional consideration of climate change and sea level rise was also include in the revised objectives.

Goal A: Protect people and property by reducing damages to the existing built environment from the impacts of natural hazards.

Objectives:

VII. Ensure that critical infrastructure sites are protected from natural hazards;

VIII. Maintain existing mitigation infrastructure in good condition;

IX. Protect existing residential and business areas from flooding, by strengthening regulations for improvements and structures in Special Flood Hazard Areas;

X. Ensure that non-conforming uses going through a permit process incorporate mitigation best practices;

XI. Continue budgeting for and completing public works projects that reduce damages from natural hazards;

XII. When feasible, increase resilience along the shoreline to protect against current flood risk future conditions, including sea level rise.

Goal B: Protect future development from damages associated with natural hazards.

Objectives:

V. Continue to enforce existing zoning and building regulations when evaluating possible changes to address the risks of climate change and sea level rise;

VI. Encourage future development to be resilient and less prone to natural hazards;

VII. Make efficient use of public funds for hazard mitigation;

VIII. Ensure that the City remains resilient and able to respond to various natural hazard events.

Goal C: Educate the public and stakeholders on how to become more resilient to .natural hazards

Objectives:

V. Educate the public about zoning and building regulations, particularly with regard to changes in regulations that may affect tear-downs and new construction.

VI. Work with surrounding communities to ensure regional cooperation and solutions for hazards affecting multiple communities such as coastal erosion.

VII. Educate the public about natural hazards and mitigation measures.

VIII. Promote increased purchase of flood insurance.

6.3 Selecting and Prioritizing Mitigation Measures

The status of the mitigation measures from the previous 2005 and 2012 plans were updated through in-person meetings with local staff or via email or phone interviews. The actions from the 2012 plan formed the starting point for discussion about what mitigation measures are needed for the 2018 plan. Many 2012 measures were carried forward into the 2018-2023 plan cycle. In addition, a new range of measures were identified by the City.

Table 6.1 provides a summary of the recommended hazard mitigation activities developed by the planning team to achieve the above goals and objectives, and to assist in reducing impacts from natural hazards which may impact the City. These include those activities which the City, including offices cutting across multiple departments, may implement as part of their ongoing work programs and contingent on available resources and/or funding, if applicable.

Table 6.1 includes the following information for each recommended activity:

1. **Activity #:** Identifies the unique number for the activity.
2. **Goal/Strategy:** Ties the strategy to the corresponding goal(s) and objective(s) it is intended to help achieve. This helps to demonstrate how each activity contributes to the overall City mitigation strategy.
3. **Problem Statement and Activity Description:** Provides a problem statement describing the need for mitigation and a narrative description of the recommended mitigation activity. For activities that were carried over from the 2012 plan, the narrative also includes an update on the activity's current status in terms of implementation progress.
4. **Lead Agency:** Identifies the lead department and specific office assigned with primary responsibility for implementation of the activity.

5. **Estimated Cost (if applicable):** Provides a general estimate of the anticipated total costs required to complete the activity. In addition to dollar estimates, this may include "staff time" or "in-kind resources."
6. **Potential Funding Sources (if applicable):** Identifies potential funding sources to support implementation of the activity, including any known Federal, State or non-governmental sources.
7. **Timeframe for Completion:** Identifies the target timeline (duration) or specific completion date (month/year) for the activity. In some cases this may include the statement of "ongoing/continuous" for those actions already underway and/or to be continued as a sustained mitigation practice with no end date.
8. **Hazard(s) to be Addressed:** Identifies the specific natural hazard the recommended activity is designed to mitigate against. This may include a single, multiple, or all natural hazards identified in the plan.
9. **Priority Level:** Identifies the priority level (i.e., high, medium, low) assigned to the activity, based on the STAPLE-E evaluation and prioritization process described below.

The decisions on priorities were made at a meeting of the local committee. 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. The committee 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.

6.4 Assessment of Recommended Mitigation Activities

Each mitigation activity listed in Table 6.1 was evaluated and prioritized according to the "STAPLE-E" evaluation method (Social, Technical, Administrative, Political, Legal, Economic, and Environmental). The specific criteria used in the application of the STAPLE-E method are provided in Appendix D. In addition, the planning team considered the following factors in its general assessment of recommended mitigation activities:

- Feasibility of implementation (both on a state and local level); and
- Potential mitigation gains that could be achieved by the activity.

Following these ranking activities, an exercise was conducted, where the group was given a limited number of stickers to assign to a larger number or projects to narrow down priority level. The last Column in Table 6.1 reflects the results of the above.

Activity #	Goal/Strategy	Activity Description	Lead Agency	Support Agencies	Estimated Cost*	Potential Funding Sources	Timeframe for Completion	Hazard(s) to be Addressed										Priority Level
								Hurricanes/ TS	Tornado	Severe Weather /T-Storm	Winter Storm	Flood	Extreme Temps	Wildland Fire	Drought	Earthquake	Climate Change	
1	A-I A-II	**Problem Statement:** Repetitive flooding of Cummings Center ground floor at Buildings 100, 800 and 900 buildings. Minor flooding at Cabot/Herrick Street area. **Mitigation Strategy:** Installation of tide gate at the outlet of the culvert from Cummings Center "Lower Shoe Pond" at Bass River (Elliott St.). Installation of 36" drain pipe at building 900 and various backflow valves, seals and protective devices at exterior openings buildings 100, 800, 900.	DPS		$1.1 Million (including engineering, permitting and construction)	Sewer Enterprise Fund and FEMA HMA Grants	Dependent on FEMA approval of Change of scope					X					X	High
2	A-II	**Problem Statement:** Flooding lower Chubbs Brook drainage area at MBTA Rail/Beach Street impacting Beach Street sewer Pump Station. **Mitigation Strategy:** Construct Chubbs Brook improvements to speed up discharge, at the culvert under Route 127.	DPS		$200,000 culvert paid by MA Dot if Bev designs and permits	MA DOT	2021-2023					X					X	High
3	A-II	**Problem Statement**: Beverly's drainage system is aging and in need of improvements to prevent nuisance flooding and damage to infrastructure. **Mitigation Strategy:** Complete localized drainage improvements Citywide	DPS		$50,000 - $100,000 per year	Sewer Enterprise Fund	2018-2023 Annual		X			X					X	High
4	A-IV A-V A-VI BI-III	**Problem Statement:** Beverly has identified the acquisition of open space as a community goal when funding is available. That goal presents the opportunity for mitigation of damages from several natural hazards. **Mitigation Strategy:** Acquire undeveloped open space, prioritizing at risk property	Con. Comm.	Planning	TBD	Community Preservation Act Grants – MA Park and Land Grant	2018-2023					X		X			X	Medium
5	A-III B-I-II C-I	**Problem Statement:** With Sea Level Rise and increasing intensity rainfall events, along with increasing flood risks in general, the minimum NFIP elevation standards may soon be inadequate to protect new construction and substantial improvements. **Mitigation Strategy:** Evaluate and implement as appropriate freeboard in NFIP regulations to account for SLR	Planning	DPS	Staff Time	Staff Time	2018	X				X					X	Low
6	A-I-II	**Problem Statement:** At the Youth Center parcel at Bass River is a Storm Sewer Pump Station that pumps stormwater during an event from the gravity pipe with 4 pumps to a higher elevation. The gravity pipe is subject to tidal water inflow. **Mitigation Strategy:** Install a tide gate/flapper valve on existing 4' pipe near Youth Center at Bass River to address long term SLR.	DPS		$150,000	Capital Budget/FEMA Grants/MA CZM Coastal Resource Grants	2018-2019					X					X	Medium
7	A-1 A-V A-VI	**Problem Statement:** Concern that the Harbor Master Building could potentially flood from storm surge. Engineering study phase 100K**.** **Mitigation Strategy:** Engineering analysis potentially raise seawall elevation (Reference Beverly Coastal Resiliency Plan)	DPS		$100,000	Capital Budget Grant	2018	X				X						Medium
8	A-1 A-V A-VI	**Problem Statement:** Due to the poor condition of the Bay View Seawall, the Coast Guard Commander's House and road are at risk of flooding and erosion. **Mitigation Strategy:** Repair or rebuild the Bay View Seawall, to protect, coast guard commanders house and the road.	DPS	Planning	$900k rebuild or $74k repair	Capital Budget Grant / MA CZM Coastal Resource Grants	2019-2021	X		X	X	X					X	Medium

Activity #	Goal/Strategy	Activity Description	Lead Agency	Support Agencies	Estimated Cost*	Potential Funding Sources	Timeframe for Completion	Hazard(s) to be Addressed										Priority Level
								Hurricanes/ TS	Tornado	Severe Weather /T-Storm	Winter Storm	Flood	Extreme Temps	Wildland Fire	Drought	Earthquake	Climate Change	
9	A-I-III A-V-VI	**Problem Statement:** Due to the eroded western coastal bank, on the east side of Obear Park, the salt marsh is currently being compromised and may increase flooding. Also a safety issue due to erosion. **Mitigation Strategy 1:** Repair the eroded western coastal bank on the eastern side of Obear Park. **Mitigation Strategy 2:** Install large box culvert, currently built into scope of dredging project, to protect the salt marsh and alleviate coastal flooding.	DPS		$250,000	Capital Budget FEMA Grant	2018/2019	X		X	X	X					X	High
10	B-II-IV C-II-IV	**Problem Statement:** The current Beverly Master Plan does not adequately address natural hazards or the impacts of climate change and sea level rise. **Mitigation Strategy:** Master Plan Update: During the update of the Beverly Master Plan (2020) include a section on the impacts of climate change and sea level rise. Incorporate resilience and sustainability throughout the document	Planning		$200,000	Capital Budget	2019 - 2021	X	X	X	X	X	X	X	X	X	X	Medium
11	A-I A-II	**Problem Statement:** As identified in Chapter 4, Hazard ID and Risk Assessment, the more rural areas of Beverly are at risk to wildland fires. Climate change and increases in drought conditions will continue to exacerbate this condition. **Mitigation Strategy:** Purchase ½ mile of new 1.5 inch forestry hose, new 4x4, 350 gallon, 2-ton forestry truck and new hand held fire pumps	Fire / EM		TBD	Capital Budget / Forestry Grants	2019-2021							X			X	Medium
12	A-I A-IV B-III B-IV C-III	**Problem Statement**: As identified in the Hazard ID and Risk Assessment Beverly faces a risk of earthquake damages. With a high vulnerability but very low probability and return frequency, mitigation alternatives are a challenge. **Mitigation Strategy:** Use recently acquired Community Preservation Act funds to assess the earthquake vulnerability of all public buildings. Make recommendation on improvements to public buildings to make them more earthquake resistant (Golf and Tennis Facilities)	DPS	Inspectional Services	TBD	CPA Grant	2018-2020									X		Low
13	A-I A-IV B-III B-IV C-III	**Problem Statement:** Same as #12 **Mitigation Strategy:** When pursuing Community Preservation Act funds for preservation planning and City owned properties, incorporate earthquake considerations	Planning	Inspectional Services	TBD	CPA grants	2018-2023									X		Low
14	A-I A-II	**Problem Statement:** Several sewer Pump Stations are prone to flooding. They are also prone to power outages caused by nearly all natural disasters. Potentially could cause sewer overflow depending on number of failures. **Mitigation Strategy:** Use SLR projections for inland flooding aligned with 2030/2070 scenarios from the Coastal Resiliency Plan to inform relocation of pump stations, as necessary. Purchase generators for back-up power supply.	DPS		TBD	Capital Budget / FEMA Grants	2018-2023	X	X	X	X	X				X	X	Medium
15	A-1 A-2	**Problem Statement:** Pershing Ave seawall protects a pump station at Wenham Lake and is in need of repair. If the pump station is "down" the City Water Storage Tank off Brimbal Avenue would not replenished impacting potable water supply to residents and fire-fighting capability. **Mitigation Strategy:** Rebuild approximately 100 feet of seawall along Pershing Avenue to protect the pump station.	DPS		$150,000+	Capital Budget / FEMA Grants / MA CZM Coastal Resource Grants	2018-2023	X			X	X						Medium

Activity #	Goal/Strategy	Activity Description	Lead Agency	Support Agencies	Estimated Cost*	Potential Funding Sources	Timeframe for Completion	Hazard(s) to be Addressed										Priority Level
								Hurricanes/ TS	Tornado	Severe Weather /T-Storm	Winter Storm	Flood	Extreme Temps	Wildland Fire	Drought	Earthquake	Climate Change	
16	A-1 B-III B-IV	**Problem Statement:** Lightning strike and potential fire of building. **Mitigation Strategy:** Purchase and install Lightning Rods for Harbor Master House	DPS		$25,000+	TBD	2018-2023		X	X								Low
17	C-II C-III	**Problem Statement:** There are currently no controls in place or programs to encourage water conservation during periods of drought. Many homes have irrigation systems on timers that operate regardless of moisture conditions. **Mitigation Strategy:** Implement an educational /outreach program for the public on the use of humidity sensors on irrigation systems	Planning, DPS thru Water Dept.	Salem Sound Coastwatch	Staff time	Capital Budget	2019								X			Low
18	A-1 A-II	**Problem Statement**: Crane Pier is among the top five catch ports in Massachusetts and is vital to the local economy. It is considered critical infrastructure for the fishing industry. Install a new crane. Also note activity #7. **Mitigation Strategy:** Crane pier steel piles and concrete deck replacement.to provide viable local commercial fishing industry and additional protection to Harbor Master Building.	DPS		1.9M	Capital Budget Seaport Advisory	2019	X			X	X					X	Medium
19	A-1 A-II C-III	**Problem Statement:** Bass River, when properly opened, provides a safe harbor where the commercial fishing industry and recreational boaters can seek shelter from storms and protect their livelihood. Such safe harbor is vital to the local fishing economy. **Mitigation Strategy:** Dredge the Bass River to allow access by the commercial fishing industry as a safe harbor and educate commercial fishing industry.	DPS	Harbor Mgmt. Authority	$5.5 Million	USACE (if it can be defined as a federal channel) / MassWorks Grant with 50% Capital Match	2018-2023	X		X	X	X					X	Medium
20	A-II B-III B-IV	**Problem Statement:** A seawall and coastal structure inventory, maintained by MA CZM was updated 4-5 years ago with support of Beverly. There are still inaccuracies in ownership and conditions data. The City would benefit from further updating the inventory. **Mitigation Strategy:** Continue to improve and update seawall inventory in coordination with MA CZM. More accurate data will make it easier to prioritize mitigation actions.	DPS	Planning / GIS	Staff time	MA CZM	2018-2023	X			X	X					X	Low
21	A-II B-III B-IV	**Problem Statement:** A neighborhood adjacent to the Dane Street Beach Seawall and a roadway are at risk of flooding and erosion, due to storm events and Northeaster's. The Lothrop Street/Bay Street area is prone to flooding. **Mitigation Strategy: Complete** Dane Street Beach Seawall improvements and extension or some other alternative.	DPS		>$250,000	Capital Budget	2018-2023											Medium
22	A-I A-II	**Problem Statement:** Tree trimming equipment is 20+ years old and in distressed condition. **Mitigation Strategy**. Purchase new chipper and truck to protect city property and public safety and the property of others.	DPS	Fire	$100,000	TBD	2018-2023	X	X	X	X		X				X	Medium
23	A-III B-I B-II B-IV C-I C-IV	**Problem Statement:** The FEMA Limited to Moderate Wave Action (LiMWA) mapped area is inaccurate. A Conservation Commission Special Conditions Permit is required for any development in these areas and complications are encountered due to the mapping inaccuracies. This problem was not corrected by a previous Letter of Map Revision (LOMR).	DPS	Planning, Con Com	$50,000	Capital Budget / FEMA CTP	2018					X						High

Activity #	Goal/Strategy	Activity Description	Lead Agency	Support Agencies	Estimated Cost*	Potential Funding Sources	Timeframe for Completion	Hazard(s) to be Addressed										Priority Level
								Hurricanes/ TS	Tornado	Severe Weather /T-Storm	Winter Storm	Flood	Extreme Temps	Wildland Fire	Drought	Earthquake	Climate Change	
		Mitigation Strategy: Petition and work with FEMA Region I to correct LiMWA accuracy issues and obtain a FEMA sponsored Letter of Map Revision.																
24	B-III B-IV C-III	**Problem Statement:** As identified in Chapter 4, Hazard ID and Risk Assessment, the more rural areas of Beverly are at risk to wildland fires. Climate change and increases in drought conditions will continue to exacerbate this condition. **Mitigation Strategy:** Provide Firewise USA Communities info to homeowners – available at touch a truck, in library, other venues	Fire	Endicott College	Staff Time	Capital Budget and Volunteer Time	2018-2023							X			X	Low
25	A-II B-11 B-III B-IV	**Problem Statement:** As identified in Chapter 4, Hazard ID and Risk Assessment, the more rural areas of Beverly are at risk to wildland fires. Climate change and increases in drought conditions will continue to exacerbate this condition. Fuel Maintenance has not been conducted in many years. **Mitigation Strategy:** Develop a program to include both fuel maintenance on City owned high risk land and the maintenance of fire roads to allow access for fire suppression apparatus.	Fire Dept.		Staff Time	Capital Budget / Forestry Grants	2019 - 2023							X			X	Medium
26	A-II B-III B-IV C-III	**Problem Statement:** Current master fire alarm boxes are in poor or non-working condition in many locations and in need of technology upgrades **Mitigation Strategy:** Replace current master fire alarm boxes with radio master box alarms.	Fire Dept.		$100,000	Capital Budget	2019 – 2023							X				Medium
27	A-III B-I B-II B-III	**Problem Statement:** Preservation of open space in floodprone areas is needed to reduce future risk. The Open Space Residential Design (OSRD) standards provide an opportunity to preserve flood prone land. **Mitigation Strategy:** When reviewing project for Open Space Residential Design (OSRD) – Cluster development, consider land set aside for open space for land vulnerable to flooding	Planning		Staff Time	Staff Time	2018-2023					X					X	Medium
28	B-II	**Problem Statement:** Additional protection from flooding in the upper region of Chubbs Brook is needed. **Mitigation Strategy: Create a**dditional flood storage area off Hart Street. This task was in an early project; however, Mass DEP refused to permit. STAPLE/E risks were identified during ranking. The committee chose to leave in the update as a low priority project.	DPS	Mass DEP	100K	Grant	Unknown	X			X	X					X	Low
29	A-I A-II B-III B-IV	**Problem Statement:** Damage to sea wall at Lynch Park and erosion on land-ward side of Lynch Park sea wall and retaining wall to Woodbury Beach from March 2018 "Riley" Northeaster **Mitigation Strategy:** Repair seaward side of sea wall and fortify the land-ward of the sea wall and retaining wall and Increase elevation of sea wall	DPS		500K	Capital Budget State Dam/Seawall Grant	2019	X			X	X					X	High
30	A-I B-IV	**Problem Statement:** From the Coastal Resiliency Plan the South Essex Sewer District (SESD) Pump Station is at risk in a 2030 1% event. This pump station pumps all of sanitary sewer from Beverly and Danvers to the SESD plant in Salem.	DPS		250K	SESD and Beverly/Danvers Grant	2019	X			X	X					X	High

Activity #	Goal/Strategy	Activity Description	Lead Agency	Support Agencies	Estimated Cost*	Potential Funding Sources	Timeframe for Completion	Hazard(s) to be Addressed										Priority Level
								Hurricanes/ TS	Tornado	Severe Weather /T-Storm	Winter Storm	Flood	Extreme Temps	Wildland Fire	Drought	Earthquake	Climate Change	
		Mitigation Strategy: Engineering study to determine alternatives to fortify the SESD pump station for sea level rise and storm serge																
31	A-II B-III B-IV	**Problem Statement:** As a result of sea-level rise coinciding with astronomical high tides and medium to strong coastal storms, many streets and homes are now impacted by flooding on lower Marsh Ave, Foster Point, Lower Bailey Ave, Shore Ave, and Parkview. Specifically, these areas include: • The South/West corner of the City, along the Danvers River in the low areas from Fosters Point to Shore Ave; and • The Bass River, at Elliot Street, Lower Green Street (Across the River from the tide gate noted in Activity 1). **Mitigation Strategy:** Investigate the extent of the problem currently and project future impacts. Prepare appropriate mitigation measures, such as seawalls, where necessary, raising foundations of individual structures, raising road grades, hardening sewer pump stations (See Activity 14 and Critical Assets List), at Marsh Ave and Fosters Point, or other viable measures. Bank erosion should also be considered in the analysis	DPS		$25,000+ and Staff Time for Investigation	Capital Budget / FEMA and other Grants	2019-2023	X		X		X					X	High

6.5 Progress in Hazard Mitigation Activities from 2012–2017

Table 6.2, provides a summary of the progress and current status of those hazard mitigation activities included in the previous (2012) plan. This includes activities which have been carried over for implementation in 2018-2023, as noted in the table under "Current Status."

Table 6-2 includes the following information for each hazard mitigation activity:

1. **Hazard Area and Mitigation Measure:** Provides a narrative description of the mitigation activity from the 2012 plan and lists the hazard addressed.
2. **Implementing Agency:** Identifies the lead department assigned with primary responsibility for implementation of the activity.
3. **Current Status:** Describes the current implementation status of the activity, including whether the action was completed, completed/to be continued, partially completed/in progress, deferred, deleted, or deemed an ongoing/continuous activity.
4. **Current Status Description:** Provides a narrative description of the implementation status in 2018.
5. **Priority Level:** Identifies the priority level (i.e., high, medium, low) assigned to the activity, based on the prioritization process completed for the 2012 plan.
6. **Carry Over?:** Identifies whether the activity is to be carried over from the 2012 plan to the 2018 plan.

It is important to note that some previous activities, while they may be continued, have been moved to Chapter 5 (Capabilities Assessment and Existing Measures) because they are more appropriately considered ongoing program activities. These activities have been highlighted with light gray shading. Any previous activities which have been deleted since the 2012 plan are highlighted in dark gray shading.

Table 6-2 – Status of 2012 Mitigation Measures

Hazard Area	Mitigation Measure	Implementation Responsibility	2018 Measure Update (continued/cancelled/completed?)
High Priority			
A) Flooding	Chubb Brook	DPW	Completed
B) Flooding	Install a tide gate at the mouth of the Bass River.	DPW	Underway. See Table 6-1, Activity 1.
C) Storms/Multi-hazard	Purchase a new excavator and brush grapple. The PDM Team identified the need to clear brush and fallen tree limbs from streets and power quickly following high wind events as a top priority.	DPW	Completed - A Homeland Security Grant helped to fund a regional equipment purchase for the Northeast EM Region. Equipment is shared and deployed on an as needed basis.
D) Flooding	Identify resources to maintain City drainage infrastructure on an ongoing basis.	DPW	Completed on an annual basis. A new strategy was added to continue this activity with measurable parameter and an identified funding source. See Table 6-1, Activity 3.
E) NFIP Compliance	Floodplain Management - update flood management district regulations	Planning	Completed - Updated in 2014 to adopt new FIRM
F) NFIP Compliance	Maintain up to date maps of local FEMA identified floodplains.	Planning	Completed. New maps adopted in 2014. LOMR Complete in 2017. Removed
G) NFIP Compliance	Acquisition of Vacant Flood Prone Lands	Conservation Commission	Deferred - Re-written and included in update. See Table 6-1, Activity 4.
H) NFIP Compliance	Acquisition of Vacant Flood Prone Lands	Conservation Commission	Duplicate of Above. Removed.
I) Multi-hazard	Acquire a new, towable, multi-phase, diesel generator.	DPW	Removed. Not completed. Regional Risk Program purchased one for sharing on an as needed basis.
Medium Priority			

Hazard Area	Mitigation Measure	Implementation Responsibility	2018 Measure Update (continued/cancelled/completed?)
J) Flooding	Install a tide gate/flapper valve on existing four foot drain line on the Bass River near the 103 Elliot Street commercial condominiums.	DPW	Deferred - Re-written and included in update. See Table 6-1, Activity 6.
K) Storms	Replace approximately 6000- 8000 square feet of bottom-anchored floats at Beverly Harbor Center with concrete, pile-held floats	DPW	Completed. Removed from update.
L) Storms/Coastal Flooding	Repair the Bay View seawall.	DPW	Deferred. Re-written and included in update. See Table 6-1, Activity 8.
M) Storms	Repair the eroded western coastal bank at Obear Park.	DPW	Deferred. An eroded culvert was replaced but the overall project was not addressed. Re-written and included in update. See Table 6-1, Activity 9.
N) Storms/Coastal Flooding	Master Plan Update: Include a section on Climate Change and its potential impacts on Beverly in the next update of the Master Plan.	Planning	Removed. Master Plan has not been updated, but a Coastal Resilience Plan was completed in June of 2017 and will be incorporated by reference when the City Masterplan is updated.
O) Flooding	Purchase twelve, 2-inch submersible pumps for basement pump outs and other flood-related response efforts.	DPW/Fire Department	Completed. Removed from update.
P) Brush Fires	Purchase .5 miles of new 1.5-inch forestry hose; new 4x4, 350 gallon, 2-ton woods fire truck; new hand held fire pumps	Fire Department	Deferred. Re-written and included in update. See Table 6-1, Activity 11.
Q) Earthquakes	Assess the earthquake vulnerability of all public buildings. Investigate options to make all public buildings earthquake-resistant.	Fire Department	Deferred. Re-written and included in update. See Table 6-1, Activity 12.
Lower Priority			
R) Multi-hazard	Purchase 50 new handheld radios for Fire Department	Fire Department	Not Completed – Removed and replaced with new strategy.

Hazard Area	Mitigation Measure	Implementation Responsibility	2018 Measure Update (continued/cancelled/completed?)
S) Multi-hazard	Replace current master fire alarm boxes with radio master box alarms.	Fire Department	Not Completed – Carried over to new plan.

7. Plan Adoption and Maintenance

7 Plan Adoption and Maintenance

7.1 Plan Adoption

The Beverly Hazard Mitigation Plan was adopted by the City Council on December 17, 2018. See Page 1, for the Adoption Resolution documentation. The plan was approved by FEMA on November 27, 2018, pending adoption, for a five-year period that will expire on December 17, 2023.

7.2 Plan Maintenance

The Local Hazard Mitigation Planning Team (LHMPT) and the larger Stakeholder Group will continue to meet on a tri-annual basis to function as the Local Hazard Mitigation Implementation Group, with one City official designated as the coordinator. Additional members could be added to the local implementation group from businesses, non-profits, and institutions. At the tri-annual meeting the group will conduct the following activities:

1. Review the Mitigation Measures Action Tracker, included in Appendix E and add comments in the status column.
2. Record any new disaster or damage history data since the last plan in a format that can be easily used in the next plan update.
3. Maintain and update a running log of potential changes to the next plan update, including ideas for new strategies or measures.

7.3 Implementation Schedule

Bi-Annual Survey on Progress– The coordinator of the Hazard Mitigation Implementation Team will prepare and distribute a biannual survey in years two and four 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. The Hazard Mitigation Implementation Team will have primary responsibility for tracking progress and updating the plan. A public survey will be prepared and issued simultaneously to gather public input on changes in priorities and perceived hazards and to inform the public on progress.

Develop a Year Three Update – During the third year after plan adoption, the coordinator of the Hazard Mitigation Implementation Team will convene the team to begin to prepare for an update of the plan, which will be required by the end of year five in order to maintain approved plan status with FEMA. The team will use the information from the year four

biannual review and from the data produced at the tri-annual plan maintenance meetings to identify the needs and priorities for the plan update.

Prepare and Adopt an Updated Local Hazard Mitigation Plan – 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 the time required to secure a planning grant, potentially solicit for and contract with a planning support consultant, prepare an updated plan, and complete the approval and adoption of an updated plan, the local Hazard Mitigation Planning Team should begin the process by the end of Year 3. This will help the City avoid a lapse in its approved plan status and grant eligibility when the current plan expires.

At this point, the Hazard Mitigation Implementation Team may decide to undertake the update themselves or contract with outside help to update the plan. 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 Beverly Hazard Mitigation Plan will be forwarded to MEMA and DCR for review and to FEMA for approval.

7.3.1 Integration of the Plans with Other Planning Initiatives

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

- Fire / Emergency Management
- Police
- Public Works / Highway
- Engineering
- Planning and Community Development
- Conservation
- Parks and 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 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 comment.

Appendix A – Committee Meeting Materials and Outreach

LOCAL HAZARD MITIGATION PLANNING COMMITTEE

MEETING #1

2017 City of Beverly Hazard Mitigation Plan Update
Mitigation Planning Committee Meeting Number 1
Wednesday, January 17, 2017 – 2:00 – 3:30 PM
Beverly Public Library

Name	Organization / Address	Email	Telephone
Scott R. Choquette	Dewberry / 280 Summer St, Boston, MA 02210	schoquette@dewberry.com	617.531.0750
Roland Atkins	COB CDS Coordinator Project Manager	ratkins@beverlyma.gov	978-921-6000
Daniel McPherson	C.B Harbormaster	dmcpherson@beverlyma.gov	978 921-6059
Greg St. Louis	COB City Engineer	gstlouis@beverlyma.gov	978.605-2360
SAM CLEAVES	MAPC	scleaves@mapc.org	617-933-0748
AMY MAXNER	COB PLANNING DEPT.	AMAXNER @ BEVERLYMA.GOV	978-605-2345
Barbara Warren	Salem Sound Coastwatch MASS BAYS	barbara.warren@salemsound.org	978.741-7900
STEVE FREDERICKSON	COB- MUNICIPAL INSPECTIONS	SFREDERICKSON @BEVERLYMA.GOV	978 921 6025
DENNIS MONACO	ENDICOTT COLLEGE	dmonaco@endicott.edu	978-232-2357
AARON CLAUSEN	COB- PLANNING	aclausen@beverlyma.gov	605-2341

Name	Organization / Address	Email	Telephone
Sue Brown	Town of Manchester	brownsc@manchester.ma.us	978-525-6436
Mike Collins	C of B	mcollins@beverlyma.gov	978-605-2430
Kevin Haruturian	C of B Chief of Staff	kharuturian@beverlyma.gov	978-605-2333

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CITY OF BEVERLY 2017 LHMP UPDATE - MEETING AGENDA

Date: January 18, 2017

Time: 2:00 – 3:30

Location: Beverly Public Library, Barnett Room

Purpose: LHMPC Milestone Meeting #1

Attendees: Local Hazard Mitigation Planning Team, Dewberry Consultants

Agenda

1. **Introductions**

2. **Overview of Hazard Mitigation Planning**
   Benefits of having a hazard mitigation plan
   Requirements for updating the hazard mitigation plan
   Questions / Answers

3. **Planning process / Public Outreach**

   Confirm Public Outreach / Engagement Process
   a. Issue online survey for public input
   b. Release select portions of plan (DRAFT HIRA update and Mitigation Strategy Progress) for public review and comment (will be posted on web site)
   c. Release complete Public Review Draft
   d. Board of Supervisors Adoption
   e. Submittal to MEMA / FEMA
   f. Discuss public meeting

4. **Hazard Prioritization**

   a. New events?
   b. Disaster declarations?
   c. Significant damages?
   d. Additional hazards of concern?

   Complete prioritization exercise facilitated by Dewberry

5. **Asset Inventory**
   Collect available and most current GIS data for:

a. Improved Property
b. Emergency Facilities
c. Critical Infrastructure and Utilities
d. Other Essential Facilities

Review current critical facilities list.

6. **Mitigation Strategy**
   Review Sections VI-VIII Mitigation Action Plan and report on progress since 2012

7. **Next Steps / Questions**

   a. Support the public outreach efforts by disseminating the survey (Dewberry will provide outreach guidance)

   b. Review 2012 LHMP for out of date information and provide input to Scott Choquette at schoquette@dewberry.com or 617.531.0750

   c. Others as identified

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CITY OF BEVERLY 2017 HAZARD MITIGATION PLAN UPDATE - LOCAL HAZARD MITIGATOIN PLANNING COMMITTEE MILESTONE MEETING #1

Date:	January 18, 2017
Time:	2:00 – 3:30, PM
Location:	Beverly Public Library, Barnett Room
Purpose:	LHMPC Milestone Meeting #1
Represented:	Beverly: GIS, Engineering & PW, Harbormaster, Planning, Inspections, Mayor's Office. Others: Town of Manchester, Endicott College, Metro Area Planning Council, Dewberry Engineers. (See Sign-In Sheet)

1. Introductions

- Since the LHMPC has expanded since the 2012 Update, to include a broader range of stakeholders, the meeting started with introductions. Beverly is simultaneously working to create its first Coastal Resiliency Plan. Many Committee members overlap with the committed focused on that effort.

2. Overview of Hazard Mitigation Planning

- Following introductions, Roland Adams, gave a brief presentation on the history of mitigation planning in Beverly, noting that it has evolved, since the original plan in 2005, from being narrowly focused on a few flooding issues, to being a much more comprehensive look at hazards overall. Mr. Adams also discussed the funding sources and interrelations with State and Federal partners.

- Scott Choquette, of Dewberry Engineers, the consultant for the project gave an overview presentation of roles and responsibilities of the LHMPC, benefits of having a plan, requirements for updating the plan and the general timeline.

3. Planning process / Public Outreach

- A discussion of the public and stakeholder engagement approaches was held. Consensus was reached that the following vehicles would be used:
  - An online public survey
  - Public postings of completed sections of the plan to the Beverly website for review and comment
  - Piggybacking of some public engagement workshops for the CR Plan process – including a booth at an upcoming public event

- Exacerbation of Hazard due to climate change will be addressed in all appropriate hazards
- Sea Level Rise will be included in the flooding analysis.
- Integration of the findings of the CR plan will also be a part of the flooding section of the HIRA.

6. **Asset Inventory**
   - An extensive list of critical facilities, infrastructure and assets from the 2012 plan was discussed. The list is also being evaluated by the CR planning team. A decision was made that Roland Adams would review the list internally with team member from City Government and provide an updated list for review. That action item is complete as of the writing of these minutes.

7. **Mitigation Strategy**
   - Choquette asked the group to Review Sections VI-VIII Mitigation Action Plan and report on progress since 2012
   - A formal data call needed to complete the capability assessment will be sent to members shortly

8. **Next Steps / Schedule / Questions**
   - The meeting concluded approximately 15 minutes late, with a quick overview of schedule and next steps.

City of Beverly, MA
Local Hazard Mitigation Plan Update

Hazard Mitigation Planning Team
Meeting #1
January 18, 2017

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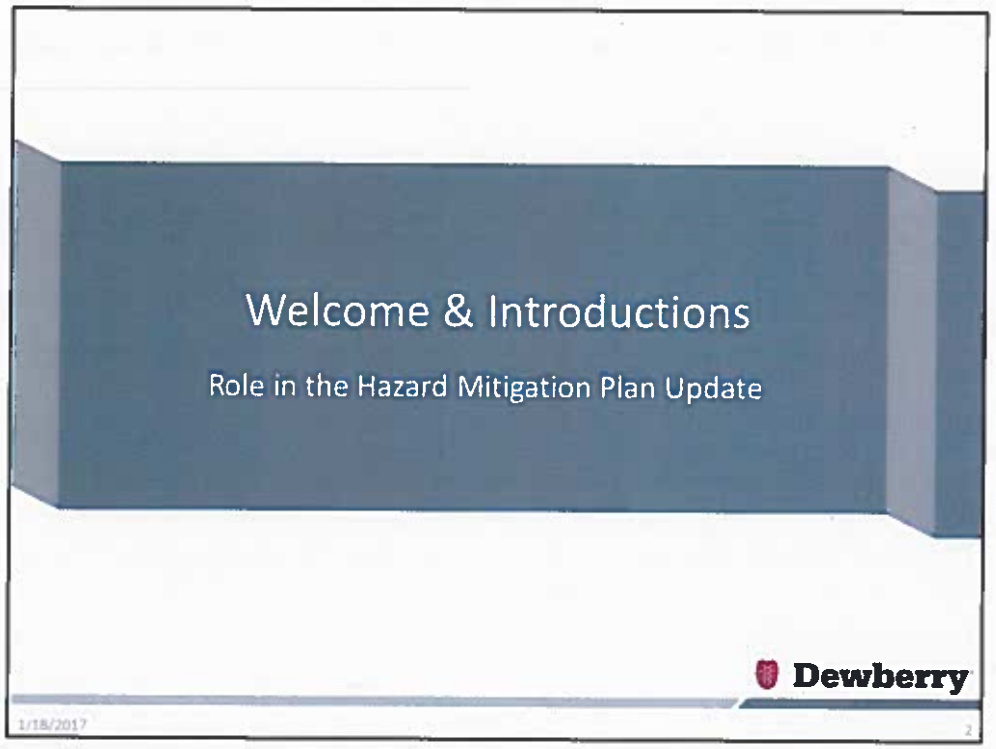

SDOEM to open meeting

It's Your Plan!

- ***We are here to:***
  - ✓ Facilitate the process
  - ✓ Lend technical expertise & consultation
  - ✓ Do the heavy lifting
- ***You need to:***
  - ✓ Participate and contribute hazard information
  - ✓ Make the final decisions
  - ✓ Ensure a feasible plan that meets your needs

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Meeting Agenda

- LHMP Update Requirements
  - Planning Process / Public Outreach
  - Hazard Prioritization
    - Asset Inventory
  - Mitigation Strategy
- Next Steps / Questions

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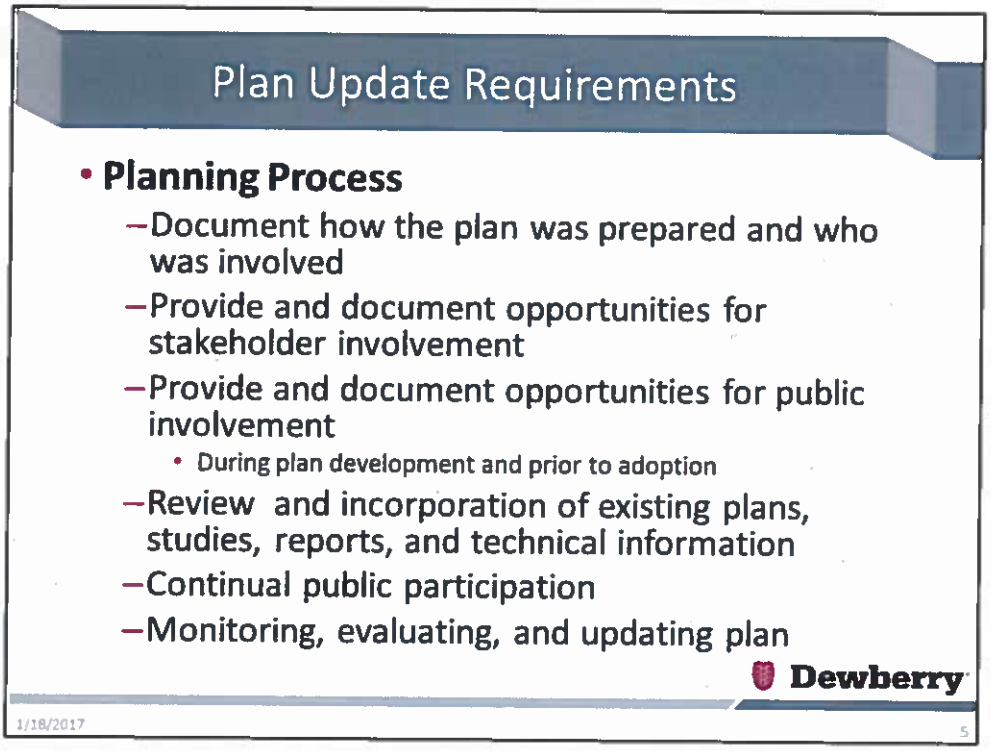
FEMA has specific things they look for in approving updated plans. We want to make sure you understand those, so you understand why we ask for the data and participation that we ask for throughout the process.



Stakeholder involvement is you, the Hazard Mitigation Planning Council

We are required to have at least two opportunities for public involvement. At least one opportunity during plan development and one opportunity just before the plan is adopted. We are beginning the public engagement efforts today with a public meeting scheduled for this evening. We have also set up an online survey to collect public input. You can help by spreading the word about the survey to your colleagues and agencies, non-profits, associations that you or your organization work with on a regular basis. If you have a website, Facebook, and/or Twitter accounts we'll give you guidance as to how you can promote the online survey to help us reach as many members of the public as possible.

Plan Update Requirements

- **Hazard Identification and Risk Assessment**
  - Description of all hazards that affect the planning area & rationale for omitting recognized hazards from analysis
  - Hazard Profiles
    - Location
    - Extent
    - Previous occurrences
    - Probability of future events
  - Vulnerability Assessment
    - Summary of the City's vulnerability to each hazard
    - Summary of potential impacts of each hazard
    - Summary of repetitive loss properties

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Plan Update Requirements

- **Capability Assessment**
  - Review of existing authorities, policies, programs and resources available to accomplish hazard mitigation
- **Mitigation Strategy**
  - Progress of previous mitigation actions
  - Description of participation in the NFIP
  - Mitigation Goals
  - Identification & Prioritization of new/updated Mitigation Actions
  - Action Plan
  - Integration with planning mechanisms
- **Adoption**

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Planning Process / Public Outreach

- **Proposed Public Engagement**
  - Online Survey
  - Public Review of Draft Portions
  - City Council Study Session
  - Public Review of Complete Plan Update
  - City Council Adoption

What methods work best in Beverly for engaging the public & soliciting their input?

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These are recommended / potential options for engaging the public. What will work best in this County? What are your preferred methods for engaging the public and soliciting input?

Hazard Mitigation Plan Update Process

- Data Collection & 2012Plan Evaluation
- Update Plan
  - Hazard Identification & Risk Assessment
  - Mitigation Goals, Strategies, and Projects (progress, revisions and additions)
  - Capability Assessment
  - Plan Implementation & Maintenance
- Draft Plan Submittal and Review
- Plan Adoption
- Plan Submission to MEMA & FEMA

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2017 HMP – Discussion with group

- What can be improved?
- HIRA to inform mitigation projects/activities
- Does your department/organizations have new data sources or information that have been created or changed since the 2012 plan revision?
- What types of data would you like to see in the revision?

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Hazard Identification & Risk Assessment

- **Purpose:** Provides a factual basis for prioritizing hazard mitigation activities

- **Major components:**
  - Identify and profile natural hazards affecting the City
  - Describe vulnerability to critical facilities and estimate losses
  - Vulnerability in terms of current and future land use and development

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Historical Disaster Databases

- List of Federally Declared Disasters from FEMA
  - Nature of disaster
  - Type(s) of assistance provided
- NWS / National Climatic Data Center (NCDC) Storm Events Database
  - Area Impacted
  - Damages
  - Description of event

- ***Other Data Sources??***

Hazard Identification

Hazard Selected in 2012 Plan

Hazard	Frequency	Severity
Flooding	High	Serious
Winter storms	High	Serious
Hurricanes	Medium	Serious
Earthquakes	Low	Extensive
Tornadoes	Low	Serious
Landslides	Low	Minor
Brush fires	Medium	Minor
Dam failures	Low	Serious

New events? Disaster declarations?
Significant damages from past events?
Additional hazards of concern?
Climate change exacerbations?

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Hazard Prioritization

switch to Excel tool

See Hazard Ranking Legend Attachment

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1/19/2017

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Sample Results of Hazard Prioritization

Hazard Type	Probability	Impact			Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts	
Flood	4	3	4	4	Significant
Hurricane and Tropical Storm	3	4	4	4	Moderate
Extreme Heat	4	4	1	3	Moderate
Windstorm	4	3	2	2	Moderate
Storm Surge	2	4	3	3	Moderate
Coastal Erosion	3	4	1	1	Moderate
Lightning	4	1	2	1	Limited
Tornado	2	1	4	2	Limited
Wave Action	2	4	1	1	Limited
Hailstorm	2	2	1	1	Limited
Wildfire	2	1	1	1	Limited
Infectious Disease	1	3	1	1	Limited
Sea Level Rise	1	1	1	1	Limited
Earthquake	1	3	1	3	Limited

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Asset Inventory

- **Critical Facilities/Infrastructure/Asset Inventory subsection**
  - Additional facilities to include?
- **Collect available and most current GIS data for:**
  - Improved Property
  - Emergency Facilities
  - Critical Infrastructure and Utilities
  - Other Essential Facilities

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Note alignment with Silver Jackets goals

Areas of Concern from 2012 Plan

HAVE THESE CHANGED?

- **Flooding**
  - North Beverly Brook: mostly completed as of 2010: flooding
  - Lawrence Street Brook: some work completed since 2005: flooding
  - Chubb Creek: flooding
  - Water Street: coastal flooding
  - Millbrook Road: flooding
  - Bayview Seawall: coastal flooding/storms
  - Tide gate at head of Bass River: coastal flooding/storms
  - Tide Gate at Bass River: coastal flooding /storms
- **Fire**
  - Land near Endicott College
  - Sally Mulligan Park area
  - Branch Lane area
  - Greenwood Avenue area

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HIRA Approach and Data Needs

Hazard	Data/Analysis 2010	Needs from City
Flooding	Hazus RL properties SFHL intersections with Critical Infrastructure Estimated damages using approximations for "flood areas"	RL Data (data in plan is from 2005) Local Flood "hot spots" Possible interest in CRS?
Winter storms	Ave annual snowfall intersections with Critical Infrastructure	Have there been significant winter events that should be added? Dates?
Hurricanes	Hurricane track data up to 2000 Storm Surge intersections with Critical Infrastructure Hazus completed	Storm surge data
Earthquakes	Hazus completed	
Tornadoes		Should this be a separate hazard or included in wind? The current plan lists as a hazard but does not have a profile for the hazard.
Landslides	Landslide intersections with Critical Infrastructure	
Brush fires/Wildfire	Beverly Fire Department stats	Data from Fire Dept. # calls, # fires, types/causes, acres burned
Dam failures	4 dams in city	

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HIRA → Informs → Mitigation Strategies

Reduce societal, economic, and environmental exposure to natural hazard impacts

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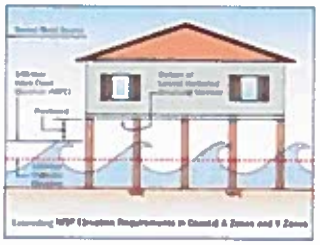
Mitigation Strategy

- **Refer to Sections VI-VIII – Mitigation Action Plan**
  - Completed, Deferred, Ongoing, In Progress, Delete
  - Status report for each action is required
  - FEMA funded projects since last update



FEMA Definition of Hazard Mitigation:
"Any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards."

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Schedule

Refer to Schedule Handout

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Next Steps / Questions

- Support the public outreach efforts
- Review 2012 LHMP for out of date info

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Hazard Mitigation Plan

Local Planning Committee

January 9, 2017

Core Team-From Coastal Resiliency Team

Aaron Clausen	Director Planning	aclausen@beverlyma.gov
Greg St. Louis	City Engineer	gstlouis@beverlyma.gov
Amy Maxner	Conservation Agent	amaxner@beverlyma.gov
Roland Adams	GIS Coordinator	radams@beverlyma.gov

Core Team-Additions HMP

Mike Collins	Commissioner Public Services & Engineering	mcollins@beverlyma.gov
Mark Foster	Director Emergency Management	mfoster@beverlyma.gov
Paul Cotter	Fire Chief	pcotter@beverlyma.gov
John LeLacheur	Police Chief	beverlychief@beverlyma.gov
Daniel McPherson	Harbor Master	dmcpherson@beverlyma.gov
Steve Frederickson	Director/Building Commissioner	sfrederickdon@beverlyma.gov
Darlene Wynne	Assistant Planning Director-Planning Board	dwynne@beverlyma.gov
Kevin Harutunian	Chief of Staff-Mayor's Office	kharutunian@beverlyma.gov
To ne Determined	Beverly Airport	

Advisory Team-Extended

David Gardner	Resident-Coastal Resiliency Team (CRT)	adfg@comcast.net
Barbara Warren	Salem Sound Coastwatch-(CRT)	barbara.warren@salemsound.org
Rachel Lewis	Student at Endicott College-(CRT)	tlewi342@endicott.edu
Chris Tripler	Endicott College-(CRT)	ctripler@endicott.edu
Man Butler	Endicott College-(CRT)	mbutler@endicott.edu
Nancy Schalch	Beverly High School-Teacher-(CRT)	nschalch@beverlyschools.org
Steve Drohosky	VP General Manager Cummings	sjd@cummings.com
John Somes	Executive Director Greater Beverly Chamber of Commerce	jsomes@greaterbeverlychamber.com
Dennis Monaco	Endicott College-Director of Physical Plant	dmonaco@endicott.edu
Martin Pillsbury	MAPC	mpillsbury@mapc.org
Neighboring Communities-Salem-Initial contact-Tom Daniel		tdaniel@salem.com
Neighboring Communities-Danvers-Initial contact-Karen Nelson		'knelson@danversma.gov'
Neighboring Communities-Wenham-Initial contact-Margaret Hoffman		MHoffman@wenhamma.gov
Neighboring Communities-Manchester--Sue Brown		Sue Brown <browns@manchester.ma.us>

ONLINE HMP UPDATE PAGE FOR PUBLIC COMMENT SOLICITATION

your input is needed!

The City of Beverly hired Dewberry Engineers, Inc. to facilitate the Hazard Mitigation Plan update process. Dewberry's kickoff presentation outlines the plan/ scope of the project. *Click here for the PowerPoint*. Dewberry's PowerPoint presentation outlines the basis for prioritizing Hazard Identification and Hazard Prioritization, the first step in developing the plan.

The Committee is now asking for the Public's input to discuss and define the Hazard Prioritization and Hazard Ranking Worksheet that is in progress based on the information/guidelines as developed by the Committee at the January 18, 2017 meeting. *Click here for the Hazard Ranking Worksheet.*

The Committee discussed hazards and then ranked each hazard. The ranking included evaluating each hazard for:

- Probability
- Area at risk/ percent damage
- Primary impacts
- Secondary impacts

An algorithm used produced a score for each hazard on the weighted parameters. The score was then assigned to a corresponding range including:

- Significant
- Moderate
- Limited

A meeting has been planned for February 14, 2017 at Beverly City Hall. The meeting will feature a brief overview of the materials outlined above, followed by an open discussion. Please come to participate and be part of the discussion. We appreciate all feedback on this important project.

City of Beverly

Hazard Mitigation Plan Up-Date

The City of Beverly has received a FEMA Grant to up-date the City's 2012 Hazard Mitigation Plan adopted February 6, 2012

Mitigation plans form the foundation for a community's long-term strategy to reduce disaster losses and break the cycle of disaster damage, reconstruction, and repeated damage. The planning process is important as it creates a framework for risk-based decision making to reduce damages to lives, property, and the economy from future disasters

Mitigation plans identify the natural hazards that impact communities, identify actions to reduce losses from those hazards, and establish a coordinated process to implement the plan. All natural hazards are considered, coastal storms, hurricanes, storm surge, flooding, wildfire, earthquakes to name a few. The plan has four stages the planning process, assessing risks, developing a mitigation strategy and plan adoption, monitoring and evaluation.

STAKEHOLDER PRESENTATION TO BEVERLY COASTAL RESILIENCE PLANNING COMMITTEE

Date 02/07/2017

Topic BERT Meeting # 3

Meeting Objectives See agenda

Sign In Sheet

Attendees

Notes

Attendee Name	Company / Organization	E-mail
Katie Moniz	BSC Group	kmoniz@bscgroup.com
Jeffrey Malloy	BSC Group	jmalloy@bscgroup.com
David Suminsky	Beverly Harbor Management	jdavidsuminsky@yahoo
Scott Choquette	Dewberry Eng. Inc	schoquette@dewberry.com
AARON CLARKEN	CITY OF BEVERLY	aclarksen@beverlyma.gov
DAVID GARDNER	OPEN SPACE Comm. Bev.	ADFG@comcast.net
Robert Buckbaum	Bev Conscomm / Mass Audubon	rbuckbaum@massaudubon.org
Emily Flaherty	Salem Sound Coastwatch	emilyflaherty@salemsound.org
Nancy Schalch	Beverly High School	nschalch@beverlyschools.org
Amy MAXNER	CITY of BEVERLY	AMAXNER@BEVERLYMA.GOV
Greg St. Louis	CDB Eng.	gstlouis@beverlyma.gov
Richard Adams	CDB GIS Coordinator	radams@beverlyma.gov
Mark Foster	EMD	on file

Action Items

City of Beverly, MA
Local Hazard Mitigation Plan Update

Stakeholder Presentation to CR Plan Advisory Committee
Expanded Stakeholder Meeting #1

February 7, 2017

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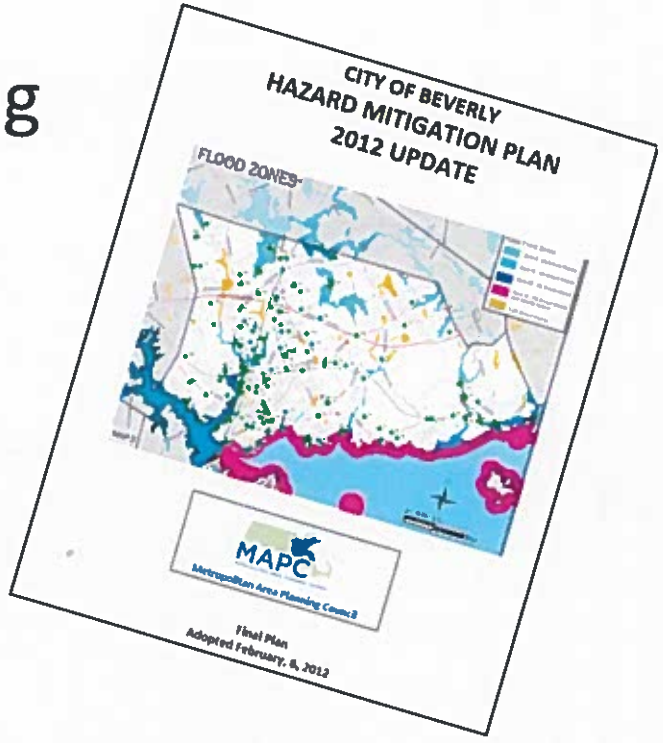
Mitigation Plan Update Requirements

- **LHMP Update Requirements**
  - Planning Process / Public Outreach
  - Hazard Prioritization / Profiling
    - Asset Inventory
  - Risk and Vulnerability Assessment
  - Mitigation Strategy
  - Maintenance, Monitoring, Evaluation



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Plan Update Requirements

- **Planning Process**
  - Document how the plan was prepared and who was involved
  - Provide and document opportunities for stakeholder involvement
  - Provide and document opportunities for public involvement
    - During plan development and prior to adoption
  - Review and incorporation of existing plans, studies, reports, and technical information
  - Continual public participation
  - Monitoring, evaluating, and updating plan

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Plan Update Requirements

- **Hazard Identification and Risk Assessment**
  - Description of all hazards that affect the planning area & rationale for omitting recognized hazards from analysis
  - Hazard Profiles
    - Location
    - Extent
    - Previous occurrences
    - Probability of future events
  - Vulnerability Assessment
    - Summary of the City's vulnerability to each hazard
    - Summary of potential impacts of each hazard
    - Summary of repetitive loss properties

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Hazard Selection and Ranking Complete

Hazard Type	Probability	Impact			Survey Rating	Total Score	Hazard Planning Consideration	
		Affected Area	Primary Impact	Secondary Impacts				
Flood (Riverine, Drainage, Coastal Surge, Sea Level Rise - includes flooding from Noreasters)	3	2	3	4		37.20	Significant	Current Plan, SLR added
Winter Storms (Snow, Ice, Wind, including Noreasters and Extreme Cold)	4	4	1	3		39.20	Significant	Current Plan, Extreme Cold added
Hurricanes	2	4	3	3		26.00	Moderate	Current Plan
Earthquakes	1	2	4	4		14.00	Limited	Current Plan
Tornadoes	2	1	4	2		20.40	Limited	Current Plan
Landslides	1	1	2	1		5.60	Limited	Removed
Drought (incl: wildfire and extreme heat)	2	3	1	1		12.00	Limited	New
Dam Failures	1	1	2	1		5.60	Limited	Removed
Extreme Heat and Cold (will be included in Winter Storm and Drought Sections)	3	1	4	1		26.40	Moderate	New
Invasive Pests	3	3	2	1		22.80	Limited	New
Cyber Threat - Evaluated and dismissed as not consistent with scope of this plan						0.00	Limited	Considered
Thunderstorm, Lightening, and Hail	4	2	1	1		20.00	Limited	New

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Plan Update Requirements

- **Capability Assessment**
  - Review of existing authorities, policies, programs and resources available to accomplish hazard mitigation
- **Mitigation Strategy**
  - Progress of previous mitigation actions
  - Description of participation in the NFIP
  - Mitigation Goals
  - Identification & Prioritization of new/updated Mitigation Actions
  - Action Plan
  - Integration with planning mechanisms
- **Adoption**

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Schedule

Refer to Schedule Handout

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Next Steps / Questions

Scott Choquette
schoquette@dewberry.com
617.531.0750

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ANNUAL "TOUCH A TRUCK" EVENT HAZARD MITIGATION PLAN UPDATE DISPLAY

zard Mitigation Plan Update 2017

TOUCH A TRUCK EVENT 2017

SUNDAY MAY 21, 2017 10 AM – 1 PM

BEVERLY HIGH SCHOOL • 100 SOHIER RD

The Touch-A-Truck Event is an annual event held in Beverly during National Public Works Week. We bring our equipment for display, picture taking and the opportunity for children to see and explore the vehicles. An example of some of the equipment we plan to bring to the event are backhoes, loaders, dump trucks and mowers. It is a Citywide event for people of all ages sponsored by the Department of Public Services. We communicate this event by sending notices/flyers to the PTO, YMCA, Library and Schools. In addition, we advertise on the City website, the Recreation Department website and the local TV access channel (BevCam).

Local Police, Fire and Emergency Medical teams plan to attend as well. Tables will be set up at the event for water conservation, recycling, waste oil collection notices and other services that the City offers the residents of Beverly. Food vendors will also join us for this day of fun and exploration.

We are asking individual contractors if you would like to participate, as we are sure you would make a great addition to this years event . Please contact me by May 15, 2017 if you'd like to be a part of the festivities so that we can update our list. If you have any questions please don't hesitate to contact us.

Thank you for your time and consideration,

Fran Sordillo
City of Beverly
978-726-8749 cell
978-921-6057 office
fsordillo@beverlyma.gov

Building Beverly Since 1914

TOUCH A TRUCK EVENT 2017

SUNDAY
MAY 21
10 AM – 1 PM
BEVERLY HIGH SCHOOL
100 SOHIER RD

Brought to you by the City of Beverly, Department of Public Services

The annual Touch-A-Truck Event is a unique, interactive, one-day event held in Beverly during National Public Works Week. This event allows children to see, touch & explore their favorite big trucks & vehicles as well as meet the personnel who protect, serve & build the Beverly community.

Building Beverly Since 1914

TOUCH A TRUCK EVENT 2017

SUNDAY MAY 21, 2017 10 AM – 1 PM

BEVERLY HIGH SCHOOL • 100 SOHIER RD

Greetings,

The annual Touch-A-Truck Event is fast approaching!

Included in this event are informational tables available for use by all City Departments. We are reaching out to you at this time for any information your department would like to distribute to the public.

This is a great opportunity to communicate your upcoming Spring/Summer events to the residents of Beverly.

Please forward any information you would like to have added to the tables at the Touch-A-Truck Event by May 19, 2017.

If you have any suggestions and/or questions, please don't hesitate to contact us @ 978-921-6057.

Thank you

The Touch-A-Truck Event Committee

Building Beverly Since 1914

ONLINE PUBLIC SURVEY

(SEE APPENDIX B)

BEVERLY LOCAL HAZARD MITIGATION COMMITTEE MEETING #2

HMGP Meeting
June 7

Name	
Blanca Stevens	COB
Amy MAXNER	COB
DAVID GARDNER	COB
BARBARA WARREN	SSCW
Gregory St. Louis	COB
Mat Fisher	COB
AARON CLAUSEN	COB - PLANNING

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CITY OF BEVERLY 2017 LHMP UPDATE - MEETING AGENDA

Date: June 7, 2017

Time: 5:00 – 6:30 PM

Location: Beverly Public Library, Barnett Room

Purpose: LHMPC Milestone Meeting #2

Attendees: Local Hazard Mitigation Planning Team, Dewberry Consultants

Agenda

1. **Introductions**

2. **Overview of Hazard Mitigation Planning Schedule, Requirements, and Progress**

   Questions / Answers

3. **Presentation of Draft Hazard ID, Risk and Vulnerability Assessment**

4. **Review of Previous Mitigation Actions**
   Review Sections VI-VIII Mitigation Action Plan and report on progress since 2012

5. **Distribute Mitigation Actions Update/Ideas Assignment**

6. **Next Steps**

   Questions / Answers

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City of Beverly
Hazard Mitigation Plan Update

Hazard Identification and Risk Assessment Results
Local Mitigation Planning Committee Meeting #2

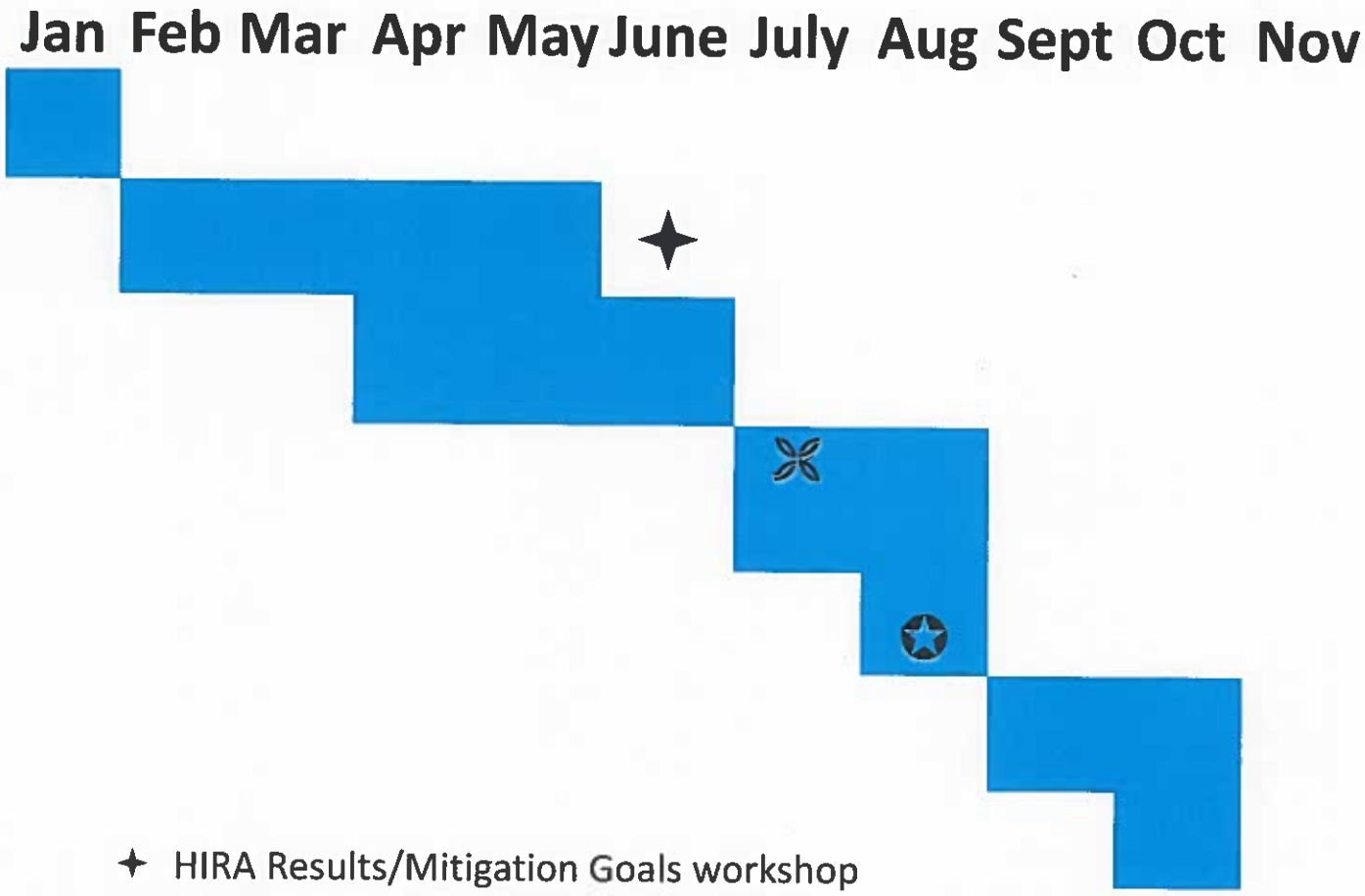
June 7th, 2017

Beverly Public Library

Agenda

1. Welcome & Introductions
2. Project Schedule
3. Risk Assessment Overview
4. Mitigation Strategy
5. Next Steps: Schedule and Plan Update Process

Project Schedule (2017)



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Hazard Identification and Risk Assessment

Purpose:

To provide a factual basis for prioritizing hazard mitigation activities

Major Components

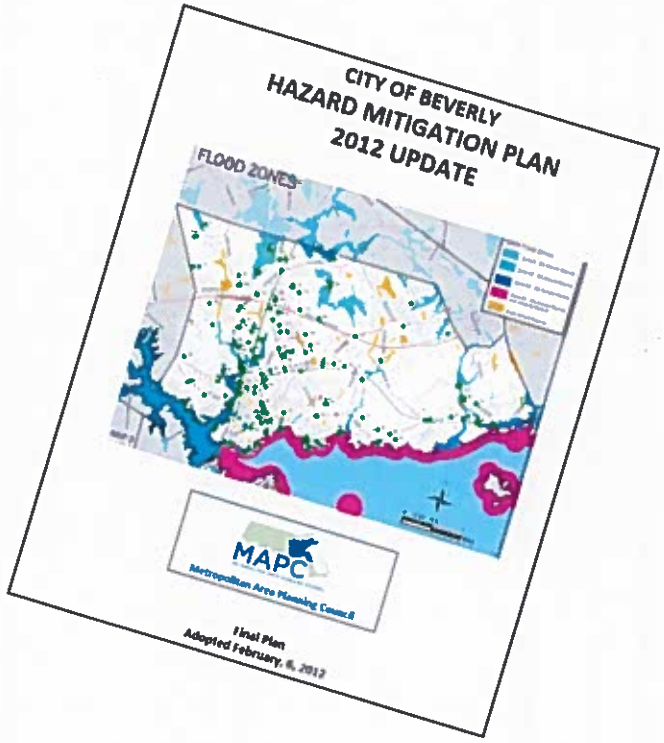
- Identify and profile hazards affecting the city
- Describe vulnerability to critical facilities and estimate losses of general building stock
- Describe vulnerability in terms of current and future land use and development

Plan Update Requirements

- **Hazard Identification and Risk Assessment**
  - Description of all hazards that affect the planning area & rationale for omitting recognized hazards from analysis
    - Background
    - Location/Extent
    - Previous occurrences
    - Probability of future events
  - Vulnerability Assessment
    - Hazard Ranking
    - Summary of potential impacts of each hazard to people and property

2017 Plan Update Changes

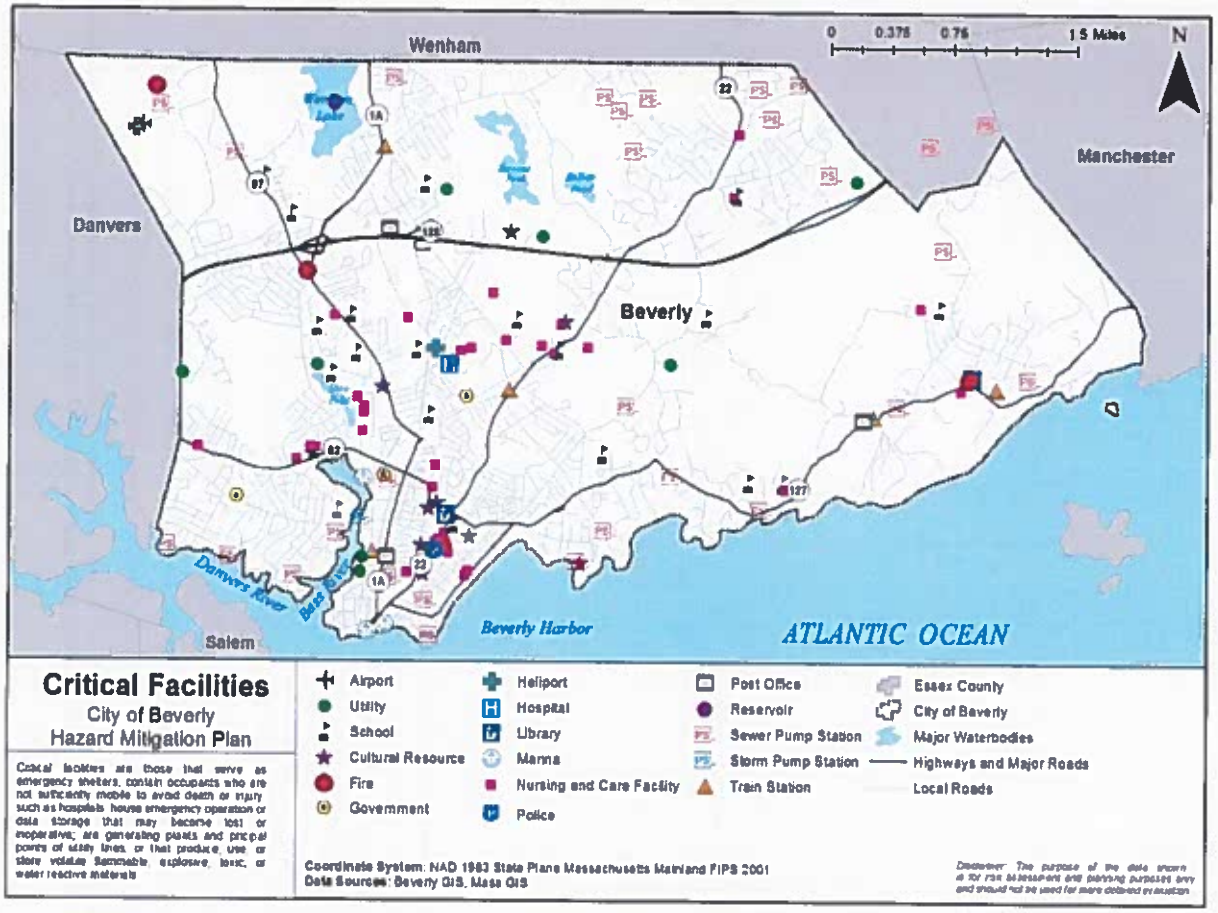
- Standardizing hazard ranking
- New Hazards:
  - Severe Weather (thunderstorms)
  - Extreme Temperatures
  - Invasive Pests
- New analyses including:
  - Refreshing hazard profiles
  - Inclusion of updated NOAA NCEI storm events data
  - Updating the previous occurrences
  - Updating the assessment of risk based on new data:
    - Hazus-MH analysis for flood and hurricane
    - Assessing risk based on an updated critical facility listing
  - Hazard ranking included at end of each hazard section
- New maps based on updated data
- Addition of a HIRA summary that includes overall relative risk and critical facility risk comparison by hazard.



Background, Exposure and Hazard Data

Critical Facilities

- Provided by City GIS Department



Facility Type	Number of Facilities
Adult Day Care	2
Assisted Living	4
Bridge	3
Cell Tower	3
Children Residence	3
Church	15
College	2
Cultural Resource	9
Dam	1
Day Care	20
Government	12
Hazmat	13
Heliport	2
Landing Strips	1
Library	2
Marina	4
Mortuary	1
Nursing Home	3
Pharmacies	6
Reservoir	1
School	18
Sewer Pump Station	29
Storm Pump Station	1
Supermarket	4
Train Station	5
Utility	6
Total:	170

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Building Footprints and Tax Parcels

Neighborhood	Total Assessed Building Value*	Total Building Count
Beverly Farms	$302,182,100.00	766
Centerville	$382,768,800.00	1323
Cove	$419,104,750.00	1583
Downtown	$591,276,090.00	2070
Fish Flake	$23,190,100.00	104
Folly Hill	$49,724,500.00	97
Gloucester Crossing	$31,074,000.00	128
Goat Hill	$51,448,100.00	262
Kittridge Crossing	$415,161,600.00	1060
Monteserrat	$217,271,160.00	572
North Beverly-East	$173,557,800.00	735
North Beverly-West	$303,022,090.00	677
Prides Crossing	$211,764,100.00	240
Prospect Hill	$105,299,700.00	473
Raymond Farms/The Colleges	$76,722,900.00	434
Ryal Side-North	$149,676,200.00	777
Ryal Side-South	$181,208,400.00	978
Shingleville	$59,781,800.00	290
Beverly Golf & Tennis Club	$1,030,900.00	3
Grand Total	$3,745,265,090.00	12572

Summarized tax parcel data provided by City's GIS to show total assessed building value and building county by neighborhood.

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FEMA Federally Declared Disasters

List of Federally Declared Disasters from FEMA:

- Nature of disaster
- Type(s) of assistance provided

Disaster Number	Disaster Type	Incident Type	Incident Begin Date	Programs Declared			
				IH	IA	PA	HM
325	DR	Flood	3/6/1972		X	X	X
357	DR	Fishing Losses	9/28/1972		X		
546	DR	Flood	2/6/1978		X	X	X
650	DR	Fire	12/3/1981		X	X	X
751	DR	Hurricane	9/27/1985			X	X
790	DR	Flood	3/30/1987		X	X	X
914	DR	Hurricane	8/19/1991		X	X	X
920	DR	Coastal Storm	10/30/1991		X	X	X
975	DR	Coastal Storm	12/11/1992		X	X	X
1090	DR	Snow	1/7/1996			X	X
1142	DR	Flood	10/20/1996		X	X	X
1224	DR	Flood	6/13/1998		X		
1364	DR	Severe Storm(s)	3/5/2001		X		X
1512	DR	Flood	4/1/2004	X	X		X
1614	DR	Severe Storm(s)	10/7/2005	X	X	X	X
1642	DR	Severe Storm(s)	5/12/2006	X	X	X	X
1701	DR	Severe Storm(s)	4/15/2007			X	X
1813	DR	Severe Ice Storm	12/11/2008			X	X
1895	DR	Severe Storm(s)	3/12/2010	X		X	X
1959	DR	Snow	1/11/2011			X	X
4110	DR	Severe Storm(s)	2/8/2013			X	X
4214	DR	Severe Storm(s)	1/26/2015			X	X

NOAA NCEI Storm Events Database

Hazard Type	Total Events	Property Damage (2017$)	Deaths	Injuries
Drought	**9**	**$0.00**	**0**	**0**
Drought	9	$0.00	0	0
Extreme Temperatures	**8**	**$0.00**	**0**	**0**
Excessive Heat	1	$0.00	0	0
Extreme Cold/Wind Chill	4	$0.00	0	0
Heat	3	$0.00	0	0
Flood	**130**	**$55,555,601.94**	**2**	**3**
Coastal Flood	26	$7,261,479.77	0	0
Flash Flood	25	$24,618,481.32	0	0
Flood	46	$23,263,234.77	2	3
Heavy Rain	24	$0.00	0	0
Storm Surge/Tide	9	$412,406.08	0	0
Hurricanes	**2**	**$2,335,390.48**	**0**	**0**
Tropical Storm	2	$2,335,390.48	0	0
Severe Weather	**540**	**$16,731,680.45**	**5**	**16**
Hail	83	$183,587.35	0	0
High Wind	65	$4,051,102.66	0	4
Lightning	39	$1,324,311.11	3	4
Strong Wind	100	$315,297.64	1	1
Thunderstorm Wind	253	$10,857,381.69	1	7
Tornadoes	**16**	**$2,670,954.68**	**0**	**4**
Funnel Cloud	3	$0.00	0	0
Tornado	12	$2,670,954.68	0	4
Waterspout	1	$0.00	0	0
Winter Storms	**194**	**$14,413,710.12**	**0**	**0**
Blizzard	3	$57,400.26	0	0
Heavy Snow	113	$11,046,025.45	0	0
Ice Storm	1	$2,218,101.93	0	0
Winter Storm	39	$1,069,329.49	0	0
Winter Weather	38	$22,852.99	0	0
Grand Total	**899**	**$91,707,337.67**	**7**	**23**

NCEI Storm Events Database publishes data at the county level, therefore totals are reported for Essex County, of which Beverly is a part.

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Hazard Priority Ranking Criteria
New for 2017 Plan Update

Hazard Priority Ranking Criteria

Probability	Affected Area	Primary Impact	Secondary Impact	Community Survey Rating
Weighting: 2	*Weighting: 0.5*	*Weighting: 0.8*	*Weighting: 0.7*	*Weighting: 1.0*
Unlikely *Less than 1% probability in next 100 years or has a recurrence interval of greater than every 100 years.*	**Isolated** *Less than 1% of area affected*	**Negligible** *Less than 10% damage*	**Negligible** *No loss of function, downtime, and/or evacuations*	**Low** *No perceived threat to neighborhood or home*
Somewhat Likely *Between 1 and 10% probability in next year or has a recurrence interval of 11 to 100 years.*	**Small** *Between 1 and 10% of area affected*	**Limited** *Between 10% and 25% damage*	**Limited** *Minimal loss of function, downtime, and/or evacuations*	**Medium-Low** *Minimal perceived threat to neighborhood or home*
Likely *Between 10 and 100% probability in next year or has a recurrence interval of 10 years or less.*	**Medium** *Between 10 and 50% of area affected*	**Critical** *Between 25% and 50% damage*	**Moderate** *Some loss of function, downtime, and/or evacuations*	**Medium-High** *Some perceived threat to neighborhood or home*
Highly Likely *Near 100% probability in next year or happens every year.*	**Large** *Between 50 and 100% of area affected*	**Catastrophic** *More than 50% damage*	**High** *Major loss of function, downtime, and/or evacuations*	**High** *Major perceived threat to neighborhood or home*

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Ranking 2012 Plan Update

Table 6. Hazard Risks Summary (2012 Plan)		
Hazard	**Frequency**	**Severity**
Flooding	High	Serious
Winter storms	High	Serious
Hurricanes	Medium	Serious
Earthquakes	Low	Extensive
Tornadoes	Low	Serious
Landslides	Low	Minor
Brush fires	Medium	Minor
Dam failures	Low	Serious

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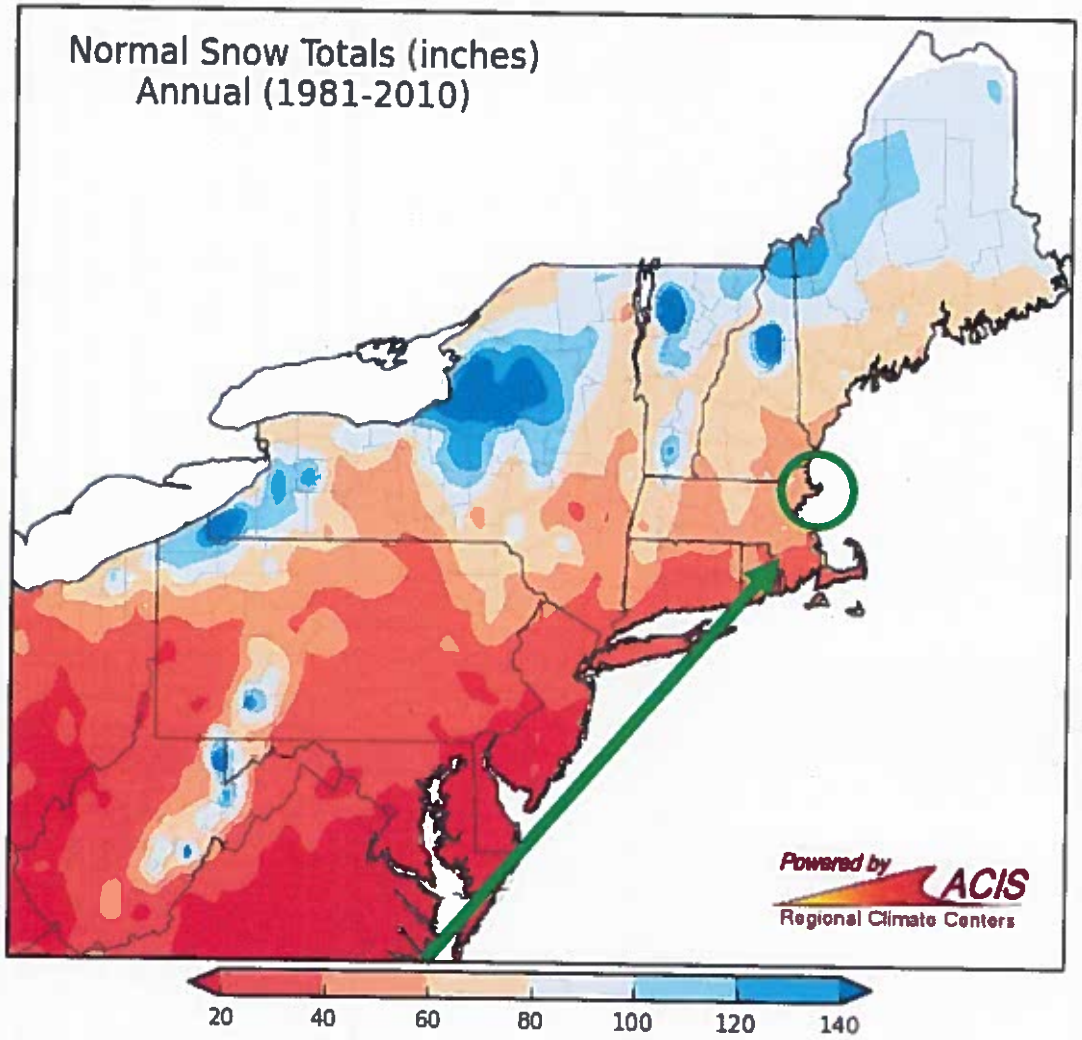
New Hazard Ranking

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Winter Storms	Highly Likely	Large	Negligible	Moderate	High	Significant
Flood	Likely	Small	Critical	High	Medium-High	Significant
Severe Weather (Thunderstorms)	Highly Likely	Small	Negligible	Limited	High	Moderate
Extreme Temperatures	Likely	Isolated	Catastrophic	Negligible	Medium-High	Moderate
Hurricanes	Somewhat Likely	Large	Critical	Moderate	Medium-High	Moderate
Invasive Pests	Likely	Medium	Limited	Negligible	Medium-High	Limited
Tornadoes	Somewhat Likely	Isolated	Catastrophic	Limited	Medium-Low	Limited
Earthquakes	Unlikely	Small	Catastrophic	High	Medium-Low	Limited
Drought	Somewhat Likely	Medium	Negligible	Negligible	Medium-High	Limited
Wildfire	Somewhat Likely	Medium	Negligible	Negligible	Medium-High	Limited

Hazard Specific Analysis

Winter Storm



Source: Northeast Regional Climate Center

194 severe winter weather events in Essex County since 1996:

- Blizzard (3)
- Extreme Cold/Wind Chill (2)
- Heavy Snow (113)
- Ice Storm (1)
- Winter Storm (39)
- Winter Weather (38)

Annualized Occurrence	Annualized Property Damage
8.8	$655,169

Dewberry

Roof Analysis

FEMA P-957 Snow Load Safety Guide states the following roof types are more vulnerable to increased snow accumulation and unbalanced loads:

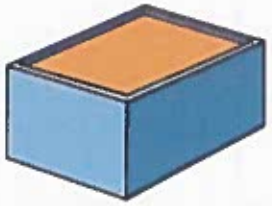


Figure 3a. Flat or low-slope roof with or without roof drains

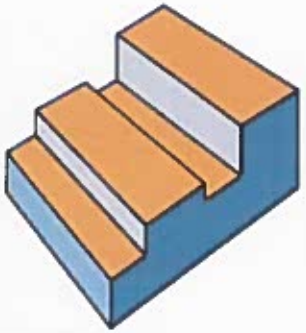


Figure 3b. Stepped roof

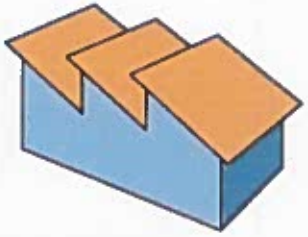


Figure 3c. Saw-tooth roof

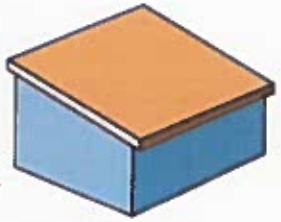


Figure 3d. Mono-slope roof

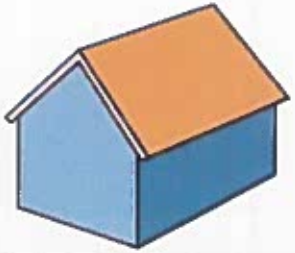


Figure 3e. Gable/multi-span gable roof

Roof Type	Number of Buildings
Bow	2
Flat	963
Gable	8955
Gambrel	509
Hip	1881
Mansard	115
Saltbox	11
Sawtooth	2
Shed	4
(blank)	129
Total	**12,571**

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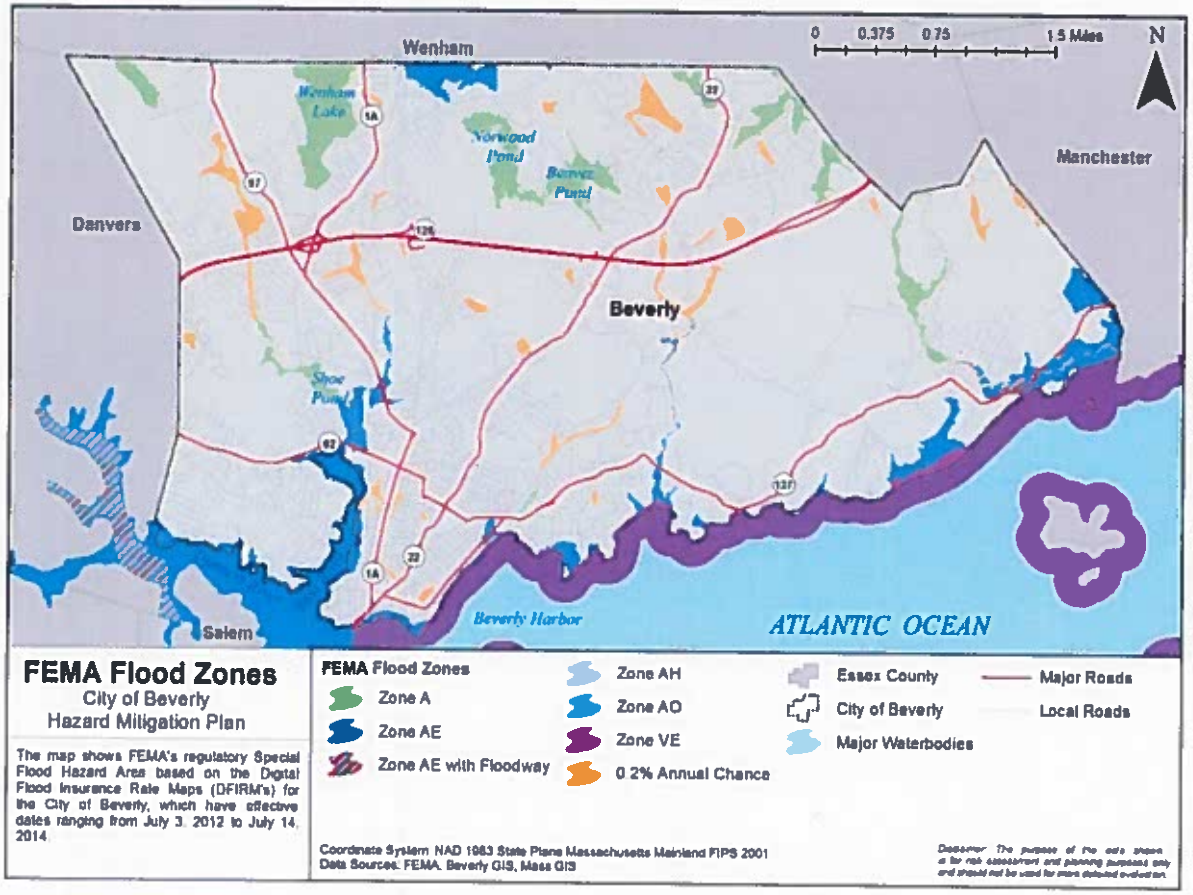
Flooding



130 flood related events reported in Essex County since 1996:

- Coastal Flood (26)
- Flash Flood (25)
- Flood (46)
- Heavy Rain (24)
- Storm Surge/Tide (9)

Annualized Occurrence	Annualized Property Damage	Annualized Deaths	Annualized Injuries
5.91	$2,525,255	0.09	0.14

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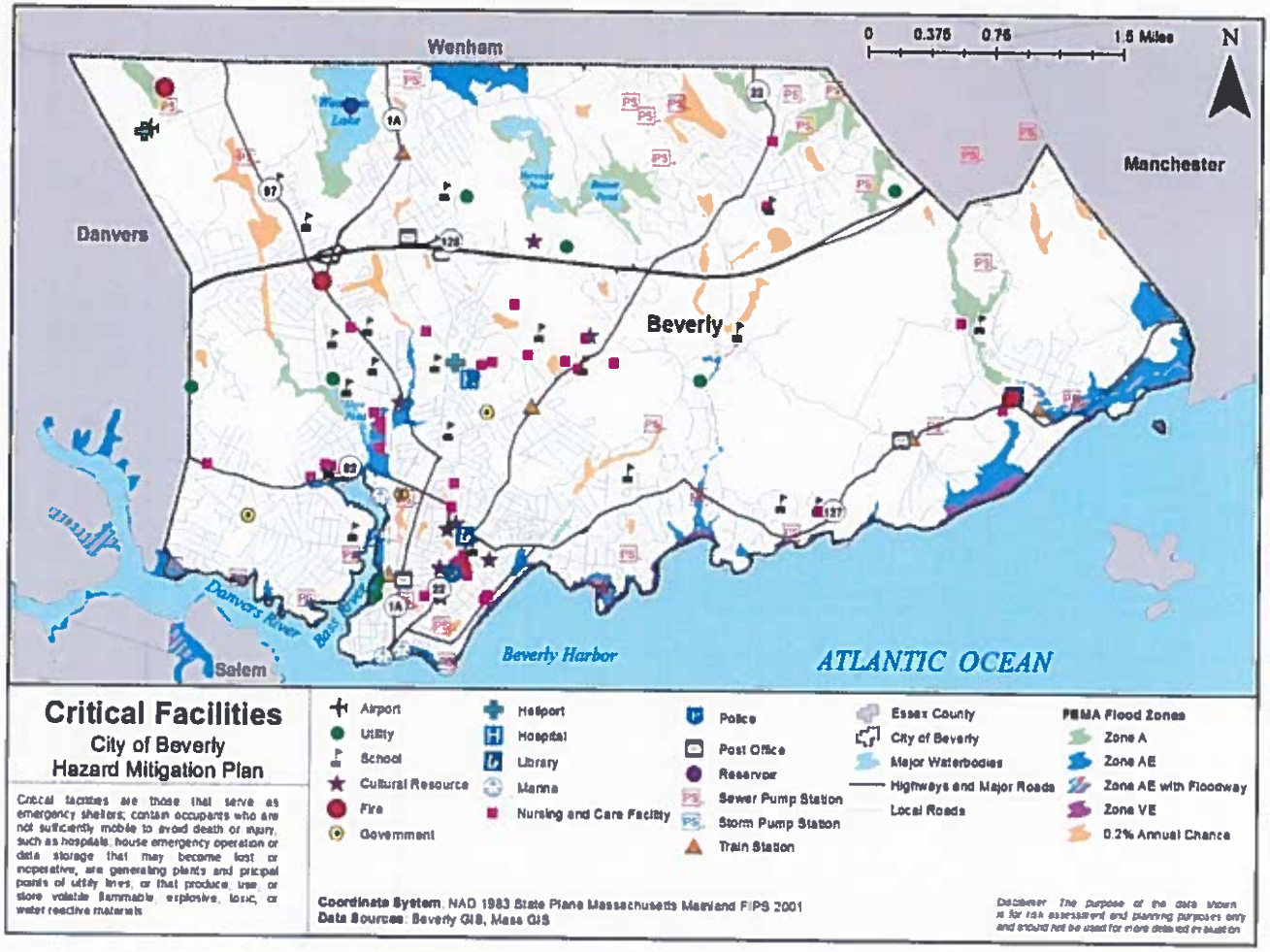
Flooding (continued)



Flood Zone	Count of Critical Facilities
A	3
AE	19
X	148
Total	**170**

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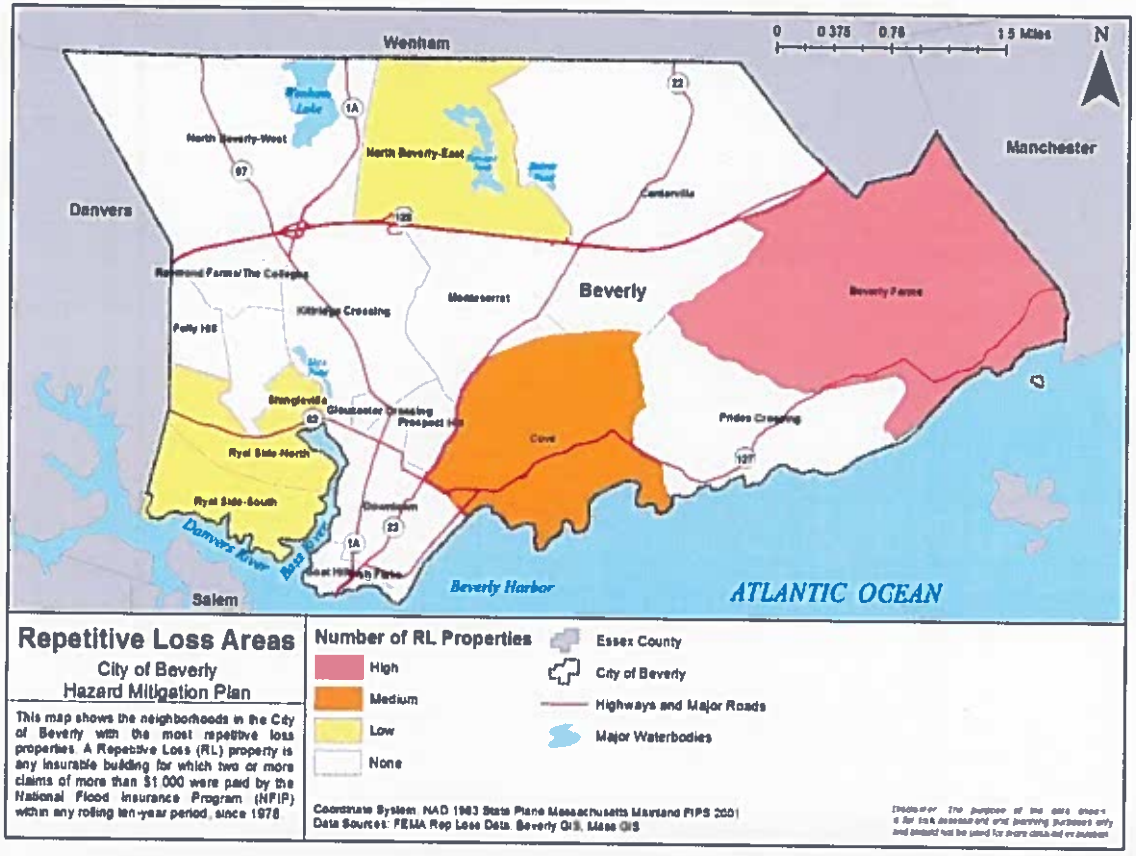
NFIP Statistics and Repetitive Loss

Community Name	Number of Policies	Total Coverage	Total Premium	Total Claims Since 1978	Total Paid since 1978
Beverly, City of	358	$91,416,800	$ 277,974	145	$1,552,558
Essex County	9,931	$2,550,466,700	$ 10,964,803	4,709	$73,398,477



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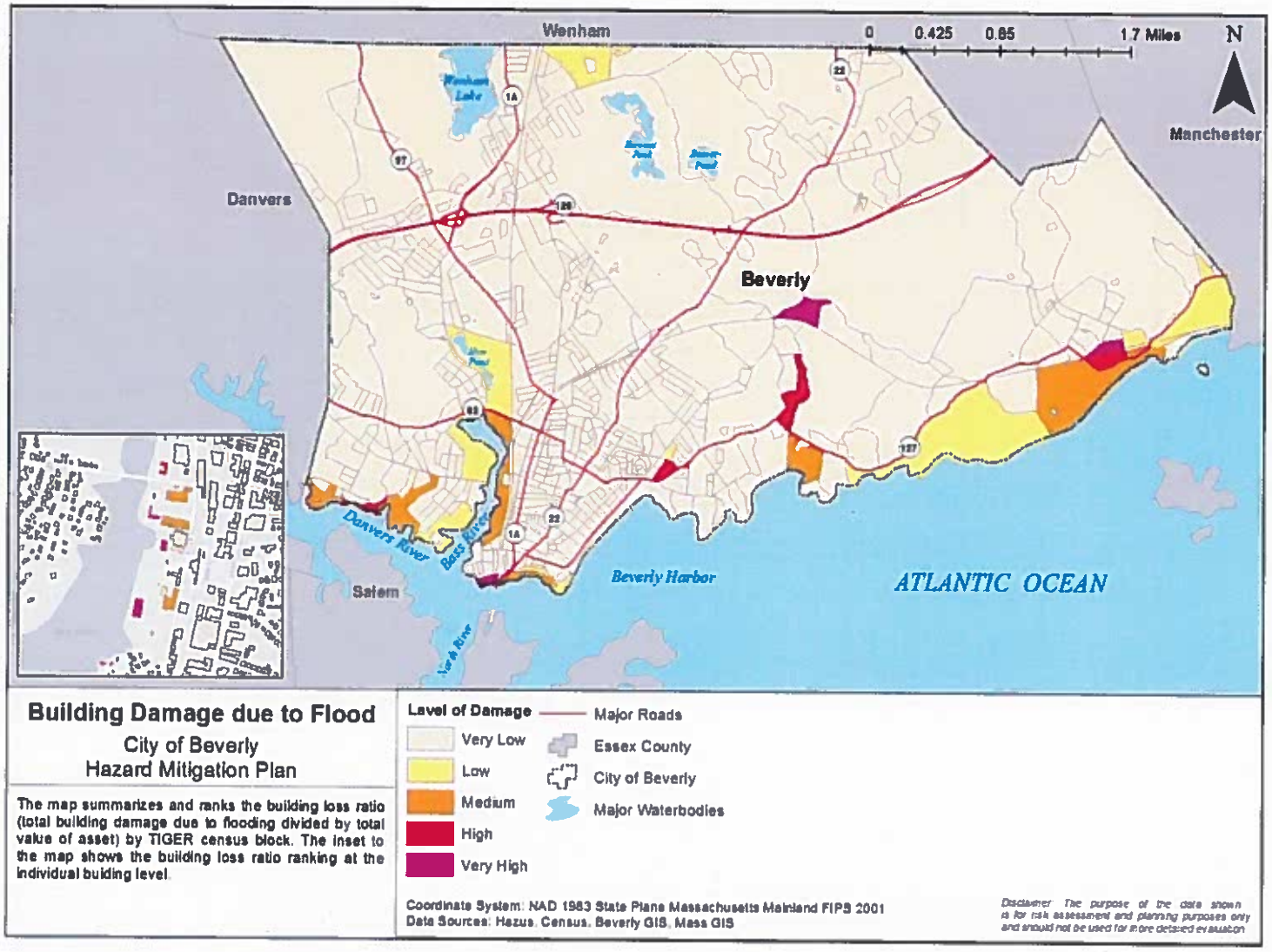
Hazus Level II Analysis

User Defined Facility (UDF) Average Annua Building Loss due to Flood *Summarized at Census Block Level*



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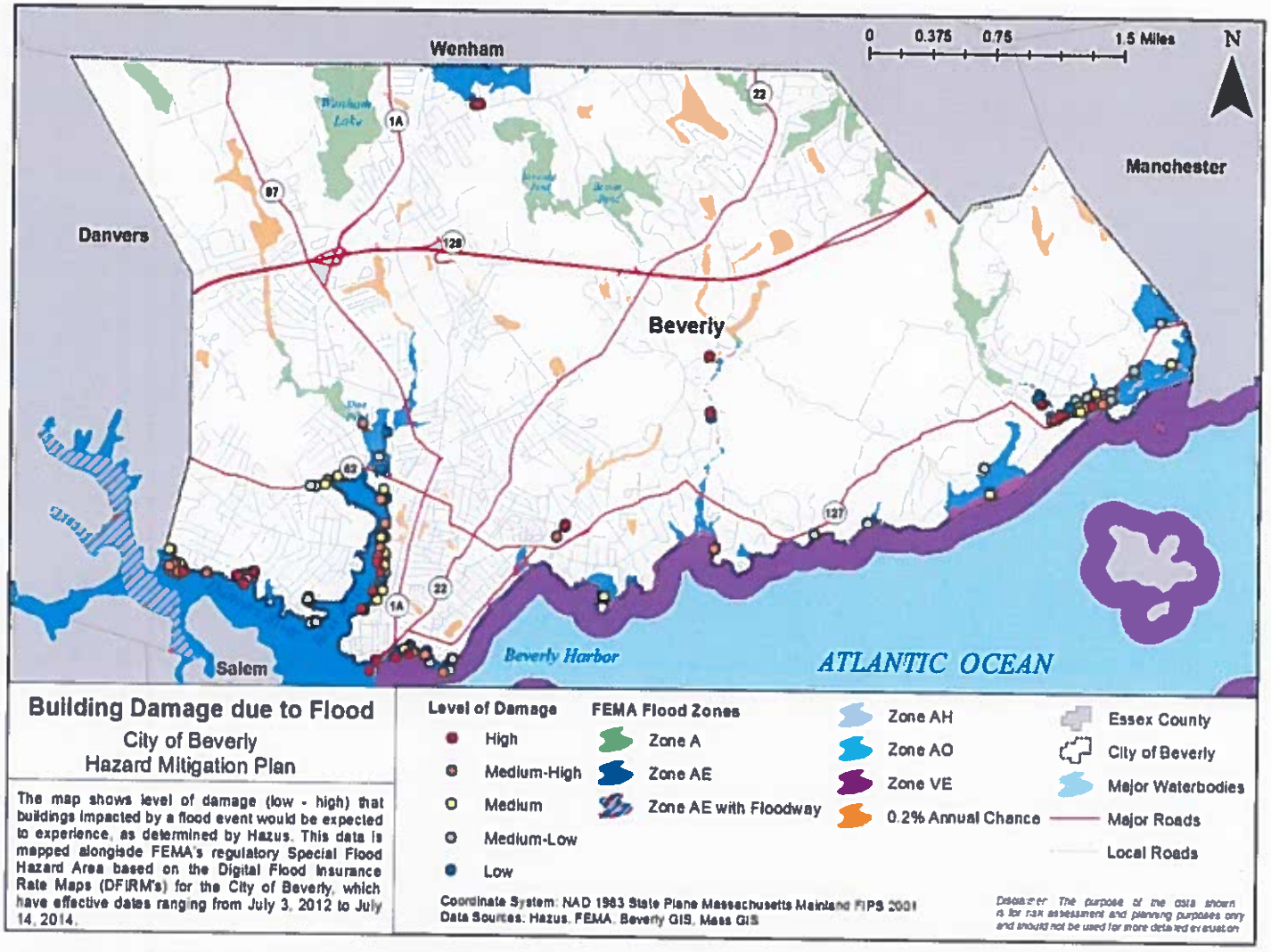
Annualized Level of Damage for Buildings (UDF) Impacted by Flood



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Hazus Results Summary

UDF Average Annual Total Losses by General Occupancy Type from Flood

	Commercial	Government	Industrial	Residential	Total
Exposure/Value	$566,649,029	$655,356	$6,006,307	$54,900,509	$628,211,203
Total Losses	$1,534,841	$2,528	$28,875	$499,159	$2,065,404
Percent Damage	0.27%	0.39%	0.48%	0.91%	0.33%

UDF 100-Year and Average Annual Losses from Flood

Return Period	Building Losses	Content Losses	Inventory Losses	Total Losses
100-Year	$6,887,700	$7,211,391	$2,921,438	$17,020,530
Average Annual	$876,629	$1,056,143	$132,632	$2,065,404

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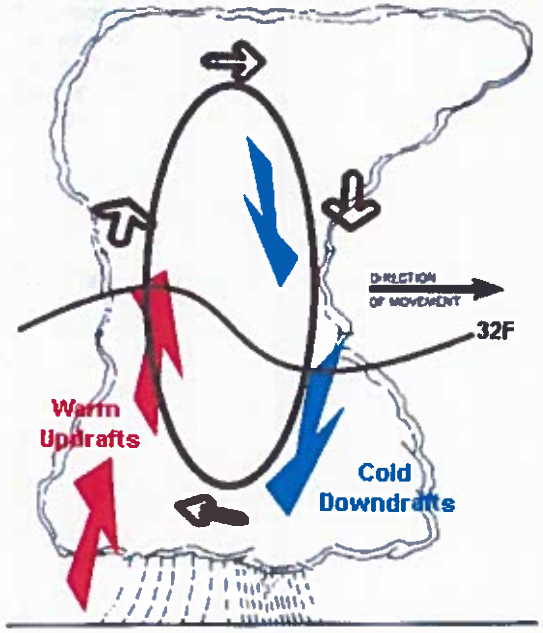
Severe Weather



Formation of Hail (Source: NOAA)

540 severe weather events reported in Essex County since 1957:

- Severe Wind (418)
- Lightning (39)
- Hail (83)

Annualized Occurrence	Annualized Property Damage	Annualized Deaths	Annualized Injuries
8.57	$265,582	0.01	0.73

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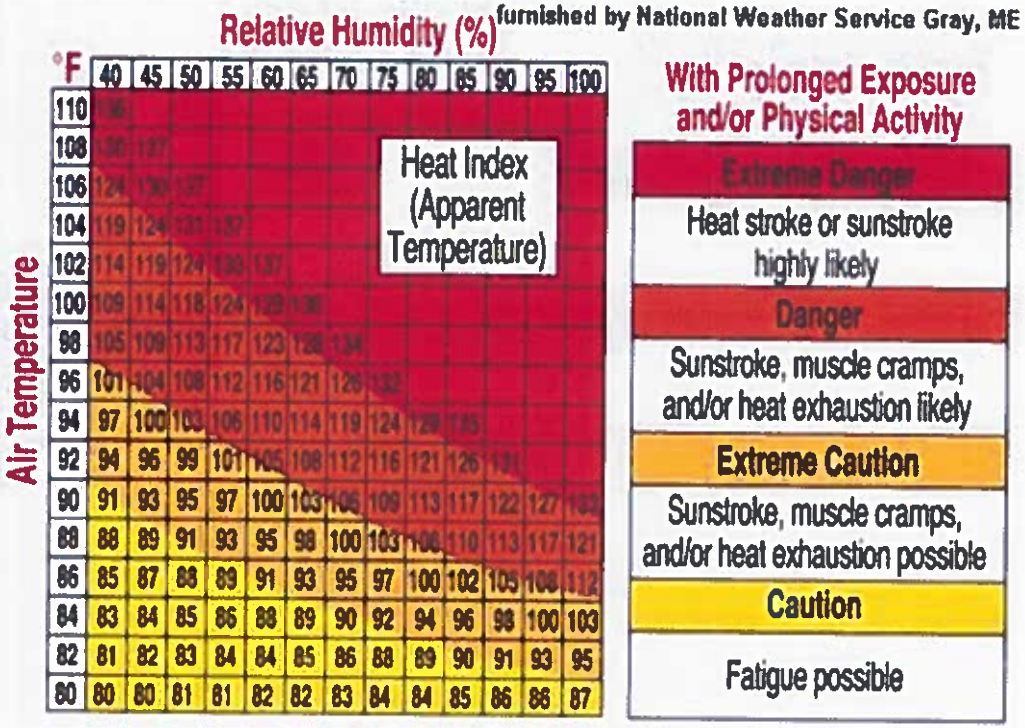
Extreme Temperature



9 extreme temperature related events reported in Essex County since 2010:

- High Heat (1)
- Excessive Heat (1)
- Extreme Cold/Wind Chill (4)

Hazard	Annualized Occurrence	Annualized Property Damage
Extreme Temperatures	0.36	$0.00
Extreme Heat	0.18	$0.00
Extreme Cold	0.18	$0.00

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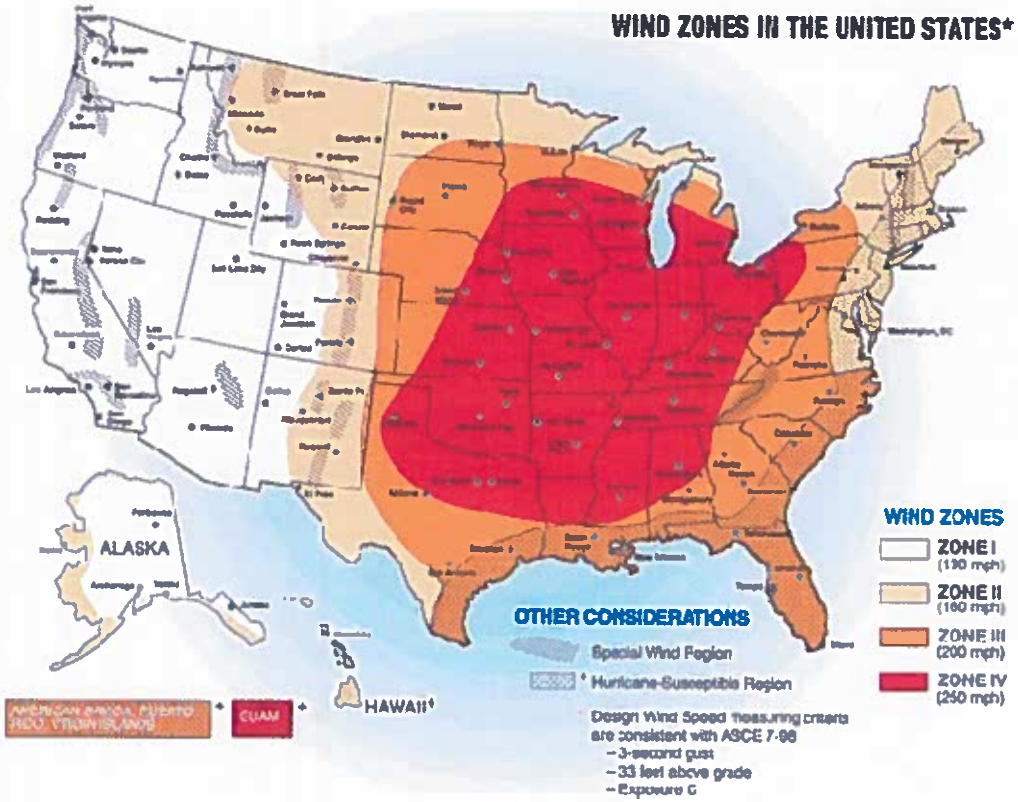
Hurricane/Tropical Storm



22 hurricane and tropical storm events reported in Massachusetts since 1938

Annualized Occurrence	Annualized Property Damage
0.09	$106,154

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Hurricane Hazus Results

Hurricane Probabilistic Number of Buildings Damaged

Return Period	Minor	Moderate	Severe	Destruction	Total
10	0	0	0	0	0
20	8	0	0	0	9
50	99	6	0	0	105
100	455	40	1	0	495
200	1170	149	4	2	1325
500	2281	463	27	19	2789
1000	3094	845	83	55	4077

Hurricane Probabilistic Economic Loss

Return Period	Residential Property Damage	Total Property Damage	Business Interruption (income loss)
10	-	-	-
20	$1,842,568	$1,842,568	$356,940
50	$16,232,411	$16,827,455	$99,623,167
100	$37,622,916	$42,175,913	$982,115,720
200	$70,192,455	$91,494,537	$2,599,326,698
500	$137,129,136	$234,229,917	$9,402,798,933
1000	$223,895,063	$440,249,656	$19,097,637,311
Annualized	**$1,673,000**	**$2,710,000**	**$93,525,000**

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Invasive Pests

The Massachusetts Invasive Plant Advisory Group defines "invasive plants" as: "non-native species that have spread into native or minimally managed plant systems in Massachusetts, causing economic or environmental harm by developing self-sustaining populations and becoming dominant and/or disruptive to those systems."

Common Name	Scientific Name	Number of Records	Plant Variety
perennial pepperweed	*Lepidium latifolium*	731	Forbs/Herbs
oriental bittersweet	*Celastrus orbiculatus*	137	Vines
purple loosestrife	*Lythrum salicaria*	132	Aquatic Plants
multiflora rose	*Rosa multiflora*	132	Shrub or Subshrub
Norway maple	*Acer platanoides*	65	Hardwood Trees
European common reed	*Phragmites australis ssp. australis*	50	Aquatic Plants
Japanese barberry	*Berberis thunbergii*	43	Shrub or Subshrub
glossy buckthorn	*Frangula alnus*	37	Shrub or Subshrub
Japanese knotweed	*Reynoutria japonica*	37	Forbs/Herbs
garlic mustard	*Alliaria petiolata*	31	Forbs/Herbs

Source: Invasive Plant Atlas of New England (IPANE)

Lepidium latifolium

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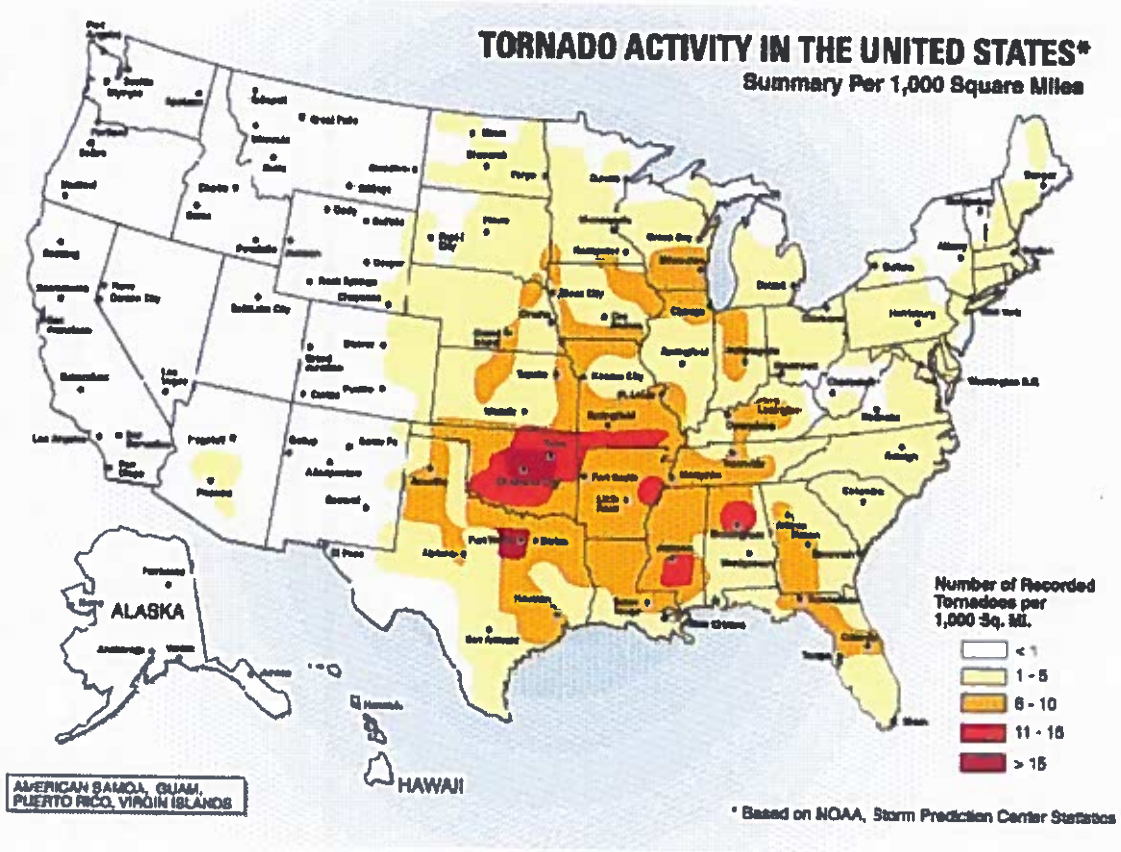
Tornado



0 tornado event reported in the City of Beverly.
16 tornado events reported in Essex County since 1950:

- Tornadoes (12)
- Funnel clouds (3)
- Waterspout (1)

Annualized Occurrence	Annualized Property Damage
0.235	$39,279

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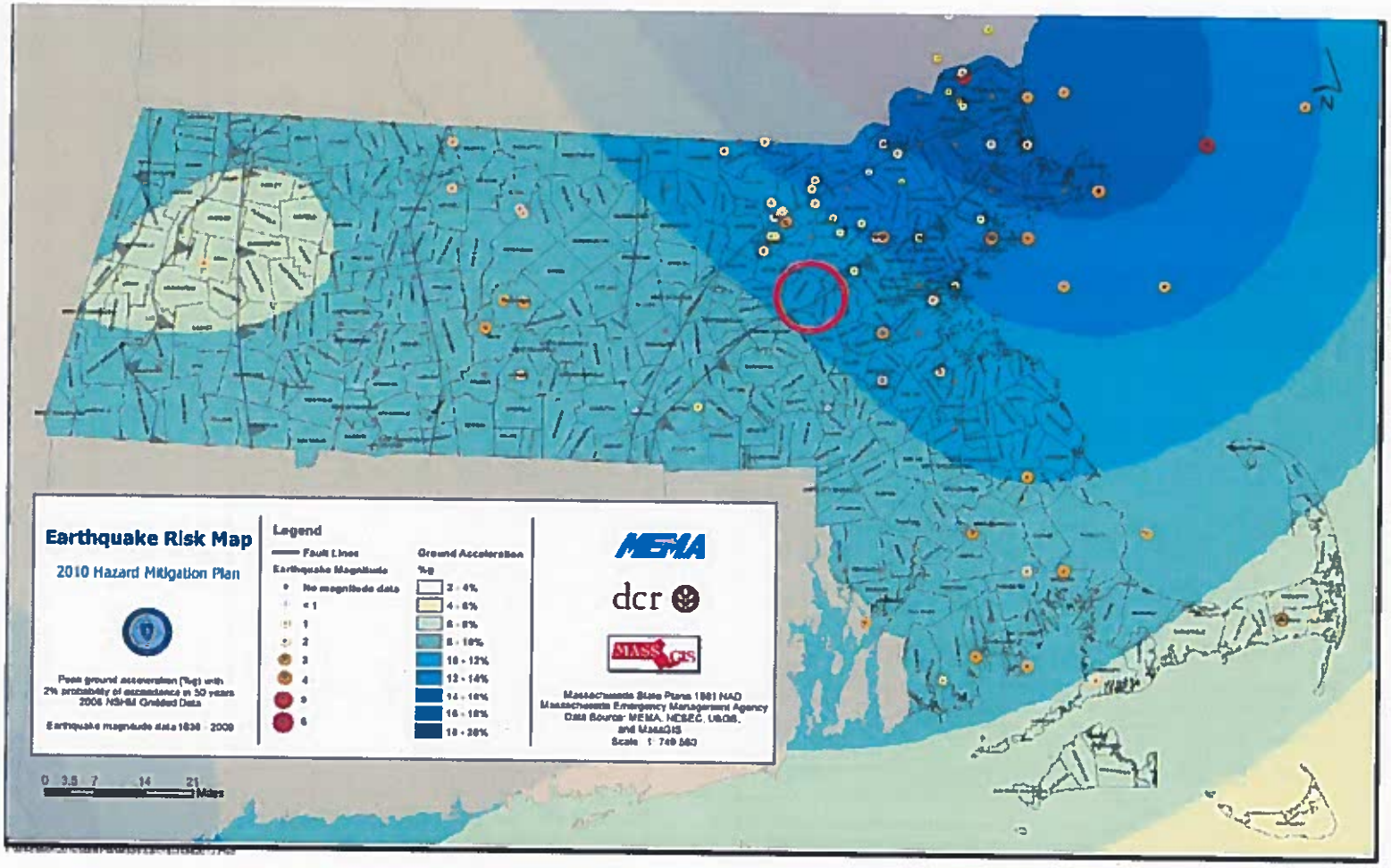
Earthquake



0 earthquake events reported in the City of Beverly.

From 1627 to 2008, 366 earthquakes were recorded in Massachusetts

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Earthquake Losses (Mass State HMP)

EARTHQUAKE ESTIMATED POTENTIAL LOSSES TO BUILDINGS (STRUCTURE AND CONTENTS) HAZUS-MH PROBABILISTIC SCENARIOS

	100-Year MRP	500-Year MRP	1,000 Year MRP	2,500-Year MRP
Essex	$0	$23,010,003	$85,379,039	$366,462,378

TABLE 8-9.
ESTIMATED NUMBER OF INJURIES AND CASUALTIES, HAZUS-MH

	100-Year MRP Event			500-Year MRP Event			1,000-Year MRP Event			2,500-Year MRP Event		
	2 a.m.	2 p.m.	5 p.m.	2 a.m.	2 p.m.	5 p.m.	2 a.m.	2 p.m.	5 p.m.	2 a.m.	2 p.m.	5 p.m.
Essex												
Injuries	0	0	0	49	47	43	141	140	127	522	616	535
Hospitalization	0	0	0	5	6	5	18	22	20	91	123	119
Casualties	0	0	0	1	1	1	3	3	3	16	24	21

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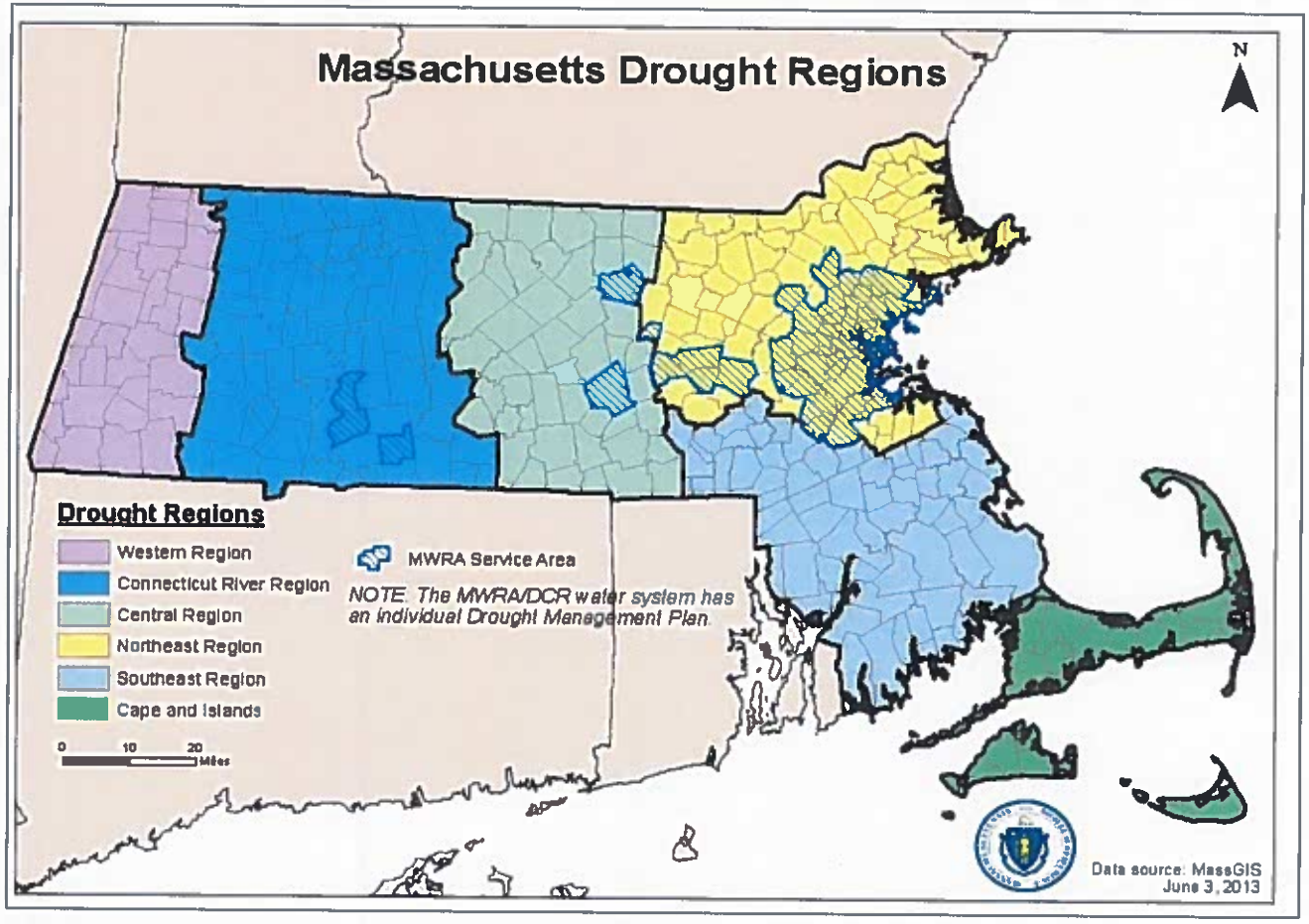
Drought



4 drought events reported in Massachusetts from 2012 to 2016.

Annualized Occurrence	Annualized Property Damage	Annualized Crop Damages
0.21	$0	$0

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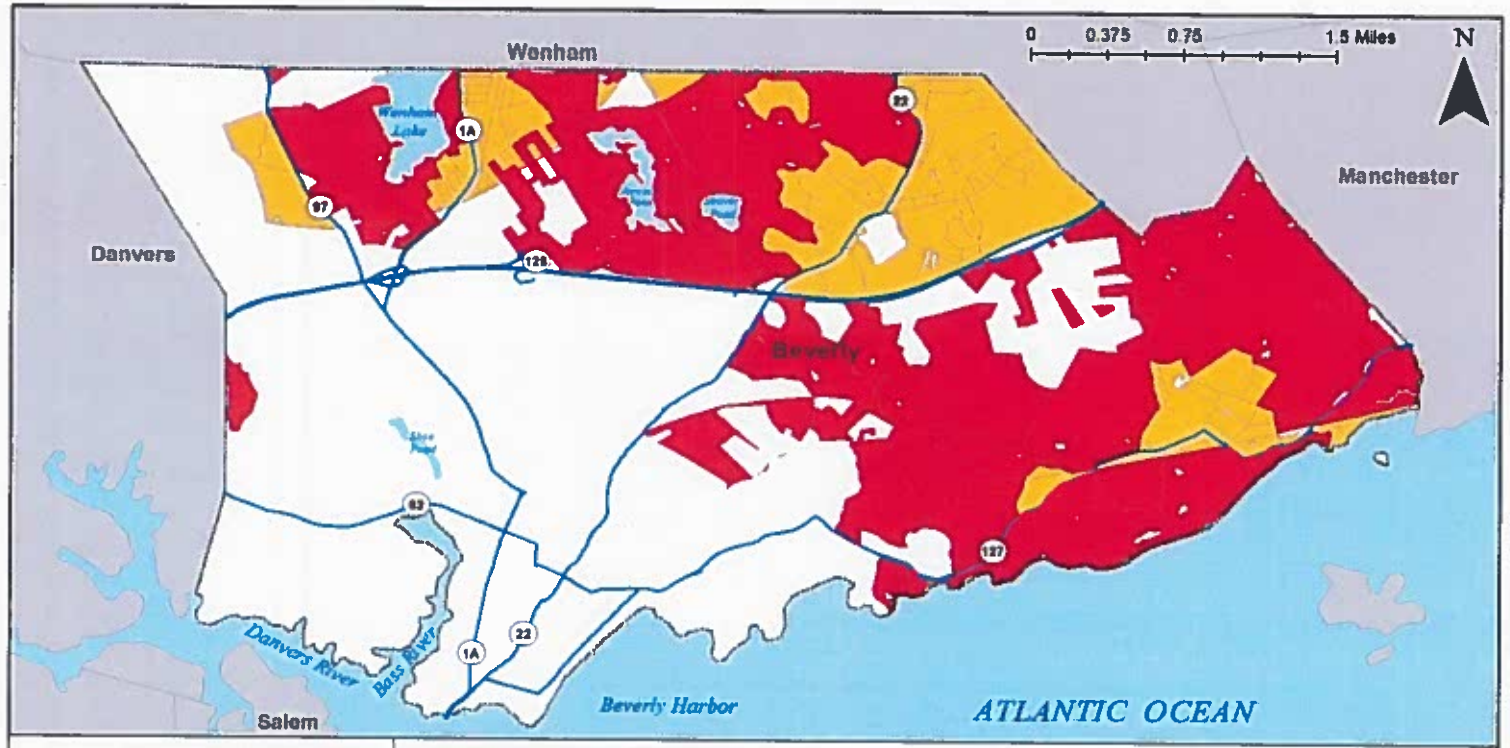
Wildfire



Wildland Urban Interface

City of Beverly, Massachusetts
Hazard Mitigation Plan

The WUI is defined as the area where structures and human development meet or intermingle with undeveloped wildland and creates an environment in which fire can move readily between structural and vegetation fuels.

Intermix communities are places where housing and vegetation intermingle. In intermix, wildland vegetation is continuous, >50% vegetation, in areas with >1 house per 40 acres.

Interface communities are areas with housing in the vicinity of contiguous vegetation. Interface areas have >1 house per 40 acres, have <50% vegetation, and are within 1.5 miles of an area >1,325 acres that is >75% vegetated.

Wildland Urban Interface (WUI)
- Intermix
- Interface

- StateRoutes
- Essex County
- City of Beverly
- Major Waterbodies

Coordinate System: NAD 1983 State Plane Massachusetts Mainland FIPS 2001
Data Sources: SILVIS Lab, Beverly GIS, Mass GIS

Disclaimer: The purpose of the data shown is for risk assessment and planning purposes only and should not be used for more detailed evaluation

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Critical Facilities in WUI Zones

WUI Zone	Count of Critical Facilities
Low Density Intermix	4
Medium Density Intermix	15
High Density Interface	2
Medium Density Interface	21
High Density No Vegetation	35
Medium Density No Vegetation	49
Uninhabited No Vegetation	33
Uninhabited Vegetated	1
Very Low Density No Vegetation	7
Water	3
Total	**170**

Facility Name	Type
Music Theater	Cultural Resource
Sewer Pump-Upper Parsons	Sewer Pump Station
Salem-Beverly Water Supply Board	Hazmat
Sewer Pump-Lower Parsons	Sewer Pump Station
Sewer Pump-Dyer Rd	Sewer Pump Station
Sewer Pump-Grover #1	Sewer Pump Station
Sewer Pump-Grover #2	Sewer Pump Station
Glenn Urquhart School	School
Covenant Christian School	School
Cape Ann Waldorf School	School
North Beverly Elementary School	School
Sewer Pump-Beach St	Sewer Pump Station
Cell Tower	Cell Tower
NG-East Beverly No 51	Utility
Beverly Water Tank	Utility

Summary and Next Steps

Potential Annualized Loss

Hazard	Annualized Occurrence	Annualized Property Damage	Annualized Deaths Reported	Annualized Injuries Reported
Drought	0.41	$0.00	0.00	0.00
Extreme Temperatures	0.36	$0.00	0.00	0.00
Flood	5.91	$2,525,254.63	0.09	0.14
Hurricanes	0.09	$106,154.11	0.00	0.00
Severe Weather	8.57	$265,582.23	0.08	0.73
Tornadoes	0.24	$39,278.75	0.00	0.06
Winter Storms	8.82	$655,168.64	0.00	0.00

Hazard Ranking Comparison

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Winter Storms	Highly Likely	Large	Negligible	Moderate	High	Significant
Flood	Likely	Small	Critical	High	Medium-High	Significant
Severe Weather (Thunderstorms)	Highly Likely	Small	Negligible	Limited	High	Moderate
Extreme Temperatures	Likely	Isolated	Catastrophic	Negligible	Medium-High	Moderate
Hurricanes	Somewhat Likely	Large	Critical	Moderate	Medium-High	Moderate
Invasive Pests	Likely	Medium	Limited	Negligible	Medium-High	Limited
Tornadoes	Somewhat Likely	Isolated	Catastrophic	Limited	Medium-Low	Limited
Earthquakes	Unlikely	Small	Catastrophic	High	Medium-Low	Limited
Drought	Somewhat Likely	Medium	Negligible	Negligible	Medium-High	Limited
Wildfire	Somewhat Likely	Medium	Negligible	Negligible	Medium-High	Limited

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HIRA → inform → Mitigation Strategy

Reduce societal, economic, and environmental exposure to hazard impacts

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Definitions

Goal: general guidelines that describes what planning region would like to achieve

Objective: specific and measurable strategies that must be implemented to achieve the identified goals

Action: more specific than an objective with identified responsible parties, timeframes, and potential funding sources

Goals – 2012 HMP Update

- Ensure that critical infrastructure sites are protected from natural hazards.
- Protect existing residential and business areas from flooding.
- Maintain existing mitigation infrastructure in good condition.
- Continue to enforce existing zoning and building regulations.
- Educate the public about zoning and building regulations, particularly with regard to changes in regulations that may affect tear-downs and new construction.
- Work with surrounding communities to ensure regional cooperation and solutions for hazards affecting multiple communities such as coastal erosion.
- Encourage future development in areas that are not prone to natural hazards.
- Educate the public about natural hazards and mitigation measures.
- Make efficient use of public funds for hazard mitigation.
- Protect the City's ability to respond to various natural hazard events.

What's Next?

- Comments on Draft HIRA – submit by June 30, 2017
- Public Outreach – Public Meeting - June, 22, 2017
- Mitigation Goals, Objectives and Actions Meeting - July, 2017
- Draft Plan Complete - August 2017
  - Additional Public Outreach
  - Committee Review
  - Submit to MEMA

Scott Choquette
schoquette@dewberry.com
617.531.0750

Questions

STAKEHOLDER ENGAGEMENT AT BEVERLY COASTAL RESILIENCE PLAN PUBLIC MEETING, WITH HMP UPDATE BOOTH

CR workshop

June 10

Mitigation Booth Only

Jamie Jamieson	scoopjamieson@AOL.com
Ann Nichols	arnichols@verizon.net
Ray + Patty Freeman-Lynde	pf1cambridge@gmail.com r.freeman lynde@gmail.com
Margaret Vaccaro	31 Ellingwood ct.
Elaine Yuan	eY02151@Yahoo.com

City of Beverly

BSC GROUP
Transportation • Energy • Land Development

PLANNING AND DEVELOPMENT DEPARTMENT
Aaron Clausen
City of Beverly Director of Planning and Community Development

Lynch Park Carriage House
55 Obear Street
Beverly, Massachusetts 01915

The City of Beverly Planning and Engineering Departments will host a third (and final) community workshop on June 10th to introduce the public to the potential effects of climate change and sea level rise on the City of Beverly. Short presentations will be made on the ways that Beverly can become more resilient through planning, infrastructure enhancements, protecting green spaces and utilizing natural systems to protect the coastline and further community engagement. Activities to visual sea level rise will be showcased at Lynch Park. Additionally, local nonprofit organizations, such as Salem Sound Coastwatch, Mass Audubon and others will be available to educate everyone on ways to get involved locally to promote climate change awareness and resiliency projects throughout the region.

Map of Lynch Park Area – 2030
Projected Flood Depth due to
100-year Coastal Storm Event

Map of Lynch Park Area – 2070
Projected Flood Depth due to
100-year Coastal Storm Event

Please come to participate and learn about the potential impacts of our changing climate for the City of Beverly. The meeting will be held at the **Lynch Park Carriage House** on Saturday, **June 10th from 11 AM to 1 PM**. This is an all ages event!

BEVERLY HAZARD MITIGATION PLAN UPDATE PUBLIC MEETING #1

(ALSO AIRED ON BevCam LOCAL TELEVISION STATION)

2017 City of Beverly Hazard Mitigation Plan Update
Mitigation Planning Public Meeting #1
Thursday June 22, 2017 – 5:00 – 6:30 PM
Beverly City Hall

Name	Organization / Address	Email	Telephone
Scott R. Choquette	Dewberry / 280 Summer St, Boston, MA 02210	schoquette@dewberry.com	617.531.0750
Robert J. Lewis	903 Hale St Beverly, MA	robert.lewis.3@uscedu	978-922-4560
JOHN E GLOVSKY	GLOVSKY & GLOVSKY BEVERLY MA	jglovsky@glovsky.com	9787703103
JOHN NEWBERRY	1 Beach St Beverly	bignewb@aol.com	978 927 5500
Joy Duperault	mass DCR, Boston & 11 Agate St. Beverly	joy.duperault@state.ma.us	617-626-1406
Shelly + Ralph CERUNDOLO	104 West ST. Beverly	R.CERUNDOLO@COMCAST.NET	978-927-5555
Pat Danielson	79 Lothrop 01915	pat_danielson@yahoo	978-922-0207
MICHAEL O'BRIEN	9 WILLOW ST.	MIKE@BEVERLYINS.COM	9789989553
Tom Muscante	12 Willow St.	tonithetiger37@COMCAST.NET	978-927-2373
Bruce Egan	Egan Environmental LLC 75 Lothrop St. Beverly	Bruce@Eganenvironmental.com	978 524 7677
John Hamilton	109 WATER ST. UNIT 203 BEVERLY	JOHN.W.HAMILTON@VERIZON.NET	617 548 0209

Name	Organization / Address	Email	Telephone
Rolland Adm			

City of Beverly, MA
Local Hazard Mitigation Plan Update

Public Meeting
June 22, 2017

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Welcome & Introductions

Role in the Hazard Mitigation Plan Update

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What is Hazard Mitigation Planning?

Any sustained action taken to reduce or eliminate the impacts of disasters on property, infrastructure or people, thereby reducing the need to respond

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Why a Plan Update?

- Required every 5 years in order to remain eligible for Hazard Mitigation Assistance Funding
  - Hazard Mitigation Grant Program (HMGP)
  - Flood Mitigation Assistance Program (FMA)
  - Pre-Disaster Mitigation (PDM)
- Assists with Capital Planning
- Re-assesses vulnerability
- Revisits priorities

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Hazard Mitigation Plan Update Process

- Data Collection & 2012 Plan Evaluation
- Update Plan
  - Hazard Identification & Risk Assessment
  - Mitigation Goals, Strategies, and Projects (progress, revisions and additions)
  - Capability Assessment
  - Plan Implementation & Maintenance
- Draft Plan Submittal and Review
- Plan Adoption
- Plan Submission to MEMA & FEMA

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Planning Process / Public Outreach

- **Public Engagement**
  - Online Survey
  - Public Review of Draft Portions
  - City Council Study Session
  - Public Review of Complete Plan Update
  - City Council Adoption

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Hazard Identification and Risk Assessment

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Hazard Identification & Risk Assessment

- **Purpose:** Provides a factual basis for prioritizing hazard mitigation activities

- **Major components:**
  - Identify and profile natural hazards affecting the City
  - Describe vulnerability to critical facilities and estimate losses
  - Vulnerability in terms of current and future land use and development

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Hazard Priority Ranking Criteria
New for 2017 Plan Update

- **Probability**: likelihood of occurrence from historical data.
- **Affected Area**: size of geographical area of community affected by hazard
- **Primary Impact**: percent of damage to typical facility in the community
- **Secondary Impact**: hazard impacts to economy and community health
- **Community Survey Rating**: community's perceived risk in terms of hazards impacting the survey responders' home and neighborhood.

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Ranking 2012 Plan Update

Table 6. Hazard Risks Summary (2012 Plan)		
Hazard	**Frequency**	**Severity**
Flooding	High	Serious
Winter storms	High	Serious
Hurricanes	Medium	Serious
Earthquakes	Low	Extensive
Tornadoes	Low	Serious
Landslides	Low	Minor
Brush fires	Medium	Minor
Dam failures	Low	Serious

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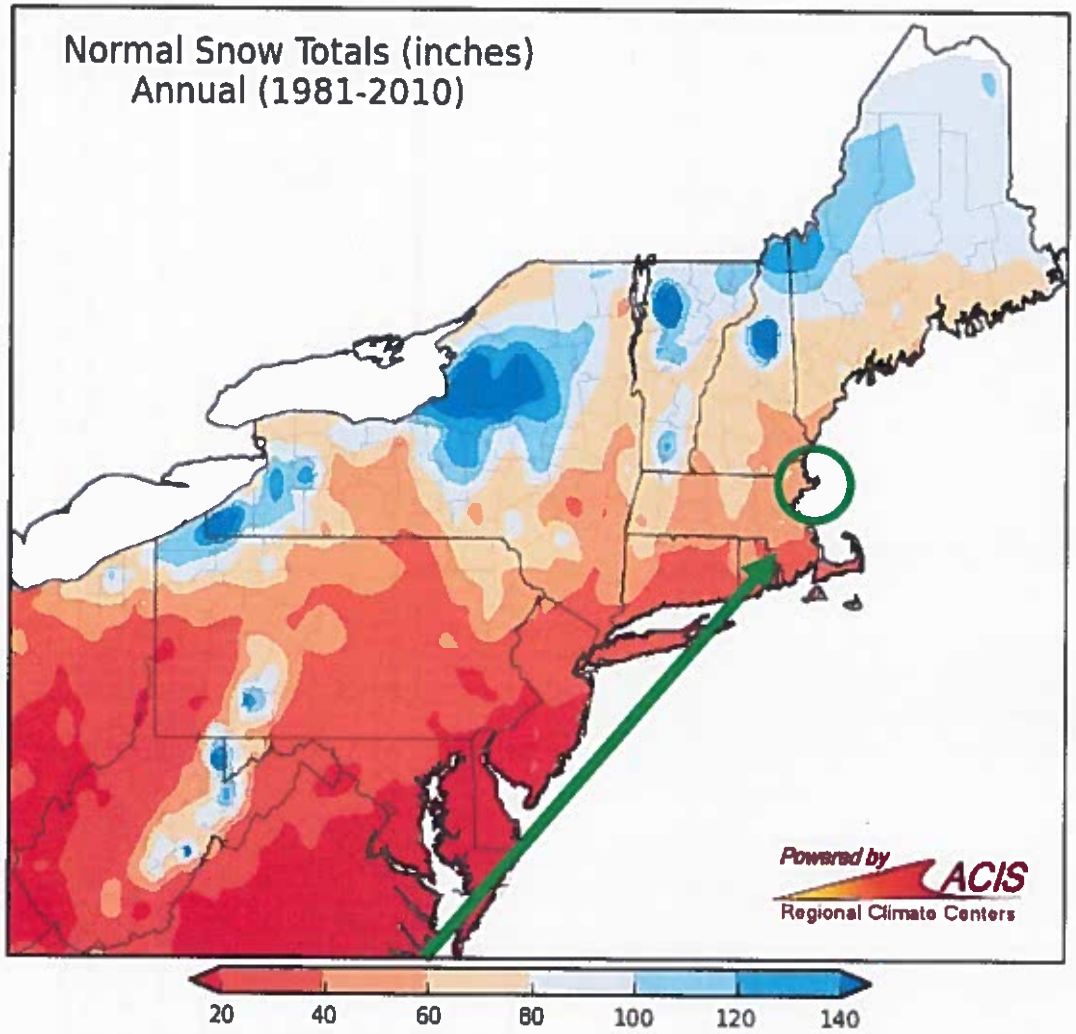
Hazard Ranking Comparison

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Winter Storms	Highly Likely	Large	Negligible	Moderate	High	Significant
Flood	Likely	Small	Critical	High	Medium-High	Significant
Severe Weather (Thunderstorms)	Highly Likely	Small	Negligible	Limited	High	Moderate
Extreme Temperatures	Likely	Isolated	Catastrophic	Negligible	Medium-High	Moderate
Hurricanes	Somewhat Likely	Large	Critical	Moderate	Medium-High	Moderate
Invasive Pests	Likely	Medium	Limited	Negligible	Medium-High	Limited
Tornadoes	Somewhat Likely	Isolated	Catastrophic	Limited	Medium-Low	Limited
Earthquakes	Unlikely	Small	Catastrophic	High	Medium-Low	Limited
Drought	Somewhat Likely	Medium	Negligible	Negligible	Medium-High	Limited
Wildfire	Somewhat Likely	Medium	Negligible	Negligible	Medium-High	Limited

Dewberry

Hazard Profiles

Winter Storm



Source: Northeast Regional Climate Center

194 severe winter weather events in Essex County since 1996:

- Blizzard (3)
- Extreme Cold/Wind Chill (2)
- Heavy Snow (113)
- Ice Storm (1)
- Winter Storm (39)
- Winter Weather (38)

Annualized Occurrence	Annualized Property Damage
8.8	$655,169

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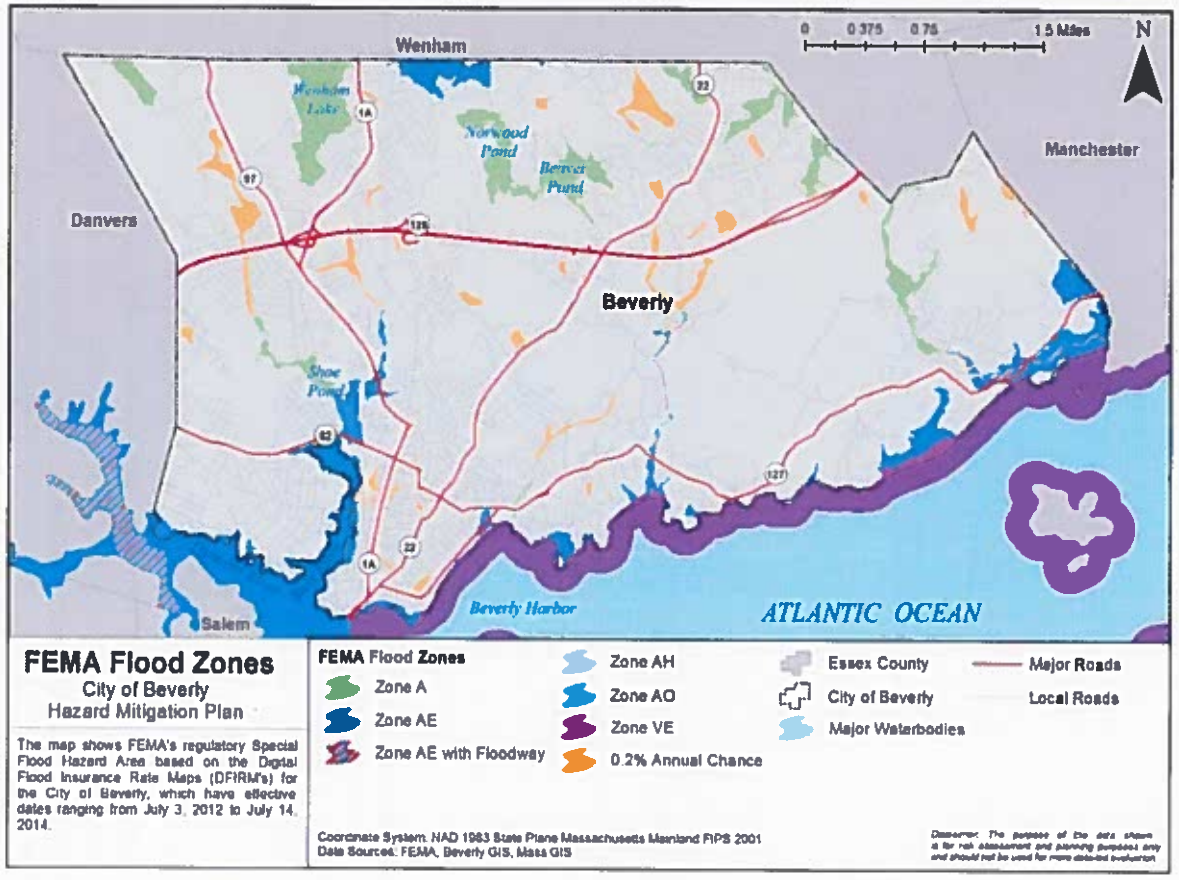
Flooding



130 flood related events reported in Essex County since 1996:

- Coastal Flood (26)
- Flash Flood (25)
- Flood (46)
- Heavy Rain (24)
- Storm Surge/Tide (9)

Annualized Occurrence	Annualized Property Damage	Annualized Deaths	Annualized Injuries
5.91	$2,525,255	0.09	0.14

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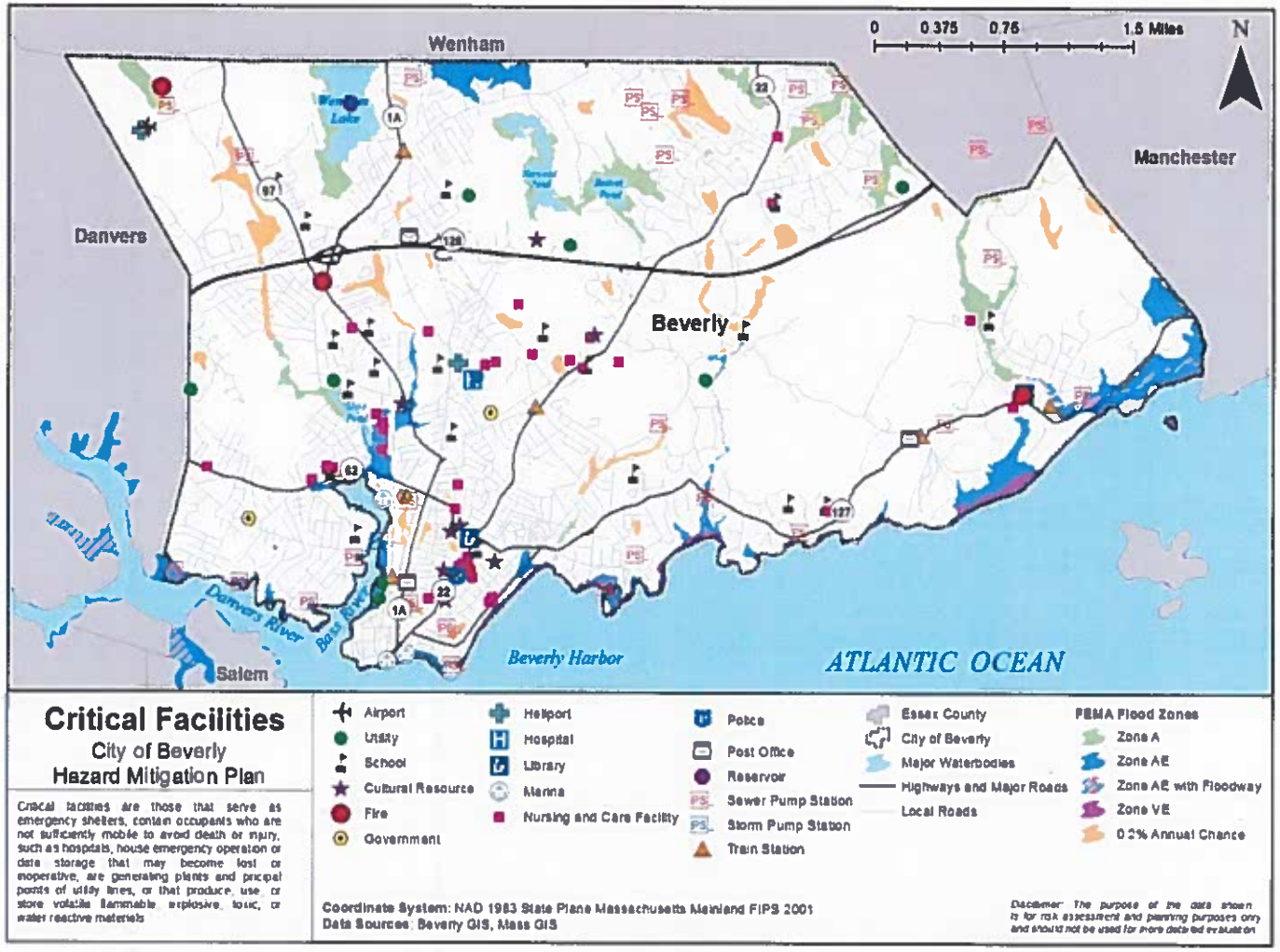
Flooding (continued)



Flood Zone	Count of Critical Facilities
A	3
AE	19
X	148
Total	**170**

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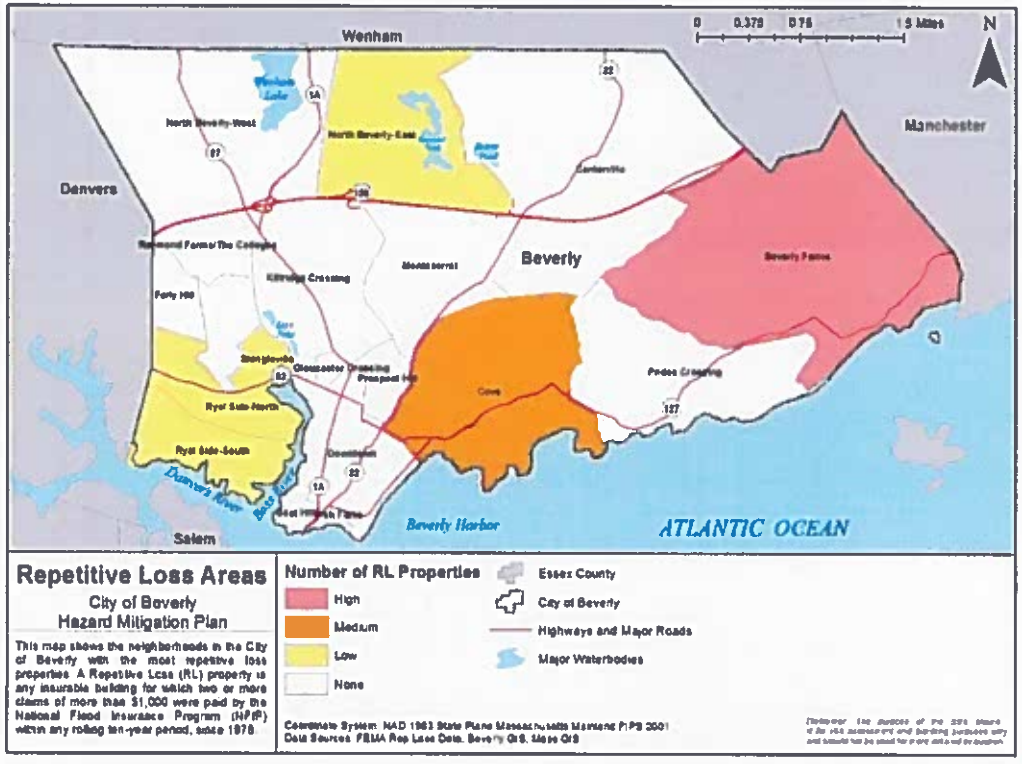
NFIP Statistics and Repetitive Loss

Community Name	Number of Policies	Total Coverage	Total Premium	Total Claims Since 1978	Total Paid since 1978
Beverly, City of	358	$91,416,800	$ 277,974	145	$1,552,558
Essex County	9,931	$2,550,466,700	$ 10,964,803	4,709	$73,398,477



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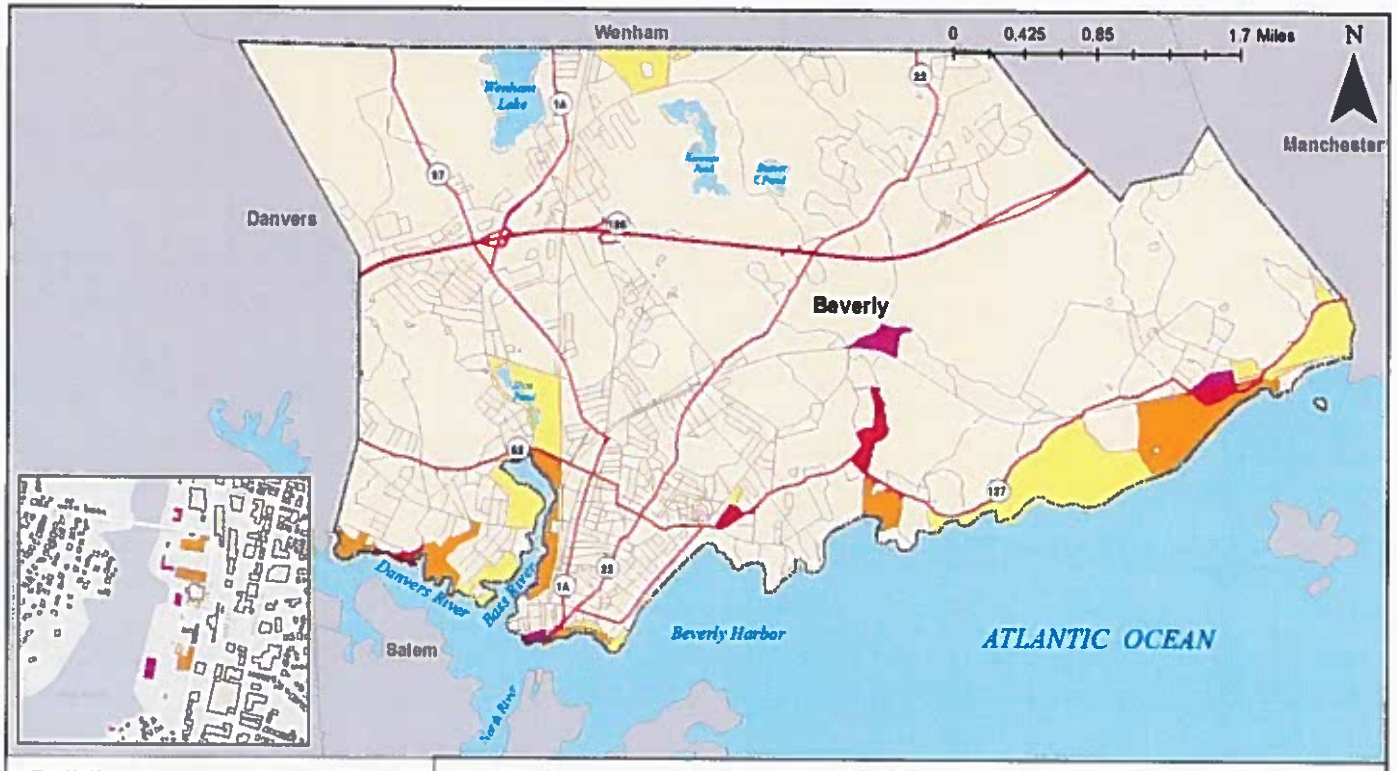
User Defined Facility (UDF) Average Annual Building Loss due to Flood

Summarized at Census Block Level



Building Damage due to Flood

City of Beverly
Hazard Mitigation Plan

The map summarizes and ranks the building loss ratio (total building damage due to flooding divided by total value of asset) by TIGER census block. The inset to the map shows the building loss ratio ranking at the individual building level.

Level of Damage
- Very Low
- Low
- Medium
- High
- Very High

- Major Roads
- Essex County
- City of Beverly
- Major Waterbodies

Coordinate System: NAD 1983 State Plane Massachusetts Mainland FIPS 2001
Data Sources: Hazus, Census, Beverly GIS, Mass GIS

Disclaimer: The purpose of the data shown is for risk assessment and planning purposes only and should not be used for more detailed evaluation

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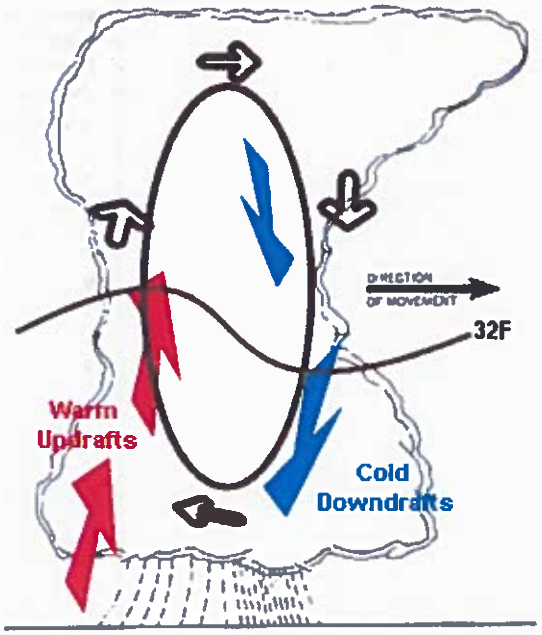
Severe Weather



Formation of Hail (Source: NOAA)

540 severe weather events reported in Essex County since 1957:

- Severe Wind (418)
- Lightning (39)
- Hail (83)

Annualized Occurrence	Annualized Property Damage	Annualized Deaths	Annualized Injuries
8.57	$265,582	0.01	0.73

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HIRA → Informs → Mitigation Strategies

Reduce societal, economic, and environmental exposure to natural hazard impacts

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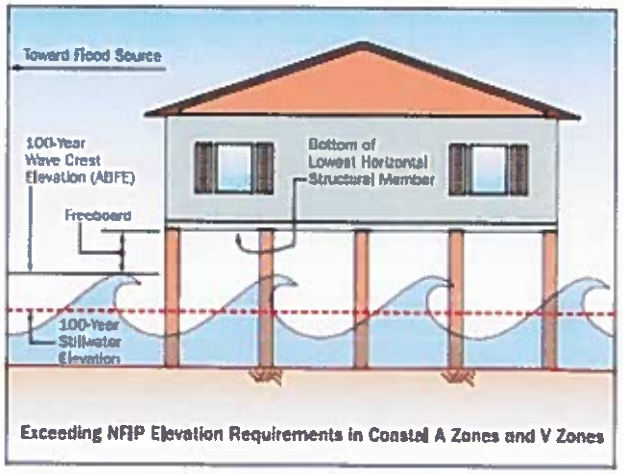
Mitigation Strategy

- **Refer to Sections VI-VIII – Mitigation Action Plan**
  - Completed, Deferred, Ongoing, In Progress, Delete
  - Status report for each action is required
  - FEMA funded projects since last update



FEMA Definition of Hazard Mitigation:
"Any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards."

Next Steps / Questions

- Create new mitigation actions/goals
- Complete draft plan

Scott Choquette
schoquette@dewberry.com
617.531.0750

Dewberry

BEVERLY LOCAL HAZARD MITIGATION PLANNING COMMITTEE MEETING #3

2017 City of Beverly Hazard Mitigation Plan Update
Mitigation Planning Committee Meeting Number 3
Thursday, September 7, 2017 – 1:00 – 3:30 PM
Beverly City Hall, Engineering Department Conference Room

Name	Organization / Address	Email	Telephone
Scott R. Choquette	Dewberry / 280 Summer St, Boston, MA 02210	schoquette@dewberry.com	617.531.0750
Roland Adam	COB	radam@beverlyma.gov	
AARON CLAUSEN	"	aclausen@beverlyma.gov	978.605-2341
Greg St. Louis	COB - Eng	gstlouis@beverlyma.gov	978.605-2360
Mike Collins	COB	mcollins@beverlyma.gov	978-605-2430

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CITY OF BEVERLY 2017 LHMP UPDATE - MEETING AGENDA

Date: September 7, 2017
Time: 1:00 – 3:30 PM
Location: Engineering Conference Room, City Hall
Purpose: LHMPC Milestone Meeting #3
Attendees: Local Hazard Mitigation Planning Team, Dewberry Consultants

Agenda

1. **Quick Overview of Hazard Ranking**
2. **Review / Revisit / Update Goals from 2012 Plan**
3. **Review / Revisit Capability Assessment from 2012 Plan**
4. **Review and Update Status of Mitigation Actions / Strategies from 2012 Plan**
5. **Brainstorm a Range of New Actions / Strategies Addressing Identified Hazards**
6. **Exercise to Rank New Mitigation Actions**
7. **Distribute Mitigation Actions Update / Ideas Follow-Up Assignments**
8. **Next Steps / Meetings and Final Schedule**
    a. **Next full committee meeting to review draft and finalize hazard ranking**
    b. **MEMA delivery for review**

Questions / Answers

Scott Choquette
9/7/2017
Meeting notes

Snow load Roof Collapses

Housing Rehab program
used to Help with w/ new
Look at alternate funds CPA? Housing trust fund Roofs
CDBG must 15 yr. loan

→ Support alternative fuels to reduce carbon footprint.

~~Solar pri~~

Drought

Beverly has Reservoirs.
Surrounding towns don't
enough capacity for
2 years of Source.

- Annual Leak Detection
- Low Flow Fixtures on City.

not included as of 11/8/

More detailed scope

meetings.

Move cases

visits, 3

quick check

phase III

clarify public meetings.

Jim spell out meeting

Aloud

Additional Chubb Brook Improvement

EQ

When pursuing CPA funds for preservation planning & City owned properties consider e.g. vulnerability

ISO coordinator / visit

traffic signal pump system fails alarm says call mike linked to traffic

phase IV

put in writing that reg. material will be referenced to existing inventory

encourage / Educate people on Humidity Sensors on Irrigation

New projects

Pump Stations are prone to flooding.
- use SLR projections for inland flooding alligned w/ 2030/2070 scenarios

→ power outages. wind/ tornado
New generators
- some vulnerable to SLR.
- few.

Seawall needs to be rebuilt
100+ feet - Pershing area
pump station weakest link
drinking water pump station protected

Local drainage upgrades
flood, hurricane (Replace w/)
Crane pier steel piles & concrete deck.
among top 3rd highest catch port in MA
protects fishing

- Buss River is a Safe Harbor
✓ needs dredging
in support of commercial
fishing Industry

- Continue to improve & update
✓ Seawall inventory in coordination
w/ CZM — Done

✓ Dune street Beach Seawall
improvement

- Winter Storm — wind power / Trees —
tree truck 20yrs old
chipper 20yrs old
✓ City property only.

No private tree hazard assessment
at all. — Natural Gas
does it

Lightning Rods for Harbor master
House ✓

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City of Beverly
Hazard Mitigation Plan Update
Local Hazard Mitigation Planning Committee

Mitigation Goals / Strategy Review and Development Meeting

September 7th, 2017

Agenda

1. Quick Overview of Hazard Ranking
2. Review / Revisit / Update Goals from 2012 Plan
3. Review / Revisit Capability Assessment from 2012 Plan
4. Review and Update Status of Mitigation Actions / Strategies from 2012 Plan
5. Brainstorm a Range of New Actions / Strategies Addressing Identified Hazards
6. Exercise to Rank New Mitigation Actions
7. Distribute Mitigation Actions Update / Ideas Follow-Up Assignments
8. Next Steps / Meetings and Final Schedule

Hazard Priority Ranking Criteria
New for 2017 Plan Update

- **Probability**: likelihood of occurrence from historical data.
- **Affected Area**: size of geographical area of community affected by hazard
- **Primary Impact**: percent of damage to typical facility in the community
- **Secondary Impact**: hazard impacts to economy and community health
- **Community Survey Rating**: community's perceived risk in terms of hazards impacting the survey responders' home and neighborhood.

Hazard Priority Ranking Criteria

Probability	Affected Area	Primary Impact	Secondary Impact	Community Survey Rating
Weighting: 2	*Weighting: 0.5*	*Weighting: 0.8*	*Weighting: 0.7*	*Weighting: 1.0*
Unlikely *Less than 1% probability in next 100 years or has a recurrence interval of greater than every 100 years.*	**Isolated** *Less than 1% of area affected*	**Negligible** *Less than 10% damage*	**Negligible** *No loss of function, downtime, and/or evacuations*	**Low** *No perceived threat to neighborhood or home*
Somewhat Likely *Between 1 and 10% probability in next year or has a recurrence interval of 11 to 100 years.*	**Small** *Between 1 and 10% of area affected*	**Limited** *Between 10% and 25% damage*	**Limited** *Minimal loss of function, downtime, and/or evacuations*	**Medium-Low** *Minimal perceived threat to neighborhood or home*
Likely *Between 10 and 100% probability in next year or has a recurrence interval of 10 years or less.*	**Medium** *Between 10 and 50% of area affected*	**Critical** *Between 25% and 50% damage*	**Moderate** *Some loss of function, downtime, and/or evacuations*	**Medium-High** *Some perceived threat to neighborhood or home*
Highly Likely *Near 100% probability in next year or happens every year.*	**Large** *Between 50 and 100% of area affected*	**Catastrophic** *More than 50% damage*	**High** *Major loss of function, downtime, and/or evacuations*	**High** *Major perceived threat to neighborhood or home*

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Ranking 2012 Plan Update

Table 6. Hazard Risks Summary (2012 Plan)		
Hazard	**Frequency**	**Severity**
Flooding	High	Serious
Winter storms	High	Serious
Hurricanes	Medium	Serious
Earthquakes	Low	Extensive
Tornadoes	Low	Serious
Landslides	Low	Minor
Brush fires	Medium	Minor
Dam failures	Low	Serious

HIRA → inform → Mitigation Strategy

- Reduce societal, economic, and environmental exposure to hazard impacts
- Comprehensive range of actions and projects that address all identified hazards
- Ranked
- "Ongoing" no longer allowed

Hazard Ranking Comparison

Hazard Type	Probability	Impact			Community Survey Ranking	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Winter Storms	Highly Likely	Large	Negligible	Moderate	High	Significant
Flood	Likely	Small	Critical	High	Medium-High	Significant
Severe Weather (Thunderstorms)	Highly Likely	Small	Negligible	Limited	High	Moderate
Extreme Temperatures	Likely	Isolated	Catastrophic	Negligible	Medium-High	Moderate
Hurricanes	Somewhat Likely	Large	Critical	Moderate	Medium-High	Moderate
Tornadoes	Somewhat Likely	Isolated	Catastrophic	Limited	Medium-Low	Limited
Earthquakes	Unlikely	Small	Catastrophic	High	Medium-Low	Limited
Drought	Somewhat Likely	Medium	Negligible	Negligible	Medium-High	Limited
Wildfire	Somewhat Likely	Medium	Negligible	Negligible	Medium-High	Limited

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Definitions

Goal: general guidelines that describes what planning region would like to achieve

Objective: specific and measurable strategies that must be implemented to achieve the identified goals

Action: more specific than an objective with identified responsible parties, timeframes, and potential funding sources

Goals – 2012 HMP Update

- Ensure that critical infrastructure sites are protected from natural hazards.
- Protect existing residential and business areas from flooding.
- Maintain existing mitigation infrastructure in good condition.
- Continue to enforce existing zoning and building regulations.

— compensatory ~~flood~~ storage.

1) strengthen Regs building in FP Requires special permit

Re-evaluate

2) explore zoning Regs to add freeboard to deal w/ SLR climate CA

Salem Con Comm

Aaron Ang > LW prohibits.

Require Humanity for SLR

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Goals – 2012 HMP Update

– Ensure properties going through permit process non-conforming

- Educate the public about zoning and building regulations, particularly with regard to changes in regulations that may affect tear-downs and new construction. – Educate around A's in Regs should they occur

Build in mitigation

- Work with surrounding communities to ensure regional cooperation and solutions for hazards affecting multiple communities such as coastal erosion.

– Bass River overlay District

– Solar installation

SMC (Create overarching goals,

Goals – 2012 HMP Update

- Encourage future development to be resilient & less prone to natural hazards. ~~in areas that are not prone to natural hazards~~. Bass River Preserve is contrary,
- Educate the public about natural hazards and mitigation measures.
- Make efficient use of public funds for hazard mitigation.
- Ensure city remains resilient and able to... ~~Protect the~~ City's ability to respond to various natural hazard events.

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2012 Mitigation Actions Status Review

- Assignment: Look these over; amend, correct and complete.
- Add an explanation in the Notes column of why any "high" priority strategy was not completed or was "discontinued."

Mitigation Actions

- Preventative Measures
- Property Protection
- Emergency Services
- Structural Projects
- Natural Resources Protection
- Public Information Programs

2017 – 2022 Actions

- 2012 "Carry-forward" actions
- Actions must include:
  - **Strategy/action statement**
  - **Responsible Department**
  - **Priority**
  - **Goals supported (Dewberry will align to Goals)**
  - **Hazard Addressed**
  - **Timeframe**
  - **Resources – funding source, staff, etc.**
  - **Check the project category box (or Dewberry will complete)**

What's Next?

- 2012 Mitigation Action Status to Beverly by September 15th
- 2017 – 2022 Mitigation Actions to Full Committee Review Meeting to finalize Ranking
- Draft Plan to Beverly and Committee by October 5th
- Final Pre-Adoption Public / Stakeholder Involvement
  - discuss
- Submittal to MEMA by October 25th

BEVERLY LOCAL HAZARD MITIGATION PLANNING COMMITTEE MEETING #4

2017 City of Beverly Hazard Mitigation Plan Update
Mitigation Planning Committee Meeting Number 4 –Core Group
Wednesday, November 8, 2017 – 2:00 – 4:30 PM
Beverly City Hall

Name	Organization / Address	Email	Telephone
Scott R. Choquette	Dewberry / 280 Summer St, Boston, MA 02210	schoquette@dewberry.com	617.531.0750
Peter Garvey	Dewberry / 280 Summer St, Boston, MA 02210	pgarvey@dewberry.com	617.531.0760
Richard Atkins	CFJB	ratkins@beverly ma.gov	977
Barbara Warren	12 Federal St.	barbara.warren @salemsound.org	978-741-7900
Amy MAXNER	City of BEVERLY	AMAXNER BEVERLYMA.GOV	978-605-2345
AARON CLAWSON	CITY OF BEVERLY	aclawson@beverly ma.gov	x. 2391

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CITY OF BEVERLY 2017 LHMP UPDATE - MEETING AGENDA

Date: November 8, 2017
Time: 2:00 – 4:30 PM
Location: Engineering Conference Room, City Hall
Purpose: LHMPC Core Group Meeting #4
Attendees: Local Hazard Mitigation Planning Team, Dewberry Consultants

Agenda

1. **Review of Plan Sections**
2. **Mitigation Strategy Development and Ranking**
    a. **Strategy Brainstorming**
    b. **Ranking Exercise**
3. **Stakeholder review approach**
4. **Public review approach**
5. **Next Steps**

BEVERLY LOCAL HAZARD MITIGATION PLANNING COMMITTEE MEETNG #5

2018 City of Beverly Hazard Mitigation Plan Update
Mitigation Planning Committee Meeting Number 5 – Full Stakeholder Group
Thrusday, May 24, 2018 – 1:00 – 3:00 PM
Beverly City Hall

Name	Organization / Address	Email	Telephone
Scott R. Choquette	Dewberry / 280 Summer St, Boston, MA 02210	schoquette@dewberry.com	617.531.0750
Roland Adams			
Peter O'Connor	BFD	Poconnore@beverlyma.gov	978 778 8352
Amy MAXNER	PLANNING DEPT.	AMAXNER@BEVERLYMA.GOV	978-605-2345
AARON CLAUSEN	"	aclausen@beverlyma.gov	978-605-2341
Mike Collins	DPS	mcollins@beverlyma.gov	978-605-2430

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CITY OF BEVERLY 2018 LHMP UPDATE - MEETING AGENDA

Date: May 24, 2018
Time: 1:00 – 3:00 PM
Location: City Hall – Conference Room B
Purpose: LHMPC Full Stakeholder Group Meeting #5
Attendees: Local Hazard Mitigation Planning Team, Dewberry Engineers

Agenda

1. **Brief Review of Plan Sections**
2. **Mitigation Strategy Development Review and Ranking**
    a. **STAPLE/E Review**
    b. **Additional Strategy Brainstorming**
    c. **Ranking Exercise**
3. **Discussion of Final Stakeholder / Public Review Approach**
4. **Next Steps Toward Approval**

THIS WILL BE THE FINAL IN PERSON COMMITTEE MEETING, BARRING ANY SIGNIFICANT CHANGES THE REVIEWERS MAY REQUIRE NEEDING YOUR INPUT.

STAPLEE Criteria Worksheet

S Social	• Is the proposed action socially acceptable to the community(s)? • Are there equity issues involved that would mean that one segment of a community is treated unfairly? • Will the action cause social disruption?
T Technical	• Will the proposed action work? • Will it create more problems than it solves? • Does it solve a problem or only a symptom? • Is it the most useful action in light of other community(s) goals?
A Administrative	• Can the community(s) implement the action? • Is there someone to coordinate and lead the effort? • Is there sufficient funding, staff, and technical support available? • Are there ongoing administrative requirements that need to be met?
P Political	• Is the action politically acceptable? • Is there public support both to implement and to maintain the project?
L Legal	• Is the community(s) authorized to implement the proposed action? Is there a clear legal basis or precedent for this activity? • Are there legal side effects? Could the activity be construed as a taking? • Is the proposed action allowed by a comprehensive plan, or must a comprehensive plan be amended to allow the proposed action? • Will the community(s) be liable for action or lack of action? • Will the activity be challenged?
E Environmental	• How will the action affect the environment? • Will the action need environmental regulatory approvals? • Will it meet local and state regulatory requirements? • Are endangered or threatened species likely to be affected?
E Economic	• What are the costs and benefits of this action? • Do the benefits exceed the costs? • Are initial, maintenance, and administrative costs taken into account? • Has funding been secured for the proposed action? If not, what are the potential funding sources (public, non-profit, and private)? • How will this action affect the fiscal capability of the community(s)? • What burden will this action place on the tax base or local economy? • What are the budget and revenue effects of this activity? • Does the action contribute to other community goals, such as capital improvements or economic development? • What benefits will the action provide?

Worksheet #4 Evaluate Alternative Mitigation Actions step 2

1. *Fill in the goal and its corresponding objective. Use a separate worksheet for each objective. The considerations under each criterion are suggested ones to use; you can revise these to reflect your own considerations (see Table 2-1).*
2. *Fill in the alternative actions that address the specific objectives the planning team identified in Worksheet #1.*
3. *Scoring: For each consideration, indicate a plus (+) for favorable, and a negative (-) for less favorable.*

When you complete the scoring, negatives will indicate gaps or shortcomings in the particular action, which can be noted in the Comments section. For considerations that do not apply, fill in N/A for not applicable. Only leave a blank if you do not know an answer. In this case, make a note in the Comments section of the "expert" or source to consult to help you evaluate the criterion.

Goal: _____

Objective: _____

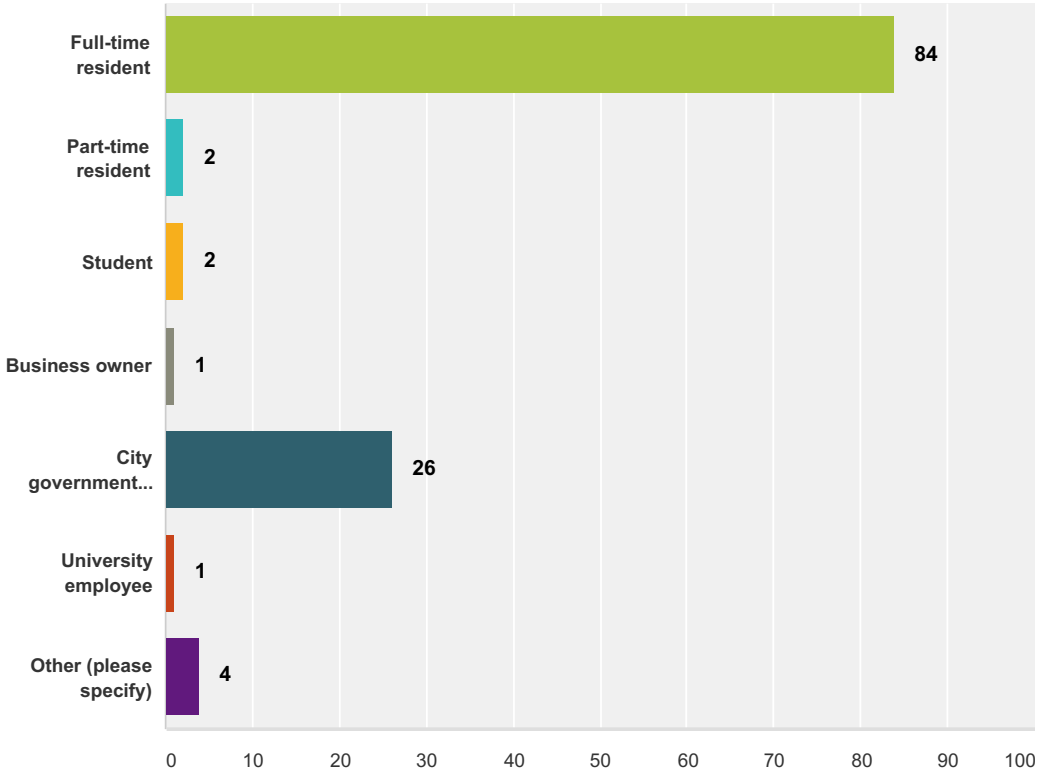
STAPLEE Criteria	S (Social)		T (Technical)			A (Administrative)			P (Political)			L (Legal)			E (Economic)				E (Environmental)				
Considerations → for Alternative Actions ↓	Community Acceptance	Effect on Segment of Population	Technical Feasibility	Long-term Solution	Secondary Impacts	Staffing	Funding Allocated	Maintenance/ Operations	Political Support	Local Champion	Public Support	State Authority	Existing Local Authority	Potential Legal Challenge	Benefit of Action	Cost of Action	Contributes to Economic Goals	Outside Funding Required	Effect on Land/ Water	Effect on Endangered Species	Effect on HAZMAT/ Waste Sites	Consistent with Community Environmental Goals	Consistent with Federal Laws

Source: **Federal Emergency Management Agency. 2003.** ***State and Local Mitigation Planning How-To Guide: Developing the Mitigation Plan – Identifying Mitigation Actions and Implementation Strategies.*** **FEMA.** http://www.fema.gov/fima/planning_howto3.shtm

Appendix B – Public Survey Results

Q1 What is your affiliation to the City of Beverly? (check all that apply)

Answered: 96 Skipped: 0

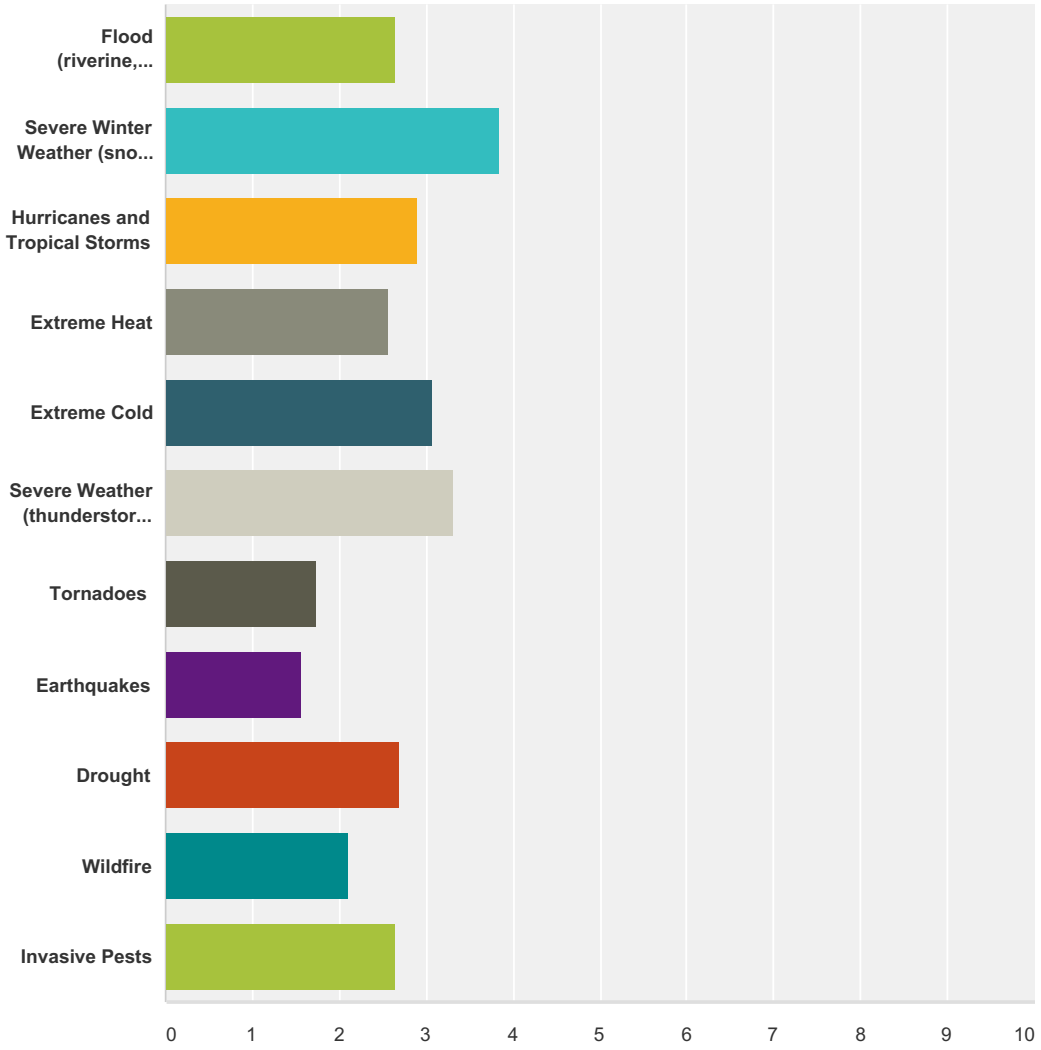


Answer Choices	Responses	
Full-time resident	**87.50%**	84
Part-time resident	**2.08%**	2
Student	**2.08%**	2
Business owner	**1.04%**	1
City government employee	**27.08%**	26
University employee	**1.04%**	1
Other (please specify)	**4.17%**	4
Total Respondents: 96		

#	Other (please specify)	Date
1	Planning Board, CPC	3/14/2017 3:13 PM
2	City employee	3/13/2017 12:43 PM
3	City Human Rights Committee	3/1/2017 1:53 PM
4	Human Rights Committee	3/1/2017 1:46 PM

Q2 Please rate each of the following hazards on a scale of 1 (low) to 5 (high) indicating the level of threat each presents to your neighborhood or home.

Answered: 89 Skipped: 7

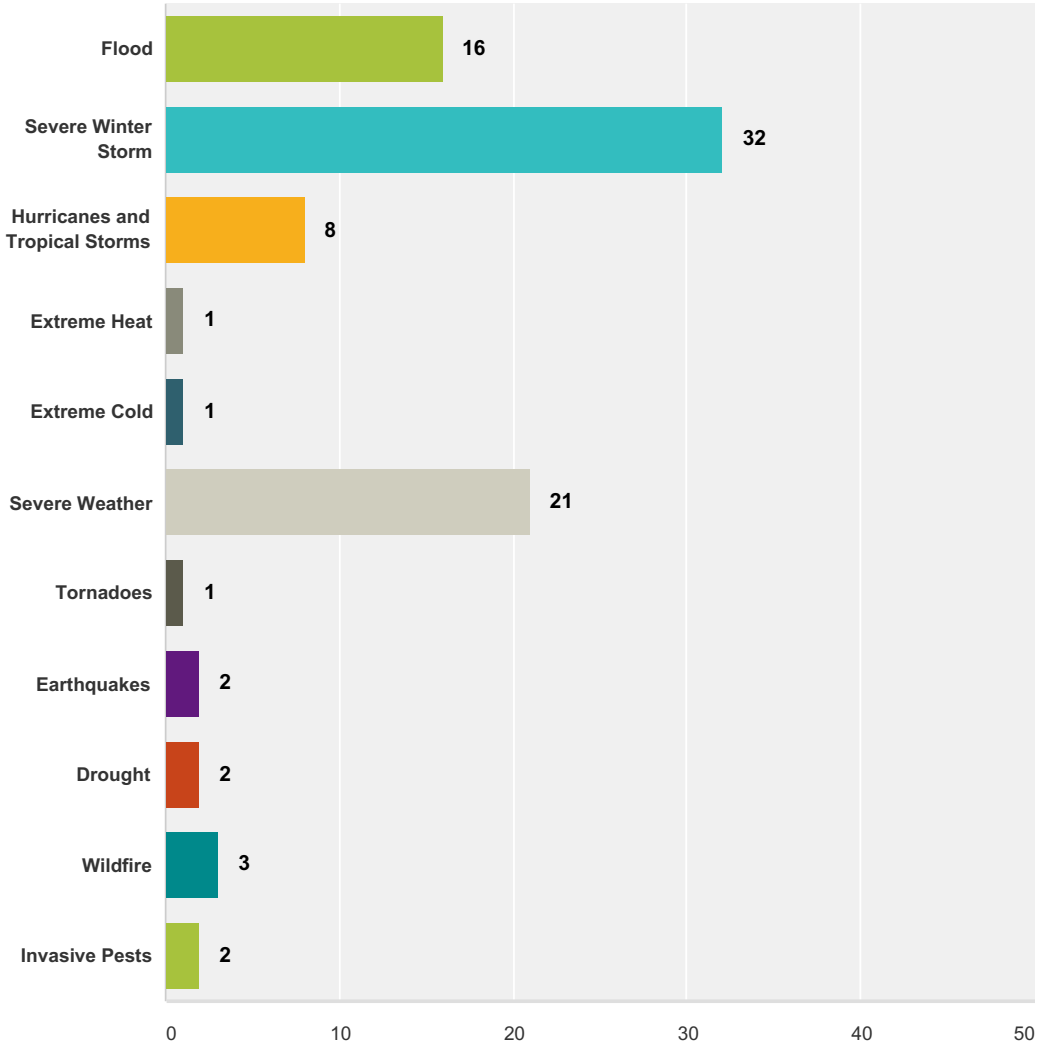


	Low	Medium-Low	Medium	Medium-High	High	Total	Weighted Average
Flood (riverine, drainage, coastal storm surge, sea level rise)	**22.47%** 20	**25.84%** 23	**23.60%** 21	**19.10%** 17	**8.99%** 8	89	2.66
Severe Winter Weather (snow, blizzard, ice, nor'easters)	**2.25%** 2	**8.99%** 8	**23.60%** 21	**31.46%** 28	**33.71%** 30	89	3.85
Hurricanes and Tropical Storms	**14.61%** 13	**22.47%** 20	**31.46%** 28	**20.22%** 18	**11.24%** 10	89	2.91
Extreme Heat	**15.73%** 14	**37.08%** 33	**28.09%** 25	**12.36%** 11	**6.74%** 6	89	2.57
Extreme Cold	**7.87%** 7	**29.21%** 26	**26.97%** 24	**21.35%** 19	**14.61%** 13	89	3.06

Severe Weather (thunderstorms, lightening, hail, high wind)	**3.37%** 3	**20.22%** 18	**33.71%** 30	**26.97%** 24	**15.73%** 14	89	3.31
Tornadoes	**55.06%** 49	**22.47%** 20	**17.98%** 16	**2.25%** 2	**2.25%** 2	89	1.74
Earthquakes	**67.42%** 60	**15.73%** 14	**12.36%** 11	**2.25%** 2	**2.25%** 2	89	1.56
Drought	**17.98%** 16	**25.84%** 23	**33.71%** 30	**14.61%** 13	**7.87%** 7	89	2.69
Wildfire	**38.20%** 34	**26.97%** 24	**23.60%** 21	**7.87%** 7	**3.37%** 3	89	2.11
Invasive Pests	**17.98%** 16	**25.84%** 23	**35.96%** 32	**12.36%** 11	**7.87%** 7	89	2.66

Q3 Which hazard poses the greatest risk to Beverly?

Answered: 89 Skipped: 7

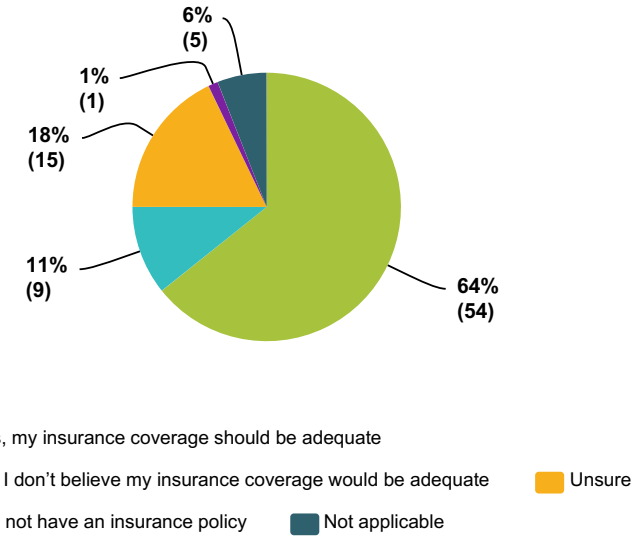


Answer Choices	Responses	
Flood	17.98%	16
Severe Winter Storm	35.96%	32
Hurricanes and Tropical Storms	8.99%	8
Extreme Heat	1.12%	1
Extreme Cold	1.12%	1
Severe Weather	23.60%	21
Tornadoes	1.12%	1
Earthquakes	2.25%	2
Drought	2.25%	2

Wildfire	**3.37%**	3
Invasive Pests	**2.25%**	2
Total		**89**

Q4 If you are a homeowner, do you have adequate basic homeowners insurance to cover the hazards that could impact your home?

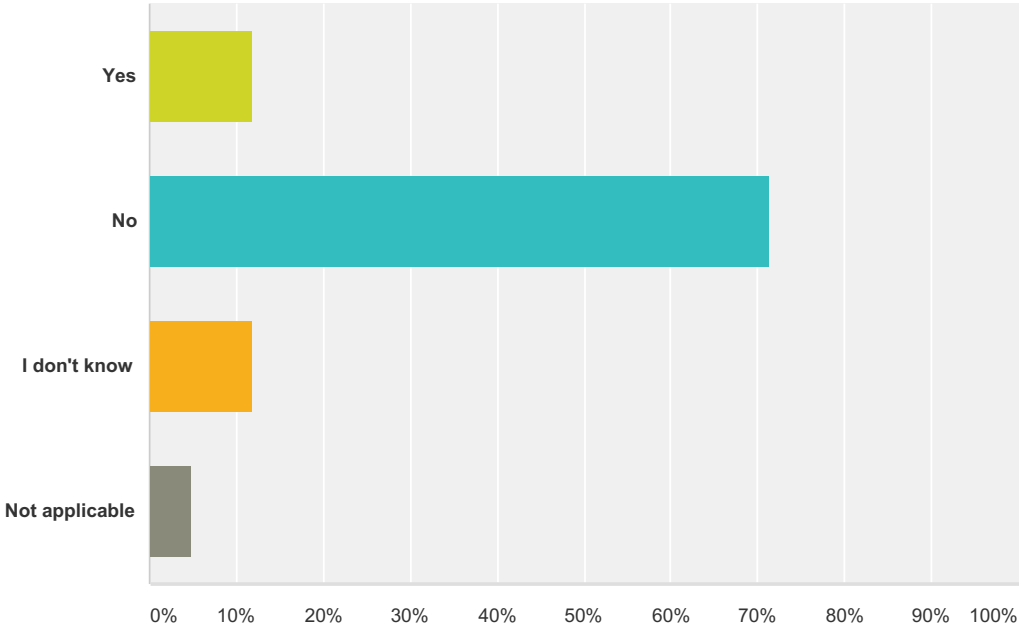
Answered: 84 Skipped: 12



Answer Choices	Responses	
Yes, my insurance coverage should be adequate	**64%**	54
No, I don't believe my insurance coverage would be adequate	**11%**	9
Unsure	**18%**	15
I do not have an insurance policy	**1%**	1
Not applicable	**6%**	5
Total		**84**

Q5 Do you have any other insurance? (e.g., flood, subsidence, etc.)

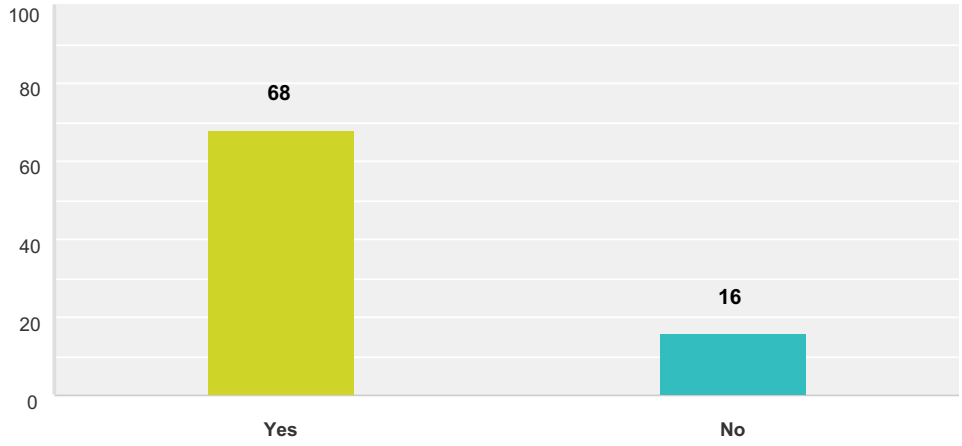
Answered: 84 Skipped: 12



Answer Choices	Responses	
Yes	**11.90%**	10
No	**71.43%**	60
I don't know	**11.90%**	10
Not applicable	**4.76%**	4
Total		**84**

Q6 Did you know that most standard homeowner's insurance policies do not cover rising water (flooding) or minor subsidence (sinkhole)?

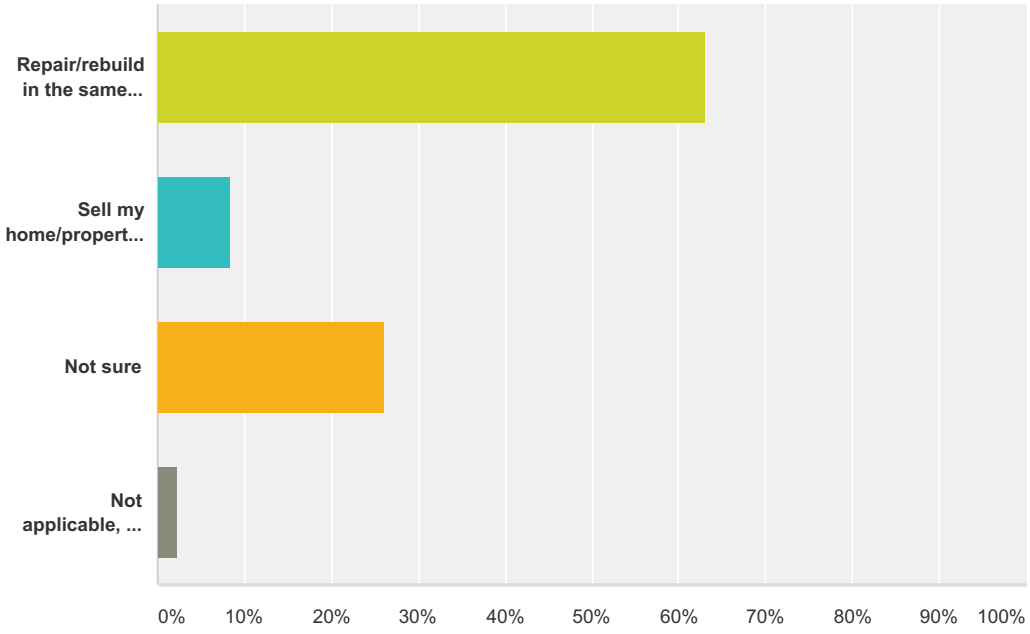
Answered: 84 Skipped: 12



Answer Choices	Responses	
Yes	80.95%	68
No	19.05%	16
Total		84

Q7 If you are a homeowner and a disaster substantially damaged your home, which of the following would be the most likely option you would pursue?

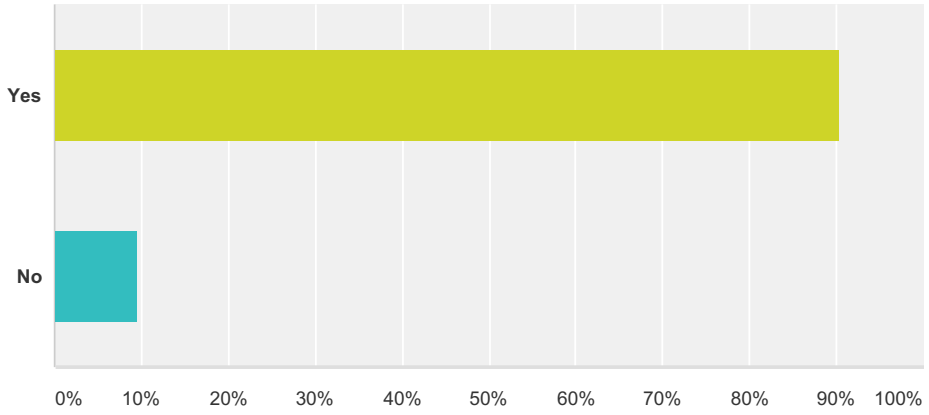
Answered: 84 Skipped: 12



Answer Choices	Responses	
Repair/rebuild in the same location to current building code standards	**63.10%**	53
Sell my home/property and relocate	**8.33%**	7
Not sure	**26.19%**	22
Not applicable, I rent my current residence	**2.38%**	2
Total		**84**

Q8 Are you aware that you would have to comply with local/state codes, ordinances and laws that would require permits and affect rebuilding and recovery in the wake of a disaster?

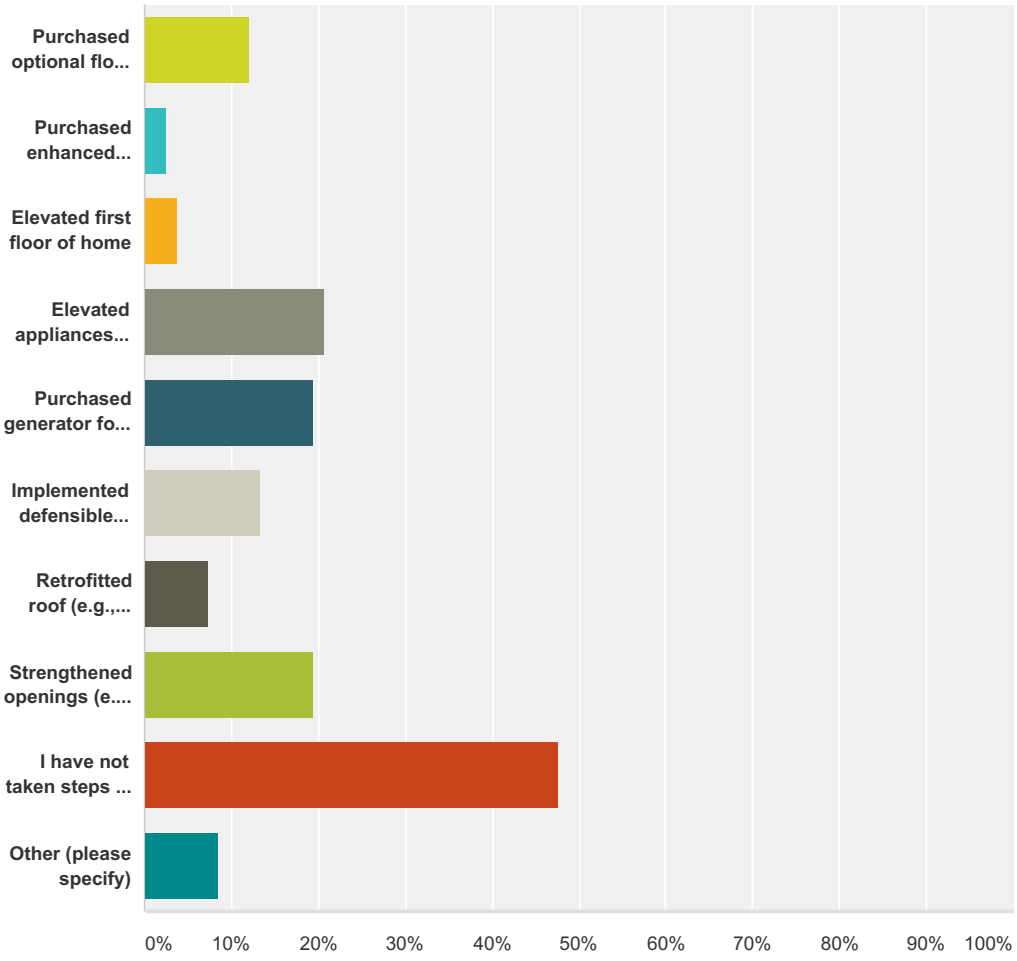
Answered: 84 Skipped: 12



Answer Choices	Responses	
Yes	**90.48%**	76
No	**9.52%**	8
Total		**84**

Q9 What have you done to reduce risk of damage from natural and human-caused hazards? (choose all that apply)

Answered: 82 Skipped: 14



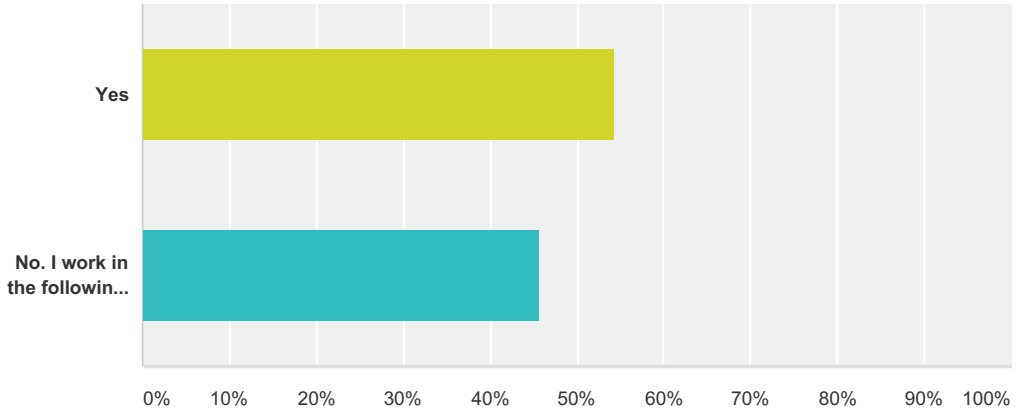
Answer Choices	Responses	
Purchased optional flood insurance	**12.20%**	10
Purchased enhanced homeowner insurance coverage (sinkhole, additional wind coverage)	**2.44%**	2
Elevated first floor of home	**3.66%**	3
Elevated appliances (i.e., hot water heater) or mechanical systems (i.e., air conditioning)	**20.73%**	17
Purchased generator for home	**19.51%**	16
Implemented defensible space landscaping (clear vegetation around house to reduce wildfire risk)	**13.41%**	11
Retrofitted roof (e.g., fire resistant shingles, hurricane brackets, etc)	**7.32%**	6
Strengthened openings (e.g., doors, windows, and/or garage door to reduce high-hazard wind risk)	**19.51%**	16
I have not taken steps to reduce my risk of damage from natural and human-caused hazards	**47.56%**	39
Other (please specify)	**8.54%**	7

Total Respondents: 82	

#	Other (please specify)	Date
1	increased pest control due to road construction and significant construction of large project in our neighborhood.	3/21/2017 3:52 PM
2	Sump pumps	3/17/2017 12:42 PM
3	French drain	3/6/2017 12:42 PM
4	drought resistant plantings, enhanced drainage, areas for securing outdoor items to reduce flying objects,	3/2/2017 5:47 PM
5	Two sump pumps in basement- one with battery backup	3/2/2017 5:09 PM
6	2 sump pumps with backup battery.	3/2/2017 9:28 AM
7	the family before us took care to equip the home with many safety features, but we are not very attentive to these issues and know we should be better.	3/1/2017 1:55 PM

Q10 Do you work in the City of Beverly?

Answered: 81 Skipped: 15



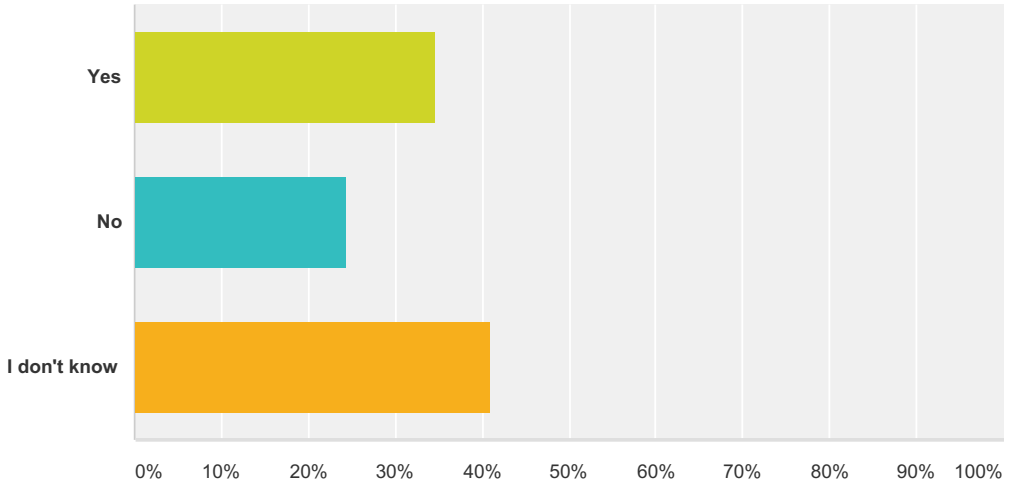
Answer Choices	Responses	
Yes	**54.32%**	44
No. I work in the following zip code:	**45.68%**	37
Total		**81**

#	No. I work in the following zip code:	Date
1	01923	3/24/2017 4:05 PM
2	02116	3/22/2017 8:05 AM
3	01923	3/19/2017 12:41 PM
4	01945	3/18/2017 2:50 PM
5	02114	3/17/2017 12:58 PM
6	03054	3/17/2017 12:44 PM
7	01923	3/16/2017 7:37 PM
8	02142	3/16/2017 8:33 AM
9	01845	3/14/2017 3:18 PM
10	02135	3/12/2017 10:06 AM
11	02176	3/10/2017 12:21 PM
12	01960	3/8/2017 1:20 PM
13	01945	3/6/2017 5:08 PM
14	retired	3/6/2017 4:35 PM
15	00000	3/6/2017 2:24 PM
16	02180	3/6/2017 12:44 PM
17	02114	3/6/2017 12:39 PM
18	01970	3/6/2017 12:28 PM
19	02110	3/4/2017 11:32 AM
20	01984	3/2/2017 11:48 PM

21	retired	3/2/2017 5:48 PM
22	01902	3/2/2017 5:09 PM
23	01937	3/2/2017 1:13 PM
24	retired	3/2/2017 11:11 AM
25	01864	3/2/2017 10:57 AM
26	03054	3/2/2017 9:30 AM
27	01923	3/2/2017 9:24 AM
28	01945	3/2/2017 8:47 AM
29	Homemaker	3/1/2017 2:30 PM
30	01938	3/1/2017 2:29 PM
31	not applicable	3/1/2017 2:15 PM
32	work from home consulting for washington dc	3/1/2017 1:55 PM
33	01982	3/1/2017 1:49 PM
34	02114	3/1/2017 1:28 PM
35	02114	3/1/2017 1:22 PM
36	bbbbbbbbbbbbbbbbbb	3/1/2017 12:40 PM
37	99978	2/23/2017 4:08 PM

Q11 If you answered "yes" to Question 10: Does your employer have a plan for disaster recovery in place?

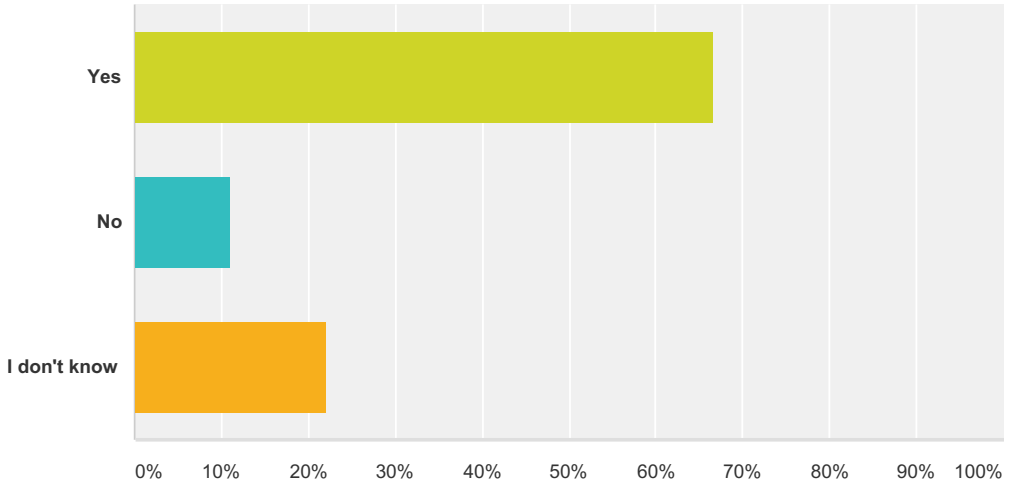
Answered: 49 Skipped: 47



Answer Choices	Responses	
Yes	**34.69%**	17
No	**24.49%**	12
I don't know	**40.82%**	20
Total		**49**

Q12 If you answered "yes" to Question 10: Does your employer have a means of getting in touch with you following a disaster?

Answered: 45 Skipped: 51



Answer Choices	Responses	
Yes	**66.67%**	30
No	**11.11%**	5
I don't know	**22.22%**	10
Total		**45**

Q13 What one action could the City of Beverly take to reduce the long-term impact of disasters to the community?

Answered: 72 Skipped: 24

#	Responses	Date
1	Pre-incident planning.	3/25/2017 2:25 PM
2	More trained professionals. Firefighters and police	3/24/2017 4:06 PM
3	How would I know?	3/22/2017 8:08 AM
4	Over the years, development has been allowed in wet areas and/or filled land. I would Support a program to fix drainage across all wards.	3/19/2017 12:44 PM
5	Do what we can to reduce our carbon footprint and therefore global warming by instituting better recycling practices and diverting more waste. In addition, we should insert screens in our storm drains to capture trash. This will help keep the drains open and clear.	3/18/2017 2:55 PM
6	Best practices in planning, communication	3/17/2017 2:21 PM
7	We need a plan in place to deal with rising sea levels.	3/17/2017 12:59 PM
8	Drainage systems	3/17/2017 12:46 PM
9	increase emergency response time such as fire fighters	3/16/2017 7:38 PM
10	upgrade and increase personnel and equipment	3/16/2017 6:29 PM
11	Trim trees along roads to prevent power outages and cut down dead or dying trees	3/16/2017 5:18 PM
12	More Fire department personal to protect the citizens from fire and natural disasters.	3/16/2017 3:59 PM
13	Ensure that the City is fully staffed with fire/police and other necessary resources, i.e. appropriate equipment & personnel, etc. to respond to disasters.	3/16/2017 9:09 AM
14	Keep storm drains clear and repaired, trim city-owned trees	3/16/2017 8:36 AM
15	Education of the public	3/14/2017 4:22 PM
16	Identify and mitigate areas with greatest exposure to storm surge and rising water levels	3/14/2017 3:19 PM
17	In our area we advocated for a berm to prevent ocean flooding but the check valve that was recommended by engineers was never installed & storm drain flooding occurs with high tides during storms.	3/13/2017 5:13 PM
18	Educate city workers and the community with coherent and easily accessible disaster plan	3/13/2017 12:48 PM
19	Prevention.	3/13/2017 10:37 AM
20	Improve stormwater management and flood/high-water control measures in susceptible areas.	3/13/2017 10:28 AM
21	More education on retrofit/preparedness financing options available to homeowners, similar to the MassSave program we are constantly hearing about that encouraged us to do a home energy assessment and take action to improve our heating system.	3/12/2017 10:09 AM
22	Climate change legislative	3/10/2017 7:36 PM
23	Review building codes to insure buildings are able to withstand potential disaster situations	3/10/2017 12:26 PM
24	Be more informative in planning process for people to step forward with knowledge.	3/10/2017 12:22 PM
25	aggressive tree removal/pruning	3/10/2017 11:54 AM
26	They can get more personal to get the job done. But not just any. Ones that actually work and not stand around watch the other ones do it.	3/8/2017 1:23 PM
27	Continue flood mitigation activities	3/8/2017 11:01 AM
28	Preventive maintenance of city infrastructure	3/7/2017 5:57 PM

29	Make sure a fire and police are at full complement	3/6/2017 5:15 PM
30	Make sure we have a full complement of fire personnel and police personnel	3/6/2017 5:09 PM
31	updated information on city web site or through outreach (e.g., twitter or phone tree)	3/6/2017 4:35 PM
32	.	3/6/2017 4:09 PM
33	put power and tele lines under ground	3/6/2017 2:26 PM
34	Help with more personnel i.e. Firefighters police officers etc. trained professionals to aid in relief	3/6/2017 2:06 PM
35	Increase # of first responders	3/6/2017 1:49 PM
36	Better comms system	3/6/2017 12:40 PM
37	increase in first responders	3/6/2017 12:29 PM
38	I would like to see the city add more first responders in case of disasters. Our community is dangerously low compared to other cities in this aspect.	3/6/2017 12:29 PM
39	Increase emergency response personnel and resources	3/6/2017 12:16 PM
40	Increase the number of emergency responders.	3/6/2017 11:01 AM
41	Hire additional emergency responders and make sure they have adequate equipment to handle emergencies	3/6/2017 10:10 AM
42	The Beverly Fire Department is understaffed and does not meet the NFPA standards for a simple house fire. 15 people on duty is the minimum required staffing for a normal working house fire. Several of the fire department groups do not even have 15 people on them and the usual staffing for the remaining groups is almost never 15 due to city budget contraints. A city the size of Beverly should be able to staff 15 firefighters every shift without difficulty. Local similarly sized cites are able to do it, we should do. We have an airport, seaport, highway and industrial hazards and poor staffing to support them.	3/6/2017 9:50 AM
43	Add more 1st responders. Fire/ems	3/6/2017 9:34 AM
44	I honestly have no idea	3/4/2017 11:32 AM
45	Install tide-gates at outfalls	3/3/2017 9:21 AM
46	Fix roads	3/2/2017 11:49 PM
47	Communicate city action plans and what people can do at home.	3/2/2017 9:35 PM
48	evacuation planning, neighborhood groups to assist with disaster work,	3/2/2017 5:51 PM
49	Help us understand how to navigate the FEMA site to learn our homes risk. Educate us via Patch or Salem News about how to prevent hurricane, high wind and ice dam damage. I spent lots of time on YouTube and the web a few winters ago trying to understand what causes ice dams and how to prevent them. Wishing I was a roofer or architectural engineer- wound up with damage.	3/2/2017 5:15 PM
50	?	3/2/2017 2:51 PM
51	flood planning	3/2/2017 1:54 PM
52	Protect beaches and tidal pools and no more development on low lying land.	3/2/2017 11:23 AM
53	Better snow removal equipment	3/2/2017 11:12 AM
54	Make LEPC more active again, as it was in 1980-90	3/2/2017 11:03 AM
55	Keep the roads in good condition	3/2/2017 10:59 AM
56	May involve reducing greenhouse house gases	3/2/2017 9:25 AM
57	drainage, road repair	3/2/2017 8:49 AM
58	Increase In Public Safety Staffing	3/1/2017 7:38 PM
59	Not sure	3/1/2017 5:04 PM
60	Provide education/grants/assistance to homeowners re: actions we can take to mitigate the effects of natural disasters.	3/1/2017 2:33 PM
61	Determine risk of rising ocean levels	3/1/2017 2:31 PM
62	Community education (I like the participatory approach to this effort---even this is making me think)	3/1/2017 1:56 PM
63	Address the waterfront set backs and height of seawalls/riverbanks	3/1/2017 1:52 PM

64	restrict development in flood zone areas	3/1/2017 1:31 PM
65	Have an updated flood and hurricane risk management plan identifying vulnerable assets and containing a risk mitigation plan, and an adaptation plan.	3/1/2017 1:29 PM
66	Publish a plan	3/1/2017 1:12 PM
67	Start taking public safety seriously. Find like other cities fund them. Stop pretending your Wenham.	3/1/2017 12:15 PM
68	increasing public services police,fire,public works to prepare in advance for emergencies	3/1/2017 11:44 AM
69	Unknown	3/1/2017 9:20 AM
70	Public education	2/28/2017 2:26 PM
71	seawalls	2/24/2017 1:20 PM
72	Clean culverts.	2/23/2017 4:08 PM

Q14 Please provide us with any additional comments/suggestions that you have regarding natural disasters and the City of Beverly Hazard Mitigation Plan.

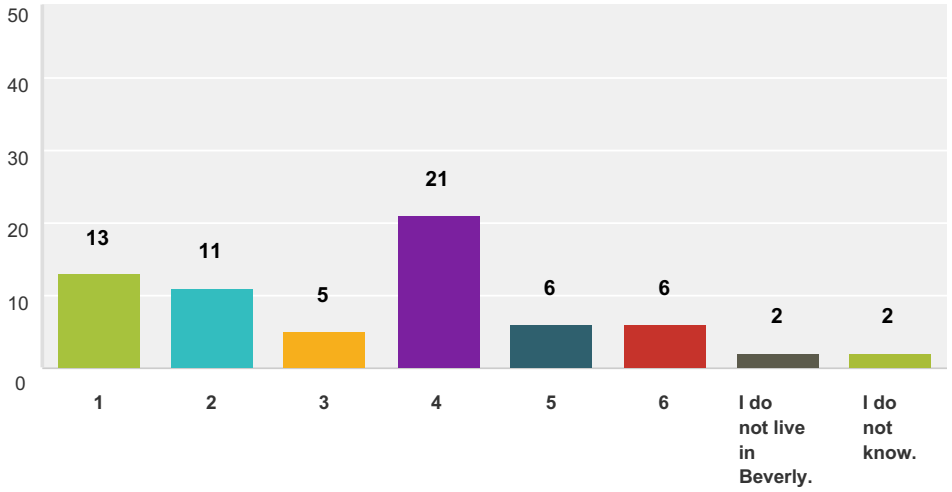
Answered: 28 Skipped: 68

#	Responses	Date
1	In the short term, we need to be concerned with tidal flooding during major weather events. In the long term, we need to prevent ocean waters from encroaching on our beaches and low residential and commercial areas.	3/18/2017 2:55 PM
2	None	3/17/2017 2:21 PM
3	Very pleased Beverly is forward thinking on the subject of Natural Disasters.	3/17/2017 12:46 PM
4	clean out storm drains completely, trim back trees and shrubs from streets and side walks, clean out streams and brooks	3/16/2017 6:29 PM
5	Better manning of fire department and police department and public works staffing all to low	3/16/2017 5:18 PM
6	Make sure evacuation routes are clearly marked and make sure they are adequate. Too much growth with new housing is already causing streets to become congested at normal conditions.	3/16/2017 8:36 AM
7	The flap low maintenance check valve should be installed to protect our area from flooding. This mitigation effort is relatively low cost, especially in light of the risk to residents in the area and disruption to traffic and public services required during an event.These known needs should be addressed as a priority before additional development occurs on the water such as is planned for the Bass River area.	3/13/2017 5:13 PM
8	city buildings flood quite easily, perhaps lead by example and get buildings fixed	3/13/2017 12:48 PM
9	Prevention, information, and assistance to those in need that is simple to access seem to me to be good ways to help Beverly residents/business owners in the time of a natural disaster. Thank you.	3/13/2017 10:37 AM
10	I'm very encouraged to know city officials are paying attention to this issue and I support even more outreach and public engagement/community building to ensure Beverly neighbors are there for each other in times of crisis.	3/12/2017 10:09 AM
11	Please inform local, state & federal legislators of citizens concern of Trump's inadequate climate change policies.	3/10/2017 7:36 PM
12	make sure rivers and streams are not blocked homeowner education	3/10/2017 11:54 AM
13	None	3/8/2017 11:01 AM
14	City services need to be brought in line with the amount of city growth that has and is happening right now.	3/7/2017 5:57 PM
15	.	3/6/2017 4:09 PM
16	Give question 10 a third option for those who are retired or do not work	3/6/2017 2:26 PM
17	Extra personnel and equipment specifically to aid in support in case of natural disasters	3/6/2017 2:06 PM
18	The phone calls to inform the public are very good. This should be part of the Hazard Mitigation Plan.	3/2/2017 5:51 PM
19	Just response to #13. Thanks.	3/2/2017 5:15 PM
20	None	3/2/2017 2:51 PM
21	Communication for instructions to families. Where are shelters? Building of safe space in houses. Insurance recommendations. Emergency evacuation instructions.	3/2/2017 11:23 AM
22	Worked on developing an Emergency Response plan for the Salem-Beverly Water Supply. Participated on LEPC for Beverly	3/2/2017 11:03 AM
23	Extremely concerned with the staffing level of the public safety departments,and the condition of equipment and buildings.	3/1/2017 7:38 PM
24	I get worried about the flooding around colon and Lothrop because of stories I hear	3/1/2017 1:56 PM
25	Assessments of all property now included in the redrawn flood zone map. Not just the oceanfront properties.	3/1/2017 1:52 PM
26	Should consider climate change impacts	3/1/2017 1:31 PM

27	The City either needs to develop, or to make more widespread, a reverse 311 plan to communicate about potential hazard development (e.g., approaching storm, expected flood levels, expected wind levels) and how the public should response. This is something we had when I lived in Somerville but none of my neighbors that I spoke with recently knew about Beverly having this type of reverse 311 program.	3/1/2017 1:29 PM
28	As a City that is continually growing in population and structures, we do and will not have enough Emergency First Responders to be able to handle and sustain the care and response needed. This City is "rolling the dice" and "playing the odds" by under staffing in this most critical component of public safety. We must have enough TRAINED people in place before it's too late.	2/28/2017 2:26 PM

Q15 If you live in the City of Beverly, please select which ward you currently live in.

Answered: 66 Skipped: 30



Answer Choices	Responses	
1	19.70%	13
2	16.67%	11
3	7.58%	5
4	31.82%	21
5	9.09%	6
6	9.09%	6
I do not live in Beverly.	3.03%	2
I do not know.	3.03%	2
Total		**66**

Appendix C – Hazard Identification and Risk Assessment Supplemental Materials

Appendix C – Hazus Modeling Results

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Introduction

As part of the larger effort to update the City of Beverly's Hazard Mitigation Plan (HMP), Dewberry was asked to perform HAZUS flood and hurricane wind modeling for the Hazard Identification and Risk Assessment (HIRA) chapter.

The work performed seeks to update the previous HIRA chapter maps, text and tables. Given the nature of hazard mitigation planning and the goals that the Federal Emergency Management Agency (FEMA) has set for jurisdictions to continually improve HMP's from one revision to the next, Dewberry has significantly improved the nature of the Hazus flood modeling on behalf of City of Beverly. This report documents the various modeling efforts performed and, where appropriate, denotes modeling efforts given available scope, schedule, and budget of the project.

This report documents the methodology used to construct the HAZUS modeling efforts and also discusses core model results where applicable. Users of this document are directed to the final HMP that will be completed in the future by Dewberry that will include this work effort in the HIRA sections for Hurricane Wind and Flooding.

Inventory Development

Hazus

Hazus-MH is a nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods, and hurricanes. Note that as of April 2017, Hazus also includes functionality to analyze Tsunami hazard. Hazus uses Geographic Information Systems (GIS) technology to estimate physical, economic, and social impacts of disasters. It graphically illustrates the limits of identified high-risk locations due to earthquake, hurricane, flood, and tsunami. Users can then visualize the spatial relationships between populations and other more permanently fixed geographic assets or resources for the specific hazard being modeled, a crucial function in the pre-disaster planning process.

Hazus is used for mitigation and recovery, as well as preparedness and response. Government planners, GIS specialists, and emergency managers use Hazus to determine losses and the most beneficial mitigation approaches to take to minimize them. Hazus can be used in the assessment step of the mitigation planning process, which is the foundation for a community's long-term strategy to reduce disaster losses and break the cycle of disaster damage, reconstruction, and repeated damage. Being ready will aid in recovery after a natural disaster.

Potential loss estimates analyzed in Hazus include:

- Physical damage to residential and commercial buildings, schools, critical facilities, and infrastructure;
- Economic loss, including lost jobs, business interruptions, repair, and reconstruction costs;
- Social impacts, including estimates of shelter requirements, displaced households, and population exposed to scenario floods, earthquakes, and hurricanes

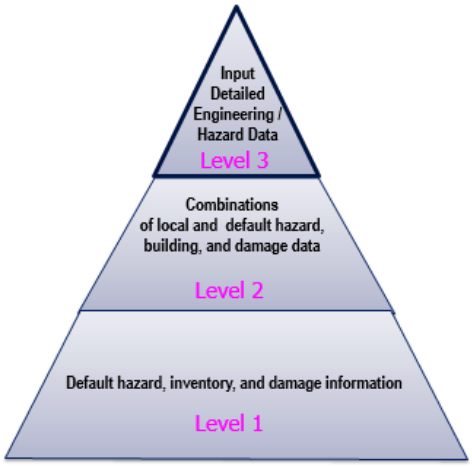
As the number of Hazus users continues to increase, so do the types of uses. Increasingly, Hazus is being used by states and communities in support of risk assessments that perform economic loss scenarios for certain natural hazards and rapid needs assessments during hurricane response. Other communities are using Hazus to increase hazard awareness[1].

Hazus – MH Levels of Analysis

- Level 3 or Advanced
- **Level 2 or Refined – This Project**
- Level 1 or Basic Defaults

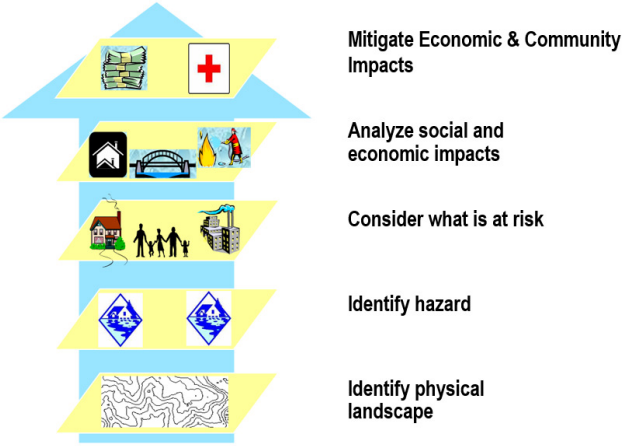
Hazus – MH Flood Model Loss Estimation Process

The Hazus-MH Flood Model allows planners and other practitioners to carry out a wide range of flood hazard analyses, including:



- Studies of specific return intervals of floods (e.g., 100-year return interval).
- Studies of discharge frequencies, including analysis of discharges from specific streams and the exposure to buildings and population from the resultant flooding.
- Studies of annualized losses from flooding.
- Quick Look assessments, which allows the user to quickly evaluate potential flooding from specific flood depths at specific locations.
- What if scenarios, which allow users to evaluate the consequences of specific actions, such as the introduction of flow regulation devices, acquisition of flood-prone properties and other mitigation measures.

The flood loss estimation methodology consists of two modules that carry out basic analytical processes: flood hazard analysis and flood loss estimation analysis. The flood hazard analysis module uses characteristics, such as frequency, discharge and ground elevation to estimate flood depth, flood elevation and flow velocity. The flood loss estimation module calculate physical damage an economic loss from the results of the hazard analysis[2].



[1] https://www.fema.gov/hazus/

[2] https://www.fema.gov/hazus-mh-flood-model

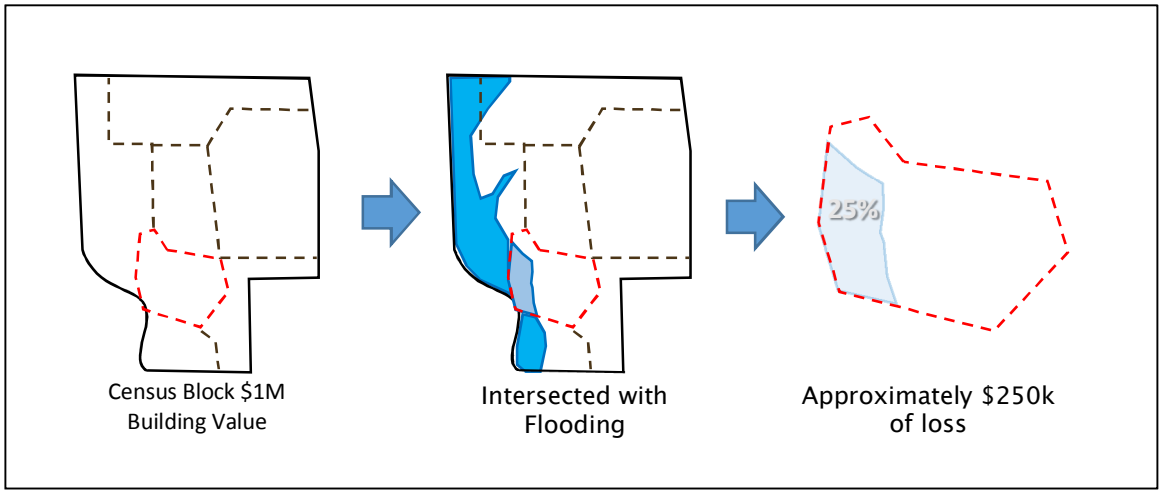
Hazus – MH Flood Model – Building Level Approach for City of Beverly

The modeling approach is described below in a series of items to include release versions, inventory data (i.e., Data Preparation and Updates), hazard data and modeling parameters utilized for the Loss Analysis:

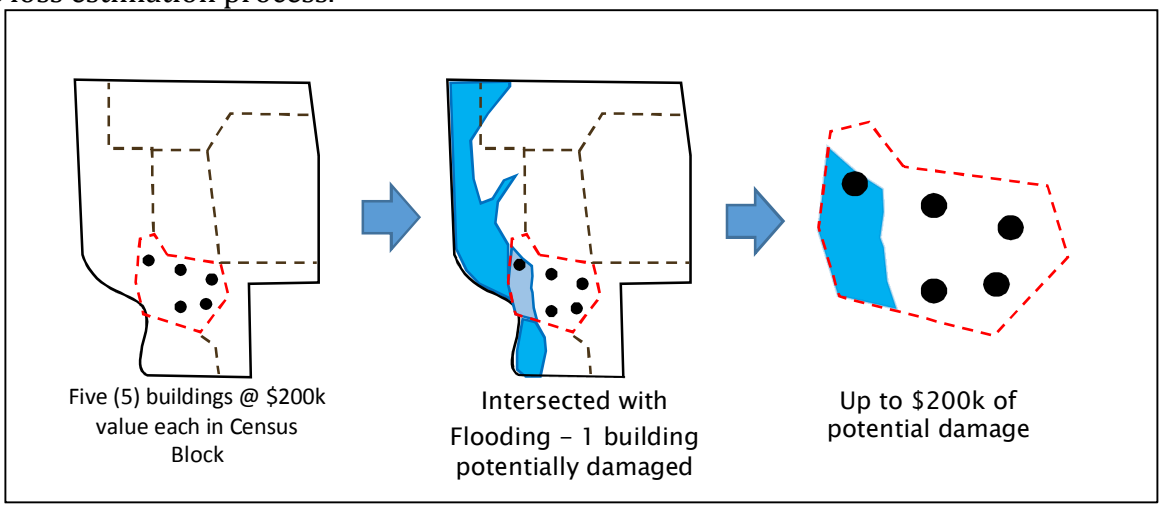
Version Used – Version 3.2 (released October 31, 2016) – Final analyses occurred while Hazus Version 3.2 was the current release.

Inventory Development – Inventory data (INV) includes various datasets utilized to capture and describe the built environment. Inventory is utilized as input to all of the Hazus models (Flood, Hurricane, Earthquake and now Tsunami) which is then analyzed against data representing the natural hazards to ultimately estimate potential damage and loss. Inventory can be provided in multiple forms and establishes the economic basis for estimated loss within the built environment. Hazus is made available with "pre-packaged" or "Stock" inventory datasets that are assembled from a variety of 'national-level' data inventory resources. This document focuses on work that was performed to update and improve multiple "Stock" inventory datasets. This document does not focus on details of how "Stock" Hazus data was created. Users are encouraged to review Hazus documentation. Notwithstanding, methods utilized for stock data creation, in certain instances such as cost-per-square-foot methods have been based on the stock data creation methods. Current Hazus documentation exists as a series of User Manuals, Technical Manuals and other supplementary documents available from FEMA. Specific discussion on approaches to updating Stock Inventory for flood modeling are discussed in Chapter 7. Modifying Inventory Data of Multi-hazard Loss Estimation Methodology Flood Model Hazus®-MH User Manual (DHS/FEMA 2006).

General Building Stock (GBS) – GBS is the Hazus-based phrase that describes data assembled at the census block and/or tract geographic-levels. Within the Hazus Flood model, GBS analysis only utilizes census blocks. GIS polygons of census blocks are utilized to store tabular attributes about the built-environment within each respective census block; attributes such as summaries of building square footage, estimated building counts or estimated building value. These various attributes are categorized by attributes such as occupancy (i.e., building use types), core-construction types of buildings (e.g., Wood, Steel, Concrete) and includes financial values such as estimated replacement costs and value of contents. GBS flooding loss estimations methods therefore can only be performed by intersection a flood area with the inventory areas; namely census blocks. Consequently, loss estimates are generalizations over a specific area impacted. The figure below offers an oversimplified example of the loss estimation process.

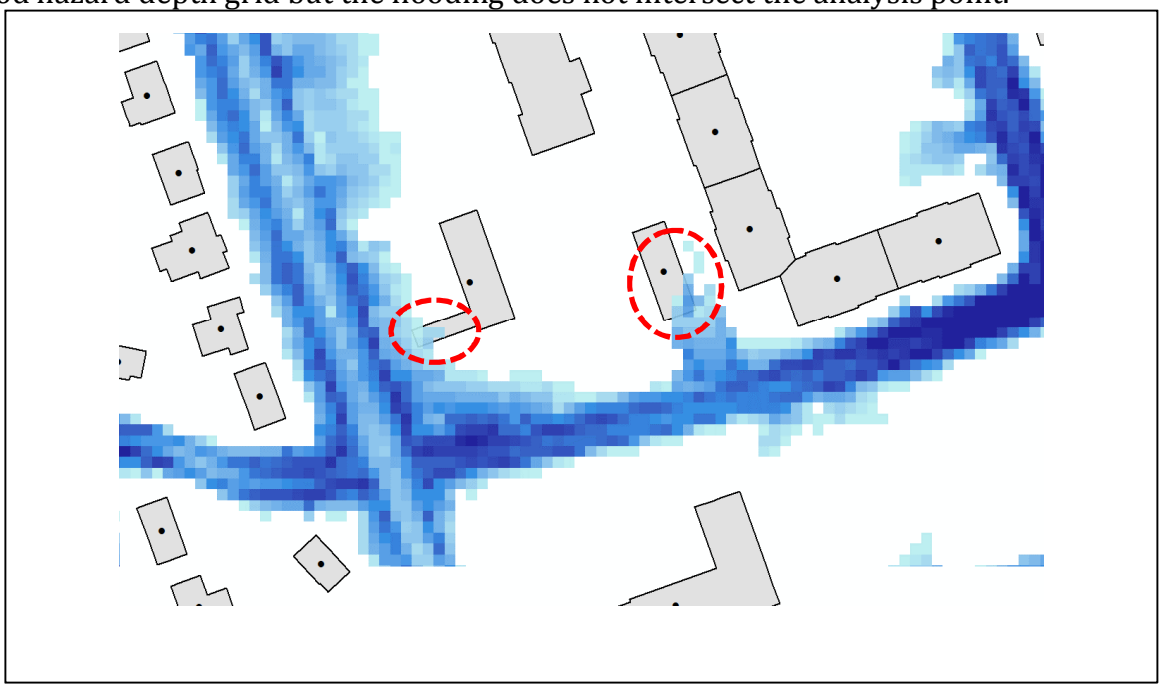


Site-specific Data – Phraseology or terminology of Hazus data types can present some confusion to new users and readers, therefore it is important for users to understand a few basics - the most logical approach is to view data in two (2) different categories – the aforementioned GBS and then Site specific data. Site-specific inventory data is a more detailed inventory at an individual building-level (versus the GBS which is a summarization of multiple building characteristics at the census block-level). There are multiple sub-modules within Hazus for which the user can define site-specific data and, the respective sub-modules each have similarities but also differences. For example, consider a Police Station. The results of a Police Station in the Essential Facility module (EF) will include restoration time estimates however the same building as analyzed in the User-Defined Facility module (UDF) will not report restoration time. Ultimately, the various site-specific flooding loss estimations are considered superior to the aforementioned area-based method of the GBS. Site-specific flood analysis occurs at the intersection of the flooding and a point representing the individual building. The figure below offers a simplified example of the loss estimation process.



Consequently, the simplified loss estimation methods demonstrated the increased potential accuracy available by examining the inventory (i.e., built environment) at the site-specific level. However, users and readers should also be aware that site-specific analysis may not account for all potential building loss because the analysis is performed at a single

point location. Ultimately point placement is of significance. The methodology of point placement utilized included use of the centroid. The centroid of a polygon feature (or building footprint) may vary depending on the shape of the building and it is possible that the flood may intersect the building footprint but not the analysis point representing the building. The figure below demonstrates two (2) building footprints intersected by the flood hazard depth grid but the flooding does not intersect the analysis point.



Incidentally, for the examples shown above, street-side photography reveals that both of the buildings would most likely not sustain any damage. The portion of the L-shaped building that is intersected by the flooding is actually open and not enclosed; it is a type of attached awning. The other rectangular building does not have an opening to the structure (e.g., a doorway) on the corner that intersects the flooding. Consequently, it can be understood that the best location for point features include placement in the exact location where openings for ingress and egress exist. While such point placement is considered best, the reader should also understand that the level of effort to accomplish such placement, while not impossible, would be great and has not been considered as part of the scope of this project.

Table 1 below enumerates the various data that may be available for update in Hazus - and those data that were created or updated as part of this project.

Table 1. Data Used for Hazus Analysis

Data		Updated Stock	Stock Count	Updated Count	GBS or Site-Specific (SS)
User-Defined Facilities (UDF) – Newly Created for this project		N/A	0	11,424	SS
General Building Stock (GBS)	Building Counts (Block & Tract)	YES	--	--	GBS
	Building Square Footage (Block & Tract)	YES	--	--	GBS
	Demographics (Block & Tract)	NO	--	--	GBS
	Building Dollar Exposure (Block & Tract)	YES	--	--	GBS

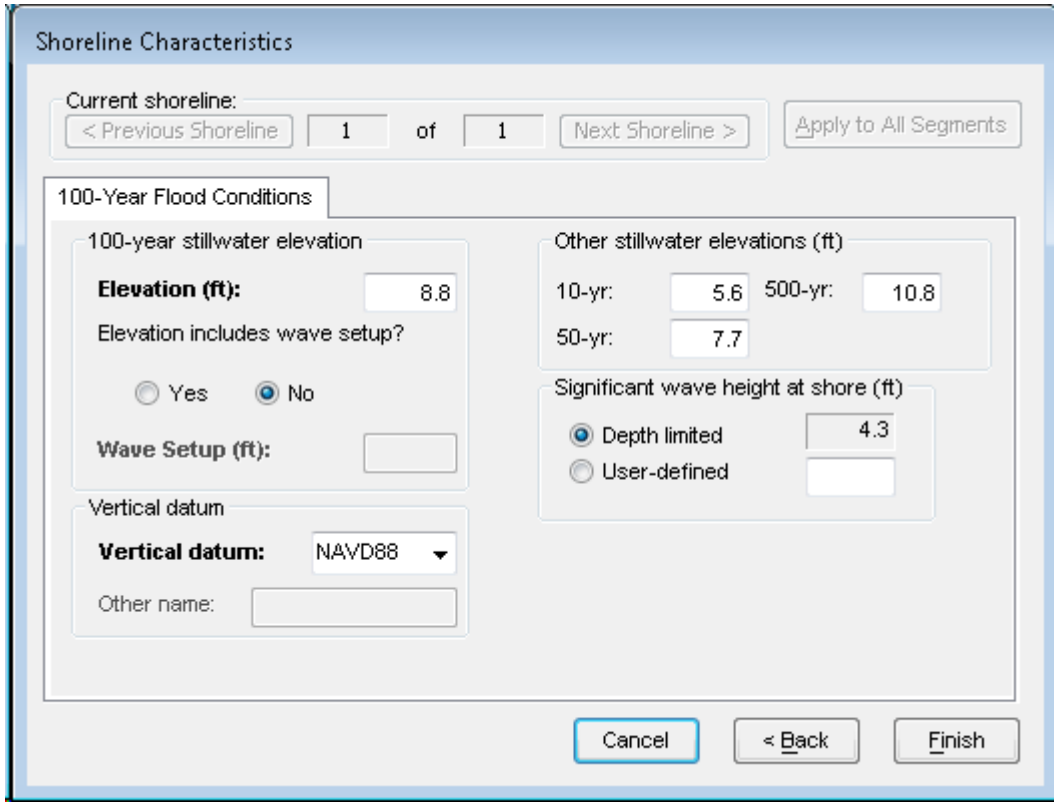
Table 1. Data Used for Hazus Analysis					
Data		Updated Stock	Stock Count	Updated Count	GBS or Site-Specific (SS)
	Contents Dollar Exposure (Block & Tract)	YES	--	--	GBS

Hazard Data & Modeling Parameters – Hazard data within the Hazus Flood Model are represented by flooding depth grids. The depth values and geographic extents of the depth grids for City of Beverly from the lowest water levels (10-year frequency) to the highest (500-year frequency) were created utilizing Hazus Version 3.2. The hazard flood modeling included the following:

- **National Elevation Dataset (NED) 1/3-Arc Second Digital Elevation Models** – NED 1/3 is roughly equivalent to 10-meter grid cells. Therefore, the input ground data utilized for this effort has utilized a dataset that improves upon typical Hazus Level 1 modeling efforts; most Level 1 hazard modeling efforts utilize NED 1-Arc Second DEM's which are equivalent to roughly 30-meter cell size.
- **Riverine Drainage Threshold** – the riverine modeling drainage threshold was set at 1.0 square-mile for this modeling effort which improves greatly upon typical Hazus Level 1 modeling efforts; most Level 1 hazard modeling efforts utilize a 10-square mile drainage threshold. The difference between 1.0 and 10.0 square mile thresholds is that the automated modeling techniques will develop hazard data that extends much further upstream with a 1.0 threshold and therefore will include the flooding potential into riverine areas that otherwise would go un-analyzed at a 10.0 square mile threshold.
- **Coastal Flood Modeling** – the coastal modeling included consultation of the currently effective Flood Insurance Study (FIS) published by FEMA on July 16, 2014. Table 8 was utilized to establish the Hazus Coastal 'Shoreline Conditions'. Specifically, the 100-Year Stillwater Elevation of the 100-Year Flood Conditions dialogue was established at an Elevation of 8.8 feet per the following shoreline section in Table 8 of the effective FIS:
    - ***Shoreline of Massachusetts Bay, Salem Harbor, and Beverly Harbor***

  It is important for the reader and user to understand certain details of this coastal modeling effort so that future efforts can continually transcend the previous risk assessment methods to include the following:

    - **Wave Setup** – the FIS Table 8 states that the Stillwater of 8.8 feet includes wave setup however it DOES NOT provide a value that represents the wave setup. Notes in the FIS refer the reader to the previously effective FIS, however once again the previous FIS only makes reference to the standards utilized to compute wave setup. Therefore, the setting that was ultimately utilized included defining the 100-year Stillwater per the 8.8 feet but wave setup was assumed to not be included. The figure below are the coastal Shoreline Characteristics defined for this project:



A single shoreline was defined along the coast of the City of Beverly utilizing the values in the figure above.

- **Potential Future Solution** – readers and users are encouraged to consider improving upon the flood hazard development for future risk assessments to include creating 'User-Defined Depth Grids' for both coastal and riverine flooding following at-minimum, FEMA Guidelines & Standards for Non-Regulatory Risk Assessments.

- **Depth-Damage Functions** – while User-Defined Facilities (UDF) of each individual building was developed, depth-damage functions were NOT assigned on a building-by-building basis. Therefore, Hazus automatically utilizes auto-assignment methods based on input building characteristics which are inherent to the software.
- **Other Modeling Parameters** – Customized modeling parameters were NOT defined for the variety of bulleted items enumerated below. These modeling parameters (primarily GBS-type parameters) were not modified and therefore default parameters inherent to Hazus would have been utilized. Analysis Parameters are factors or variables within multiple flood model sub-routines that users can modify to potentially refine the loss analyses which may better represent local conditions. It is important to note that primary focus of the project was placed on refining the flood hazard (depth grids) and individual building data development (UDF); therefore users may want to consider adjustments to certain default parameters for future analyses. Users should consult Section 9.6 of the Multi-hazard Loss Estimation Methodology Flood Model Hazus®-MH User Manual (DHS/FEMA 2006).

- Debris Parameters – The debris module will determine the expected amounts of debris generated within each census block. Output from this module is the debris weight (in tons). The classes of debris are defined as; Building Finishes, Structural Components and Foundation Materials.[3]
- Shelter Parameters - Shelter Parameters depend on four factors: Evacuation (depth of restricted ingress/egress), Utility Factors (outage duration), Weighting Factors (income and age), and Modification Factors (population that will seek public shelter).[4]
- Agricultural Parameters – Specifically, agricultural parameters define the day and month of the flood event.[5] It is standard within the mitigation-planning discipline to supply a day and month that would generate a likely "worst-case" scenario. Such a scenario would coincide with a time-frame that would correspond to loss of a mature crop and also exist at a time in which it would theoretically be too late to replant a second or "recovery" crop. In addition to the agricultural parameters, stock GIS polygon areas representing agricultural lands can be revised to better reflect current land-use.
- Direct Economic Parameters - Direct Economic Loss Parameters are based on three factors: Business Inventory (Annual Gross Sales), Restoration Time (anticipated time for repair), and Income Loss Data (relocation expenses and loss of income).[6]
- Indirect Economic Parameters - The indirect economic data refers to the post-flood change in the demand and supply of products, change in employment and change in tax revenues. The user can specify the levels of potential increase in imports and exports, supply and product inventories and unemployment rates.

Hazus – MH Flood Model – Inventory Development Details

Hazus comes pre-packaged with national-level datasets that can be utilized to represent the built-environment. These national-level datasets are typically described as "Hazus Stock Data". The stock data includes default information about buildings but ONLY at aggregated census geographies (Tracts and Blocks). The stock data may only include a handful of site-specific features but in no way represents the entirety of buildings in the United States. While these default datasets may provide a good starting point for flood risk analyses in communities that lack more robust data, <u>a key goal of this project was to collect better data on the community's inventory of buildings</u>. From a cost-perspective it is challenging to individually identify and inventory each man-made structure. Therefore, mass-attribution methodologies were utilized to develop many of the required building

[3] FEMA Multi-hazard Loss Estimation Methodology, Hazus-MH Flood Model User Manual, FEB 2012, Section 9.6.1, Page 9-6.

[4] FEMA Multi-hazard Loss Estimation Methodology, Hazus-MH Flood Model User Manual, FEB 2012, Section 9.6.3, Page 9-7.

[5] FEMA Multi-hazard Loss Estimation Methodology, Hazus-MH Flood Model User Manual, FEB 2012, Section 9.6.4, Page 9-8.

[6] FEMA Multi-hazard Loss Estimation Methodology, Hazus-MH Flood Model User Manual, FEB 2012, Section 9.6.5, Page 9-9.

characteristics. Mass-attribution techniques were employed and were based on data provided to translate from existing form to Hazus-ready form.

Data development is a process that often utilizes parcel and/or building data. Local parcel data often includes a number of attributes found within the Hazus Flood Model database design, and therefore parcel data is often a valuable starting point. Dewberry solicited such data from the City and received City Parcels and Building Roofprint datasets. Once a baseline of local data was established, Dewberry moved forward with data development to meet Hazus flood model data needs. Parcel data and building roofprints established the baseline for Hazus building data development.

Hazus Flood model building-level data needs are presented in Table 2 (below).

Table 2. Hazus Data Input Fields

Required	Non-Required
Hazus Sub-occupancy type	Name of Facility or Owner
Building Type	Address
Building Cost	City
Content Cost	State
Year Built	Zip Code
Number of Stories	Contact
Design Level	Phone
Foundation Type	Area*
First-floor Height	Flood Protection
Building Damage Function ID	Shelter Capacity
Content Damage Function ID	Back-up Power
Inventory Damage Function ID	County
Latitude of building centroid	Comments
Longitude of building centroid	* NOTE: required when estimating replacement cost via cost per sq.ft.

Given the scope and budget of the project, the building roofprints and parcel data provided by the city were used to determine the **User Defined Facility data needed for the Hazus Flood Model ONLY**. **Table 3** shows what fields were provided in the Parcel data and what correlated to the data needed for Hazus analysis.

Table 3. Parcel Data Relation to Valid Hazus Data

Parcel_Tax	Hazus Attribute Relation
FID	
Shape	
OBJECTID	
MAP_PAR_ID	
LOC_ID	
POLY_TYPE	
LAST_EDIT	

Table 3. Parcel Data Relation to Valid Hazus Data	
Parcel_Tax	**Hazus Attribute Relation**
X_Coor	
Y_Coor	
CAMA_ACCT	
PID	
ZONE1	
StNum2	
StSuf_2	
STREET	
Ass_Add	Address
CONDO_NUM	
CONDO_UNIT	
OWNER_1	Contact
OWNER_2	
OWNER_3	
MAIL_ADD	
MAIL_ADD2	
MAIL_CITY	
MAIL_ST	
MAIL_ZIP	
ZONE_2	
WATER	
SEWER	
GAS	
TRAFFIC	
LUC	
YEAR_BUILT	YearBuilt
YEAR_BUI_1	
LAND_ACRE	
GROSS_BLDG	
BLDG_TYPE	Occupancy (Proxy for most values)
FIN_AREA	Area
BLDG	Estimate of Number of Buildings on the Parcel
STORY	NumStories
UNIT	
ROOM	
BEDROOM	
BATH	
BATH_TQ	
BATH_HALF	

Table 3. Parcel Data Relation to Valid Hazus Data	
Parcel_Tax	**Hazus Attribute Relation**
BATH_COND	
KITCHEN	
KIT_COND	
FIREPLACE	
HEAT_TYPE	
FUEL	
AC_PERCENT	
BSMT_AREA	FoundationType (Establishes Basement)
FIN_BSMT	Related to Cost (Basement Cost Adjustment)
ROOF_STYLE	
ROOF_MTL	
SIDING	
INTERIOR	
ATT_GAR	Related to Cost (Garage Cost Adjustment)
DET_GAR	
POOL	
FRAME	BldgType
FLOOR	
FY	
BLDG_GRADE	Related to Cost (Construction Quality)
BLDG_COND	
DEED_REF	
DEED_DATE	
SALE	
NAL	
GRANTOR	
PREV_DEED	
PREV_DATE	
PREV_SALE	
PREV_NAL	
PREV_GRANT	
LAND_ASS	
YARD_ASS	
BLDG_ASS	Not utilized – Replacement Cost was estimated by cost per square foot methods
TOTAL_ASS	
COMMENT	Comment
MASS_GISKE	
Shape_Leng	
Shape_Area	

Table 3. Parcel Data Relation to Valid Hazus Data	
Parcel_Tax	**Hazus Attribute Relation**
RL	

Most of the data Hazus needed to relate or calculate values were computed with GIS. The fields within these two datasets were adequate enough to provide quick relations to 93% of the buildings. The other seven percent were analyzed and assigned manually.

Hazus Domains & Values

Table 4, Table 5, Table 6, and Table 7 show the different codes, types, and descriptions that were associated with the building roofprints and parcel data before it could be analyzed by Hazus.

Table 4. Specific Occupancy Codes	
Code	**Code Description**
RES1	RES1 - Single-Family Dwelling
RES2	RES2 - Mobile Home
RES3A	RES3A - Multi-Family Dwelling - Duplex
RES3B	RES3B - Multi-Family Dwelling - 3 to 4 Units
RES3C	RES3C - Multi-Family Dwelling - 5 to 9 Units
RES3D	RES3D - Multi-Family Dwelling - 10 to 19 Units
RES3E	RES3E - Multi-Family Dwelling - 20 to 49 Units
RES3F	RES3F - Multi-Family Dwelling > 50+ Units
RES4	RES4 - Temporary Lodging
RES5	RES5 - Institutional Dormitory
RES6	RES6 - Nursing Home
AGR1	AGR1 - Agriculture
COM1	COM1 - Retail Trade
COM10	COM10 - Parking Garages (Not Parking Lots)
COM2	COM2 - Wholesale Trade
COM3	COM3 - Personal and Repairs Services
COM4	COM4 - Business/Professional/Technical Services
COM5	COM5 - Depository Institutions
COM6	COM6 - Hospital
COM7	COM7 - Medical Office/Clinic
COM8	COM8 - Entertainment & Recreation
COM9	COM9 - Theaters
EDU1	EDU1 - Schools/Libraries
EDU2	EDU2 - Colleges/Universities
GOV1	GOV1 - General Services
GOV2	GOV2 - EmergencyResponse
IND1	IND1 - Heavy Industrial
IND2	IND2 - Light Industrial

Table 4. Specific Occupancy Codes	
Code	**Code Description**
IND3	IND3 - Food/Drugs/Chemicals
IND4	IND4 - Metal/Minerals Processing
IND5	IND5 - High Technology
IND6	IND6 - Construction (Facilities and Offices)
REL1	REL1 - Church/Membership Organizations
ACC	ACC- Accessory (Non-Valid UDF)

Table 5. Number of Stories Codes		
Code	**Type**	**Code Description**
1	1	1 - One & Two stories
2	3	3 - Three & Four stories
3	5	5 - 5 or more stories
4	9	9 - split level RES buildings

Table 6. Foundation Type Codes	
Code	**Code Description**
1	1 - Pile
2	2 - Pier
3	3 - Solid Wall
4	4 - Basement/Garden
5	5 - Crawl Space
6	6 - Fill
7	7 - Slab On Grade

Table 7. Construction Quality Codes		
Code	**Construction Type**	**Code Description**
1	Economy	Economy - a (RES-type structures only)
2	Average	Average - b (RES-type structures only)
3	Custom	Custom - c (RES-type structures only)
4	Luxury	Luxury - d (RES-type structures only)

The method utilized to understand the data as well as develop tabular tools for mass-attribution included performing a GIS Frequency Analysis and/or Duplicate Analysis. Essentially, the operator is seeking to understand the variety of records that exist across the data provided in order to establish translation or correlation values. Table 8 below constitutes a primary translation table developed to define required Hazus Specific Occupancy:

Table 8. Parcel Building Type Counts and Relations to Hazus Building Occupancy Types				
Count of Parcel Types	**BLDG_TYPE**	**General Occupancy**	**Specific Occupancy**	**Notes**
952		UNK	UNK	Research required to assign Occupancy
1	2-SBarn-Good	AGR	AGR1	
96	Antique	RES	RES1	
46	Apt- Garden	RES	RES3?	Combined with "BLDG" and "UNIT", reasonable occupancy can be determined
3	Apt- Hi Rise	RES	RES3?	Combined with "BLDG" and "UNIT", reasonable occupancy can be determined
3	Apt- TnHs	RES	RES3?	Combined with "BLDG" and "UNIT", reasonable occupancy can be determined
204	Apt 4-8	RES	RES3?	Combined with "BLDG" and "UNIT", reasonable occupancy can be determined
109	Apts/Comm	RES	RES3?	Combined with "BLDG" and "UNIT", reasonable occupancy can be determined
3	Assist Livin	RES	RES7	
4	Auto Dealer	COM	COM1	
8	Bank	COM	COM5	
1	Bathhouse	COM	COM8	
1	Bowling All.	COM	COM8	
267	Bungalow	RES	RES1	
2	Camp-Seas.	RES	RES4	
2	Camp - YrRnd	RES	RES4	
1874	Cape	RES	RES1	
1	Car Wash	COM	COM3	
13	Carriage Hse	RES	RES1	
19	Church/Syn.	REL	REL1	
50	Cndo Medical	COM	COM7	
1	College	EDU	EDU2	
1759	Colonial	RES	RES1	
1287	Colonial Old	RES	RES1	
66	Colonial, Lg	RES	RES1	
7	Comm. Block	COM	COM?	
477	Condo Conv	RES	RES1	
508	Condo Garden	RES	RES3?	Appears to be individually-owned but in multi-family type structure; could assume based on area.
14	Condo Mans,			
36	Condo Office	COM	COM4	
26	Condo Retail	COM	COM1	
376	Condo TnHs.	RES	RES1	Should check to make sure some aren't multi-fam.; check BLDG & UNIT
28	Condo Whs.	COM	COM2	

Table 8. Parcel Building Type Counts and Relations to Hazus Building Occupancy Types				
Count of Parcel Types	**BLDG_TYPE**	**General Occupancy**	**Specific Occupancy**	**Notes**
131	Contempory	RES	RES1	
14	Conv. Market	COM	COM1	
15	Conventional	RES	RES1	
1	Day Care	COM	COM3	
10	Dormitory	RES	RES5	
47	Duplex	RES	RES3A	
250	Dutch Col	RES	RES1	
8	Fast Food	COM	COM8	
3	Fire Station	GOV	GOV2	
2	Funeral Home	COM	COM3	
1	Garage	COM	COM1	
4	Govt. Bldg.	GOV	GOV1	
1	Greek Reviv.	RES	RES1	
4	Group Home	RES	RES3?	Combined with "BLDG" and "UNIT", reasonable occupancy can be determined
1	Gymnasium	COM	COM8	
1	Hanger	COM	COM4	
7	Health Club	COM	COM8	
1	Hotel	RES	RES4	
2	Indust - Hvy	IND	IND1	
7	Indust - Lt	IND	IND2	
16	Industrial	IND	IND3	
4	Laundromat	COM	COM3	
2	Library	EDU	EDU1	
16	Lodge	COM	COM8	
72	Mansion	RES	RES1	
1	Motel	RES	RES4	
1033	Multi-Conver	RES	RES1	
3	Nursing Home	RES	RES6	
43	Office	COM	COM4	
4	Office - A	COM	COM5	
4	Office - B	COM	COM6	
1	Office - C	COM	COM7	
9	Office - Pro	COM	COM8	
686	Old Style	RES	RES1	
1	Parking	COM	COM10	
2	Post Office	GOV	GOV1	

Table 8. Parcel Building Type Counts and Relations to Hazus Building Occupancy Types				
Count of Parcel Types	**BLDG_TYPE**	**General Occupancy**	**Specific Occupancy**	**Notes**
7	Pump House	COM	COM4	
2	R/M Shop	GOV	GOV1	
1352	Ranch	RES	RES1	
2	Rectory	RES	RES1	
29	Repair Gar.	COM	COM3	
7	Res. + Devl.	RES	RES1	
20	Restaurant	COM	COM8	
1	Rink	COM	COM8	
439	RR/SplEnt	RES	RES1	Split-Level
31	Saltbox	RES	RES1	
26	School	EDU	EDU1	
9	Service Ctr	COM	COM3	
4	Shop-Ctr Nei	COM	COM1	
54	Spl/Rsd Cape	RES	RES1	Split-Level
14	Split Gamb	RES	RES1	Split-Level
142	Split Level	RES	RES1	Split-Level
56	Store	COM	COM1	
3	Super Market	COM	COM1	
1	Take Out	COM	COM1	
2	Tennis Club	COM	COM8	
3	Theater	COM	COM9	
5	Tudor	RES	RES1	
5	Util. Bldg.	COM	COM4	
27	Victorian	RES	RES1	
28	Warehouse	COM	COM2	
3	Whse - Mini	COM	COM3	

Cost Per Square-Foot Value Assignment

The methodology employed to compute estimated replacement costs followed the standard methods published in the Hazus Flood Model Technical Manual. The method includes computing replacement cost from RS Means published cost per square-foot. The published values noted are from year 2006 and therefore adjustments were made following FEMA Modeling Task Force (MOTF) adjustment method of adjusting the RS Means 2006 values by the most recently available CPI[7]. These adjustments are shown in Table 9. Table 9. RS Means 2006 to 2017 Cost Adjustment and Assignments

Specific Occupancy	Description	Cost per Square Foot	CPI Adjusted Cost per Square Foot to 2017
RES2	Mobile Home	35.75	43.16
RES3A	Multi Family Dwelling - Duplex	79.48	95.97
RES3B	Multi Family Dwelling - 3 To 4 Units	86.6	104.56
RES3C	Multi Family Dwelling - 5 To 9 Units	154.31	186.32
RES3D	Multi Family Dwelling - 10 To 19 Units	137.67	166.22
RES3E	Multi Family Dwelling - 20 To 49 Units	135.39	163.47
RES3F	Multi Family Dwelling - 50+ Units	131.93	159.29
RES4	Temporary Lodging	132.52	160.01
RES5	Institutional Dormitory	150.96	182.27
RES6	Nursing Home	126.95	153.28
COM1	Retail Trade	82.63	99.77
COM2	Wholesale Trade	75.95	91.7
COM3	Personal and Repair Services	102.34	123.57
COM4	Business/Professional/Technical Services	133.43	161.1
COM5	Depository Institutions	191.53	231.26
COM6	Hospital	224.29	270.81
COM7	Medical Office/Clinic	164.18	198.23
COM8	Rentertainment & Recreation	170.51	205.88
COM9	Theaters	122.05	147.36
COM10	Parking Story Structures	43.72	52.79
IND1	Heavy	88.28	106.59
IND2	Light	75.95	91.7
IND3	Food/Drug/Chemicals	145.07	175.16
IND4	Metals/Minerals Processing	145.07	175.16
IND5	High Technology	145.07	175.16
IND6	Construction	75.95	91.7
AGR1	Agriculture	75.95	91.7
REL1	Church/Membership Organizations	138.57	167.31
GOV1	General Services	107.28	129.53
GOV2	Emergency Response	166.59	201.14
EDU1	Schools/Libraries	115.31	139.23

[7] U.S. Bureau of Labor Statistics | Division of Consumer Prices and Price Indexes, PSB Suite 3130, 2 Massachusetts Avenue, NE Washington, DC 20212-0001, https://data.bls.gov/cgi-bin/cpicalc.pl.

The methodology employed to compute estimated replacement costs followed the standard methods published in the Hazus Flood Model Technical Manual. The method includes computing replacement cost from RS Means published cost per square-foot. The published values noted are from year 2006 and therefore adjustments were made following FEMA Modeling Task Force (MOTF) adjustment method of adjusting the RS Means 2006 values by the most recently available CPI[7]. These adjustments are shown in Table 9. Table 9. RS Means 2006 to 2017 Cost Adjustment and Assignments

Specific Occupancy	Description	Cost per Square Foot	CPI Adjusted Cost per Square Foot to 2017
EDU2	Colleges/Universities (Not the Dormitories which are RES5)	144.73	174.75
RES1Economy1	Single Family Dwelling - Economy Quality - 1 Story	65.91	79.58
RES1Economy2	Single Family Dwelling - Economy Quality - 2 Story	70.13	84.68
RES1Economy3	Single Family Dwelling - Economy Quality - 3 Story	70.13	84.68
RES1Economy4	Single Family Dwelling - Economy Quality - 4 Story	64.46	77.83
RES1Average1	Single Family Dwelling - Average Quality - 1 Story	92.84	112.1
RES1Average2	Single Family Dwelling - Average Quality - 2 Story	90.15	108.85
RES1Average3	Single Family Dwelling - Average Quality - 3 Story	94.49	114.09
RES1Average4	Single Family Dwelling - Average Quality - 4 Story	84.96	102.58
RES1Custom1	Single Family Dwelling - Custom Quality - 1 Story	114.91	138.74
RES1Custom2	Single Family Dwelling - Custom Quality - 2 Story	112.91	136.33
RES1Custom3	Single Family Dwelling - Custom Quality - 3 Story	116.99	141.26
RES1Custom4	Single Family Dwelling - Custom Quality - 4 Story	105.25	127.08
RES1Luxury1	Single Family Dwelling - Luxury Quality - 1 Story	139.76	168.75
RES1Luxury2	Single Family Dwelling - Luxury Quality - 2 Story	133.09	160.69
RES1Luxury3	Single Family Dwelling - Luxury Quality - 3 Story	137.08	165.51
RES1Luxury4	Single Family Dwelling - Luxury Quality - 4 Story	124.81	150.7

Select Building-Specific Inventory Statistics

FEMA's Comprehensive Data Management System (CDMS) Version 3.0, a companion tool to Hazus that is designed to assist the import/export of data to/from Hazus was utilized to update data developed from the Building Master. The following tables represent exposure values created through individual building data development (A.k.a., User-Defined Facilities or UDF). Table 10 results show how much difference there is in value from the stock values to the updated values based on the UDF dataset developed.

Table 10. GBS Comparison of Stock vs Updated Values

Scenario Type	Total Exposure	RES Total Exposure
Stock GBS	$5,316,494,000	$3,900,629,000
Updated GBS	$6,127,775,000	$4,319,783,000
Difference	$811,281,000	$419,154,000

User-Defined Facilities Analyses

The final UDF dataset was prepared and uploaded into FEMA's CDMS program and then analyzed through Hazus. Of the 11,000+ buildings evaluated, nine buildings had issues and

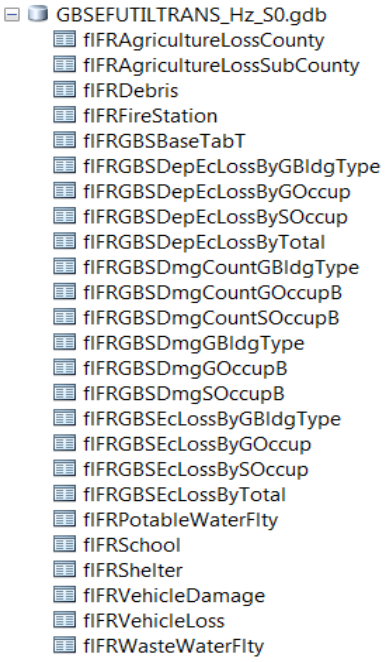
were not analyzed by Hazus even though they intersected the Hazus computed depth grids. These nine buildings are listed in Table 11. It should be noted that all buildings had the same Occupancy, Number of Stories code, and First Floor Height values. There were other similar buildings with these same properties, but they did not intersect any of the Hazus depth grids. However, given the scope and budget of the project, these were given a value of zero damage, although they could be at risk from one or more of the flood frequencies.

Table 11. UDF Buildings Analyzed with Errors

UserDefinedFacilityId	Occupancy	NumStories	FirstFloorHt
MA002908	RES1	4	-4
MA003656	RES1	4	-4
MA009636	RES1	4	-4
MA009751	RES1	4	-4
MA003905	RES1	4	-4
MA004474	RES1	4	-4
MA004092	RES1	4	-4
MA010613	RES1	4	-4
MA001831	RES1	4	-4

General Building Stock (GBS) Results Analysis

GBS results are provided in their raw form as produced by Hazus Version 3.2. The delivery package of data includes an ESRI File Geodatabases with the respective results. The following is screen capture demonstrating the data:



Summarization of Various Loss Results

Source of Loss Values

- User-Defined Facilities (Individual Buildings)
  - Building Damage Percent (%)
  - Content Damage Percent (%)
  - Building Loss Value (US Dollars - $)
  - Content Loss Value (US Dollars - $)
  - Inventory Loss Value (US Dollars - $)
- General Building Stock
  - Business Disruption; where Business Disruption = Inventory Loss + Relocation Cost + Income Loss + Rental Income Loss + Wage Loss + Output Loss

While the Hazus GBS module will produce Building Loss and Contents Loss values, users are reminded that the GBS-based values are produced through area-weighting (i.e., proportional) methods.

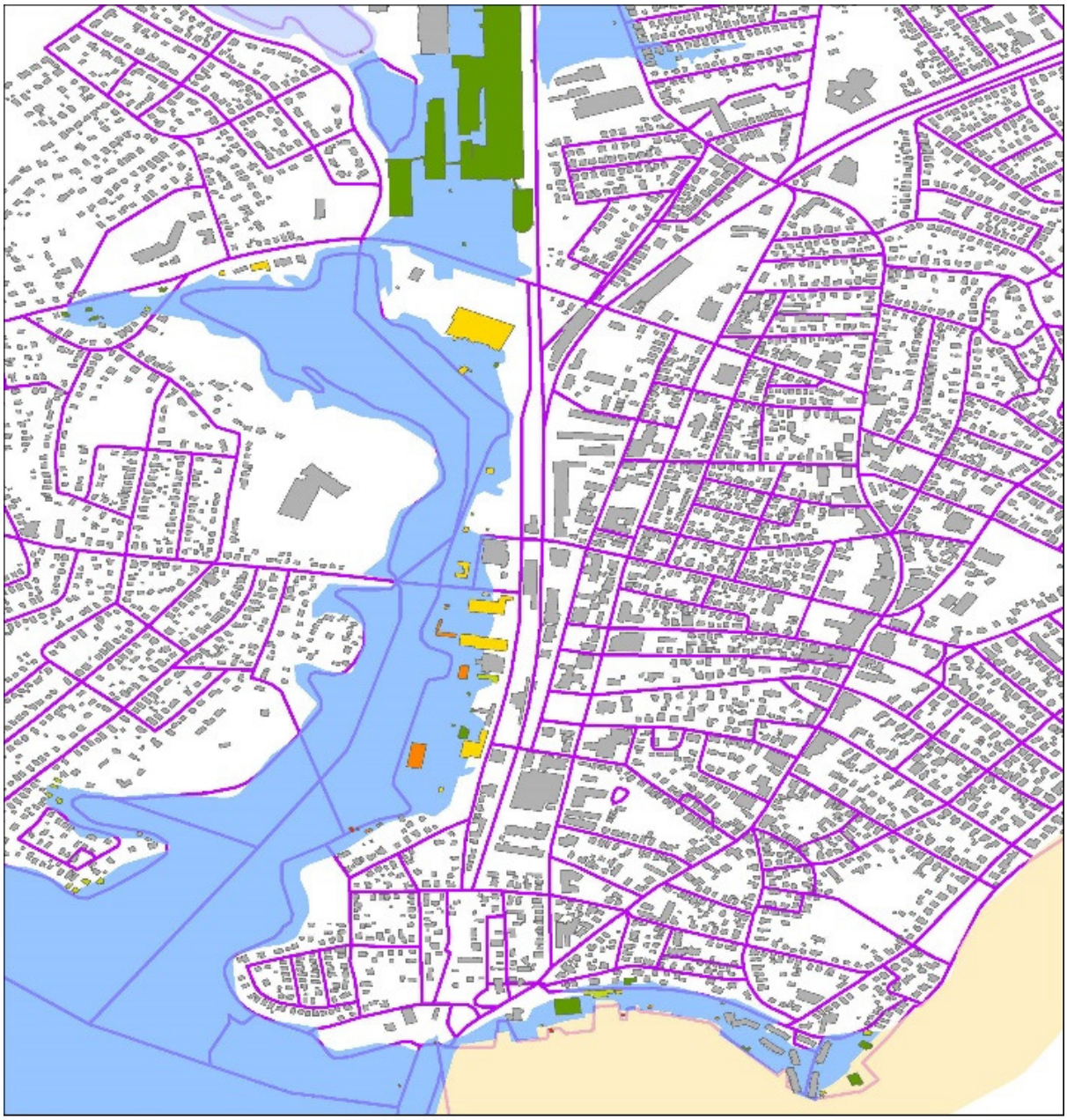
Annualized Loss Values, Ratio, and Ranking

This Hazus flood scenario model includes five (5) multi-frequency return period events; the 10-, 25-, 50-, 100- and 500-year frequency events. These return periods are also expressed as annual-chance events represented by 10%, 4%, 2%, 1% and 0.2%. Estimated loss values from each annual chance event are annualized to determine the weighted average loss (or) the expected loss in any given year across the range of years analyzed (500 years). The mathematical computation is defined as:

Annualized Loss =

*[(10% – 4%) *(Loss 10% + Loss 4%) / 2] +*
*[(4% – 2%) * (Loss 4% + Loss 2%) / 2] +*
*[(2% – 1%) * (Loss 2% + Loss 1%) / 2] +*
*[(1% – 0.2%) * (Loss 1% +Loss 0.2%) / 2] +*
*[0.2% * Loss 0.2%]*

The annualized values were computed with a python script outside of Hazus, as the 9 buildings with errors caused problems with the annualized UDF data inside Hazus. The annualized UDF results were then combined with the Building Roofprints dataset. Ratios were developed based on the Building and Content Values versus the total Building, Content, and Inventory Average Annual Damages they received in the analysis. These ratios were then ranked from 1 – 149, with 1 having the highest average annual damage ratio and 149 having the least. This includes the nine buildings that had issues, but are included as damages could occur at these locations. These ranks were then associated with the polygon roofprints feature class, which can be mapped such as the figure below.



Roofprint With Rank Beverly S Fld Haz Ar

- 1 - 21
- 22 - 49
- 50 - 78
- 79 - 106
- 107 - 149
- 150

- A - 1% Annual Chance Flood Hazard
- AE - 1% Annual Chance Flood Hazard
- Floodway
- VE - 1% Annual Chance Flood Hazard

Damaged buildings represent those individual structures that intersected the flood depth grids and experienced estimated building and or content losses. Table 12 below represent damage values for the 100-year and average annual losses.

Table 12. 100-year and Average Annual Losses Comparison

Return Period	Building Losses	Content Losses	Inventory Losses	Total Losses
100-Year	$6,887,700	$7,211,391	$2,921,438	$17,020,530
Average Annual	$876,629	$1,056,143	$132,632	$2,065,404

Other Flood Modeling Details & Discussion

The July 16, 2014 FIS Report was consulted for obtaining the needed information to create the flood depth grids and run the analysis. The FIS report was for all of Essex County, but it contained specific information for City of Beverly that Dewberry was able to use. These values were input into Hazus version 3.2 where appropriate.

The Flood - Riverine Module is the automated methodology of cross section placement which, along with typical advancements in computing hardware and software, helps in the ability to process smaller drainage thresholds. Dewberry processed the project area at the one-square mile (1 mi^2). This Riverine analysis also included use of the most recent National Elevation Dataset (NED) digital elevation model (DEM) at the one-third arc second resolution (i.e., ~ 10 meter resolution). The beneficial effect of using the smaller drainage area threshold means that the analysis of flooded streams will extend further upstream - offering a more complete representation of potential flooding. Figure 1 displays the Hazus results for buildings that were impacted by flood and their proximity to the FEMA Special Flood Hazard Area: areas shaded in blue are AE zone, red are A zone, and yellow are VE zone. Buildings were ranked based on impact level, where red is high impact and green is low impact. The figure shows that there is a direct correlation between buildings impacted by flood and their proximity in or near the SFHA.

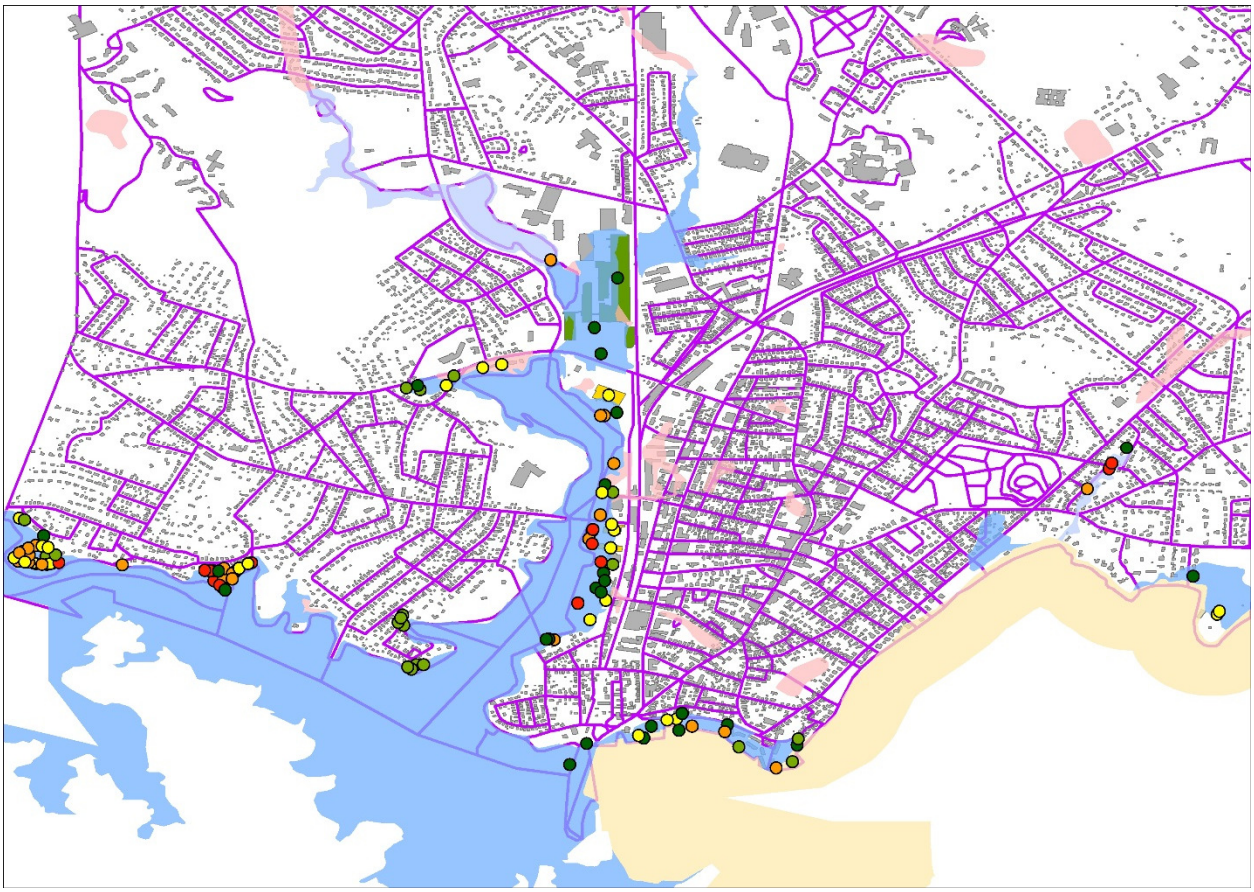


Figure 1. Buildings Impacted by Flood and Proximity to FEMA SFHA

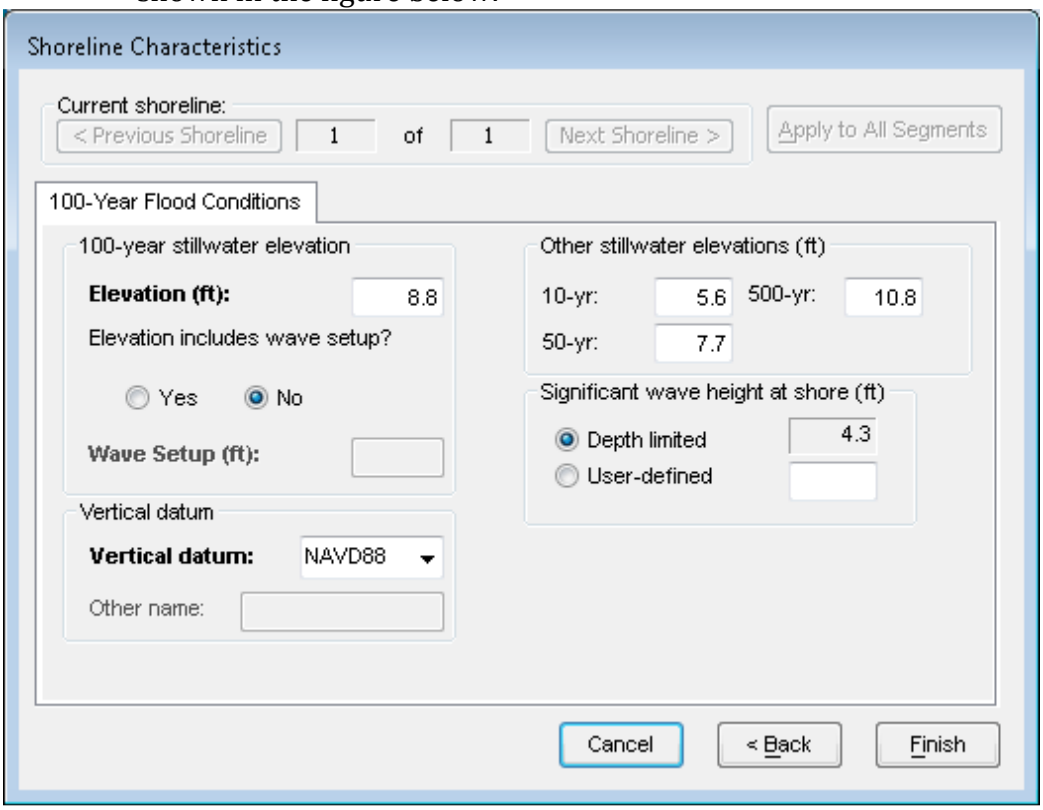
It is also important to note that most FEMA-initiated flood insurance studies use a one-square mile (1 mi^2) drainage threshold for delineation of floodplains. However, users should be warned and realize that FEMA flood studies also require the use of ground data that is much more precise than one-third arc second resolution (i.e., ~ 10 meter resolution); i.e., typical FEMA studies require DEM resolution of two-meter (2 m. or ~6.6 ft.) resolution or better. And therefore, while the Hazus Flood modeling can be improved in the future with 'User-Defined Depth Grids', it is notable to recognize the relative consistency that was obtained between the effective Digital Flood Insurance Rate Map (DFIRM) flood zones and the floodplains produced by Hazus at one-square mile (1 mi^2) drainage threshold.

Issues & Challenges Encountered:

- **Issue 1 & 2**
  - **Issue 1: Wave Setup** – the FIS Table 8 states that the Stillwater of 8.8 feet includes wave setup however it DOES NOT provide a value that represents the wave setup. Notes in the FIS refer the reader to the previously effective FIS, however once again the previous FIS only makes reference to the standard utilized to compute wave setup. THEREFORE,

the setting that was ultimately utilized included defining 8.8 feet as not including setup.

- **Issue 2: Other Stillwater elevations (ft)** - The countywide summary of Stillwater elevations that Hazus calculates by default did not match the 10%, 2%, and 0.2% elevations reported in the FIS. These were initially change to match the FIS report, but that analysis would not complete. Because of scope and budget, the default settings were used. This is shown in the figure below.



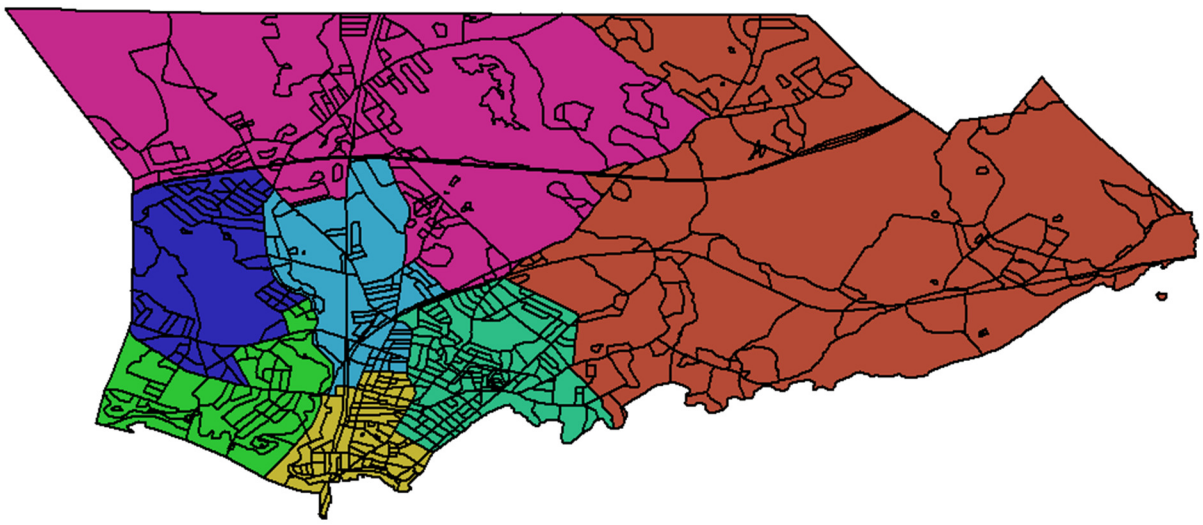
- **Potential Future Solution**: Develop 'User-Defined Depth Grids' from FEMA Flood Insurance Study and/or other detailed flood analyses.

- **Issue 3**
  - **Issue 3 – UDF Building Analyses Nine (9) Buildings Failed To Run**: Nine (9) of over 11,000 UDF's were reported to have errors and thus returned no data. Input building characteristics were reviewed but a determination as to what the analyses failed could not be determined. Users should be aware that these nine buildings, in theory, should have potential damages but the reason for failure is unknown at this time.
  - **Potential Future Solution**: Re-evaluate the inputs.

Hurricane (Wind) Modeling – Probabilistic Scenario

Setup

Dewberry performed a Probabilistic scenario in the Hazus Level 1 Hurricane (Wind) module. It is important for users to note that results of the Probabilistic Hurricane (Wind) scenario exist at the tract level and not the census block level as is the case with the Hazus Flood Model. A combined storm surge (Flood & Hurricane) was not modeled. There are 7 tract areas that comprise the City of Beverly; the figure below demonstrates the relationship between blocks (smaller geographic unit) versus the color-coded tracts (larger geographic unit). User Defined Facilities, which would be at the individual point or building-level is the most refined geographic unit however, users should note that UDF analyses were not run for the Hurricane Wind model.



Issues & Challenges Encountered

None. However, recommendations for future analyses would include developing further UDF attributes to include those building characteristics pertaining to hurricane wind. Furthermore, if such attributes are developed, they can be leveraged into a building risk assessment in Hazus for combined storm surge analyses.

Hazus Modeling Results

The final models and resulting data will be included in an attached package given with the report to City of Beverly from Dewberry. This includes the Hazus backup models that were used to develop the data. Table 13 shows how the files sizes are, and when opened with Hazus, how much space they require in the C drive or else the computer will crash.

Table 13. Model File Sizes

HPR Name	HPR File Size	Expanded File Size	Info
BevMAv32FLDStock.hpr	278 MB	670 MB	Stock Hazus data before updated with GBS calculated from the UDF data. Was not run to completion due to scope and time of project

Table 13. Model File Sizes			
HPR Name	**HPR File Size**	**Expanded File Size**	**Info**
BevMAv32FLDUpdtd.hpr	635 MB	5.25 GB	Updated Hazus data with GBS calculated from the UDF data. Was run for the 10, 25, 50, 100, and 500 year scenarios with riverine and coastal depth grids
BvrlyMAv32HURProb.hpr	16.9 MB	149 MB	Updated Hazus data with GBS calculated from the UDF data. Was run for the 10, 20, 50, 100, 200, 500, and 1000 year scenarios.

The following tables contain some of the more interesting and meaningful results. From Table 14, the total annualized losses account for about 0.33% of the total value of the city. Other percent damages for the different building occupancies are also shown in that table. In Table 15, the GBS losses for the Building, Contents, and Inventory are shown, along with other Disruption values that are commonly analyzed with Hazus. Table 16 show the number of buildings that might be damaged given the different frequency of storm analyzed. The table shows that up to 4,077 buildings could be damaged by the 1000-year storm, which accounts for about 35.7% of the 11,424 valid UDF buildings found within City of Beverly. Table 17 shows what the annualized losses are from the Hurricane model for those 4,077 buildings. Total annual losses was around $96,235,209 which accounts for about 1.57% of the total value of City of Beverly.

Table 14. UDF Damages by General Occupancy for City of Beverly					
Totals	**COM**	**GOV**	**IND**	**RES**	**Grand Total**
Exposure/Value	$566,649,029	$655,356	$6,006,307	$54,900,509	$628,211,203
Damages	$1,534,841	$2,528	$28,875	$499,159	$2,065,404
Percent Damage	0.27%	0.39%	0.48%	0.91%	0.33%

Table 15. Dasymetric GBS Total Losses Calculated by Hazus for City of Beverly								
Building Loss	**Contents Loss**	**Inventory Loss**	**Building Loss Ratio %**	**Relocation Loss**	**Capital Related Loss**	**Wages Losses**	**Rental Income Loss**	**Total Loss**
$1,231,000	$1,409,000	$15,575,000	0.1	$4,315,000	$9,653,000	$5,239,000	$2,567,000	$39,989,000

Table 16. Hurricane Probabilistic Number of Buildings Damaged					
Return Period	**Minor**	**Moderate**	**Severe**	**Destruction**	**Total**
10	0	0	0	0	0
20	8	0	0	0	9
50	99	6	0	0	105
100	455	40	1	0	495
200	1170	149	4	2	1325
500	2281	463	27	19	2789
1000	3094	845	83	55	4077

Table 17. Hurricane Direct Economic Losses For Buildings: Annualized Losses								
Cost Building Damage	**Cost Content Damage**	**Inventory Loss**	**Loss Ratio**	**Relocation Loss**	**Capital Related Loss**	**Wages Losses**	**Rental Income Loss**	**Total Loss**
$1,316,054	$525,539	$868,505	0.02	$53,751,912	$7,951,496	$9,417,518	$22,404,186	$96,235,209

Appendix D – 2012 Mitigation Strategies Status

Hazard Area	Mitigation Measure	Implementation Responsibility	2017 Measure Update (continued/cancelled/completed?)
High Priority			
A) Flooding	Chubb Brook	DPW	Completed
B) Flooding	Install a tide gate at the mouth of the Bass River.	DPW	Underway. See Table 6-1, Activity 1.
C) Storms/Multi-hazard	Purchase a new excavator and brush grapple. The PDM Team identified the need to clear brush and fallen tree limbs from streets and power quickly following high wind events as a top priority.	DPW	Completed - A Homeland Security Grant helped to fund a regional equipment purchase for the Northeast EM Region. Equipment is shared and deployed on an as needed basis.
D) Flooding	Identify resources to maintain City drainage infrastructure on an ongoing basis.	DPW	Completed on an annual basis. A new strategy was added to continue this activity with measurable parameter and an identified funding source. See Table 6-1, Activity 3.
E) NFIP Compliance	Floodplain Management - update flood management district regulations	Planning	Completed - Updated in 2014 to adopt new FIRM
F) NFIP Compliance	Maintain up to date maps of local FEMA identified floodplains.	Planning	Completed. New maps adopted in 2014. LOMR Complete in 2017. Removed
G) NFIP Compliance	Acquisition of Vacant Flood Prone Lands	Conservation Commission	Deferred - Re-written and included in update. See Table 6-1, Activity 4.
H) NFIP Compliance	Acquisition of Vacant Flood Prone Lands	Conservation Commission	Duplicate of Above. Removed.
I) Multi-hazard	Acquire a new, towable, multi-phase, diesel generator.	DPW	Removed. Not completed. Regional Risk Program purchased one for sharing on an as needed basis.
Medium Priority			

Hazard Area	Mitigation Measure	Implementation Responsibility	2017 Measure Update (continued/cancelled/completed?)
J) Flooding	Install a tide gate/flapper valve on existing four foot drain line on the Bass River near the 103 Elliot Street commercial condominiums.	DPW	Deferred - Re-written and included in update. See Table 6-1, Activity 6.
K) Storms	Replace approximately 6000- 8000 square feet of bottom-anchored floats at Beverly Harbor Center with concrete, pile-held floats	DPW	Completed. Removed from update.
L) Storms/Coastal Flooding	Repair the Bay View seawall.	DPW	Deferred. Re-written and included in update. See Table 6-1, Activity 8.
M) Storms	Repair the eroded western coastal bank at Obear Park.	DPW	Deferred. An eroded culvert was replaced but the overall project was not addressed. Re-written and included in update. See Table 6-1, Activity 9.
N) Storms/Coastal Flooding	Master Plan Update: Include a section on Climate Change and its potential impacts on Beverly in the next update of the Master Plan.	Planning	Removed. Master Plan has not been updated, but a Coastal Resilience Plan was completed in June of 2017 and will be incorporated by reference when the City Masterplan is updated.
O) Flooding	Purchase twelve, 2-inch submersible pumps for basement pump outs and other flood-related response efforts.	DPW/Fire Department	Completed. Removed from update.
P) Brush Fires	Purchase .5 miles of new 1.5-inch forestry hose; new 4x4, 350 gallon, 2-ton woods fire truck; new hand held fire pumps	Fire Department	Deferred. Re-written and included in update. See Table 6-1, Activity 11.
Q) Earthquakes	Assess the earthquake vulnerability of all public buildings. Investigate options to make all public buildings earthquake-resistant.	Fire Department	Deferred. Re-written and included in update. See Table 6-1, Activity 12.
Lower Priority			
R) Multi-hazard	Purchase 50 new handheld radios for Fire Department	Fire Department	Not Completed – Removed and replaced with new strategy.

Hazard Area	Mitigation Measure	Implementation Responsibility	2017 Measure Update (continued/cancelled/completed?)
S) Multi-hazard	Replace current master fire alarm boxes with radio master box alarms.	Fire Department	Not Completed – Carried over to new plan.

Appendix E – 2017 – 2022 Detailed Strategy Update

Activity #	Goal/Strategy	Activity Description	Lead Agency	Support Agencies	Estimated Cost*	Potential Funding Sources	Timeframe for Completion	Hazard(s) to be Addressed										Priority Level	BIENNIAL REVIEW STATUS UPDATE
								Hurricanes/ TS	Tornado	Severe Weather /T-Storm	Winter Storm	Flood	Extreme Temps	Wildland Fire	Drought	Earthquake	Climate Change		
1	A-I A-II	**Problem Statement:** Repetitive flooding of Cummings Center ground floor at Buildings 100, 800 and 900 buildings. Minor flooding at Cabot/Herrick Street area. **Mitigation Strategy:** Installation of tide gate at the outlet of the culvert from Cummings Center "Lower Shoe Pond" at Bass River (Elliott St.). Installation of 36" drain pipe at building 900 and various backflow valves, seals and protective devices at exterior openings buildings 100, 800, 900.	DPS		$1.1 Million (including engineering, permitting and construction)	Sewer Enterprise Fund and FEMA HMA Grants	Dependent on FEMA approval of Change of scope					X					X	High	
2	A-II	**Problem Statement:** Flooding lower Chubbs Brook drainage area at MBTA Rail/Beach Street impacting Beach Street sewer Pump Station. **Mitigation Strategy:** Construct Chubbs Brook improvements to speed up discharge, at the culvert under Route 127.	DPS		$200,000 culvert paid by MA Dot if Bev designs and permits	MA DOT	2021-2022					X					X	High	
3	A-II	**Problem Statement**: Beverly's drainage system is aging and in need of improvements to prevent nuisance flooding and damage to infrastructure. **Mitigation Strategy:** Complete localized drainage improvements Citywide	DPS		$50,000 - $100,000 per year	Sewer Enterprise Fund	2017-2022 Annual		X			X					X	High	
4	A-IV A-V A-VI BI-III	**Problem Statement:** Beverly has identified the acquisition of open space as a community goal when funding is available. That goal presents the opportunity for mitigation of damages from several natural hazards. **Mitigation Strategy:** Acquire undeveloped open space, prioritizing at risk property	Con. Comm.	Planning	TBD	Community Preservation Act Grants – MA Park and Land Grant	2017-2022					X		X			X	Medium	
5	A-III B-I-II C-I	**Problem Statement:** With Sea Level Rise and increasing intensity rainfall events, along with increasing flood risks in general, the minimum NFIP elevation standards may soon be inadequate to protect new construction and substantial improvements. **Mitigation Strategy:** Evaluate and implement as appropriate freeboard in NFIP regulations to account for SLR	Planning	DPS	Staff Time	Staff Time	2018	X				X					X	Low	
6	A-I-II	**Problem Statement:** At the Youth Center parcel at Bass River is a Storm Sewer Pump Station that pumps stormwater during an event from the gravity pipe with 4 pumps to a higher elevation. The gravity pipe is subject to tidal water inflow. **Mitigation Strategy:** Install a tide gate/flapper valve on existing 4' pipe near Youth Center at Bass River to address long term SLR.	DPS		$150,000	Capital Budget/FEMA Grants/MA CZM Coastal Resource Grants	2018-2019					X					X	Medium	
7	A-1 A-V A-VI	**Problem Statement:** Concern that the Harbor Master Building could potentially flood from storm surge. Engineering study phase 100K. **Mitigation Strategy:** Engineering analysis potentially raise seawall elevation (Reference Beverly Coastal Resiliency Plan)	DPS		$100,000	Capital Budget Grant	2018	X				X						Medium	
8	A-1 A-V A-VI	**Problem Statement:** Due to the poor condition of the Bay View Seawall, the Coast Guard Commander's House and road are at risk of flooding and erosion. **Mitigation Strategy:** Repair or rebuild the Bay View Seawall, to protect, coast guard commanders house and the road.	DPS	Planning	$900k rebuild or $74k repair	Capital Budget Grant / MA CZM Coastal Resource Grants	2019-2021	X		X	X	X					X	Medium	

Activity #	Goal/Strategy	Activity Description	Lead Agency	Support Agencies	Estimated Cost*	Potential Funding Sources	Timeframe for Completion	Hazard(s) to be Addressed										Priority Level	BIENNIAL REVIEW STATUS UPDATE
								Hurricanes/ TS	Tornado	Severe Weather /T-Storm	Winter Storm	Flood	Extreme Temps	Wildland Fire	Drought	Earthquake	Climate Change		
9	A-I-III A-V-VI	**Problem Statement:** Due to the eroded western coastal bank, on the east side of Obear Park, the salt marsh is currently being compromised and may increase flooding. Also a safety issue due to erosion. **Mitigation Strategy 1:** Repair the eroded western coastal bank on the eastern side of Obear Park. **Mitigation Strategy 2:** Install large box culvert, currently built into scope of dredging project, to protect the salt marsh and alleviate coastal flooding.	DPS		$250,000	Capital Budget FEMA Grant	2018/2019	X		X	X	X					X	High	
10	B-II-IV C-II-IV	**Problem Statement:** The current Beverly Master Plan does not adequately address natural hazards or the impacts of climate change and sea level rise. **Mitigation Strategy:** Master Plan Update: During the update of the Beverly Master Plan (2020) include a section on the impacts of climate change and sea level rise. Incorporate resilience and sustainability throughout the document	Planning		$200,000	Capital Budget	2019 - 2021	X	X	X	X	X	X	X	X	X	X	Medium	
11	A-I A-II	**Problem Statement:** As identified in Chapter 4, Hazard ID and Risk Assessment, the more rural areas of Beverly are at risk to wildland fires. Climate change and increases in drought conditions will continue to exacerbate this condition. **Mitigation Strategy:** Purchase ½ mile of new 1.5 inch forestry hose, new 4x4, 350 gallon, 2-ton forestry truck and new hand held fire pumps	Fire / EM		TBD	Capital Budget / Forestry Grants	2019-2021							X			X	Medium	
12	A-I A-IV B-III B-IV C-III	**Problem Statement**: As identified in the Hazard ID and Risk Assessment Beverly faces a risk of earthquake damages. With a high vulnerability but very low probability and return frequency, mitigation alternatives are a challenge. **Mitigation Strategy:** Use recently acquired Community Preservation Act funds to assess the earthquake vulnerability of all public buildings. Make recommendation on improvements to public buildings to make them more earthquake resistant (Golf and Tennis Facilities)	DPS	Inspectional Services	TBD	CPA Grant	2018-2020									X		Low	
13	A-I A-IV B-III B-IV C-III	**Problem Statement:** Same as #12 **Mitigation Strategy:** When pursuing Community Preservation Act funds for preservation planning and City owned properties, incorporate earthquake considerations	Planning	Inspectional Services	TBD	CPA grants	2018-2022									X		Low	
14	A-I A-II	**Problem Statement:** Several sewer Pump Stations are prone to flooding. They are also prone to power outages caused by nearly all natural disasters. Potentially could cause sewer overflow depending on number of failures. **Mitigation Strategy:** Use SLR projections for inland flooding aligned with 2030/2070 scenarios from the Coastal Resiliency Plan to inform relocation of pump stations, as necessary. Purchase generators for back-up power supply.	DPS		TBD	Capital Budget / FEMA Grants	2018-20122	X	X	X	X	X				X	X	Medium	
15	A-1 A-2	**Problem Statement:** Pershing Ave seawall protects a pump station at Wenham Lake and is in need of repair. If the pump station is "down" the City Water Storage Tank off Brimbal Avenue would not replenished impacting potable water supply to residents and fire-fighting capability. **Mitigation Strategy:** Rebuild approximately 100 feet of seawall along Pershing Avenue to protect the pump station.	DPS		$150,000+	Capital Budget / FEMA Grants / MA CZM Coastal Resource Grants	2018-2022	X			X	X						Medium	

Activity #	Goal/Strategy	Activity Description	Lead Agency	Support Agencies	Estimated Cost*	Potential Funding Sources	Timeframe for Completion	Hazard(s) to be Addressed										Priority Level	BIENNIAL REVIEW STATUS UPDATE
								Hurricanes/ TS	Tornado	Severe Weather /T-Storm	Winter Storm	Flood	Extreme Temps	Wildland Fire	Drought	Earthquake	Climate Change		
16	A-1 B-III B-IV	**Problem Statement:** Lightning strike and potential fire of building. **Mitigation Strategy:** Purchase and install Lightning Rods for Harbor Master House	DPS		$25,000+	TBD	2018-2022		X	X								Low	
17	C-II C-III	**Problem Statement:** There are currently no controls in place or programs to encourage water conservation during periods of drought. Many homes have irrigation systems on timers that operate regardless of moisture conditions. **Mitigation Strategy:** Implement an educational /outreach program for the public on the use of humidity sensors on irrigation systems	Planning, DPS thru Water Dept.	Salem Sound Coastwatch	Staff time	Capital Budget	2019								X			Low	
18	A-1 A-II	**Problem Statement**: Crane Pier is among the top five catch ports in Massachusetts and is vital to the local economy. It is considered critical infrastructure for the fishing industry. Install a new crane. Also note activity #7. **Mitigation Strategy:** Crane pier steel piles and concrete deck replacement.to provide viable local commercial fishing industry and additional protection to Harbor Master Building.	DPS		1.9M	Capital Budget Seaport Advisory	2019	X			X	X					X	Medium	
19	A-1 A-II C-III	**Problem Statement:** Bass River, when properly opened, provides a safe harbor where the commercial fishing industry and recreational boaters can seek shelter from storms and protect their livelihood. Such safe harbor is vital to the local fishing economy. **Mitigation Strategy:** Dredge the Bass River to allow access by the commercial fishing industry as a safe harbor and educate commercial fishing industry.	DPS	Harbor Mgmt. Authority	$5.5 Million	USACE (if it can be defined as a federal channel) / MassWorks Grant with 50% Capital Match	2018-2022	X		X	X	X					X	Medium	
20	A-II B-III B-IV	**Problem Statement:** A seawall and coastal structure inventory, maintained by MA CZM was updated 4-5 years ago with support of Beverly. There are still inaccuracies in ownership and conditions data. The City would benefit from further updating the inventory. **Mitigation Strategy:** Continue to improve and update seawall inventory in coordination with MA CZM. More accurate data will make it easier to prioritize mitigation actions.	DPS	Planning / GIS	Staff time	MA CZM	2018-2022	X			X	X					X	Low	
21	A-II B-III B-IV	**Problem Statement:** A neighborhood adjacent to the Dane Street Beach Seawall and a roadway are at risk of flooding and erosion, due to storm events and Northeaster's. The Lothrop Street/Bay Street area is prone to flooding. **Mitigation Strategy: Complete** Dane Street Beach Seawall improvements and extension or some other alternative.	DPS		>$250,000	Capital Budget	2018-2022											Medium	
22	A-I A-II	**Problem Statement:** Tree trimming equipment is 20+ years old and in distressed condition. **Mitigation Strategy**. Purchase new chipper and truck to protect city property and public safety and the property of others.	DPS	Fire	$100,000	TBD	2018-2022	X	X	X	X		X				X	Medium	
23	A-III B-I B-II B-IV C-I C-IV	**Problem Statement:** The FEMA Limited to Moderate Wave Action (LiMWA) mapped area is inaccurate. A Conservation Commission Special Conditions Permit is required for any development in these areas and complications are encountered due to the mapping inaccuracies. This problem was not corrected by a previous Letter of Map Revision (LOMR).	DPS	Planning, Con Com	$50,000	Capital Budget / FEMA CTP	2018					X						High	

Activity #	Goal/Strategy	Activity Description	Lead Agency	Support Agencies	Estimated Cost*	Potential Funding Sources	Timeframe for Completion	Hazard(s) to be Addressed										Priority Level	BIENNIAL REVIEW STATUS UPDATE
								Hurricanes/ TS	Tornado	Severe Weather /T-Storm	Winter Storm	Flood	Extreme Temps	Wildland Fire	Drought	Earthquake	Climate Change		
		Mitigation Strategy: Petition and work with FEMA Region I to correct LiMWA accuracy issues and obtain a FEMA sponsored Letter of Map Revision.																	
24	B-III B-IV C-III	**Problem Statement:** As identified in Chapter 4, Hazard ID and Risk Assessment, the more rural areas of Beverly are at risk to wildland fires. Climate change and increases in drought conditions will continue to exacerbate this condition.	Fire	Endicott College	Staff Time	Capital Budget and Volunteer Time	2018-2022							X			X	Low	
		Mitigation Strategy: Provide Firewise USA Communities info to homeowners – available at touch a truck, in library, other venues																	
25	A-II B-11 B-III B-IV	**Problem Statement:** As identified in Chapter 4, Hazard ID and Risk Assessment, the more rural areas of Beverly are at risk to wildland fires. Climate change and increases in drought conditions will continue to exacerbate this condition. Fuel Maintenance has not been conducted in many years.	Fire Dept.		Staff Time	Capital Budget / Forestry Grants	2019 - 2022							X			X	Medium	
		Mitigation Strategy: Develop a program to include both fuel maintenance on City owned high risk land and the maintenance of fire roads to allow access for fire suppression apparatus.																	
26	A-II B-III B-IV C-III	**Problem Statement:** Current master fire alarm boxes are in poor or non-working condition in many locations and in need of technology upgrades	Fire Dept.		$100,000	Capital Budget	2019 – 2022							X				Medium	
		Mitigation Strategy: Replace current master fire alarm boxes with radio master box alarms.																	
27	A-III B-I B-II B-III	**Problem Statement:** Preservation of open space in floodprone areas is needed to reduce future risk. The Open Space Residential Design (OSRD) standards provide an opportunity to preserve flood prone land.	Planning		Staff Time	Staff Time	2018-2022					X					X	Medium	
		Mitigation Strategy: When reviewing project for Open Space Residential Design (OSRD) – Cluster development, consider land set aside for open space for land vulnerable to flooding																	
28	B-II	**Problem Statement:** Additional protection from flooding in the upper region of Chubbs Brook is needed.	DPS	Mass DEP	100K	Grant	Unknown												
		Mitigation Strategy: Create additional flood storage area off Hart Street. This task was in an early project; however, Mass DEP refused to permit. STAPLE/E risks were identified during ranking. The committee chose to leave in the update as a low priority project.						X			X	X					X	Low	
29	A-I A-II B-III B-IV	**Problem Statement:** Damage to sea wall at Lynch Park and erosion on land-ward side of Lynch Park sea wall and retaining wall to Woodbury Beach from March 2018 "Riley" Northeaster	DPS		500K	Capital Budget State Dam/Seawall Grant	2019												
		Mitigation Strategy: Repair seaward side of sea wall and fortify the land-ward of the sea wall and retaining wall and Increase elevation of sea wall						X			X	X					X	High	
30	A-I B-IV	**Problem Statement:** From the Coastal Resiliency Plan the South Essex Sewer District (SESD) Pump Station is at risk in a 2030 1% event. This pump station pumps all of sanitary sewer from Beverly and Danvers to the SESD plant in Salem.	DPS		250K	SESD and Beverly/Danvers Grant	2019												
		Mitigation Strategy: Engineering study to determine alternatives to fortify the SESD pump station for sea level rise and storm serge						X			X	X					X	High	

Appendix F – Record of Changes

Record of Changes

2017 Plan Section	Heading Section	Changes Made
EXECUTIVE SUMMARY		Re-wrote Executive Summary to follow flow of the updated plan.
SECTION 1. INTRODUCTION	1.1 Mitigation	Minor Changes
	1.2 Impetus for Local Mitigation Planning	Clarified planning authorities and requirements
	1.3 City of Beverly Local Hazard Mitigation Plan 2017 Update Sections	Provided an overview of the sections of the plan and their contents
SECTION 2. PLANNING PROCESS	2.1 Local Hazrd Mitigation Planning Committee	Explained the expanded team from last plan and gave definition to Core Team, Local Hazard Mitigation Planning Committee and Additional Stakeholder Committee
	2.2 Meetings, Public Participation, Stakeholder Engement	Added/Updated a table with detail of all meetings, stakeholder involvement and public touch points
	2.3 Online Public Survey	Added section explaining the addition of a public survey and how it informed the planning process
	2.4 Public Website	Explained the use of the DPS website for soliciting public and stakeholder input
	2.5 Public Meetings	Overview of meetings with public during the update process
	2.6 Beverly Coastal Resilience Plan Coordination	Eplained how for this update there was significant overlap with public and stakeholder efforts with the simultaniously conducted Coastal Resilience Planning Effort
	2.7 Incorporation of Existing Plans and Studies	Refreshed the list of documents that were reviewed and considered in more detail in the Capability Assessment
SECTION 3. COMMUNITY PROFILE	All Subsections	Refreshed all subsections with updated date where available. Particular emphasis was placed on updating Land Use and Development Trends
SECTION 4. HAZARD IDENTIFICATION AND RISK ASSESSMENT	All Subsections were completely rewritten and the entire Section reformatted to meet regulatory requiremenst and those of updated guidance.	In order to update Beverly's risk assessment, the most recently available hazard and land use data was gathered and City staff met to identify changes in local hazard areas and development trends. City staff reviewed critical infrastructure in order to create an up-to-date list. The most recently available version of HAZUS (described below) was used to assess the potential impacts of flooding and hurricane wind on the city's infrastructure using the best available data. The 2017 plan update expands the hazard specific profiles, and consolidates, updates, and streamlines content from the 2010 hazard identification. As part of the update, the following hazards were added to the hazard identification and risk assessment section: • Severe Weather (Thunderstorms); and • Extreme Temperatures. The 2017 analysis included, but was not limited to: 1) determining annualized number of hazard events and losses using the National Centers for Environmental Information (NCEI), which was formally known as the National Climatic Data Center (NCDC) and other data sources where available; 2) updating the assessment of vulnerability and risk based on new data; 3) new analysis with updated critical facilities data; 4) creation of hazard maps specific to the city; and 5) providing overall hazard comparisons. In addition, each section of the plan was also
SECTION 5: CAPABILITY ASSESSMENT AND EXISTING MEASURES	All subsections were updated to reflect changes.	Overview of planning, regulatory and policy capabilities was updated. Additional stakeholder capabililities were added, including Endicot College and Salem Sound Coastwatch, who have added to Beverly's capabilitites as active partners in resilience. Increased emphasis on climate change and sea level rise was added along with a disucssiton of the 2017 Beverly Coastal Resilience Plan. A table was added to evaluate the effectiveness of existing programs and capabilities.
SECTION 6. HAZARD MITIGATION STRATEGY FOR 2017-2022	All subsections were updated to reflect changes.	Goals, Objectives and Strategies were updated to reflect changing conditions, public input and increased emphasis on climate change and sea level rise. A table in the section, as well as an appendix was added to discuss the disposition of the 2012 strategies. The 2017-2022 Strategies were expanded significantly to provide a better linkage to the risk assessment results, and crosswalk to the objectives

Record of Changes

2017 Plan Section	Heading Section	Changes Made
		significantly to provide a better linkage to the risk assessment results, and crosswalk to the objectives and to the hazards identified. Problem statements were added, linking most straties more specifically to the HIRA. A detailed review and ranking of the strategies, including STAPLE/E and a group exercise were added. An appendix was added with the mitigation strategies table with a status update column for use at Biennial Reviews.
SECTION 7: PLAN ADOPTION AND MAINTENANCE	All subsections were updated.	This Section was inhanced to add more parameters to regular review, evaluation and update. A subsection was also added on plan integration. Provisions were added for ensuring continued public input during implementation and update.

Appendix G – Sample Adoption Resolutions

RESOLUTION NO. _____

A RESOLUTION TO ALLOW THE CITY OF BEVERLY TO ADOPT THE BEVERLY 2017 HAZARD MITIGATION PLAN UPDATE AS THE CITY'S OFFICIAL HAZARD MITIGATION PLAN.

WHEREAS the City of Beverly has experienced past flooding and other natural hazard events that pose risks to public health and safety and which may cause serious property damage;

WHEREAS the planning process fostered by the Massachusetts Emergency Management Agency and set forth by the Federal Emergency Management Agency offers the opportunity to consider natural hazards and risks, and to identify mitigation actions to reduce future impacts of such hazards;

WHEREAS the Commonwealth of Massachusetts provided federal Hazard Mitigation Assistance program funds to the City of Beverly to support development of an updated hazard mitigation plan;

WHEREAS a *Hazard Mitigation Plan* has been developed by the Local Hazard Mitigation Planning Committee and staff from the City and other entities;

WHEREAS the *Hazard Mitigation Plan* recommends several mitigation actions that will help minimize and reduce safety threats and damage to private and public property; and

WHEREAS a public meeting was held on ____, 2018, to solicit questions and comments and to present the plan and the proposed mitigation actions.

NOW THEREFORE BE IT RESOLVED by the City Council of the City of Beverly that:

1. The *Hazard Mitigation Plan* is hereby adopted as an official plan of the City of Beverly.
2. The City offices identified in the Plan are hereby directed to pursue implementation of the recommended priority actions that are assigned to their agencies.
3. Any action proposed in the Plan shall be subject to and contingent upon budget approval, if funding is required, and this resolution shall not be interpreted so as to mandate any such appropriations.
4. The Department of Public Services and Engineering is designated to coordinate with other City offices and stakeholders and shall periodically report on the activities, accomplishments, and progress, and shall prepare a progress report as required by the Massachusetts Emergency Management Agency.

AND BE IT FURTHER RESOLVED, that this Resolution shall take effect on its passage

PASSED this _____day of _____, 2017.

[insert standard signature blocks]

Appendix H – List of Abbreviated Terms

List of Abbreviations

BFE	Base Flood Elevation
CIP	Capital Improvement Program
COOP	Continuity of Operations
CR	Coastal Resilience
CRS	Community Rating System
DFIRM	Digital Flood Insurance Rate Map
DMA	Disaster Mitigation Act
EAS	Emergency Alert System
EF Scale	Enhanced Fujita Scale
EMS	Emergency Medical Services
EOC	Emergency Operations Center
FEMA	Federal Emergency Management Agency
FHBM	Flood Hazard Boundary Maps
FIRM	Flood Insurance Rate Map
GIS	Geographic Information System
HAZUS-MH	FEMA's loss estimating software for floods, earthquakes, and hurricane winds
HIRA	Hazard Identification and Risk Assessment
HMGP	Hazard Mitigation Grant Program
LHMPC	Local Hazard Mitigation Planning Committee
MEMA	Massachusetts Emergency Management Agency
MA CZM	Massachusetts Coastal Zone Management
MA DCR	Massachusetts Department of Conservation and Recreation
MAPC	Metropolitan Area Planning Commission
NCEI	National Center for Environmental Information
NFHL	National Flood Hazard Layer
NFIP	National Flood Insurance Program
NLCD	National Land Cover Data
NOAA	National Oceanic Atmospheric and Atmospheric Administration
NWS	National Weather Service
Risk MAP	Risk Mapping, Assessment, and Planning
RL	repetitive loss
SFHA	Special Flood Hazard Area
SRL	severe repetitive loss
STAPLE/E	Social, Technical, Administrative, Political, Legal, Economic, and Environmental
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey