Community Resilience Building Workshop: Summary of Findings

Municipal Vulnerability Preparedness (MVP)

Melrose, Massachusetts

April 5 & 11, 2018

Prepared by:

CDM Smith

Citation: City of Melrose, (2018) Community Resilience Building Workshop Summary of Findings, Municipal Vulnerability Preparedness (MVP) Program. Melrose, Massachusetts.

Summary of Findings

1.1 Overview

The City of Melrose was awarded a $19,000 grant from the Massachusetts Executive Office of Energy and Environmental Affairs to conduct Community Resilience Building (CRB) workshops in the City. This funding is through a new program called Municipal Vulnerability Preparedness (MVP). Conducting the workshops allows Melrose to achieve "MVP" designation from the Commonwealth – a designation that gives the City access to further funding to implement resilient actions. Melrose is also in the process of updating the Natural Hazards Mitigation Plan (HMP) and will incorporate the findings from the CRB workshops; the HMP will be the primary resilience planning document for the City of Melrose. The City engaged the consulting firm, CDM Smith, to assist with both efforts.

1.2 Community Resilience Building Workshops

In Melrose, the workshops held in conjunction with the MVP program were a new initiative to immediately integrate community-derived priorities into a natural hazard mitigation process and identify actions to build resilience in the community. The workshops' central objectives were to:

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

A core team was established for this process, which consisted of:

- Martha Grover, Energy Efficiency Manager
- Elena Proakis Ellis, City Engineer
- John Scenna, Director of Public Works

Prior to the workshops, the core team identified preliminary hazards and areas of concerns. These were mapped and presented at the workshops and included in a participatory mapping exercise (see Appendix A). The core team, along with the consultant, identified departments and organizations recommended to attend the workshops. These were: Chamber of Commerce, Comcast, Conservation Commission, Department of Public Works, EMARC, Emergency Management Department, Fire Department, First Congregational Church, First Methodist Church, Friends of the Fells, Hallmark Health Emergency Preparedness, Health Department, Human Rights Commission, Information Technology, Mayor's Office, Melrose Energy Commission, Melrose Historical Commission, Melrose Housing Authority, Melrose Public Schools, Massachusetts Emergency Management Agency, Mystic Valley Elder Services, National Grid, Office of Planning and Community Development, Parks Department, Pedestrian and Bicycle

Advisory Committee, Police Department, Riverside Community Care, State Representatives/ Senators, and Verizon. All were invited by the Mayor to participate; see section 1.3.3 for a specific list of workshop participants. The workshops were held on two days: Thursday, April 5, and Wednesday, April 11, 2018. Prior to attending the workshops, the participants were asked to fill out a survey, a copy of which can be found in Appendix B, along with the survey results.

1.2.1 Top Hazards and Vulnerable Areas

At the first workshop, participants were asked to identify connections between ongoing community issues, hazards, and local planning and actions in Melrose. They were also asked to identify and map vulnerabilities and strengths to develop infrastructure, societal, and environmental risk profiles for Melrose. Maps reflecting City landmarks and facilities, existing and potential areas of flooding concern, and possible heat impacts were prepared for discussion (see Appendix A). To facilitate this exercise, the following definitions from the World Bank[1] were discussed with participants:

- **Hazard:** A physical process or event (hydro-meteorological or oceanographic variables or phenomena) that can harm human health, livelihoods, or natural resources.
- **Risk:** The potential for consequences where something is at stake and where the outcome is uncertain.
- **Exposure**: The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by a hazard.
- **Sensitivity**: The degree to which a system, asset, or species may be affected, either adversely or beneficially, when exposed to climate variability or change or geophysical hazards.
- **Vulnerability or Strength:** The potential effects of hazards on human or natural assets and systems. These potential effects, which are determined by both exposure and sensitivity, may be beneficial or harmful.

As a brainstorming exercise, participants were asked the following triggering questions from the CRB Workshop Guide:

- What hazards have impacted Melrose in the past? Where, how often, and in what ways?
- What hazards are impacting your community currently?
- What effects will these hazards/changes have on Melrose in the future (3, 5, 10, 25 years)?
- What/who is exposed to hazards and climate threats within your community?
- Other concerns or considerations?

[1] Source: World Bank: https://climatescreeningtools.worldbank.org/content/key-terms-0

The hazards, risks, and vulnerabilities from this brainstorming session are presented in Figure 1-1.

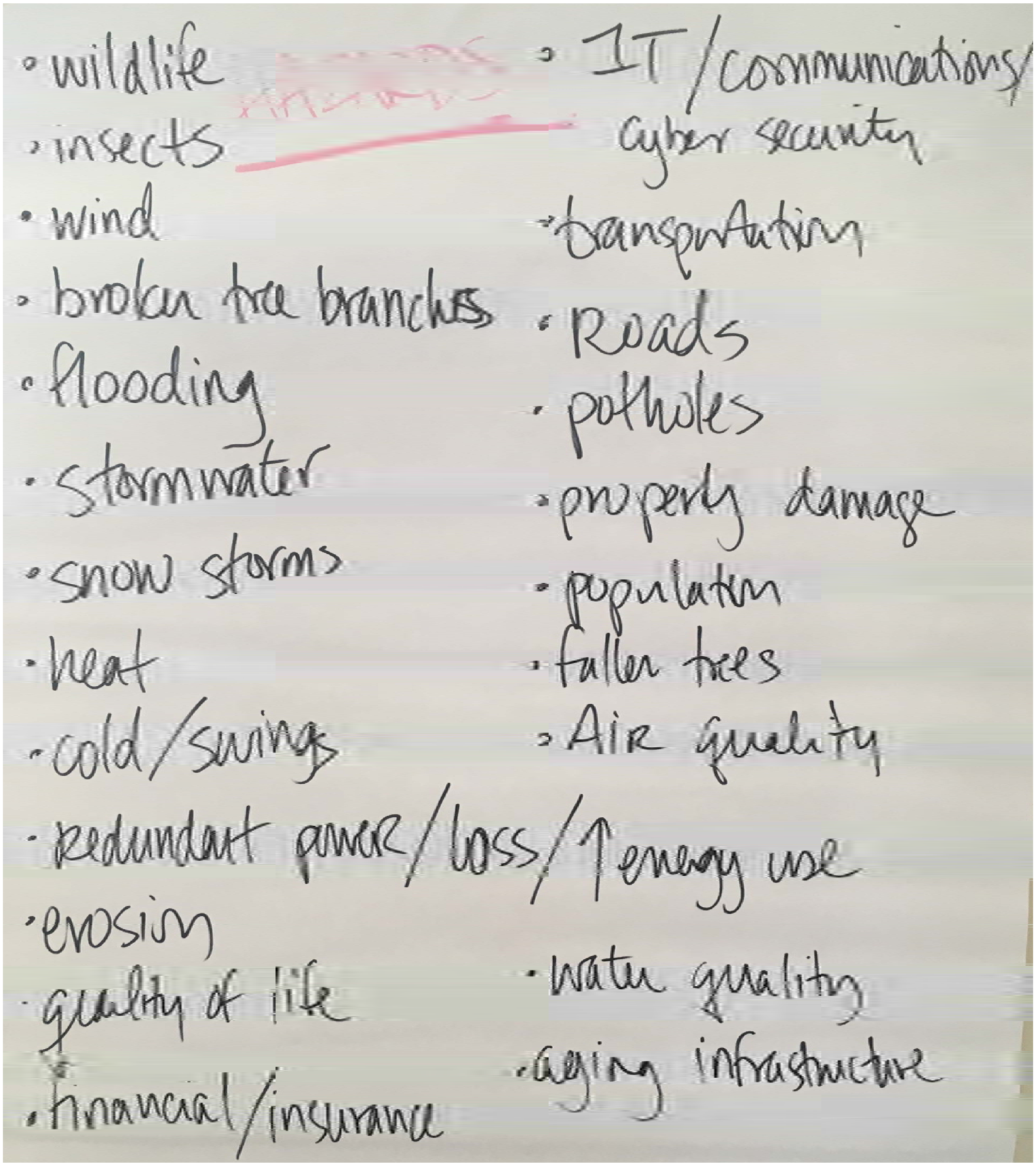


Figure 1-1
Melrose Hazards, Risks, and Vulnerabilities (brainstorm results)

1.2.1.1 Top Hazards

The Massachusetts Executive Office of Environmental Affairs (EEA) summarized the existing and expected future climate conditions by major watershed in the Commonwealth. Melrose falls into two watersheds; however, the majority of the City is in the Boston Harbor Basin. Therefore, projections from this basin were used as a basis for discussing future climate change in the City (see Appendix C). The key takeaways[2] from EEA on the future climate conditions are:

- Regardless of geographic scale, rising temperatures, changing precipitation, and extreme weather will continue to affect the people and resources of the Commonwealth.
- Average, maximum, and minimum temperatures are expected to increase; seasonally, maximum summer and fall temperatures are expected to see the highest projected increase and minimum winter and fall temperatures are expected to increase.
- The number of days receiving precipitation over one inch are variable, fluctuating between loss and gain of days.
- Seasonal projections for total precipitation are also variable for the Boston Harbor basin. The winter season is expected to experience the greatest change with an increase of 0-20% by mid-century, and 3-34% by end of century.
- Annual and seasonal projections for consecutive dry days, or for a given period, are variable.
- Precipitation will be more variable. "Extreme" precipitation events are likely to occur more often.

With these climate change impacts in mind, the group was divided into three working groups, each of which was asked to identify the top four hazards from this list or others they felt were important to address. The Top Hazards were:

- Extreme temperature[3] (3 groups)
- Flooding (2 groups)
- Major Storms (2 groups)
- Wind (2 groups)
- Power Loss (2 groups)
- Disease (1 group)

[2] These impacts are direct from the document provided by EEA to MVP communities in December 2017 entitled "Massachusetts Climate Change Projections."
[3] One group identified extreme heat; two groups identified extreme temperatures which includes heat and cold.

1.2.1.2 Areas of Concern Identified by Core Team

Prior to the meeting, the core team identified areas of concern due to potential hazards. They included sanitary sewer overflows, the ability to respond to large snowstorms, and the need for back-up power at sewer pump stations, cooling stations, and especially at City Hall. Additional areas with flooding concerns were noted to include:

- Geneva Road drainage that ties into Upham Street
- Outfalls at Wyoming Cemetery, downstream to Malden, and structure at Swain's Pond
- Connection between Towners Pond and Swain's Pond
- Lebanon Street at Sylvan Street
- City Hall parking lot
- Railway bridge at Melrose Street
- Conant Park at Ravine Terrace
- Derby Road

1.2.2 Current Concerns and Challenges Presented by Hazards

Melrose has faced natural hazards in the past like other Massachusetts communities, including flooding from the Mother's Day storm in 2006, overwhelming snowfall totals during the winter of 2015, and most recently the nor'easter events in January and March 2018. During the March 2018 storm, City Hall lost power, which disabled the phone lines to emergency responders.

In addition to the areas of concern raised by the core team, participants identified other concerns and challenges during the brainstorming session at the first workshop. These included:

- Maintaining and improving quality of life in Melrose
- Managing insects, pests, and wildlife with changes in precipitation patterns and increasing temperatures
- Ability to stay in good financial standing and obtain insurance despite climate stressors
- Cyber security concerns, maintaining communication pathways, and information technology systems (IT) during events
- Vulnerability of transportation systems to all hazards – including: 1) pothole maintenance from multiple freeze-thaw periods and 2) public transportation reliability
- Damage to property during events

- Population increases and the demands on public systems and housing availability
- Fallen trees during storms and the ability to remove them in a timely manner
- Poor air quality as temperatures rise, especially during heat waves
- Increasing energy use and strain on the electrical grid during heat waves
- Maintaining water quality through changing conditions
- Ability of aging infrastructure to withstand current and future hazards

1.2.3 Specific Categories of Concerns and Challenges

The working groups further discussed specific concerns and challenges in each of the categories of infrastructure, society, and environment. These findings, characterized as vulnerabilities, are presented in Appendix D in the Risk Matrix and in Table 1-1 below.

Of particular concern, as highlighted by every working group, was the lack of emergency generation capacity at City Hall. Melrose City Hall is the hub of communications in Melrose; calls to police, fire, ambulance, and schools are all routed through City Hall. During a power outage, like the one experienced during the March 2018 nor'easter, calls to these important services do not go through and calling out from land line phones is not feasible. This results in potential hazards of the highest magnitude through the lack of immediate communication during storm related events.

1.2.4 Current Strengths and Assets

The working groups discussed strengths and community assets in each of the categories of infrastructure, society, and environment during the latter half of the first workshop. These findings are presented in Appendix D in the Risk Matrix and in Table 1-1 below. Several strengths of note were discussed, including:

- Melrose has improved and upgraded stormwater systems to manage and mitigate existing flooding issues. These include drainage improvements to Ell Pond and have had a dramatically positive impact on the community.
- There are many faith-based organizations and associated places of worship in Melrose. These are a strength due to the community resilience they provide, the potential to use these organizations as a conduit for information to the public, and as a physical location of refuge and aid during or after an event.
- Melrose has an excellent team of first responders and emergency action plans. This coupled with a local hospital are community strengths; however, the emergency planning documents require updating, which is a vulnerability.
- Melrose has a Shelter Management Plan and identified shelters to provide for citizens during a time of need, which is a strength, although services at these locations require review (e.g., air conditioning, backup power, food availability and storage, etc.)

Table 1-1 Vulnerabilities and Strengths in Melrose

Infrastructure Vulnerabilities and Strengths	V or S?
Roadways – evacuation routes, Melrose Street bridge	V
Technology – backup phones / public safety / servers	V
Drainage infrastructure / stormwater – parking lots	V/S
Sewer system / pump stations / MWRA	V
Power outages / power provider	V
City buildings / school facilities	V/S
New development	V/S
Generator capacity	V/S
Senior Center	V/S
Transportation network	V/S
Places of worship	S
Elderly and low-income housing	V
Society Vulnerabilities and Strengths	**V or S?**
Emergency responders	S
Emergency management plans / evacuation plans	V/S
MVP community / hazard mitigation plans	S
Public facilities	V/S
Hospital	S
Bus / transportation access	V/S
Seniors / aging population	V/S
Essential services to vulnerable populations	V
Communication (internal/to public)	V/S
Chronically ill / disabled	V
Managing public fear / anxiety	V
Security (cyber, physical, public safety)	V
Quality of life	V/S
Shelter management plan / shelters	S
Faith based organizations	S
Environment Vulnerabilities and Strengths	**V or S?**
Parks / open space / conservation land / Fells / Mt. Hood / trail network	V/S
Trees / canopy	V/S
Air quality	V
Heat islands	V
Local agriculture	V/S
Rodents / insects (vectors)	V
Mosquito management	V/S
Wildlife habitat	V/S
Water quality	V/S
Sewer overflow	V
Erosion	V

Note: V = Vulnerability, S = Strength

1.2.5 Actions to Improve Resilience

The second workshop was focused on developing and prioritizing actions to improve resilience in the City. Each working group developed actions that would reduce vulnerability and enhance strengths for the features identified during the first workshop. The actions target one or multiple of the hazards in each of the categories of infrastructure, society, and environment. These actions were prioritized by each group as a high, medium, or low priority and assigned a timeframe for action of either short, long, or ongoing. These findings are presented in Appendix D in the Risk Matrix.

1.2.5.1 Top Recommendations to Improve Resilience

Each working group identified the top five priority actions to improve resilience based on vulnerabilities and strengths identified by their group. These were presented to all workshop participants, who then voted on their top priorities from the aggregated list. The top action across every team was the need to install an emergency generator at City Hall. This project naturally rose to the top of the immediate needs list for the City of Melrose. The top five priority actions presented by the working groups were:

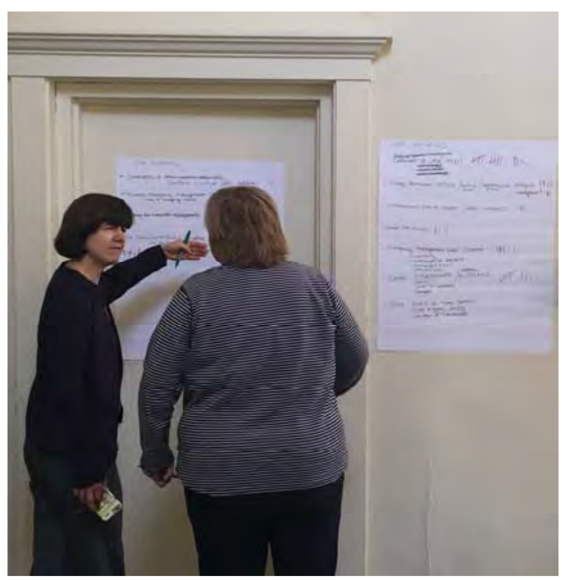
- Install a generator at critical public buildings and shelters[4] (1 group), specifically City Hall (3 groups)
- Install back-up power and bypass capability at water and sewer pump stations, including elevating infrastructure as appropriate (2 groups)
- Create a communications plan / conduct public outreach on hazards (2 groups)
- Update the emergency management plan which includes an evacuation plan, communication, and drills (2 group)

[4] One group generators at public buildings – including City Hall; two groups identified generators at City Hall specifically.

- Dredge stormwater outfalls, obtain a universal permit, and create a maintenance plan, which includes mosquito management (2 groups)
- Update the MS4 permit (1 group)
- Implement green infrastructure and green buildings, including zoning, stormwater, green energy, best management practices for developers, specific projects (1 group)
- Create a funded, dedicated emergency management director and a memorandum of understanding for emergency response (1 group)
- Create a funded tree warden position to advise on resilient tree species and consider public-private partnerships for funding for maintenance and planting (1 group)

After each team presented on their top five actions, each person was allowed three votes to allocate to any of the actions as show in Figure 1-2. This voting process determined the prioritized actions which are the Top Recommendations to Improve Resilience in Melrose. Furthermore, some sub-categories were established within these top priorities, as shown below:

1. Install an emergency generator at City Hall (17 votes)
2. Advance stormwater management actions including (9 votes):
    a. Dredge stormwater outfalls,
    b. Create a stormwater permit and maintenance plan, and
    c. Better manage mosquitos to reduce the spread of disease.
3. Improve emergency management including (9 votes):
    a. Update the emergency management plan, including evacuation routes and procedures,
    b. Improve outreach and communication to the public on emergency preparedness and climate hazards, and
    c. Create a dedicated/full-time emergency management director position.
4. Expand green infrastructure and green buildings, including (8 votes):
    a. Improving energy efficiency and expanding renewable energy throughout the City,



b. Implement best practices for stormwater management,

c. Update zoning codes and other regulatory mechanisms to facilitate green infrastructure and green buildings, and

d. Communicate and encourage best management practice implementation for developers.

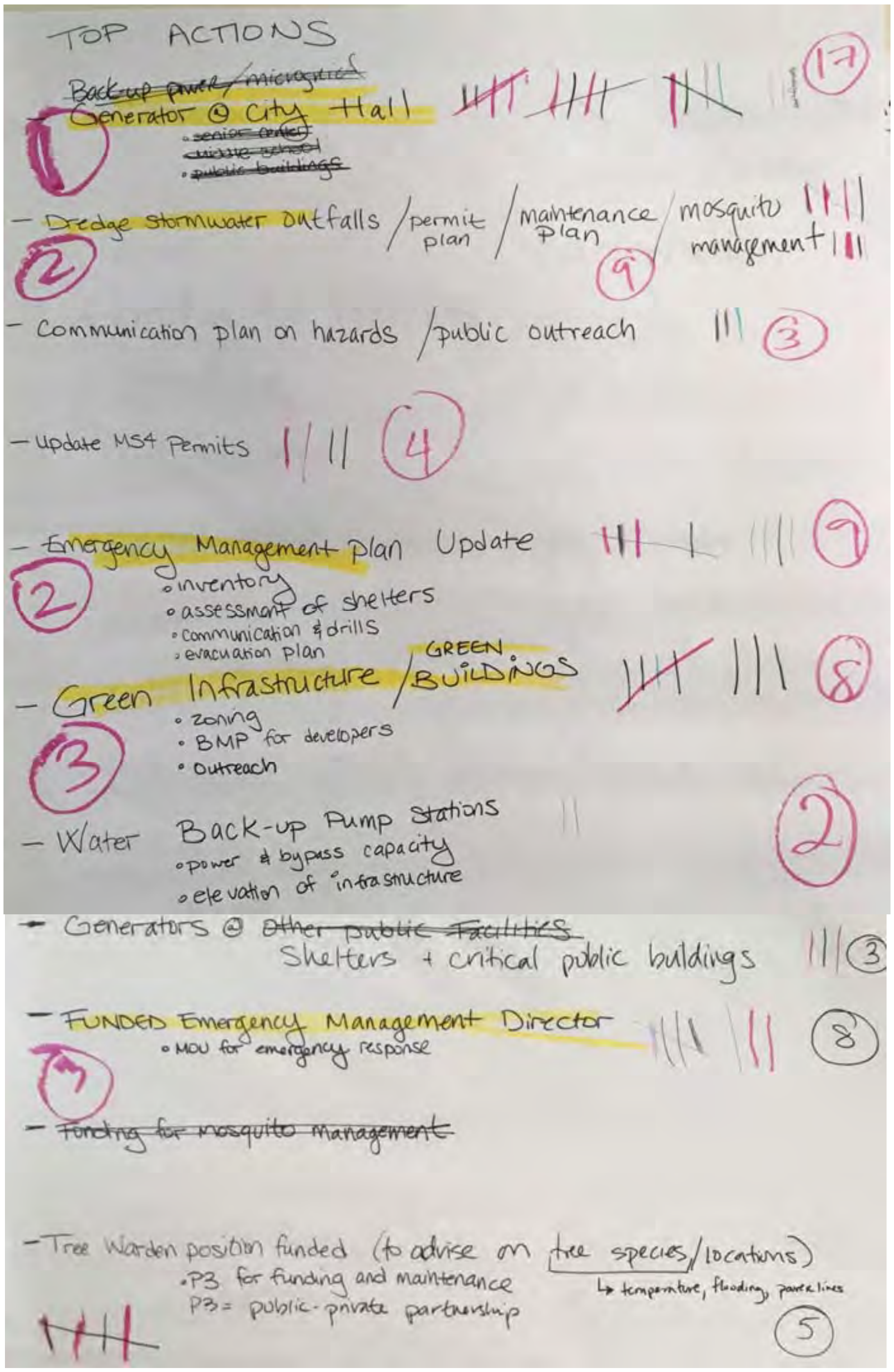


Figure 1-2
Melrose Top Actions

1.3 Acknowledgements

1.3.1 Leadership and Core Team Members

Thank you to the leadership and core team members for planning and facilitating the process described herein:

- Gail Infurna, Mayor of Melrose
- Martha Grover, Energy Efficiency Manager
- Elena Proakis Ellis, City Engineer
- John Scenna, Director of Public Works
- Lauren Miller, Lead Facilitator / Consultant Team, CDM Smith
- Lauren Klonsky, Table Facilitator / Consultant Team, CDM Smith
- Workshop scribes: Scott Dixon (Department of Public Works), Amy Heidebrecht (Department of Public Works), Lori Massa (Office of Planning and Community Development)

1.3.2 Funding and Facilities

Thank you to the Massachusetts Executive Office of Energy and Environmental Affairs for the funding to make these workshops possible.

Thank you to the Mount Hood Golf Club for providing the meeting space and refreshments.

1.3.3 Public Listening Session

The City of Melrose will hold a public listening session on June 21, 2018 open to the entire community to learn about the MVP process, next steps and actions, and how to implement resilience. The meeting will also discuss the Natural Hazards Mitigation Plan, which will identify actions to reduce the risk to the community from environmental hazards. The Natural Hazards Mitigation Plan will incorporate the findings from this report and will be the primary resilience planning document for the City of Melrose. This report and other resilience planning information may be found at: https://www.cityofmelrose.org/home/events/10693

1.3.4 Workshop Participants

Thank you to the community representatives that participated in the process, including:

Name		Department/Organization	
Brigid	Alverson	Mayor's Office	*
David	Ball	Fire Department	*
Joan	Bell	Parks Superintendent	*
Jim	Bennett	Melrose Historical Commission	
Paul	Brodeur	State Representative	*
Dan	Cameron	National Grid	*
Chris	Cinella	Chamber of Commerce	*
Ruth	Clay	Health Director, Emergency Management Director	*
Ed	Collina	Fire Department	
Paul	Cote	EMARC	
Eric	Devlin	Conservation Agent	*
Neal	Ellis	Information Technology Director	*
Denise	Gaffey	Office of Planning and Community Development	*
George	Harrington	Melrose Housing Authority	*
Faith	Hassell	National Grid	*
Andy	Henkenmeier	Hallmark Emergency Preparedness	*
Jim	Holt	Melrose Housing Authority	
Adam	LaFrance	Human Rights Commission	
Gary	LaMothe	Melrose Energy Commission, First Congregational Church	*
Stacy	Lanier	First Methodist Church	
Chris	Leary	Fire Department	
Jason	Lewis	State Senator	
Mike	Lindstrom	Mayor's Office	*
Mike	Lyle	Police Chief	*
Donna	Macdonald	Riverside Community Care	*
Mike	Main	MEMA Regional Manager, region 1	
Katie	Moore	Pedestrian and Bicycle Advisory Committee, Melrose Energy Commission, Resident	*
Ron	Morin	Friends of the Fells	
Susan	Murphy	Conservation Commission, Melrose Energy Commission	*
Dan	O'Leary	Mystic Valley Elder Services	
Judy	Santa Maria	EMARC, Director of Family Support	*
Dominic	Taranowski	First Congregational Church	
Cyndy	Taymore	Melrose Public Schools	
Lori	Timmermann	Melrose Energy Commission, First Congregational Church	*
Ann	Waitt	Department of Public Works	*
David	Young	Consulting Engineer, CDM Smith	*
Erin	Zwirko	Office of Planning and Community Development	
		Verizon	
		Comcast	

Note: *indicates attendance at the CRB Workshops. Others were invited to the meetings.

Appendices

- Appendix A: Base Maps and Participatory Mapping Maps
- Appendix B: Pre-Workshop Survey Questions and Results
- Appendix C: Climate projections provided by the Executive Office of Energy and Environmental Affairs
- Appendix D: Melrose Risk Matrix
- Appendix E: Melrose MVP Meeting Materials

Appendix A: Base Maps and Participatory Mapping Maps

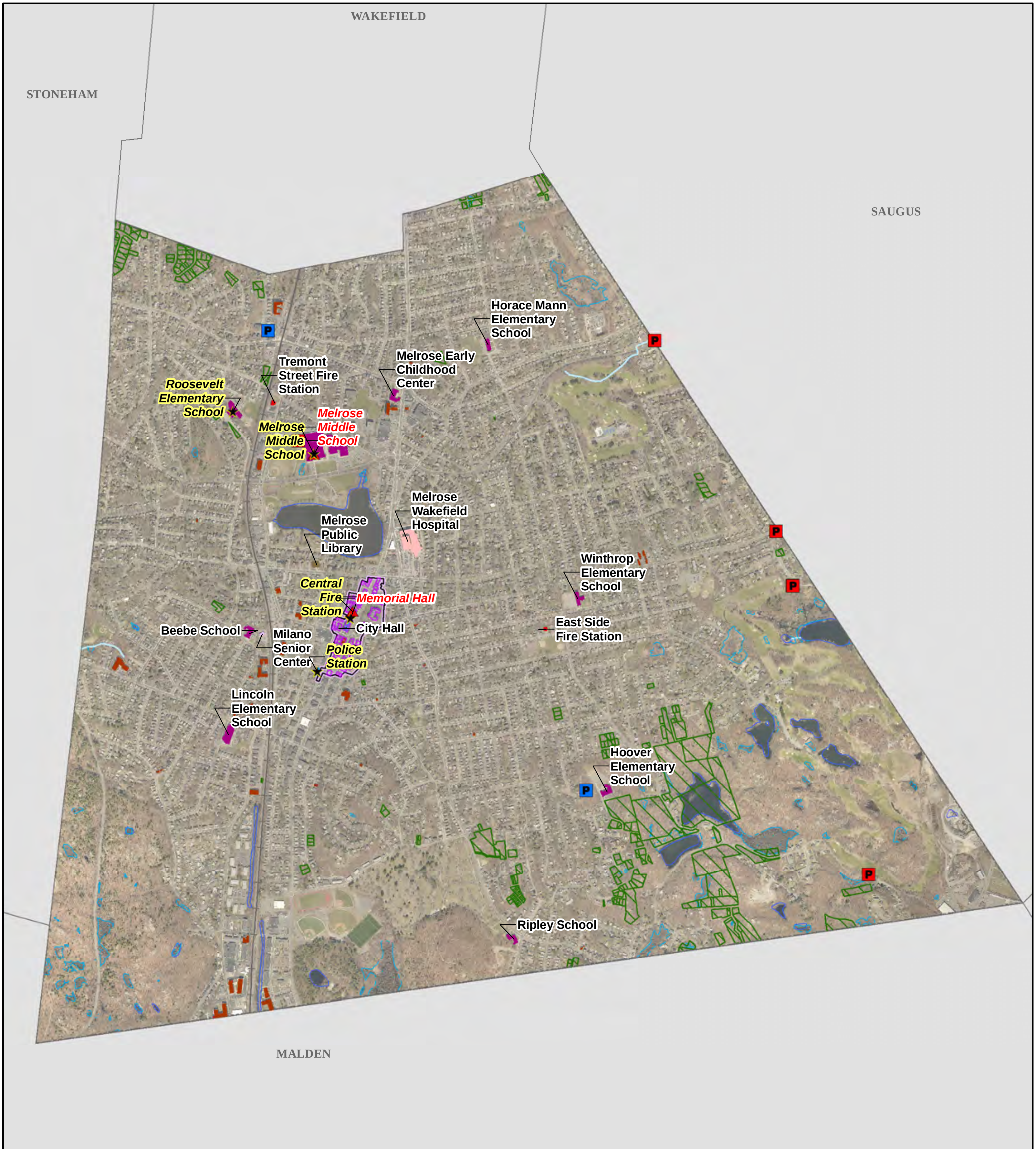


Figure 1:
Critical Facilities
City of Melrose, MA

Legend

- Police Station
- Fire Station
- City Hall
- Hospital
- School
- Library
- Affordable Housing
- Long Term Care
- Historic District Buildings
- Emergency Generators
- Emergency Shelter
- Historic District
- Conservation Land
- Town Boundary
- Railroad
- Streams
- Wetland Boundary (City of Melrose)
- Water bodies

Pump Stations

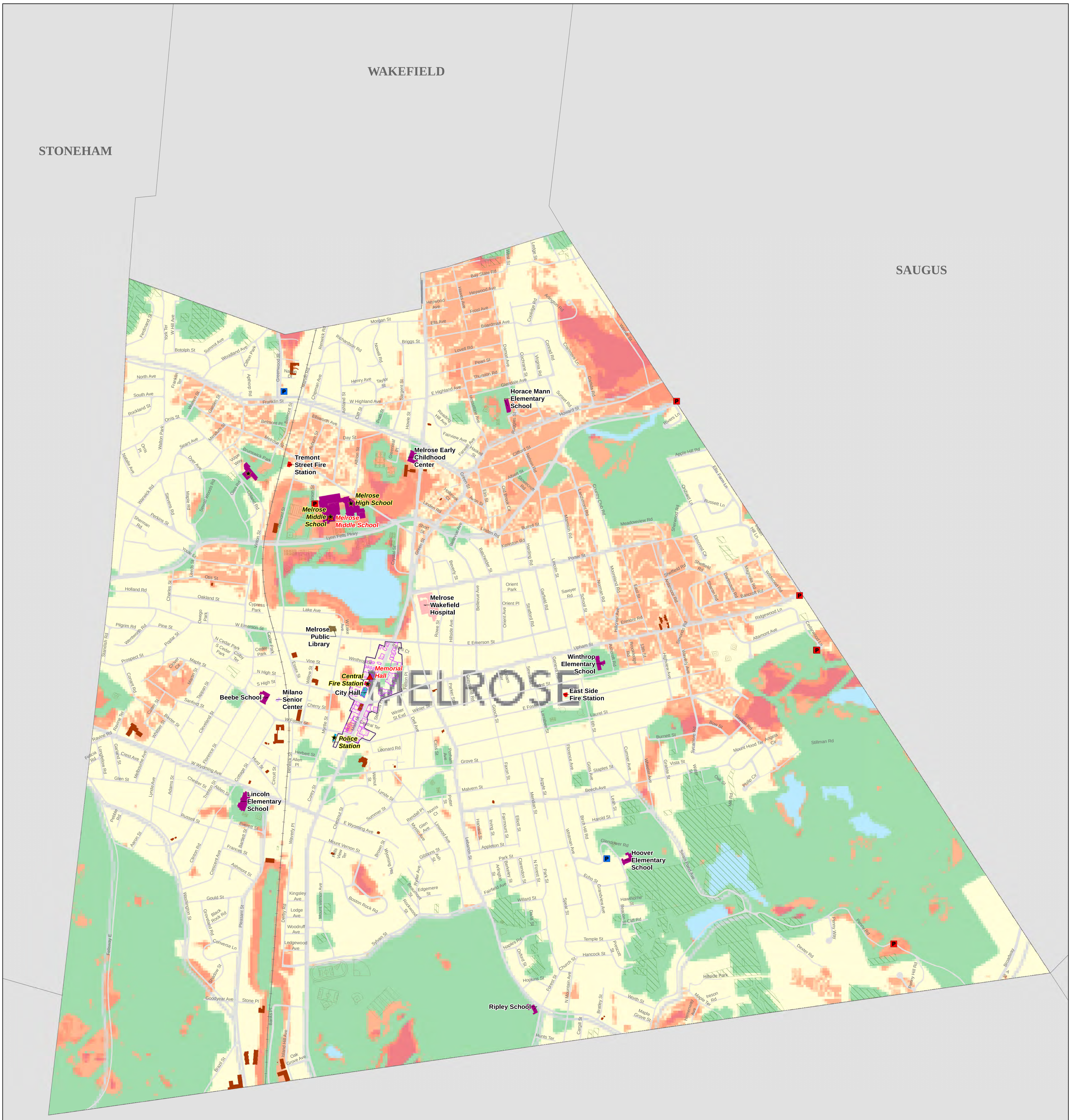
- Water Pump Station
- Wastewater Pump Station

N W E S

0 400 800 1,600 Feet

Source: City of Melrose, MassGIS, and FEMA
Coordinate System: NAD83 Mass. State Plane Mainland FIPS 2001 Feet

CDM Smith



As the Metro Mayors region grows, changes in land use coupled with changing precipitation patterns are increasing the amount of stormwater runoff during rainfall events and altering the natural hydrologic regime. Increased stormwater leads to increased nuisance flooding, increased levels of pollutants entering the region's waterbodies, and higher demands on the combined sewer system. Stormwater also creates other challenges, including increased carbon emissions as water is pumped through sewer systems and then treated in treatment plants.

This map highlights areas that may be at risk of decreased water quality and increased flooding due to increased rainfall events and was created by combining the following criteria:

Current Flood Zones
Estimated Runoff Potential
Soil Permeability
Slope
Existing Wetlands
Coastal Adaption Areas
Sinks
Water Quality

Legend

Climate-Smart Cities Layers[1]

- Metro Mayors study area boundary
- Metro Area Planning Council (MAPC) town boundary
- Priority lands already under protection
- Parks, open space, or other protected land

Addressing stormwater challenges priorities
- Very high
- High
- Moderate

- Police Station
- Fire Station
- City Hall
- Hospital
- School
- Library
- Affordable Housing
- Long Term Care
- Historic District Buildings
- Emergency Generators
- Emergency Shelter

Pump Stations
- Water Pump Station
- Wastewater Pump Station

- Pavement
- Historic District
- Conservation Land
- Town Boundary
- Railroad
- Courts

N W E S

0 400 800 1,600 Feet

Figure 2: Metro Mayor's Stormwater Challenges City of Melrose, MA

Source: City of Melrose, MassGIS, FEMA, TPL, and MAPC
1) Climate-Smart Cities: Metro Mayor Climate-Smart Region, November 13, 2017
Coordinate System: NAD83 Mass. State Plane Mainland FIPS 2001 Feet

CDM Smith

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ID	TYPE	COMMENT
1	FLOODING	Drainage problem
2	FLOODING	Drainage problem
3	FLOODING	Geneva Road at Upham St
4	FLOODING	Wyoming Cemetry outfall and downstream of outfall
5	FLOODING	Outlet structure at Swain's Pond
6	FLOODING	Connection between Towners Pond and Swain's Pond
7	FLOODING	Lebanon St at Sylvan St
8	FLOODING	City Hall parking lot
9	FLOODING	Railway bridge at Melrose St
10	FLOODING	Conant Park at Ravine Terrace
11	FLOODING	Derby Road
12	FLOODING	Lebanon St at Sylvan St
13	FLOODING	Grove St
14	FLOODING	Sanitary sewer overflows
15	POWER LOSS	Emergency shelters w/ no back-up power - Middle School
16	POWER LOSS	Emergency shelters w/ no back-up power - Memorial Hall
17-22	POWER LOSS	Pump stations - risk of power loss

Figure 3:
Critical Facilities & Flooding Vulnerable Population City of Melrose, MA

Source: City of Melrose, MassGIS, FEMA, TPL, and MAPC
1) Climate-Smart Cities: Metro Mayor Climate-Smart Region, November 13, 2017
Coordinate System: NAD83 Mass. State Plane Mainland FIPS 2001 Feet

CDM Smith

C:\PROJECTS\Melrose\Fig3_Melrose_Base_Flood_Vulnerable.mxd April 02, 2018

Legend
Police Station
Fire Station
City Hall
Hospital
School
Library
Affordable Housing
Long Term Care
Historic District Buildings
Emergency Generators
Emergency Shelter
Vulnerable Populations
Cool & Climate Equity[1]
Elevated land surface temperature (July-Aug 2015)[1]
High
Moderate
Pump Stations
Water Pump Station
Wastewater Pump Station
Pavement
Historic District
Conservation Land
Field
Town Boundary
Railroad
Courts
Streams
Wetland Boundary (City of Melrose)
Wetland (MassGIS)
N
W
E
S
0 400 800 1,600 Feet
Figure 4:
Urban Heat Islands & Vulnerable Population
City of Melrose, MA
Source: City of Melrose, MassGIS, FEMA, TPL, and MAPC
1) Climate-Smart Cities: Metro Mayor Climate-Smart Region, November 13, 2017
Coordinate System: NAD83 Mass. State Plane Mainland FIPS 2001 Feet
CDM Smith
Horace Mann Elementary School
Melrose Early Childhood Center
Tremont Street Fire Station
Melrose High School
Melrose Middle School
Melrose Wakefield Hospital
Melrose Public Library
Winthrop Elementary School
Memorial Hall
Central Fire Station
City Hall
East Side Fire Station
Beebe School
Milano Senior Center
Police Station
Lincoln Elementary School
Hoover Elementary School
Ripley School

ID	TYPE	COMMENT
1	FLOODING	Drainage problem
2	FLOODING	Drainage problem
3	FLOODING	Geneva Road at Upham St
4	FLOODING	Wyoming Cemetry outfall and downstream of outfall
5	FLOODING	Outlet structure at Swain's Pond
6	FLOODING	Connection between Towners Pond and Swain's Pond
7	FLOODING	Lebanon St at Sylvan St
8	FLOODING	City Hall parking lot
9	FLOODING	Railway bridge at Melrose St
10	FLOODING	Conant Park at Ravine Terrace
11	FLOODING	Derby Road
12	FLOODING	Lebanon St at Sylvan St
13	FLOODING	Grove St
14	FLOODING	Sanitary sewer overflows
15	POWER LOSS	Emergency shelters w/ no back-up power - Middle School
16	POWER LOSS	Emergency shelters w/ no back-up power - Memorial Hall
17-22	POWER LOSS	Pump stations - risk of power loss

Legend

- Police Station
- Fire Station
- City Hall
- Hospital
- School
- Library
- Affordable Housing
- Long Term Care
- Historic District Buildings
- Emergency Generators
- Emergency Shelter

Type of Flooding Issue

- Flooding
- Power Loss
- Flooding
- Cool & Climate Equity[1]

Pump Stations

- Water Pump Station
- Wastewater Pump Station

- Pavement
- Parcel Boundary
- Historic District
- Conservation Land
- Field
- Town Boundary
- Railroad
- Courts

- Streams
- Wetland Boundary (City of Melrose)
- 1% Annual Chance Flood Hazard with BFE or Depth (100-year storm)
- 0.2% Annual Chance Flood Hazard (500-year storm)
- Wetland (MassGIS)
- Water Bodies

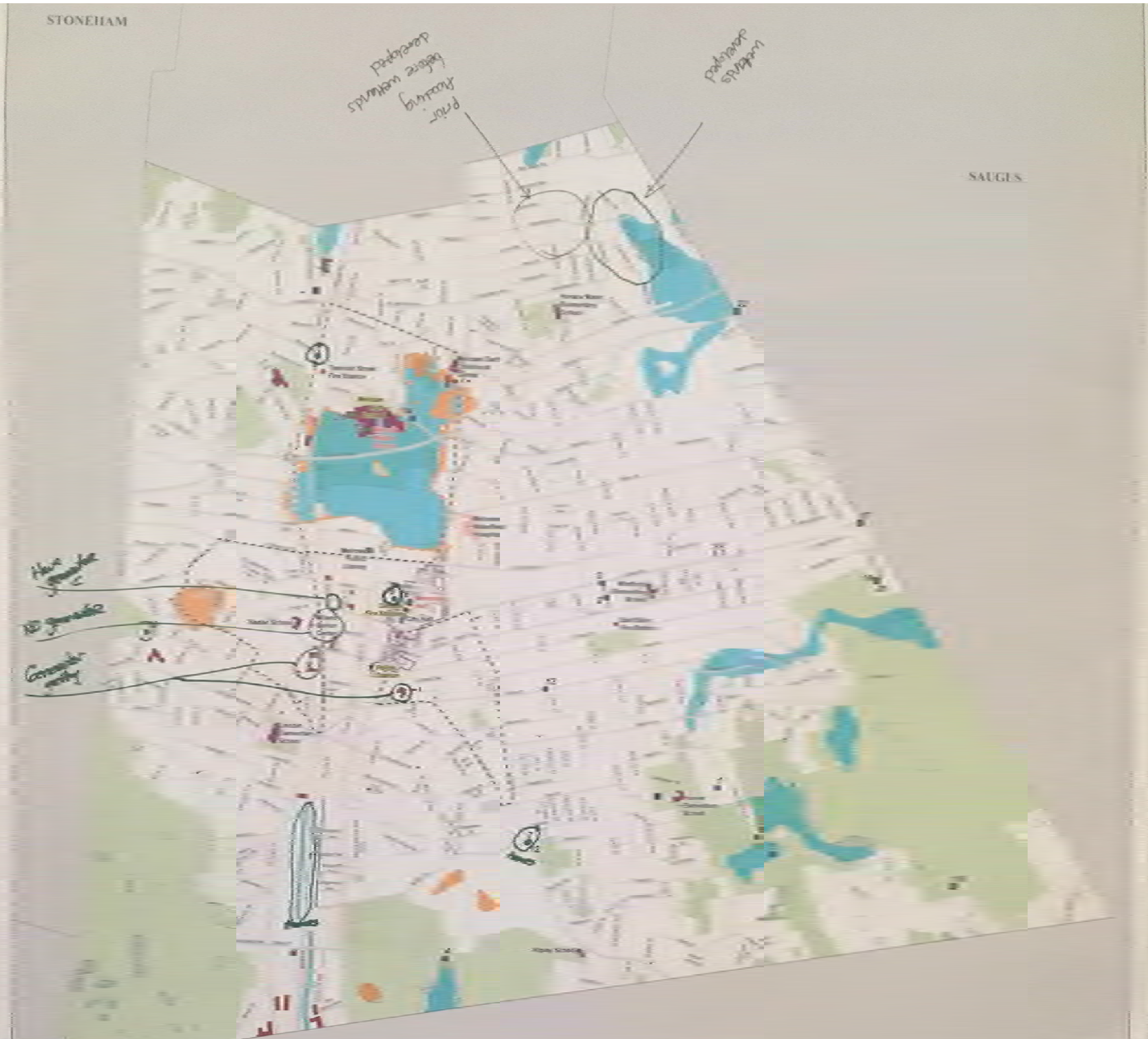
0 400 800 1,600 Feet

Figure 3: Critical Facilities & Flooding Vulnerable Population City of Melrose, MA

RED

Source: City of Melrose, MassGIS, FEMA, TPL, and MAPC
1) Climate-Smart Cities: Metro Mayor Climate-Smart Region, November 13, 2017
Coordinate System: NAD83 Mass. State Plane Mainland FIPS 2001 Feet

CDM Smith



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16	POWER LOSS	Emergency shelters w/ no back-up power - Memorial Hall
17-22	POWER LOSS	Pump stations - risk of power loss

Legend

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- School
- Library
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- Long Term Care
- Historic District Buildings
- Emergency Generator
- Emergency Shelter

Type of Flooding Issue
- Flooding
- Power Loss
- Flooding
- Cool & Climate Equity

Pump Stations
- Water Pump Station
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- Water Bodies

ORANGE

Figure 3:
Critical Facilities & Flooding
Vulnerable Population
City of Melrose, MA

CDM Smith

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5	FLOODING	Outlet structure at Swain's Pond
6	FLOODING	Connection between Towners Pond and Swain's Pond
7	FLOODING	Lebanon St at Sylvan St
8	FLOODING	City Hall parking lot
9	FLOODING	Railway bridge at Melrose St
10	FLOODING	Conant Park at Ravine Terrace
11	FLOODING	Derby Road
12	FLOODING	Lebanon St at Sylvan St
13	FLOODING	Grove St
14	FLOODING	Sanitary sewer overflows
15	POWER LOSS	Emergency shelters w/ no back-up power - Middle School
16	POWER LOSS	Emergency shelters w/ no back-up power - Memorial Hall
17-22	POWER LOSS	Pump stations - risk of power loss

Legend

- Police Station
- Fire Station
- City Hall
- Hospital
- School
- Library
- Affordable Housing
- Long Term Care
- Historic District Buildings
- Emergency Generators
- Emergency Shelter

Type of Flooding Issue

- Flooding
- Power Loss
- Flooding
- Cool & Climate Equity

Pump Stations

- Water Pump Station
- Wastewater Pump Station

- Pavement
- Parcel Boundary
- Historic District
- Conservation Land
- Field
- Town Boundary
- Railroad
- Courts

- Streams
- Wetland Boundary (City of Melrose)
- 1% Annual Chance Flood Hazard with BFE or Depth (100-year storm)
- 0.2% Annual Chance Flood Hazard (500-year storm)
- Wetland (MassGIS)
- Water Bodies

0 400 800 1,600 Feet

Figure 3:
Critical Facilities & Flooding
Vulnerable Population
City of Melrose, MA

Source: City of Melrose, MassGIS, FEMA, TPL, and MAPC
1) Climate-Smart Cities: Metro Mayor Climate-Smart Region, November 13, 2017
Coordinate System: NAD83 Mass. State Plane Mainland FIPS 2001 Feet

CDM Smith

Appendix B: Pre-Workshop Survey Questions and Results

Melrose Municipal Vulnerability Preparedness program

Pre-Workshop Survey: March/April 2018

Thank you in advance for your involvement in the two-part Community Resilience Building Workshop series for Melrose's Municipal Vulnerability Preparedness (MVP) planning process and our upcoming Community Resilience Building workshops on April 5 and April 11, 2018.

We are excited to work with you to identify and prioritize actions to improve Melrose's resilience to climate change. These actions will aim to reduce impacts from climate-related hazards to infrastructural, societal, and environmental components to our community – today, and in the future. This information will also be used in conjunction with the on-going Hazard Mitigation Plan update which gives the City the opportunity to apply for grant funding from the Federal Emergency Management Agency (FEMA) for projects that are necessary to mitigate risks to the community from natural disasters.

We are asking participants to complete this brief survey, which focuses on how the community currently perceives, assesses, and acts to reduce risks. This will help us understand your concerns and priorities to make the most of our workshops.

We look forward to your feedback!

- Martha Grover, Energy Efficiency Manager, City of Melrose

- Elena Proakis Ellis, City Engineer, City of Melrose

- Lauren Miller, MVP Trained Facilitator / Consultant, CDM Smith

1. Enter your Name and Organization.

* 2. Which of the following observed climate change impacts have already impacted your department / organization? Select all that apply.

- ☐ Increased frequency and magnitude of rain storms
- ☐ Increased frequency and magnitude of ice and snow storms
- ☐ Changes in precipitation patterns
- ☐ Increased seasonal / annual temperatures
- ☐ Temperature swings
- ☐ High wind events (including hurricanes, nor'easters, etc.)
- ☐ Other (please specify)

* 3. What climate-related hazards is your department / organization most concerned about experiencing?

- ☐ Flooding
- ☐ Drought
- ☐ Power outages
- ☐ Wildfire
- ☐ Heat waves
- ☐ Vector-borne diseases
- ☐ Changes in growing season
- ☐ Decrease in snow cover
- ☐ Exacerbated respiratory conditions (i.e. asthma, allergies)
- ☐ Other (please specify)

* 4. From your department or organization’s opinion, which of the following is Melrose most vulnerable to as the result of climate change? (Example climate change impacts are: Increased frequency and magnitude of rain, snow, or ice storms, Changes in precipitation patterns, Increased seasonal/annual temperatures, Temperature swings, Drought, High wind events)

Please rank based on order of vulnerability.
1 = Most vulnerable 8 = Least vulnerable.

Compromises to transportation infrastructure (roads, rail, bridges, trails, etc.)

Availability of utilities (water, wastewater, energy, communications, etc.)

Access to critical facilities (schools, libraries, emergency shelters, medical facilities, etc.)

Human injury, illness, or loss of life

Business interruptions (closures, economic losses, etc.)

Ability to maintain order and/or provide public amenities

Damage, contamination, or loss of ecosystems and natural resources (forests, wetlands, waterways, etc.)

Damage or loss of cultural resources (i.e. museums, historic properties, etc.)

* 5. In your opinion, how prepared is your department / organization to address climate change vulnerabilities?

Not Prepared: We expect operations would be significantly impacted by climate-related hazards.				Prepared: We have plans, tools, and resources in place to be resilient to climate change hazards.
○	○	○	○	○

* 6. Please rank the importance of each statement to your department / organization to help us determine our collective priorities for reducing climate change vulnerabilities and work towards a more resilient Melrose.

	Very Important	Somewhat Important	Neutral	Not Very Important	Not Important
Protecting critical facilities (e.g. transportation networks, hospitals, fire stations, etc.)	Protecting critical facilities (e.g. transportation networks, hospitals, fire stations, etc.) Very Important	Protecting critical facilities (e.g. transportation networks, hospitals, fire stations, etc.) Somewhat Important	Protecting critical facilities (e.g. transportation networks, hospitals, fire stations, etc.) Neutral	Protecting critical facilities (e.g. transportation networks, hospitals, fire stations, etc.) Not Very Important	Protecting critical facilities (e.g. transportation networks, hospitals, fire stations, etc.) Not Important
Protecting and reducing damage to utilities	Protecting and reducing damage to utilities Very Important	Protecting and reducing damage to utilities Somewhat Important	Protecting and reducing damage to utilities Neutral	Protecting and reducing damage to utilities Not Very Important	Protecting and reducing damage to utilities Not Important
Protecting private property	Protecting private property Very Important	Protecting private property Somewhat Important	Protecting private property Neutral	Protecting private property Not Very Important	Protecting private property Not Important
Strengthening emergency services (e.g. police, fire, ambulance)	Strengthening emergency services (e.g. police, fire, ambulance) Very Important	Strengthening emergency services (e.g. police, fire, ambulance) Somewhat Important	Strengthening emergency services (e.g. police, fire, ambulance) Neutral	Strengthening emergency services (e.g. police, fire, ambulance) Not Very Important	Strengthening emergency services (e.g. police, fire, ambulance) Not Important
Promoting cooperation among public agencies, citizens, non-profits, and businesses	Promoting cooperation among public agencies, citizens, non-profits, and businesses Very Important	Promoting cooperation among public agencies, citizens, non-profits, and businesses Somewhat Important	Promoting cooperation among public agencies, citizens, non-profits, and businesses Neutral	Promoting cooperation among public agencies, citizens, non-profits, and businesses Not Very Important	Promoting cooperation among public agencies, citizens, non-profits, and businesses Not Important

	Very Important	Somewhat Important	Neutral	Not Very Important	Not Important
Preventing new or further development in hazard areas	Preventing new or further development in hazard areas Very Important	Preventing new or further development in hazard areas Somewhat Important	Preventing new or further development in hazard areas Neutral	Preventing new or further development in hazard areas Not Very Important	Preventing new or further development in hazard areas Not Important
Enhancing the function of natural features (e.g. streams, wetlands, etc.)	Enhancing the function of natural features (e.g. streams, wetlands, etc.) Very Important	Enhancing the function of natural features (e.g. streams, wetlands, etc.) Somewhat Important	Enhancing the function of natural features (e.g. streams, wetlands, etc.) Neutral	Enhancing the function of natural features (e.g. streams, wetlands, etc.) Not Very Important	Enhancing the function of natural features (e.g. streams, wetlands, etc.) Not Important
Protecting historical and cultural landmarks	Protecting historical and cultural landmarks Very Important	Protecting historical and cultural landmarks Somewhat Important	Protecting historical and cultural landmarks Neutral	Protecting historical and cultural landmarks Not Very Important	Protecting historical and cultural landmarks Not Important
Preserving natural ecosystems and biodiversity	Preserving natural ecosystems and biodiversity Very Important	Preserving natural ecosystems and biodiversity Somewhat Important	Preserving natural ecosystems and biodiversity Neutral	Preserving natural ecosystems and biodiversity Not Very Important	Preserving natural ecosystems and biodiversity Not Important

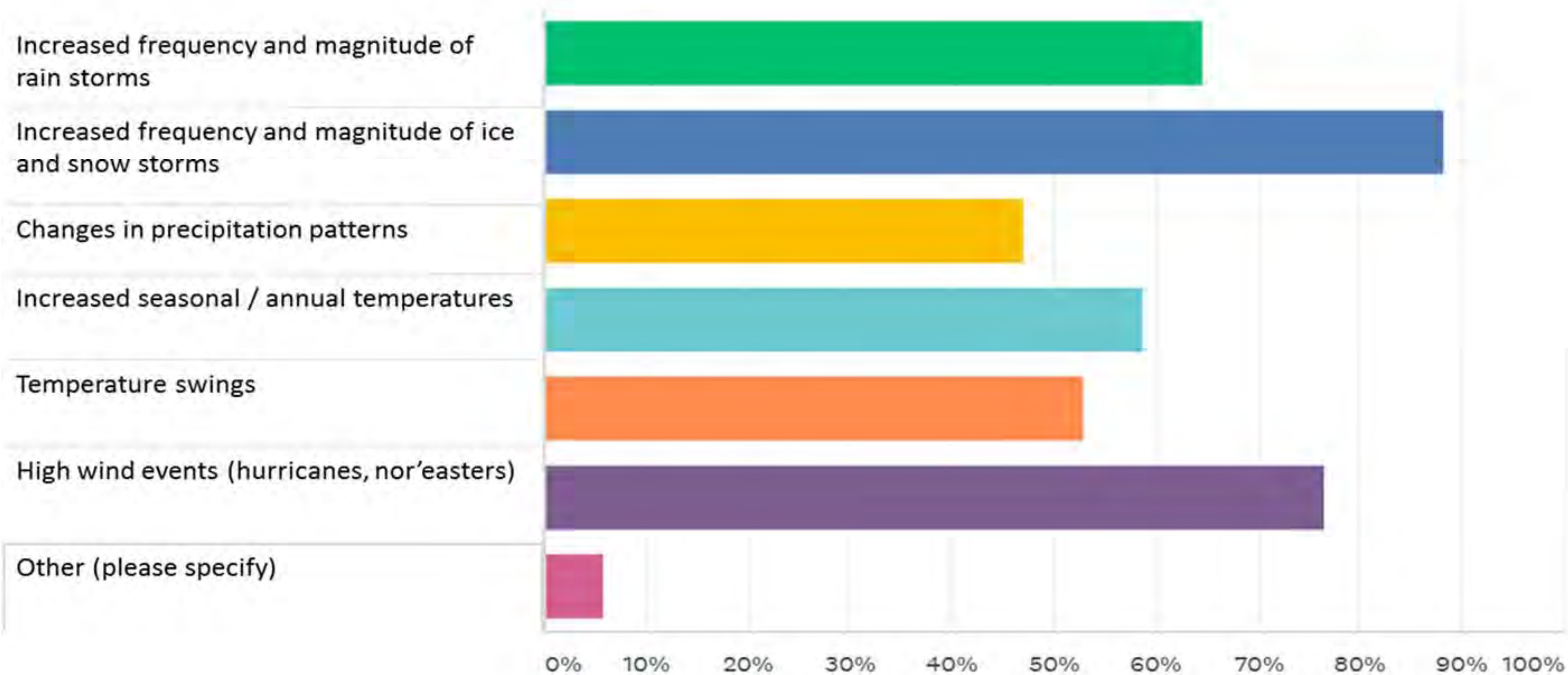
7. If you have additional comments you would like to share prior to the workshop, please provide them here.

DONE

Melrose Municipal Vulnerability Preparedness program

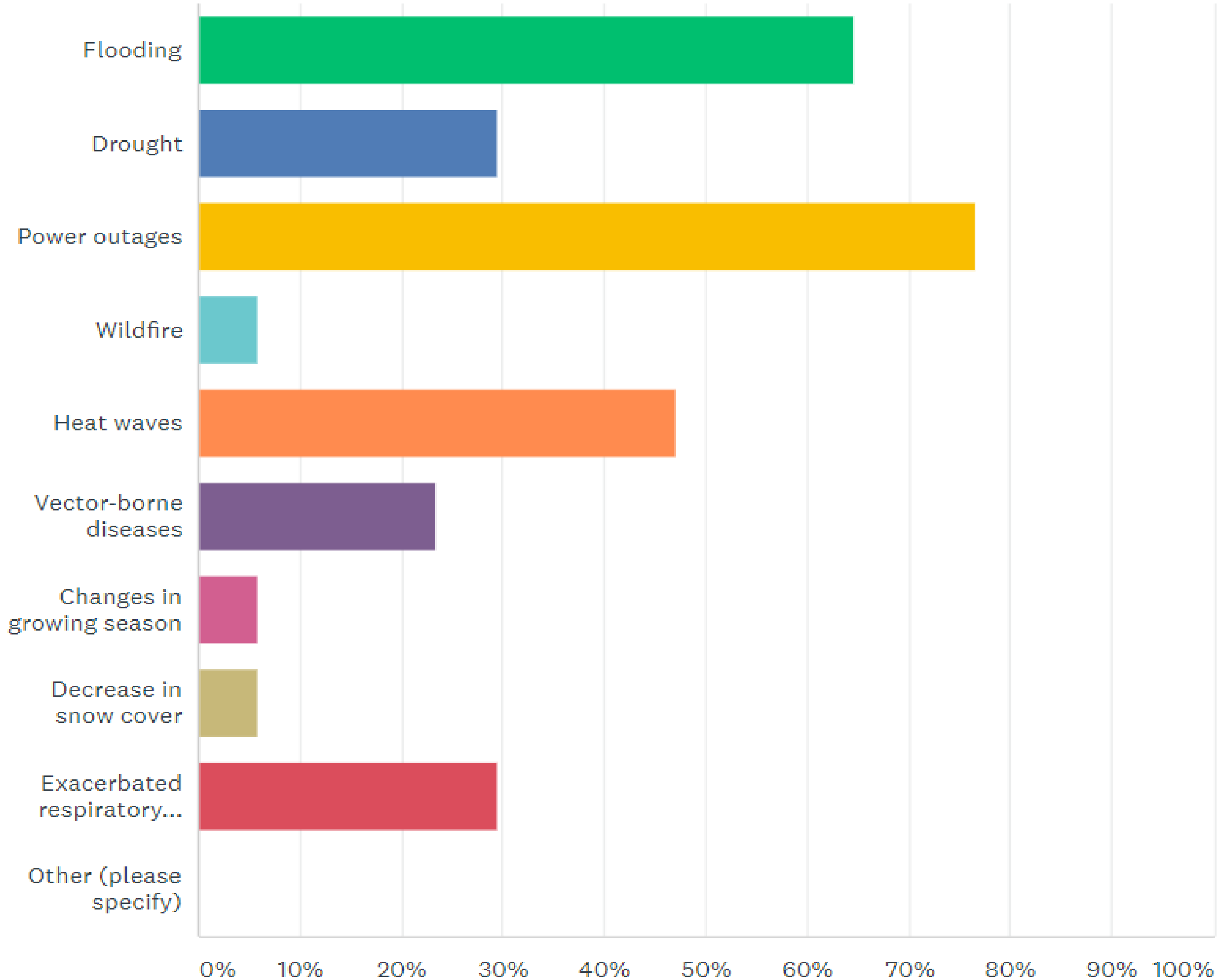
Pre-Workshop Survey Results

2. Which of the following observed climate change impacts have already impacted your department / organization? Select all that apply.



Other response: "Our Planning Board members are beginning to think about climate change when reviewing projects."

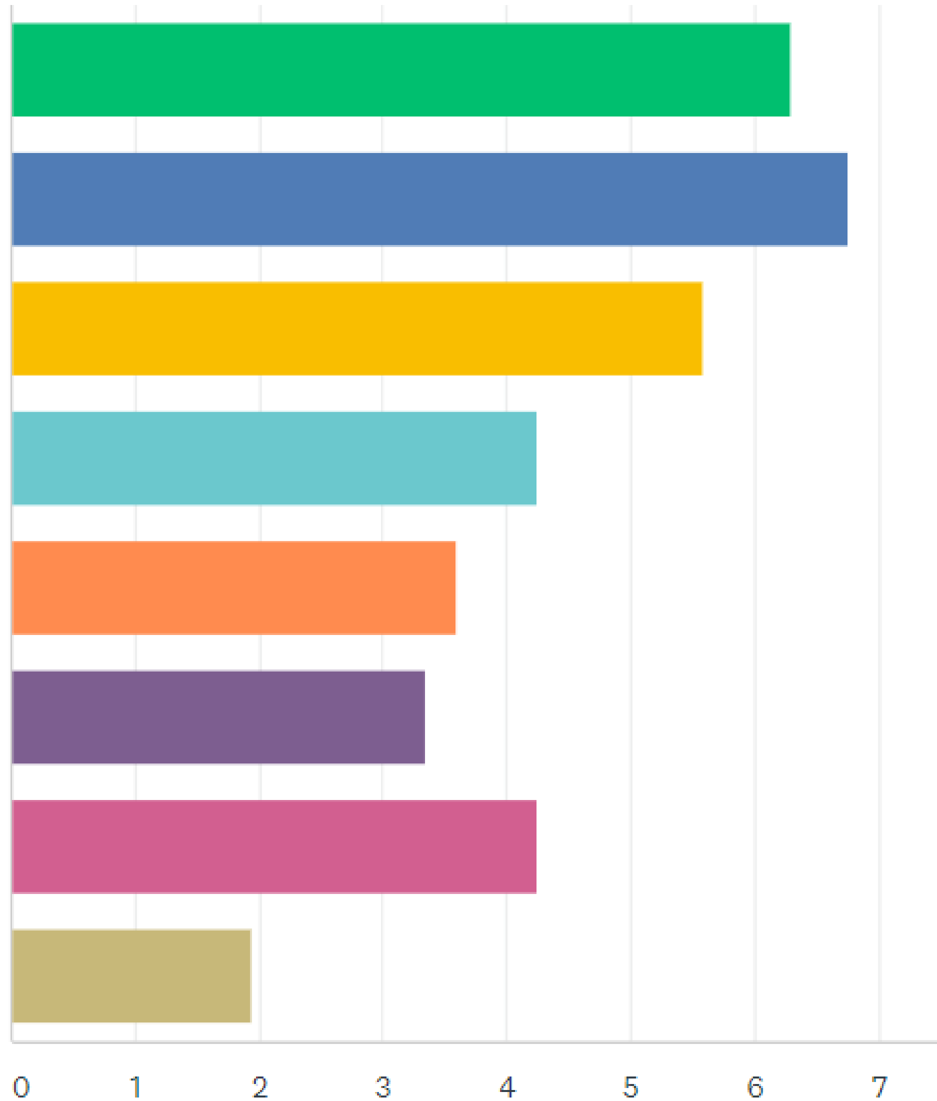
3. What climate-related hazards is your department / organization most concerned about experiencing?



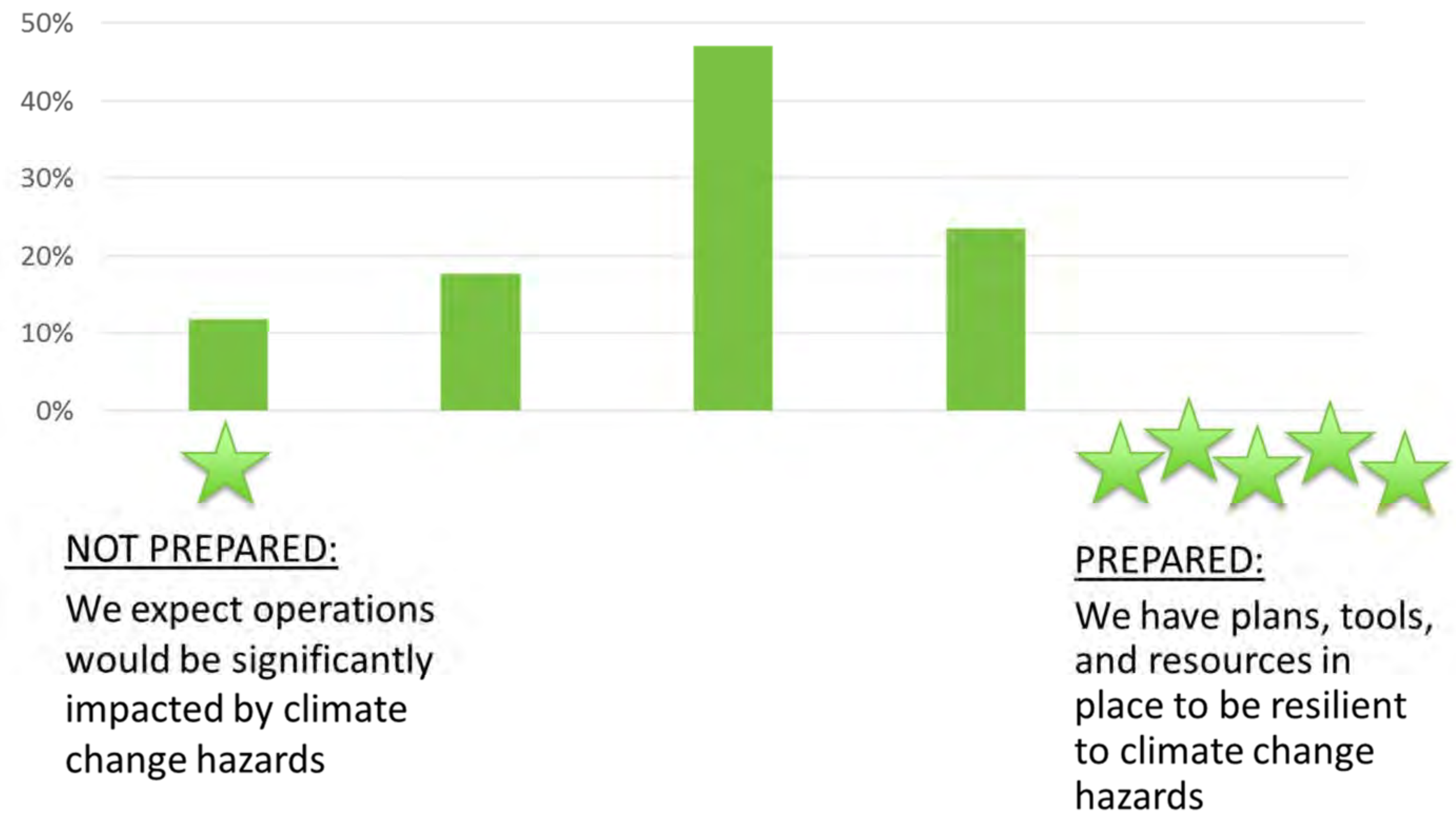
Other response: “Water quality impacts where storm water systems are undersized for more frequent extreme storms.”

4. From your department or organization's opinion, which of the following is Melrose most vulnerable to as the result of climate change? (Example climate change impacts are: Increased frequency and magnitude of rain, snow, or ice storms, Changes in precipitation patterns, Increased seasonal/annual temperatures, Temperature swings, Drought, High wind events)

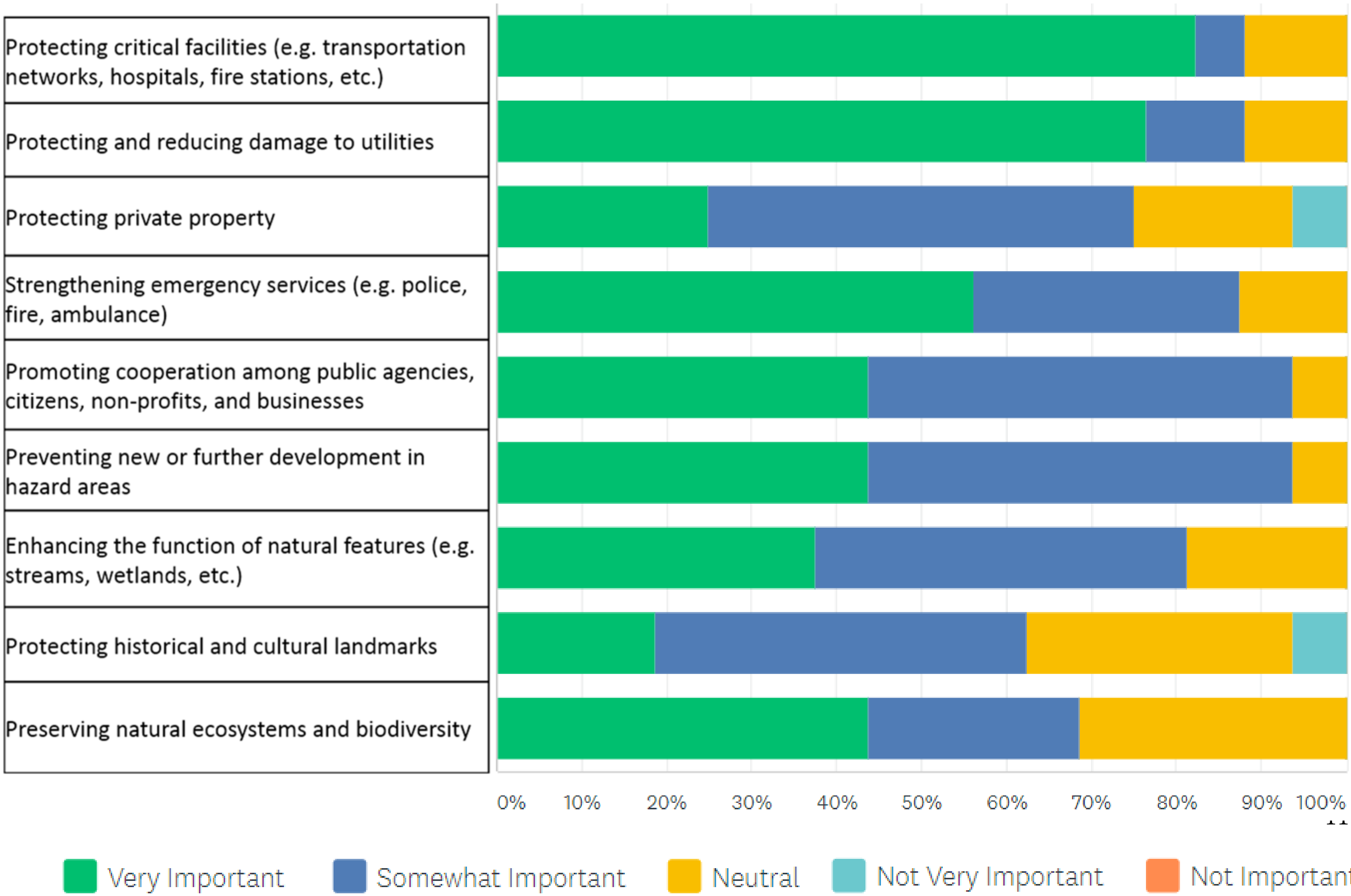
Compromises to transportation infrastructure (roads, rail, bridges, trails, etc.)	6.29
Availability of utilities (water, wastewater, energy, communications, etc.)	6.76
Access to critical facilities (schools, libraries, emergency shelters, medical facilities, etc.)	5.59
Human injury, illness, or loss of life	4.24
Business interruptions (closures, economic losses, etc.)	3.59
Ability to maintain order and/or provide public amenities	3.35
Damage, contamination, or loss of ecosystems and natural resources (forests, wetlands, waterways, etc.)	4.24
Damage or loss of cultural resources (i.e. museums, historic properties, etc.)	1.94



5. In your opinion, how prepared is your department / organization to address climate change vulnerabilities?



6. Please rank the importance of each statement to your department / organization to help us determine our collective priorities for reducing climate change vulnerabilities and work towards a more resilient Melrose.



7. If you have additional comments you would like to share prior to the workshop, please provide them here.

“My responses are based on Riverside involvement and not directly related to the city of Melrose depts.”

“So many comments... I'll wait for the workshop.”

Appendix C: Climate projections provided by the Executive Office of Energy and Environmental Affairs

MASSACHUSETTS CLIMATE CHANGE PROJECTIONS

Researchers from the Northeast Climate Science Center at the University of Massachusetts Amherst developed downscaled projections for changes in temperature, precipitation, and sea level rise for the Commonwealth of Massachusetts. The Executive Office of Energy and Environmental Affairs has provided support for these projections to enable municipalities, industry, organizations, state government and others to utilize a standard, peer-reviewed set of climate change projections that show how the climate is likely to change in Massachusetts through the end of this century.

Temperature and Precipitation Projections

The temperature and precipitation climate change projections are based on simulations from the latest generation of climate models[1] from the International Panel on Climate Change and scenarios of future greenhouse gas emissions.[2] The models were carefully selected from a larger ensemble of climate models based on their ability to provide reliable climate information for the Northeast U.S., while maintaining diversity in future projections that capture some of the inherent uncertainty in modeling climate variables like precipitation. The medium (RCP 4.5) and high (RCP 8.5) emission scenarios were chosen for possible pathways of future greenhouse gas emissions. A moderate scenario of future greenhouse gas emissions assumes a peak around mid-century, which then declines rapidly over the second half of the century, while the highest scenario assumes the continuance of the current emissions trajectory.

Fourteen climate models have been run with 2 emission scenarios each, which lead to 28 projections. The values cited in the tables below are based on the 10-90th percentiles across the 28 projections, so they bracket the *most likely* scenarios. For simplicity, we use the terms "…expected to…," and "…will be…," but recognize that these are estimates based on model scenarios and are *not predictive forecasts*. The statewide projections comprising county- and basin-level information are derived by statistically downscaling the climate model results.[3] They represent the best estimates that we can currently provide for a range of anticipated changes in greenhouse gases. Note that precipitation projections are generally more uncertain than temperature.

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[1]These latest generation of climate models are included in the Coupled Model Intercomparison Project Phase 5 (CMIP5), which formed the basis of projections summarized in the IPCC Fifth Assessment Report (2013).

[2] Future greenhouse gas emissions scenarios are typically expressed as "Representative Concentration Pathways" (RCPs). They indicate emissions trajectories that would lead to certain levels of radiative forcing by 2100, relative to the pre-industrial state of the atmosphere; RCP4.5 equates to +4.5W m^{-2}, and RCP 8.5 would be +8.5W m^{-2}. In effect, they represent different pathways that society may or may not follow, to reduce emissions through climate change mitigation measures.

[3] The Local Constructed Analogs (LOCA) method (Pierce et al., 2014) was used for the statistical downscaling of the statewide projections.

The downscaled temperature and precipitation projections for the Commonwealth are provided at three geographic scales (Table 1) for annual and seasonal temporal scales (Table 2), and can be accessed through the Massachusetts Climate Change Clearinghouse website (www.massclimatechange.org). The statewide projections are included in this guidebook, but temperature and precipitation projections at each of the Commonwealth's major basins are accessible on the website and as a supplemental PDF to this guide.

These climate projections are provided to help municipal officials, state agency staff, land managers, and others to identify future hazards related to, or exacerbated by changing climatic conditions. For the Municipal Vulnerability Preparedness (MVP) program participants, we recommend using climate projections downscaled to the major basin scale (Table 1) as there are regional differences across several climate indicators (Table 3). These projections can help MVP communities to think through how future hazards in their community may change, given projected changes in temperature and precipitation.

Regardless of geographic scale, rising temperatures, changing precipitation, and extreme weather will continue to affect the people and resources of the Commonwealth throughout the 21st century. A first step in becoming more climate-resilient is to identify the climate changes your community will be exposed to, the impacts and risks to critical assets, functions, vulnerable populations arising from these changes, the underlying sensitivities to these types of changes, and the background stressors that may exacerbate overall vulnerability.

Table 1: Geographic scales available for use for Massachusetts temperature and precipitation projections

Geographic Scale	Definition
Statewide	Massachusetts
County	Barnstable, Berkshire, Bristol, Dukes, Essex, Franklin, Hampden, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester
Major basins[4]	Blackstone, Boston Harbor, Buzzards Bay, Cape Cod, Charles, Chicopee, Connecticut, Deerfield, Farmington, French, Housatonic, Hudson, Ipswich, Merrimack, Millers, Narragansett Bay & Mt. Hope Bay, Nashua, North Coastal, Parker, Quinebaug, Shawsheen, South Coastal, Sudbury-Assabet-Concord (SuAsCo), Taunton, Ten Mile, Westfield, and Islands (presented here as Martha's Vineyard basin and Nantucket basin)

Table 2: Definition of seasons as applied to temporal scales used for temperature and precipitation projections

Season	Definition
Winter	December-February
Spring	March-May
Summer	June-August
Fall	September-November

[4] Many municipalities fall within more than one basin, so it is advised to use the climate projections for the basin that contains the majority of the land area of the municipality.

Table 3: List and definitions of projected temperature indicators

Climate Variable	Climate Indicator	Definition
Temperature	Average temperature	Average annual or seasonal temperature expressed in degrees Fahrenheit (°F).
	Maximum temperature	Maximum annual or seasonal temperature expressed in degrees Fahrenheit (°F).
	Minimum temperature	Minimum annual or seasonal temperature expressed in degrees Fahrenheit (°F).
	Days with Tmax > 90 °F	Number of days when daily maximum temperature exceeds 90°F.
	Days with Tmax > 95 °F	Number of days when daily maximum temperature exceeds 95°F.
	Days with Tmax > 100 °F	Number of days when daily maximum temperature exceeds 100°F.
	Days with Tmin < 32 °F	Number of days when daily minimum temperature is below 32 °F.
	Days with Tmin < 0 °F	Number of days when daily minimum temperature is below 0 °F.
	Heating degree-days (base 65 °F)	Heating degree-days (HDD) are a measure of how much and for how long outside air temperature was lower than a specific base temperature. HDD are the difference between the average daily temperature and 65°F. For example, if the mean temperature is 30°F, we subtract the mean from 65 and the result is 30 heating degree-days for that day. HDD serves as a proxy that captures energy consumption required to heat buildings, and is used in utility planning and building design.[5]
	Cooling degree-days (base 65 °F)	Cooling degree days (CDD) are a measure of how much and for how long outside air temperature was higher than a specific base temperature. CDD are the difference between the average daily temperature and 65°F. For example, if the temperature mean is 90°F, we subtract 65 from the mean and the result is 25 cooling degree-days for that day. CDD serves as a proxy that captures energy consumption required to cool buildings, and is used in utility planning and building design. [6]
	Growing degree-days (base 50 °F)	Growing degree days (GDD) are a measure of heat accumulation that can be correlated to express crop maturity (plant development). GDD is computed by subtracting a base temperature of 50°F from the average of the maximum and minimum temperatures for the day. Minimum temperatures less than 50°F are set to 50, and maximum temperatures greater than 86°F are set to 86. These substitutions indicate that no appreciable growth is detected with temperatures lower than 50° or greater than 86°.[7]

[5] For seasonal or annual projections, HDD are summed for the period of interest. For example, for winter HDD, one would sum the HDD for December 1 through February 28. Degree-days are not the equivalent of calendar days and thus why it is possible to have more than 365 degree-days.

[6] For seasonal or annual projections, CDD are summed for the period of interest. For example, for summer CDD, one would sum the CDD for June 1 through August 31. Degree-days are not the equivalent of calendar days and thus why it is possible to have more than 365 degree-days.

[7] Definition adapted from National Weather Service. Degree-days are not the equivalent of calendar days and thus why it is possible to have more than 365 degree-days.

Table 4: List and definitions of projected precipitation indicators

Climate Variable	Climate Indicator	Definition
Precipitation	Total precipitation	Total annual or seasonal precipitation expressed in inches.
	Days with precipitation >1 inch	Extreme precipitation events measured in days with precipitation eclipsing one inch.
	Days with precipitation > 2 inch	Extreme precipitation events measured in days with precipitation eclipsing two inches.
	Days with precipitation > 4 inch	Extreme precipitation events measured in days with precipitation eclipsing four inches.
	Consecutive dry days	For a given period, the largest number of consecutive days with precipitation less than 1 mm (0.039 inches).

Impacts from Increasing Temperatures

Warmer temperatures and extended heat waves could have very significant impacts on public health in our state, as well as the health of plants, animals and ecosystems like forests and wetlands. Rising temperatures will also affect important economic sectors like agriculture and tourism, and infrastructure like the electrical grid.

Annual air temperatures in the Northeast have been warming at an average rate of 0.5°F (nearly 0.26°C) per decade since 1970. Winter temperatures have been rising at a faster rate of 0.9°F[8] per decade on average. Even what seems like a very small rise in average temperatures can cause major changes in other factors, such as the relative proportion of precipitation that falls as rain or snow.

In Massachusetts, temperatures are projected to increase significantly over the next century. Winter average temperatures are likely to increase more than those in summer, with major impacts on everything from winter recreation to increased pests and challenges to harvesting for the forestry industry.

Beyond this general warming trend, Massachusetts will experience an increasing number of days with extreme heat in the future (Table 3). Generally, extreme heat is considered to be over 90 degrees F, because at temperatures above that threshold, heat-related illnesses and mortality show a marked increase.

Extreme heat can be especially damaging in urban areas, where there is often a concentration of vulnerable populations, and where more impervious surfaces such as streets and parking lots

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[8] NOAA National Centers for Environmental information, Climate at a Glance: U.S. Time Series, Average Temperature, published December 2017, retrieved on December 21, 2017 from http://www.ncdc.noaa.gov/cag/

and less vegetation cause a “heat island” effect that makes them hotter compared to neighboring rural areas.
Urban residents in Massachusetts – especially those who are very young, ill, or elderly, and those who live in older buildings without air conditioning – will face greater risks of serious heat-related illnesses when extreme heat becomes more common. Extreme heat and dry conditions or drought could also be detrimental to crop production, harvest and livestock.

While warmer winters may reduce burdens on energy systems, more heat in the summer may put larger demands on aging systems, creating the potential for power outages. The number of cooling degree days is expected to increase significantly by the end of the century adding to this strain. In addition, heat can directly stress transmission lines, substations, train tracks, roads and bridges, and other critical infrastructure.

Impacts from Changing Precipitation Conditions

Rainfall is expected to increase in spring and winter months in particular in Massachusetts, with increasing consecutive dry days in summer and fall. More total rainfall can have an impact on the frequency of minor but disruptive flooding events, especially in areas where storm water infrastructure has not been adequately sized to accommodate higher levels. Increased total rainfall will also affect agriculture, forestry and natural ecosystems.

More intense downpours often lead to inland flooding as soils become saturated and stop absorbing more water, river flows rise, and the capacity of urban storm water systems is exceeded. Flooding may occur as a result of heavy rainfall, snowmelt, or coastal flooding associated with high wind and wave action, but precipitation is the strongest driver of flooding in Massachusetts. Winter flooding is also common in the state, particularly when the ground is frozen. The Commonwealth experienced 22 flood-related disaster declarations from 1954 to 2017 with many of these falling in winter or early spring, or during recent hurricanes.

The climate projections suggest that the frequency of high-intensity rainfall events will trend upward. Overall, it is anticipated that the severity of flood-inducing weather events and storms will increase, with events that produce sufficient precipitation to present a risk of flooding likely increasing. A single intense downpour can cause flooding and widespread damage to property and critical infrastructure. The coast will experience the greatest increase in high-intensity rainfall days, but some level of increase will occur in every area of Massachusetts.

Intense rainfall in urbanized areas can cause pollutants on roads and parking lots to get washed into nearby rivers and lakes, reducing habitat quality. As rainfall and snowfall patterns change, certain habitats and species that have specific physiological requirements may be affected.

Climate projections for Massachusetts indicate that in future decades, winter precipitation could increase, but by the end of the century most of this precipitation is likely to fall as rain instead of snow due to warmer winters. There are many human and environmental impacts that could result from this change including reduced snow cover for winter recreation and tourism, less spring snow melt to replenish aquifers, higher levels of winter runoff, and lower spring river flows for aquatic ecosystems.

A small projected decrease in average summer precipitation in Massachusetts could combine with higher temperatures to increase the frequency of episodic droughts, like the one experienced across the Commonwealth in the summer of 2016.

Droughts will create challenges for local water supply by reducing surface water storage and the recharge of groundwater supplies, including private wells. More frequent droughts could also exacerbate the impacts of flood events by damaging vegetation that could otherwise help mitigate flooding impacts. Droughts may also weaken tree root systems, making them more susceptible to toppling during high wind events.

Table 5: Statewide projected changes of temperature and precipitation variables by the middle and end of the century, based on climate models and the medium and high pathways of future greenhouse gas emissions. Projected changes for each climate indicator are given as a 30-year mean relative to the 1971-2000 baseline, centered on the 2050s (2040-2069) and the 2090s (2080-2099).[9] The values cited are the range of the most likely scenarios (10-90th percentile).

Climate Indicator		Observed Value 1971-2000 Average	Mid-Century Projected and Percent Change in 2050s (2040-2069)	End of Century Projected and Percent Change in 2090s (2080-2099)
Average Temperature	Annual	47.6 °F	Increase by 2.8 to 6.2 °F Increase by 6 to 13 %	Increase by 3.8 to 10.8 °F Increase by 8 to 23 %
	Winter	26.6 °F	Increase by 2.9 to 7.4 °F Increase by 11 to 28 %	Increase by 4.1 to 10.6 °F Increase by 15 to 40 %
	Spring	45.4 °F	Increase by 2.5 to 5.5 °F Increase by 6 to 12 %	Increase by 3.2 to 9.3 °F Increase by 7 to 20 %
	Summer	67.9 °F	Increase by 2.8 to 6.7 °F Increase by 4 to 10 %	Increase by 3.7 to 12.2 °F Increase by 6 to 18 %
	Fall	50 °F	Increase by 3.6 to 6.6 °F Increase by 7 to 13 %	Increase by 3.9 to 11.5 °F Increase by 8 to 23 %
Maximum Temperature	Annual	58.0 °F	Increase by 2.6 to 6.1 °F Increase by 4 to 11 %	Increase by 3.4 to 10.7 °F Increase by 6 to 18 %
	Winter	36.2 °F	Increase by 2.5 to 6.8 °F Increase by 7 to 19 %	Increase by 3.5 to 9.6 °F Increase by 10 to 27 %
	Spring	56.1 °F	Increase by 2.3 to 5.4 °F Increase by 4 to 10 %	Increase by 3.1 to 9.4 °F Increase by 6 to 17 %
	Summer	78.9 °F	Increase by 2.6 to 6.7 °F Increase by 3 to 8 %	Increase by 3.6 to 12.5 °F Increase by 4 to 16 %
	Fall	60.6 °F	Increase by 3.4 to 6.8 °F Increase by 6 to 11 %	Increase by 3.8 to 11.9 °F Increase by 6 to 20 %
Minimum Temperature	Annual	37.1 °F	Increase 3.2 to 6.4 °F Increase by 9 to 17 %	Increase by 4.1 to 10.9°F Increase by 11 to 29 %
	Winter	17.1 °F	Increase by 3.3 to 8.0 °F Increase by 19 to 47 %	Increase by 4.6 to 11.4 °F Increase by 27 to 66 %
	Spring	34.6 °F	Increase by 2.6 to 5.9 °F Increase by 8 to 17 %	Increase by 3.3 to 9.2 °F Increase by 9 to 26 %
	Summer	56.8 °F	Increase by 3 to 6.9 °F Increase by 5 to 12 %	Increase by 3.9 to 12 °F Increase by 7 to 21 %
	Fall	39.4 °F	Increase by 3.5 to 6.5 °F Increase by 9 to 16 %	Increase by 4.0 to 11.4 °F Increase by 10 to 29 %

[9] A 20-yr mean is used for the 2090s because the climate models end at 2100.

Table 5 Continued

Climate Indicator		Observed Value 1971-2000 Average	Mid-Century Projected and Percent Change in 2050s (2040-2069)	End of Century Projected and Percent Change in 2090s (2080-2099)
Days with Tmax > 90°F	Annual	5 days	Increase by 7 to 26 days	Increase by 11 to 64 days
	Winter	0 days	No change	No change
	Spring	< 1 day[10]	Increase by 0 to 1 days	Increase by 0 to 4 days
	Summer	4 days	Increase by 6 to 22 days	Increase by 9 to 52 days
	Fall	< 1 day[9]	Increase by 0 to 3 days	Increase by 1 to 9 days
Days with Tmax > 95°F	Annual	< 1 day[9]	Increase by 2 to 11 days	Increase by 3 to 35 days
	Winter	0 days	No change	No change
	Spring	< 1 day[9]	No change	Increase by 0 to 1 days Increase by
	Summer	< 1 day[9]	Increase by 2 to 10 days	Increase by 3 to 32 days
	Fall	< 1 day[9]	Increase by 0 to 1 day	Increase by 0 to 3 days
Days with Tmax > 100°F	Annual	< 1 day[9]	Increase by 0 to 3 days	Increase by 0 to 13 days
	Winter	0 days	No change	No change
	Spring	0 days	No change	No change
	Summer	< 1 day[9]	Increase by 0 to 3 days	Increase by 0 to 12 days
	Fall	0 days	No change	Increase by 0 to 1 day
Days with Tmin < 32°F	Annual	146 days	Decrease by 19 to 40 days	Decrease by 24 to 64 days
	Winter	82 days	Decrease by 4 to 12 days	Decrease by 6 to 25 days
	Spring	37 days	Decrease by 6 to 15 days	Decrease by 9 to 20 days
	Summer	< 1 day[9]	No change	No change
	Fall	27 days	Decrease by 8 to 13 days	Decrease by 8 to 20 days
Days with Tmin < 0°F	Annual	8 days	Decrease by 4 to 6 days	Decrease by 4 to 7 days
	Winter	8 days	Decrease by 3 to 6 days	Decrease by 4 to 6 days
	Spring	< 1 day[9]	No change	No change
	Summer	0 days	No change	No change
	Fall	< 1 day[9]	No change	No change

[10] Over the observed period, there were some years with at least 1 day with seasonal Tmax over (or Tmin under) a certain threshold while in all the other years that threshold wasn't crossed seasonally at all.

Table 5 Continued

Climate Indicator		Observed Value 1971-2000 Average	Mid-Century Projected and Percent Change in 2050s (2040-2069)	End of Century Projected and Percent Change in 2090s (2080-2099)
Heating Degree-Days (Base 65°F)	Annual	6839 degree-days	Decrease by 773 to 1627 degree-days Decrease by 11 to 24 %	Decrease by 1033 to 2533 degree-days Decrease by 15 to 37 %
	Winter	3475 degree-days	Decrease by 259 to 681 degree-days Decrease by 7 to 20 %	Decrease by 376 to 973 degree-days Decrease by 11 to 28 %
	Spring	1822 degree-days	Decrease by 213 to 468 degree-days Decrease by 12 to 26 %	Decreases by 283 to 727 degree-days Decrease by 16 to 40 %
	Summer	134 degree-days	Decrease by 63 to 101 degree-days Decrease by 47 to 76 %	Decrease by 76 to 120 degree-days Decrease by 65 to 89 %
	Fall	1407 degree-days	Decrease by 282 to 469 degree-days Decrease by 20 to 33 %	Decrease by 289 to 752 degree-days Decrease by 21 to 53 %
Cooling Degree-Days (Base 65°F)	Annual	457 degree-days	Increase by 261 to 689 degree-days Increase by 57 to 151 %	Increase by 356 to 1417 degree-days Increase by 78 to 310 %
	Winter	0 degree-days	Increase by 0 to 5 degree-days	Increase by 0 to 5 degree-days
	Spring	17 degree-days	Increase by 15 to 48 degree-days Increase by 88 to 277 %	Increase by 18 to 110 degree-days Increase by 103 to 636 %
	Summer	397 degree-days	Increase by 182 to 519 degree-days Increase by 46 to 131 %	Increase by 260 to 1006 degree-days Increase by 65 to 253 %
	Fall	40 degree-days	Increase by 40 to 139 degree-days Increase by 100 to 350 %	Increase by 69 to 297 degree-days Increase by 175 to 750 %
Growing Degree-Days (Base 50°F)	Annual	2344 degree-days	Increase by 531 to 1210 degree-days Increase by 23 to 52 %	Increase by 702 to 2347 degree-days Increase by 30 to 100 %
	Winter	5 degree-days	Increase by 1 to 13 degree-days Increase by 21 to 260 %	Increase by 4 to 27 degree-days Increase by 74 to 563 %
	Spring	259 degree-days	Increase by 88 to 226 degree-days Increase by 34 to 87 %	Increase by 104 to 450 degree-days Increase by 40 to 174 %
	Summer	1644 degree-days	Increase by 253 to 618 degree-days Increase by 15 to 38 %	Increase by 342 to 1124 degree-days Increase by 21 to 68 %
	Fall	429 degree-days	Increase by 172 to 394 degree-days Increase by 40 to 92 %	Increase by 216 to 745 degree-days Increase by 50 to 174 %

Table 5 Continued

Climate Indicator		Observed Value 1971-2000 Average	Mid-Century Projected and Percent Change in 2050s (2040-2069)	End of Century Projected and Percent Change in 2090s (2080-2099)
Days with Precipitation Over 1"	Annual	7 days	Increase by 1 to 3 days	Increase by 1 to 4 days
	Winter	2 days	Increase by 0 to 1 days	Increase by 0 to 2 days
	Spring	2 days	Increase by 0 to 1 days	Increase by 0 to 1 days
	Summer	2 days	Increase by 0 to 1 days	Increase by 0 to 1 days
	Fall	2 days	Increase by 0 to 1 days	Increase by 0 to 1 days
Days with Precipitation Over 2"	Annual	1 day	Increase by 0 to 1 days	Increase by 0 to 1 days
	Winter	< 1 day[11]	Increase by < 1 day[10]	Increase by < 1 day[10]
	Spring	< 1 day[10]	Increase by < 1 day[10]	Increase by < 1 day[10]
	Summer	< 1 day[10]	Increase by < 1 day[10]	Increase by < 1 day[10]
	Fall	< 1 day[10]	Increase by < 1 day[10]	Increase by < 1 day[10]
Days with Precipitation Over 4"	Annual	< 1 day[10]	Increase by < 1 day[10]	Increase by < 1 day[10]
	Winter	0 days	No change	Increase by < 1 day[10]
	Spring	0 days	Increase by < 1 day[10]	Increase by < 1 day[10]
	Summer	< 1 day[10]	Increase by < 1 day[10]	Increase by < 1 day[10]
	Fall	< 1 day[10]	Increase by < 1 day[10]	Increase by < 1 day[10]
Total Precipitation	Annual	47 inches	Increase by 1 to 6 inches Increase by 2 to 13 %	Increase by 1.2 to 7.3 inches Increase by 3 to 16 %
	Winter	11.2 inches	Increase by 0.1 to 2.4 inches Increase by 1 to 21 %	Increase by 0.4 to 3.9 inches Increase by 4 to 35 %
	Spring	12 inches	Increase by 0.1 to 2 inches Increase by 1 to 17 %	Increase by 0.4 to 2.7 inches Increase by 3 to 22 %
	Summer	11.5 inches	Decrease by 0.4 to Increase by 2 inches Decrease by 3 % to Increase by 17 %	Decrease by 1.5 to Increase by 1.9 inches Decrease by 13% to Increase by 16 %
	Fall	12.2 inches	Decrease by 1.1 to Increase by 1.4 inches Decrease by 9 to Increase by 12 %	Decrease by 1.7 to Increase by 1.4 inches Decrease by 14 to Increase by 11 %
Consecutive Dry Days	Annual	17 days	Increase by 0 to 2 days	Increase by 0 to 3 days
	Winter	11 days	Decrease by 1 to Increase by 1 days	Decrease by 1 to Increase by 2 days
	Spring	11 days	Decrease by 1 to Increase by 1 day	Decrease by 1 to Increase by 1 day
	Summer	12 days	Decrease by 1 to Increase by 2 days	Decrease by 1 to Increase by 3 days
	Fall	12 days	Increase by 0 to 3 days	Increase by 0 to 3 days

[11] Over the observed period, there were some years with at least 1 day with seasonal precipitation over a certain threshold while in all the other years that threshold wasn't crossed seasonally at all.

BOSTON HARBOR BASIN

MUNICIPALITIES WITHIN BOSTON HARBOR BASIN:
Abington, Arlington, Avon, Belmont, Boston, Braintree, Brockton, Burlington, Cambridge, Canton, Chelsea, Cohasset, Dedham, Dover, Everett, Foxborough, Hingham, Holbrook, Hull, Lexington, Malden, Melrose, Medfield, Medford, Milton, Norwell, Norwood, Quincy, Randolph, Reading, Revere, Rockland, Sharon, Somerville, Stoneham, Stoughton, Wakefield, Walpole, Watertown, Westwood, Weymouth, Wilmington, Winchester, Winthrop, and Woburn

Many municipalities fall within more than one basin, so it is advised to use the climate projections for the basin that contains the majority of the land area of the municipality.

BOSTON HARBOR BASIN

Boston Harbor Basin		Observed Baseline 1971-2000 (°F)	Projected Change in 2030s (°F)	Mid-Century Projected Change in 2050s (°F)	Projected Change in 2070s (°F)	End of Century Projected Change in 2090s (°F)
Average Temperature	Annual	50.13	+2.07 to +3.99	+2.73 to +6.07	+3.18 to +8.92	+3.46 to +10.84
	Winter	29.84	+2.17 to +4.55	+2.87 to +6.89	+3.50 to +8.88	+3.87 to +10.34
	Spring	47.65	+1.69 to +3.44	+2.34 to +5.41	+2.58 to +8.02	+3.13 to +9.79
	Summer	70.07	+1.79 to +3.95	+2.34 to +6.52	+2.78 to +9.77	+3.39 to +12.11
	Fall	52.58	+2.03 to +4.69	+3.52 to +6.53	+3.30 to +9.31	+3.78 to +11.60
Maximum Temperature	Annual	59.55	+1.90 to +3.85	+2.56 to +6.00	+2.92 to +8.94	+3.19 to +10.74
	Winter	38.38	+1.85 to +4.32	+2.46 to +6.44	+3.02 to +8.26	+3.42 to +9.56
	Spring	57.46	+1.50 to +3.39	+2.03 to +5.42	+2.56 to +8.23	+3.08 to +9.66
	Summer	80.04	+1.69 to +3.99	+2.23 to +6.41	+2.70 to +9.90	+3.22 to +12.21
	Fall	61.93	+2.09 to +4.52	+3.30 to +6.66	+3.21 to +9.40	+3.63 to +11.78
Minimum Temperature	Annual	40.7	+2.17 to +4.24	+2.91 to +6.22	+3.45 to +8.91	+3.75 to +10.95
	Winter	21.31	+2.45 to +5.00	+3.24 to +7.34	+4.04 to +9.47	+4.33 to +10.91
	Spring	37.84	+1.75 to +3.47	+2.64 to +5.71	+2.62 to +7.81	+3.25 to +9.76
	Summer	60.11	+1.89 to +3.94	+2.44 to +6.76	+2.85 to +9.63	+3.56 to +12.02
	Fall	43.22	+1.99 to +4.81	+3.49 to +6.45	+3.39 to +9.29	+3.92 to +11.41

- The Boston Harbor basin is expected to experience increased average temperatures throughout the 21st century. Maximum and minimum temperatures are also expected to increase throughout the end of the century. These increased temperature trends are expected for annual and seasonal projections.
- Seasonally, maximum summer and fall temperatures are expected to see the highest projected increase throughout the 21st century.
    - Summer mid-century increase of 2.2 °F to 6.4 °F (3-8% increase); end of century increase of 3.2 °F to 12.2 °F (4-15% increase).
    - Fall mid-century increase of 3.3 °F to 6.7°F (5-11% increase); end of century increase by and 3.6 °F to 11.8 °F (6-19% increase).
- Seasonally, minimum winter and fall temperatures are expected to increase throughout the 21st century.
    - Winter mid-century increase of 3.2 °F to 7.3 °F (15-34% increase); end of century increase by 4.3 °F to 10.9 °F (20-51% increase).
    - Fall mid-century of 3.5 °F to 6.5 °F (8-15% increase); end of century increase of 3.9 °F to 11.4 °F (9-26% increase).

BOSTON HARBOR BASIN

Boston Harbor Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Maximum Temperature Over 90°F	Annual	7.85	+5.60 to +15.57	+7.75 to +29.07	+9.46 to +49.32	+11.54 to +66.93
	Winter	0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00
	Spring	0.5	+0.20 to +0.77	+0.37 to +1.35	+0.40 to +2.36	+0.29 to +3.97
	Summer	7.04	+4.66 to +13.40	+6.18 to +24.21	+8.05 to +39.68	+10.28 to +51.95
	Fall	0.31	+0.51 to +2.14	+0.73 to +4.89	+0.91 to +8.34	+1.19 to +10.97
Days with Maximum Temperature Over 95°F	Annual	1.08	+1.77 to +6.53	+2.01 to +12.66	+2.92 to +26.38	+4.55 to +40.58
	Winter	0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00
	Spring	0.01	+0.02 to +0.20	+0.02 to +0.35	+0.08 to +0.70	+0.03 to +1.51
	Summer	1.05	+1.55 to +5.99	+1.89 to +11.24	+2.70 to +23.32	+4.34 to +35.56
	Fall	0.02	+0.06 to +0.67	+0.08 to +1.55	+0.16 to +3.53	+0.26 to +4.83
Days with Maximum Temperature Over 100°F	Annual	0.05	+0.24 to +1.40	+0.32 to +3.81	+0.47 to +8.58	+0.55 to +15.67
	Winter	0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00
	Spring	0.00	+0.00 to +0.02	+0.00 to +0.06	+0.00 to +0.11	+0.00 to +0.36
	Summer	0.05	+0.21 to +1.24	+0.26 to +3.60	+0.45 to +7.71	+0.52 to +14.23
	Fall	0.00	+0.00 to +0.13	+0.00 to +0.28	+0.00 to +0.70	+0.01 to +1.21

- Due to projected increases in average and maximum temperatures throughout the end of the century, the Boston Harbor basin is also expected to experience an increase in days with daily maximum temperatures over 90 °F, 95 °F, and 100 °F.
  - Annually, the Boston Harbor basin is expected to see days with daily maximum temperatures over 90 °F increase by 8 to 29 more days by mid-century, and 12 to 67 more days by the end of the century.
  - Seasonally, summer is expected to see an increase of 6 to 24 more days with daily maximums over 90 °F by mid-century.
  - By end of century, the Boston Harbor basin is expected to have 10 to 52 more days.

BOSTON HARBOR BASIN

Boston Harbor Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Minimum Temperature Below 0°F	Annual	2.58	-0.73 to -1.72	-0.86 to -2.01	-1.02 to -2.05	-0.92 to -2.1
	Winter	2.57	-0.70 to -1.68	-0.85 to -1.96	-1.01 to -2.01	-0.91 to -2.06
	Spring	0.01	-0.08 to +0.01	-0.09 to +0.00	-0.11 to -0.00	-0.11 to -0.00
	Summer	0.00	-0.00 to -0.00	-0.00 to -0.00	-0.00 to -0.00	-0.00 to -0.00
	Fall	0.00	-0.00 to -0.00	-0.00 to -0.00	-0.00 to -0.00	-0.00 to -0.00
Days with Minimum Temperature Below 32°F	Annual	119.21	-11.79 to -27.09	-17.05 to -42.10	-21.02 to -54.79	-22.54 to -65.69
	Winter	76.48	-4.35 to -10.46	-5.24 to -17.45	-7.50 to -26.48	-8.93 to -34.12
	Spring	26.51	-3.44 to -10.21	-6.02 to -14.01	-6.70 to -18.17	-7.95 to -19.54
	Summer	0.00	-0.03 to -0.00	-0.04 to -0.00	-0.04 to -0.00	-0.03 to -0.00
	Fall	16.19	-4.11 to -8.13	-5.81 to -10.18	-6.64 to -12.56	-5.80 to -14.06

- Due to projected increases in average and minimum temperatures throughout the end of the century, the Boston Harbor basin is expected to experience a decrease in days with daily minimum temperatures below 32 °F and 0 °F.
- Seasonally, winter, spring and fall are expected to see the largest decreases in days with daily minimum temperatures below 32 °F.
    - Winter is expected to have 5 to 17 fewer days by mid-century, and 9 to 34 fewer by end of century.
    - Spring is expected to have 6 to 14 fewer days by mid-century, and 8 to 20 fewer by end of century.
    - Fall is expected to have 6 to 10 fewer days by mid-century, and 6 to 14 fewer days by end of century.

BOSTON HARBOR BASIN

Boston Harbor Basin		Observed Baseline 1971-2000 (Degree-Days)	Projected Change in 2030s (Degree-Days)	Mid-Century Projected Change in 2050s (Degree-Days)	Projected Change in 2070s (Degree-Days)	End of Century Projected Change in 2090s (Degree-Days)
Heating Degree-Days (Base 65°F)	Annual	6078.6	-500.54 to -1035.05	-672.05 to -1473.30	-798.29 to -1955.65	-899.41 to -2343.46
	Winter	3182.27	-190.90 to -420.59	-250.52 to -633.54	-311.79 to -805.90	-358.50 to -949.08
	Spring	1623.3	-132.42 to -284.51	-190.37 to -446.56	-215.51 to -630.49	-277.90 to -742.49
	Summer	77.66	-28.69 to -48.6	-34.41 to -61.51	-40.23 to -71.65	-43.54 to -74.94
	Fall	1190.96	-142.96 to -330.92	-248.43 to -418.08	-232.46 to -591.26	-253.57 to -668.90
Cooling Degree-Days (Base 65°F)	Annual	636.02	+216.50 to +443.48	+281.45 to +763.73	+326.69 to +1205.65	+381.04 to +1558.59
	Winter	nan	+0.30 to +4.18	-0.20 to +5.14	-0.53 to +3.30	-0.20 to +5.28
	Spring	26.94	+13.42 to +33.49	+23.11 to +63.87	+25.82 to +103.20	23.93 to +143.38
	Summer	544.48	+135.55 to +320.64	+175.30 to +541.04	+212.87 to +828.15	+260.68 to +1041.01
	Fall	60.45	+37.41 to +101.70	+57.30 to +191.31	+67.33 to +289.12	+94.46 to +375.83
Growing Degree-Days (Base 50°F)	Annual	2733.34	+393.15 to +798.33	+538.44 to +1251.18	+605.73 to +1995.52	+691.87 to +2508.24
	Winter	7.42	+1.44 to +16.84	+2.52 to +19.76	+7.07 to +36.68	+7.25 to +46.66
	Spring	326.56	+76.91 to +152.27	+101.00 to +261.65	+105.69 to +408.29	+122.03 to +527.10
	Summer	1846.85	+164.09 to +362.91	+214.53 to +599.63	+255.19 to +898.50	+311.56 to +1114.22
	Fall	547.36	+108.67 to +298.71	+198.14 to +441.05	+185.73 to +654.54	+236.44 to +817.90

- Due to projected increases in average, maximum, and minimum temperatures throughout the end of the century, the Boston Harbor basin is expected to experience a decrease in heating degree-days, and increases in both cooling degree-days and growing degree-days.
- Seasonally, winter historically exhibits the highest number of heating degree-days and is expected to see the largest decrease of any season, but spring and fall are also expected to see significant change.
  - The winter season is expected to see a decrease of 251 to 634 degree-days by mid-century (a decrease of 8-20%), and a decrease of 359 to 949 degree-days by the end of century (a decrease of 11-30%).
  - The spring season is expected to decrease in heating degree-days by 12-28% (190-447 degree-days) by mid-century, and by 17-46% (278-742 degree-days) by the end of century.
  - The fall season is expected to decreases in heating degree-days by 21-35% (248-718 degree-days) by mid-century, and by and 21-56% (254-669 degree-days) by the end of century.
- Conversely, due to projected increasing temperatures, summer cooling degree-days are expected to increase by 32-99% (175-541 degree-days) by mid-century, and by 48-191% (261-1041 degree-days) by end of century.

- Seasonally, summer historically exhibits the highest number of growing degree-days and is expected to see the largest decrease of any season, but the shoulder seasons of spring and fall are also expected to see an increase in growing degree-days.
    - The summer season is projected to increase by 12-32% (215-600 degree-days) by mid-century, and by 17-60% (312-1114 degree-days) by end of century.
    - Spring is expected to increase by 31-80% (101-262 degree-days) by mid-century and 37-161% (122.-527 degree-days) by end of century.
    - Fall is expected to increase by 36-81% (198-441 degree-days) by mid-century and 43-149% (236-818 degree-days) by end of century.

BOSTON HARBOR BASIN

Boston Harbor Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Precipitation Over 1"	Annual	9.06	+0.37 to +2.16	+0.78 to +3.05	+1.00 to +3.17	+1.28 to +4.43
	Winter	2.4	-0.02 to +0.97	+0.14 to +1.17	+0.30 to +1.57	+0.41 to +2.20
	Spring	2.04	-0.04 to +0.82	+0.00 to +1.08	+0.18 to +1.30	+0.23 to +1.33
	Summer	1.96	-0.10 to +0.54	-0.08 to +0.79	-0.14 to +0.68	-0.17 to +0.61
	Fall	2.64	-0.21 to +0.69	-0.11 to +0.99	-0.29 to +0.76	-0.33 to +1.01
Days with Precipitation Over 2"	Annual	1.27	+0.05 to +0.58	+0.10 to +0.74	+0.11 to +0.88	+0.27 to +1.19
	Winter	0.2	-0.02 to +0.17	-0.01 to +0.22	+0.00 to +0.30	+0.02 to +0.34
	Spring	0.21	-0.07 to +0.17	-0.01 to +0.24	-0.02 to +0.24	+0.01 to +0.36
	Summer	0.41	-0.08 to +0.23	-0.03 to +0.23	-0.09 to +0.15	-0.07 to +0.13
	Fall	0.44	-0.06 to +0.29	-0.04 to +0.26	+0.01 to +0.32	-0.08 to +0.45
Days with Precipitation Over 4"	Annual	0.08	-0.03 to +0.15	-0.01 to +0.13	-0.03 to +0.16	-0.03 to +0.20
	Winter	0.00	-0.00 to -0.00	-0.00 to -0.00	-0.00 to -0.00	-0.00 to -0.00
	Spring	0.00	-0.01 to +0.04	-0.00 to +0.03	-0.01 to +0.04	-0.00 to +0.06
	Summer	0.03	-0.03 to +0.07	-0.02 to +0.06	-0.03 to +0.06	-0.02 to +0.10
	Fall	0.05	-0.02 to +0.07	-0.01 to +0.08	-0.02 to +0.10	-0.02 to +0.12

- The projections for expected number of days receiving precipitation over one inch are variable for the Boston Harbor basin, fluctuating between loss and gain of days.
    - Seasonally, the winter season is generally expected to see the highest projected increase.
    - The winter season is expected to see an increase in days with precipitation over one inch of 0-1 days by mid-century, and by 0-2.days by the end of century.
    - The spring season is expected to see an increase in days with precipitation over one inch of 0-1 days) by mid-century, and by 0-1 days) by the end of century.

BOSTON HARBOR BASIN

Boston Harbor Basin		Observed Baseline 1971-2000 (Inches)	Projected Change in 2030s (Inches)			Mid-Century Projected Change in 2050s (Inches)			Projected Change in 2070s (Inches)			End of Century Projected Change in 2090s (Inches)		
Total Precipitation	Annual	46.07	+0.02	to	+4.67	+0.30	to	+6.20	+1.19	to	+7.67	+1.09	to	+9.03
	Winter	11.82	-0.41	to	+1.88	-0.02	to	+2.35	+0.37	to	+3.01	+0.37	to	+4.07
	Spring	11.59	-0.10	to	+2.24	+0.03	to	+2.18	+0.14	to	+2.71	+0.30	to	+2.83
	Summer	10.51	-0.49	to	+1.56	-0.41	to	+1.86	-1.01	to	+2.77	-1.66	to	+2.23
	Fall	12.18	-0.92	to	+1.18	-1.02	to	+1.60	-1.74	to	+2.08	-1.64	to	+1.78

- Similar to projections for number of days receiving precipitation over a specified threshold, seasonal projections for total precipitation are also variable for the Boston Harbor basin.
  - The winter season is expected to experience the greatest change with an increase of 0-20% by mid-century, and 3-34% by end of century.
  - Projections for the summer and fall seasons are more variable, and could see either a drop or increase in total precipitation throughout the 21st century.
    - The summer season projections for the Boston Harbor basin could see a decrease of 0.4 to an increase of 1.9 inches by mid-century (decrease of 4% to increase of 18%), and a decrease of 1.7 to an increase of 2.2 inches by the end of the century (decrease of 16% to increase of 21%).
    - The fall season projections for the Boston Harbor basin could see a decrease of 1.0 to an increase of 1.6 inches by mid-century (decrease of 8% to increase of 13%), and a decrease of 1.6 to an increase of 1.8 inches by the end of the century (decrease of 13% to increase of 15%).

Boston Harbor Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)			Mid-Century Projected Change in 2050s (Days)			Projected Change in 2070s (Days)			End of Century Projected Change in 2090s (Days)		
Consecutive Dry Days	Annual	17.46	-0.29	to	+1.41	-0.41	to	+2.17	-0.93	to	+2.88	-0.59	to	+3.64
	Winter	11.09	-0.72	to	+1.44	-0.52	to	+1.59	-0.69	to	+2.08	-1.00	to	+2.01
	Spring	11.37	-1.05	to	+0.55	-1.10	to	+1.24	-1.44	to	+1.47	-1.31	to	+1.27
	Summer	12.58	-1.16	to	+1.27	-0.95	to	+2.27	-1.26	to	+3.05	-1.44	to	+2.41
	Fall	12.78	-0.20	to	+2.02	-0.18	to	+2.66	-0.40	to	+3.08	-0.45	to	+3.00

- Annual and seasonal projections for consecutive dry days, or for a given period, the largest number of consecutive days with precipitation less than 1 mm (~0.04 inches), are variable throughout the 21st century.
  - For all the temporal parameters, the Boston Harbor basin is expected to see a slight decrease to an increase in consecutive dry days throughout this century.
  - Seasonally, the fall and summer seasons are expected to continue to experience the highest number of consecutive dry days.
    - The fall season is expected to experience an increase of 0-3 days in consecutive dry days by the end of the century.

Community Resilience Building Risk Matrix RED TEAM

www.CommunityResilienceBuilding.org

H-M-L priority for action over the **S**hort or **L**ong
V = Vulnerability **S** = Strength

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

Features	Location	Ownership	V or S	Major Storms: Rain and Snow	Extreme Temperature: Hot and Cold	Wind	Power Loss	Priority H - M - L	Time Short Long Ongoing
Infrastructural									
Roadways - Melrose Street Bridge - Evacuation Routes		City/DCR	V	Signage regarding evacuation routes, interdepartmental commercial				H	O
Technology - Backup Public Safety - Phone Servers (cooling)		City	V	City Hall generator and generator battery backup VOIP System			Close fiber optic loop	H	S
Stormwater - Parking Lots - Evacuation Routes	City Hall lots/ School lots	City	S/V	Lebanon/Sylvan outfall dredging - multi-year permit to dredge City Hall Lot - Rain gardens				H M	S L
Sewer System (pump stations)		City/MWRA	V	Backup generator for pump stations Elevate pump access				H	S
Power - outages		Ngrid/City	V		Air conditioning for IT			H	S
Buildings (schools, pumps)		City	V	Penney Road/Fellsway/Upham Pump Hardening				H	S
Societal									
Senior and Aging Population	Homes/Senior Housing	City/COA	V/S	In the event of any hazard above, need to communicate emergency plan, outreach to vulnerable population, utility life support contact list, access to emergency funds, translation services, access to meals and food for under-served populations in emergencies.				H	S
Essential Services to Vulnerable Populations	Grocery Rx Gas	City/Private	V						
Communication - Internal - to public		City	V/S						
Chronically ill - Disable		City/MWH	V						
Managing Public Fear, Anxiety		City	V						
Severity (cyber, physical, public safety)		City	V						
Environmental									
Lakes/Ponds Erosion	Throughout	City	V						
Parks/Open Space/Fells/Mt. Hood	Throughout	City/DCR	V						
Trees/canopy	Throughout	City/DCR	S/V	Plant trees that are drought, flood, disease resistant and appropriate to locations					H/S
Air Quality	Throughout	All	V		Anti-idling ordinance and technology education				
Heat Islands	Near Schools/ downtown	City	V		Plant more trees				
Local Agriculture	Regional	Private Business	V/S						
Rodents/Insets	Regional throughout	City/Regional	V/S		More bats				

Community Resilience Building Risk Matrix

ORANGE TEAM

www.CommunityResilienceBuilding.org

H-**M**-**L** priority for action over the **S**hort or **L**ong
V = Vulnerability **S** = Strength

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

Features	Location	Ownership	V or S	Flooding	Power	Disease	Extreme Temperatures	Priority H - M - L	Time Short Long Ongoing
Infrastructural									
City Hall	City Hall Lot	City	V	■ Prioritize to design green infrastructure and drainage opportunities ■ Secure funding for construction			■ Tree warden to help encourage canopy	L	O/L
Drainage Infrastructure	Ell Pond and other	City/DPW	V/S	■ Funding for Mosquito Control n Drainage Evaluation Plan n Maintain drainage infrastructure culverts by developing plans	■ Remedy Funding of Power Systems	■ Funding for Mosquito Control		M	O/L
New Development - Spread disease with increasing population / alleviated flooding	Boardment	Residential	V/S	■ Elevate electrical systems in new building ■ Build higher not wider UPDATE NEW DEVELOPMENT DESIGN REQUIREMENTS	■ Underground power lines for new development		■ Tree warden UPDATE DESIGN REQUIREMENTS	M	L
Generator Capacity - Several large in development, need more	Several	Existing & Private need Public	V/S		■ Funding for new generators at municipal facilities			H	S
Power Provider	N/A	National Grid	V/S		■ Education/communication of National Grid policies programs and practices			M	O/L
Senior Center	Several Milano center	City Council on Aging	V/S		■ Funding for generator COMMUNICATION PLAN			M	L
Societal									
Emergency Responders & MOU Capacity & EDS	Several	City/Community based/private	S	■ Maintain an emergency management director and get funding to support identify emergency management center				H	S
Evacuation Plans (have for some locations but not all)	School and Other	Public School & Emergency Management	V/S	■ Update and communicate evaluation plans (website/meetings, etc. DRILLS !!!!)				H	O
MVP Community and Hazard Mitigation Plans	Melrose	Public Planning/ DPW Management	S	■ Continue to update, track progress, and participate in these types of programs				H	O
Public Facilities (Library, Schools, Milano Center, Memorial Hall)	Several	Public DPW Facilities	V/S	■ Food and supply storage of emergency supplies at public facilities				L	O
Hospital	Downtown Lebanon & Main	Tufts Well source	S	■ Communicate capacity in times of need/hazard exposure				M	O
Bus/Transportation Access	N/A	MBTA	V/S	REGIONAL COORDINATION COMMUNICATION PLANS	■ Develop MOU for power access			M	O
Environmental									
Water bodies (Irrigation, storage capacity, flood management) (wetland)	Mt. Flood Ponds Ell Pond High School Stream Pierson	City, GMC, Mt Hood, Conservation	V/S	■ Look for other opportunities for gates to control floods via plan		■ Funding for mosquito control	■ Funding for dredging	M	O
Wildlife/Insects	Everywhere	N/A	V/S			■ Education ■ Continue Conservation ■ Fund insect management program		M	O
Mosquito Management (under funded)	Everywhere	E. Middlesex Mosquito Control Project	S/V	■ Fund program		■ Fund program		H	O/V/S
Air Quality	Everywhere	DEP Health Dept.	V			■ Complete streets program continue		M	O
Fells: Strength for community but vulnerable	IEMS	DCR	V/S	■ Collaborate maintain partnerships with DCR				L	O
Trees		DPW	V/S	■ Tree warden position funded, public/private partnerships for funding and investigate appropriate species				M/H	O/L/S

Community Resilience Building Risk Matrix

GREEN TEAM

www.CommunityResilienceBuilding.org

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

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

Features	Location	Ownership	V or S	Heat (H)	Flooding (F)	Snow Storms (S)	Wind (W)	Priority H - M - L	Time Short Long Ongoing
Infrastructural									
School facilities	Citywide	City	V&S	■ Upgrade HVAC at Schools (H, S)				H	S
City buildings	Citywide	City	V&S	■ Generator at City Hall (all)				H	S
Transportation network	Citywide	City & MBTA & MDOT & DCR	V&S	■ Communicate with MBTA on emergency plan (all)				M	O
Places of worship	Citywide	Private	S					M	O
Elderly housing	Scattered	Public/Private	V						
Low income housing	Scattered	Public/Private	V						
Water-sewer infrastructure/MWRA	Citywide	Public	V	■ Install generators and bypass capacity at water sewer pump stations (F, W)				H	S
Gas infrastructure	Citywide	Public	V	■ Continue work with National Grid leak prone pipes out of ground (current and conditions)				H	O
Electrical substations	Howard St	National Grid	V&S	■ Work with National Grid on flood mitigation at Howard Street Substation buildings (F)				M	O
Drainage system	Citywide	Public	V	■ Investigate ways of getting info on green infrastructure to public and implement at municipal land (H,F)				M H	O S
Vehicle fuel/home fuel	Citywide	Public/Private	V						
Communication network	Citywide	Public/Private	V&S						
Societal									
Quality of life	Citywide	Public/Private	V&S	■ Make sure food pantries are well stocked (H, F, S, W)				M	O
Essential services	Citywide	Public/Private	V&S	■ Encourage local agriculture (F)				M	O
Elderly Facilities Shelter management plan	Citywide	Public/Private	V&S						
Elderly Facilities Shelter management plan	Citywide	Public/Private	V&S						
Emergency management plan	Citywide	Public	V	■ Update plan including inventory and assessment of emergency shelters and non shelters of refuge (M,F,S,W)				H	S&O
Evacuation plan	Citywide	Public	V	■ Public outreach (all)				H	S&O
Faith based organizations Emergency shelters	Citywide	Private	S						
Faith based organizations Emergency shelters	Citywide	Public	V&S						
Lower household expenses Low-income population	Citywide	Public/Private	V	■ Investigate ways to encourage help a neighbor program (all)				H	O
Non-English speaking population	Citywide	Public/Private	V						
Hospital population	Wakefield Melrose Hospital	Private	S&V						
Environmental									
Ell Pond	Ell Pond	Public	S&V						
Trees	Citywide	Private/Public	S&V						
Conservation land and parks	Conservation land	Public	S&V						
Insects and vectors	Citywide	Public	V						
Wildlife habitat	Citywide	Public	S&V	■ Tree foreman becomes certified arborist (H,F,W)				L	S
Wetlands	Citywide	Public	S&V	■ Encourage native plantings (F,H.W)				M	S&O
Trail network	Citywide	Public	S&V						
Air quality	Citywide	Public	S&V	■ Anti idling campaign (H)		■ Plant city trees in prioritized heat islands (H,F)		M	S&O
Water Quality	Citywide	Public	S&V						
Sewer overflow	Citywide	Public	V						
Erosion	Citywide	Public & Private	V						

Appendix E: Melrose MVP Meeting Materials

Melrose
Municipal Vulnerability Preparedness

Agenda: Community Resilience Building Workshop #1

April 5, 2018

8:45 – 9:00	Registration and Refreshments
9:00 – 9:10	Welcome and Introductions
9:10 – 9:20	Workshop goals and Community Resilience in Melrose
9:20 – 9:40	Science and resources: Climate change projections in Melrose
9:40 – 9:45	Coffee break
9:45 – 11:45	Small Team Exercise (Led by the table facilitators) • Team introductions / identify a spokesperson • Characterize the hazards • Identify community vulnerability and strengths for infrastructure, society, and environment
11:45 – 12:00	Break / Collect lunch
12:00– 12:30	Small Team report out – present findings to the full group
12:30 – 12:45	Summary Discussion / Wrap up
12:45 - 1:00	Introduce Workshop #2 on April 11

Melrose
Municipal Vulnerability Preparedness

Community Resilience Building Workshop #1

April 5, 2018

Small Team Exercise Instructions

1. Team introductions: Name, organization/department
2. Identify the spokesperson (not the facilitator or scribe)
3. Characterize the **TOP 4** the hazards in Melrose. **20 minutes**
   - Climate change projections
   - GIS maps (flooding, Metro Mayor's stormwater risk, heat)
   - Your experience
4. Identify Community Vulnerabilities and Strengths
   - "Features" in each category of infrastructure, society, and environment. Includes mapping and identifying ownership where possible. **1 hour (20 minutes on each feature)**
   - Identify each "Features" as a Vulnerability or Strength. **20 minutes**

Definitions

- **Hazard:** A physical process or event (hydro-meteorological or oceanographic variables or phenomena) that can harm human health, livelihoods, or natural resources.
- **Risk:** The potential for consequences where something is at stake and where the outcome is uncertain.
- **Exposure**: The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by a hazard.
- **Sensitivity**: The degree to which a system, asset, or species may be affected, either adversely or beneficially, when exposed to climate variability or change or geophysical hazards.
- **Vulnerability or Strength:** The potential effects of hazards on human or natural assets and systems. These potential effects, which are determined by both exposure and sensitivity, may be beneficial or harmful.

A *hazard* is like the sun. The *risk* is sunburn. The *vulnerability* includes the length of *exposure* to the sun, how *sensitive* the skin is to it.

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.com

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

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

Step 1. 20minutes

Step 2. 20 minutes on each section (1 hour total)

Step 3. 30 minutes

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

Melrose Municipal Vulnerability Preparedness

Workshop #1

April 5, 2018

CDM Smith

Welcome and Introductions

Agenda

- 9:00 – 9:10 Welcome and Introductions
- 9:10 – 9:20 Workshop goals and Community Resilience in Melrose
- 9:20 – 9:40 Science and resources: Climate change projections in Melrose
- 9:40 – 9:45 Coffee break
- 9:45 – 11:45 Small Team Exercise (Led by the table facilitators)
  - *Team introductions / identify a spokesperson*
  - *Characterize the hazards*
  - *Identify community vulnerability and strengths for infrastructure, society, and environment*
- 11:45 – 12:00 Break / Collect lunch
- 12:00– 12:30 Small Team report out
- 12:30 – 12:45 Summary Discussion / Wrap up
- 12:45 - 1:00 Introduce Workshop #2 on April 11

Workshop Goals and Community Resilience in Melrose

GOAL of the MVP Workshops:

"The Workshops are a new initiative to immediately integrate community-derived priorities into a natural hazard mitigation process and identify actions to build resilience in the community."

This will allow Melrose to:

1. Become a "Massachusetts Municipal Vulnerability Preparedness (MVP)" rated City
2. Incorporate findings into Natural Hazards Mitigation Plan

- *Funding availability/implications*

At these Workshops we will:

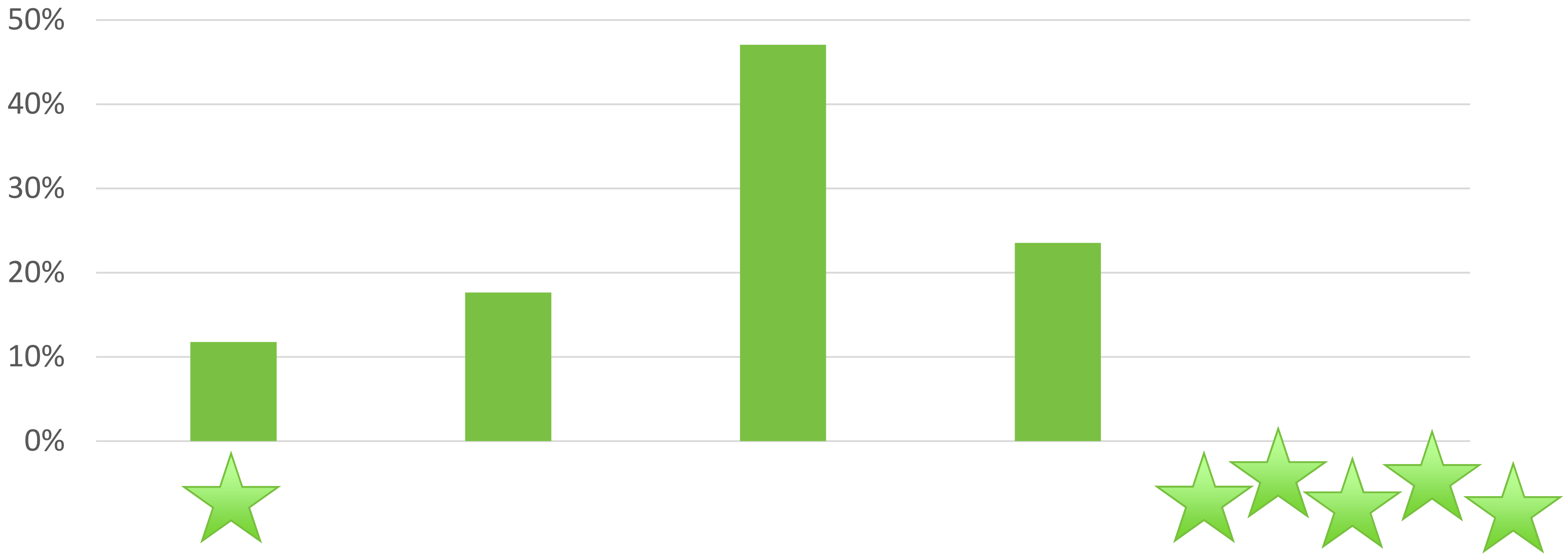
<u>Workshop #1 (today):</u>

- Understand connections between ongoing community issues, **hazards**, and local planning and actions in Melrose.
- Identify and map **vulnerabilities and strengths** to develop infrastructure, societal, and environmental **risk** profiles for Melrose.

<u>Workshop #2 (April 11, 2018):</u>

- Develop and prioritize actions and clearly delineated next steps.
- Identify opportunities to advance **actions** that further reduce the impact of hazards and increase resilience across and within Melrose.

Survey Result: How prepared is your department / organization to address climate change vulnerabilities?



NOT PREPARED:

We expect operations would be significantly impacted by climate change hazards

PREPARED:

We have plans, tools, and resources in place to be resilient to climate change hazards

Definitions

- **Hazard:** A physical process or event (hydro-meteorological or oceanographic variables or phenomena) that can harm human health, livelihoods, or natural resources.
- **Risk:** The potential for consequences where something is at stake and where the outcome is uncertain.
- **Exposure**: The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by a hazard.
- **Sensitivity**: The degree to which a system, asset, or species may be affected, either adversely or beneficially, when exposed to climate variability or change or geophysical hazards.
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Source: World Bank: https://climatescreeningtools.worldbank.org/content/key-terms-0

Climate Change Projections in Melrose

Background on Climate Data

- Summarized by the MA Executive Office of Energy and Environmental Affairs
- Based on the latest Global Climate Models (GCM) from the International Panel on Climate Change (IPCC)
  - Medium and high greenhouse gas emission scenarios
  - Bracket the "most likely" scenarios
- "Downscaled" to major watershed basin (majority of Melrose is in the Boston Harbor watershed)
  - Temperature (e.g. average/maximum/minimum temperatures annual/seasonal days over 90, 95, 100^{o}F)
  - Precipitation (e.g. total annual, seasonal, days over 1, 2, 4 inches)
  - Temperature projections are more certain than precipitation

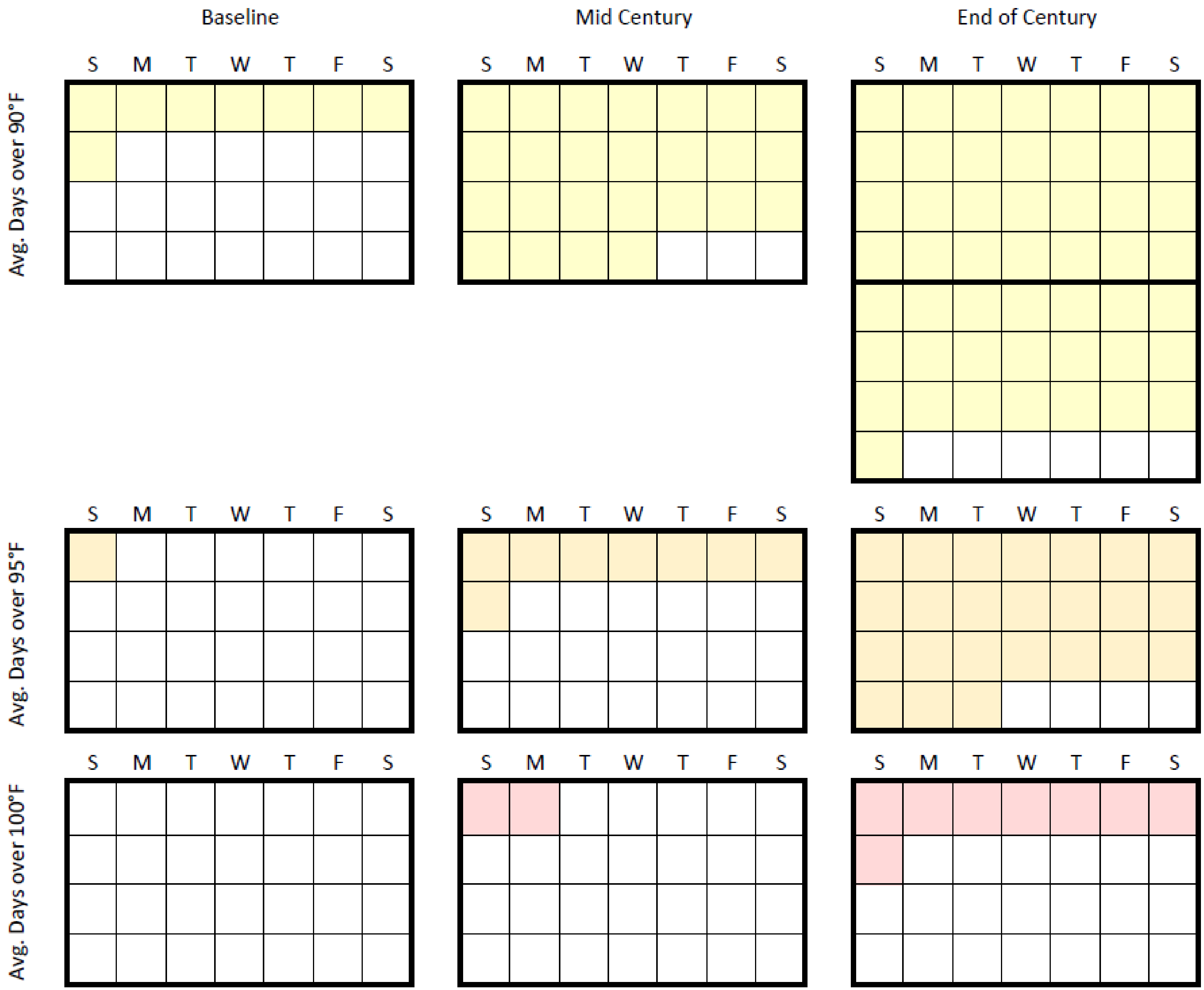
Regardless of geographic scale, rising temperatures, changing precipitation, and extreme weather will continue to affect the people and resources of the Commonwealth throughout the 21st century.

Temperature Impacts in Melrose

- Average, maximum, and minimum temperatures are expected to increase
- Seasonally, maximum summer and fall temperatures are expected to see the highest projected increase
- Seasonally, minimum winter and fall temperatures are expected to increase throughout the 21st century.

Boston Harbor Basin		Observed Baseline 1971-2000 (°F)	Mid-Century 2050 (°F)			End of Century 2090's (°F)		
Average	Annual	50.13	52.86	to	56.2	53.59	to	60.97
Maximum Temperature	Summer	80.04	82.27	to	86.45	83.26	to	92.25
	Fall	61.93	65.23	to	68.59	65.56	to	73.71
Minimum Temperature	Annual	40.7	43.61	to	46.92	44.45	to	51.65
	Winter	21.31	24.55	to	28.65	25.64	to	32.22
	Fall	43.22	46.71	to	49.67	47.14	to	54.63

Representation of Hot Days



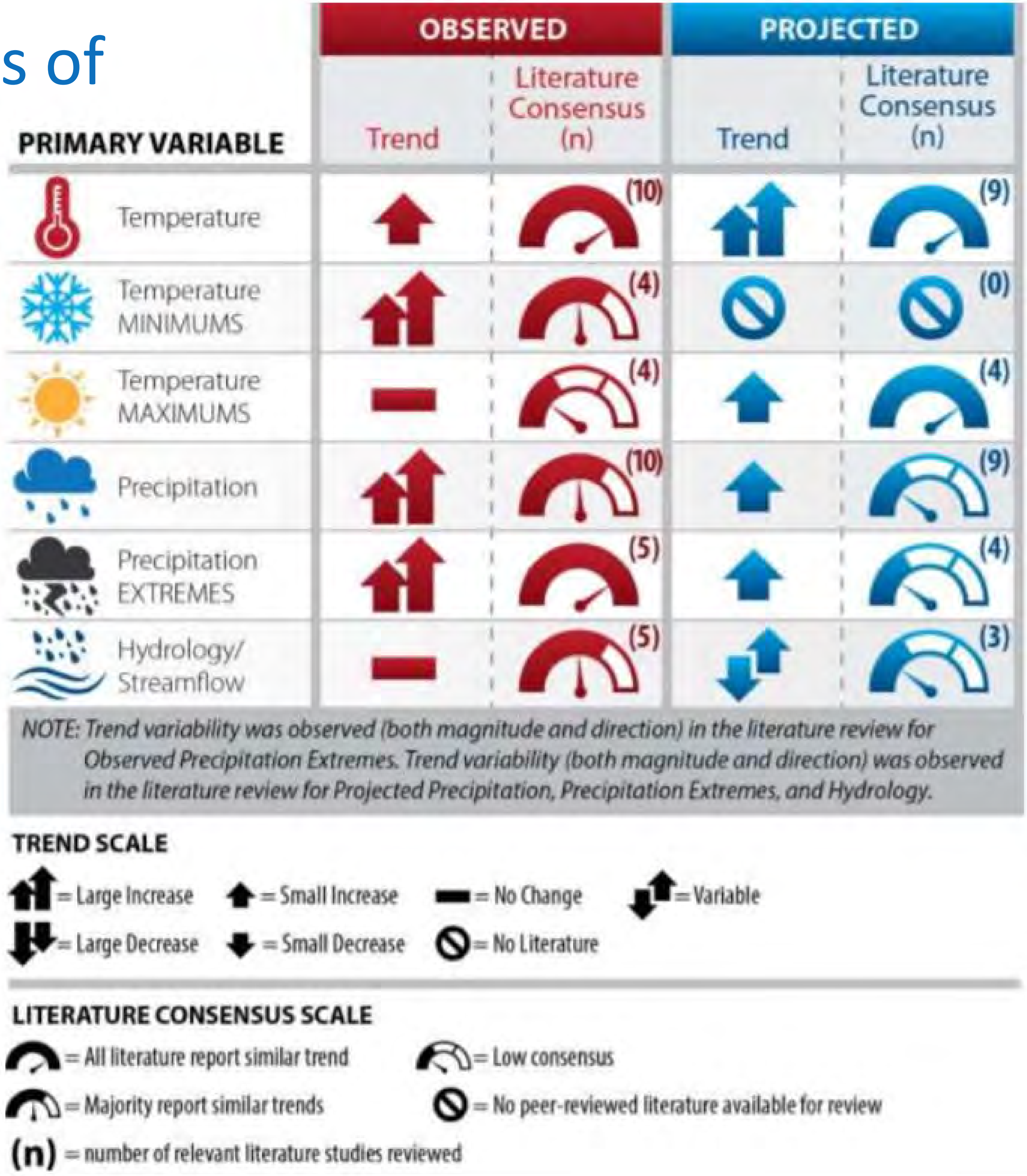
Precipitation Impacts in Melrose

- Number of days receiving precipitation over one inch are variable, fluctuating between loss and gain of days.
- Seasonal projections for total precipitation are also variable for the Boston Harbor basin.
  - The winter season is expected to experience the greatest change with an increase of 0-20% by mid-century, and 3-34% by end of century.
- Annual and seasonal projections for consecutive dry days, or for a given period, are variable throughout the 21st century.

Take away: Precipitation will be more variable. "Extreme" precipitation events are likely to occur more often.

U.S. Army Corps of Engineers

- Temperatures are rising
- Precipitation is increasing, especially extreme precipitation
- Hydrology and streamflow

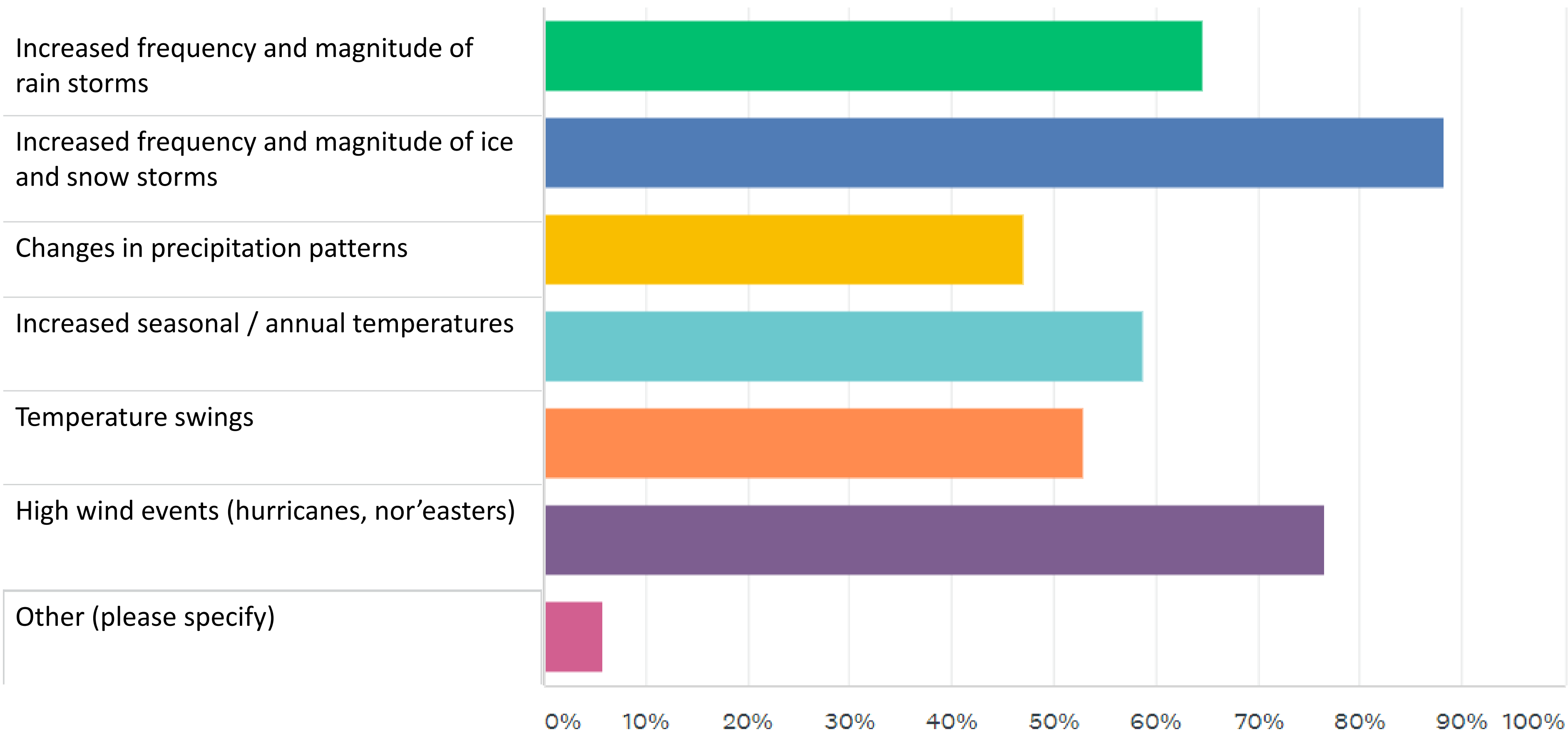


Source: USACE IWR: http://www.corpsclimate.us/docs/rccvarreports/USACE_REGION_01_Climate_Change_Report_CWTS-2015-20_Lo.pdf

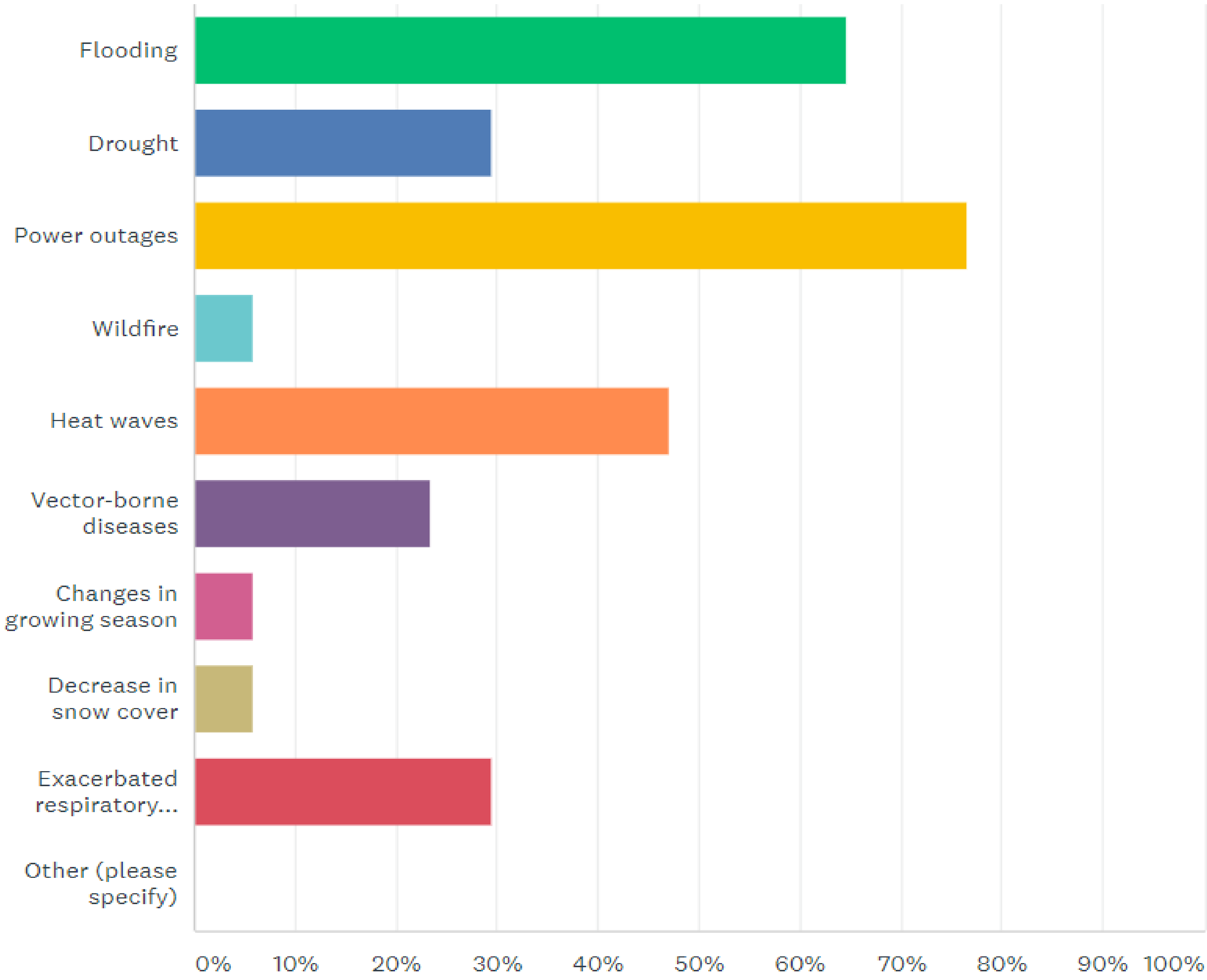
Characterize Hazards

- What hazards have impacted Melrose in the past? Where, how often, and in what ways?
- What hazards are impacting your community currently?
- What effects will these hazards/changes have on Melrose in the future3 (5, 10, 25, years?)
- What is exposed to hazards and climate threats within your community?
- Other concerns or considerations?

Which observed climate change impacts have already impacted your department/organization?



What climate-related hazards is your department / organization most concerned about experiencing?



Small Team Exercise Instructions

Small Team Exercise Instructions

1. Team introductions: Name, organization/department
2. Identify the spokesperson (not the facilitator or scribe)
3. Characterize the **TOP 4** the hazards in Melrose. **20 minutes**
   - Climate change projections
   - GIS maps (flooding, Metro Mayor's stormwater risk, heat)
   - Your experience
4. Identify Community Vulnerabilities and Strengths
   - "Features" in each category of infrastructure, society, and environment. Includes mapping and identifying ownership where possible. **1 hour (20 minutes on each feature)**
   - Identify each "Features" as a Vulnerability or Strength. **20 minutes**

Hazards - examples

- Wind
- Flooding/Stormwater
- Rain storms
- Intense rainfall
- Heat waves
- Cold
- Temperature swings
- Major storms (Hurricane, nor’easter)
- Disease

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.com

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

Step 1. 20minutes

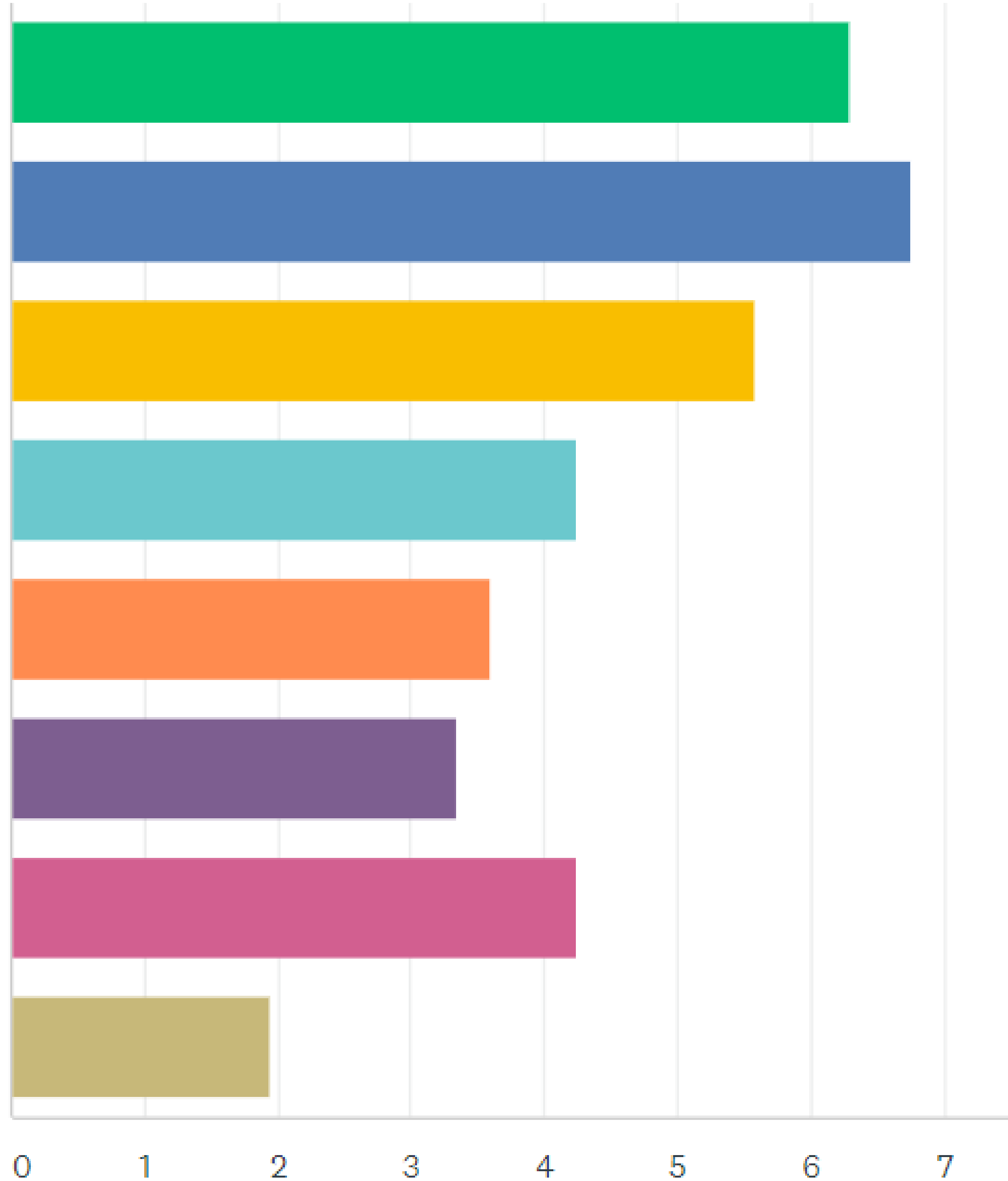
Step 2. 20 minutes on each section (1 hour total)

Step 3. 30 minutes

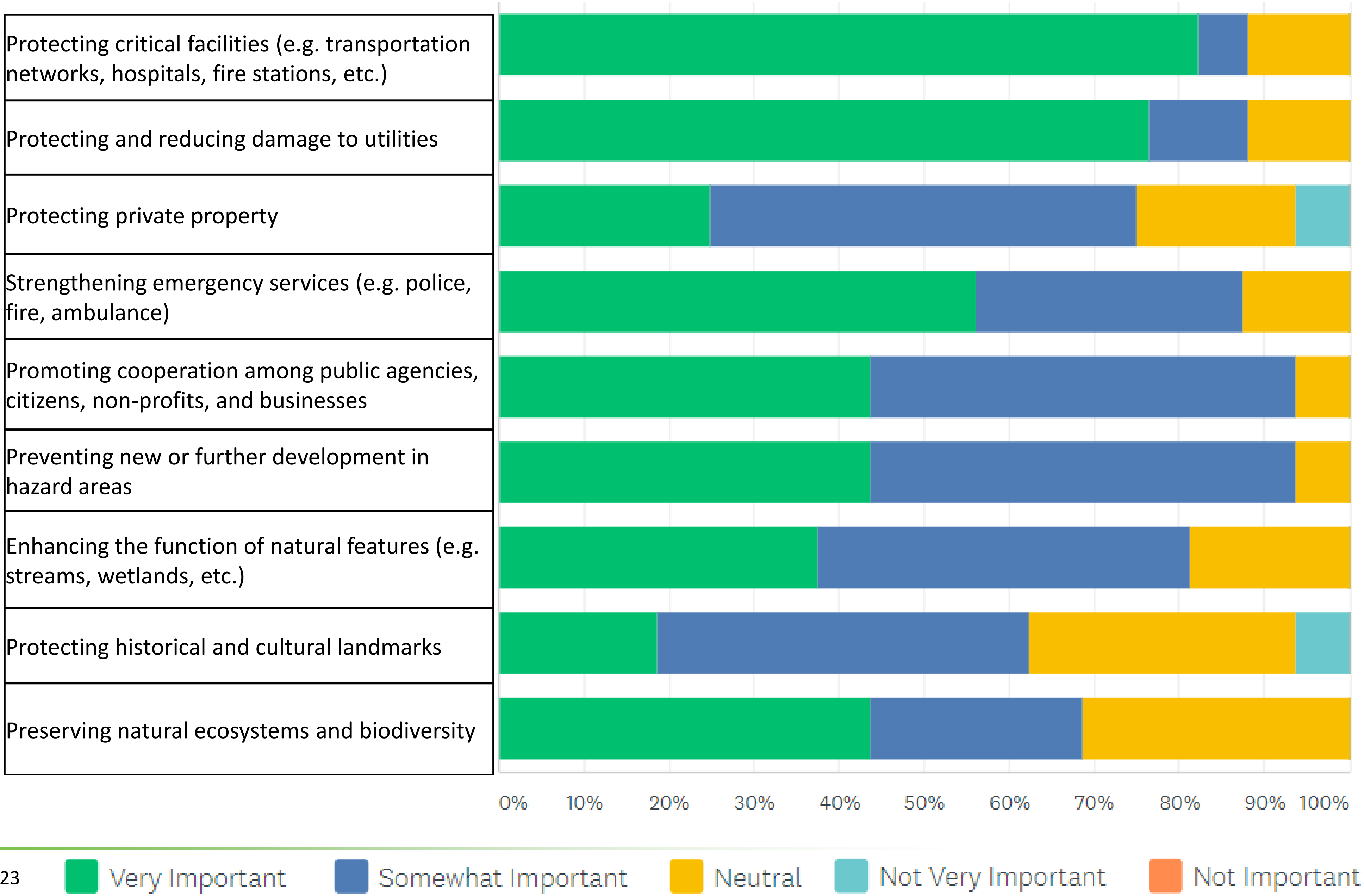
				Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)				Priority	Time
Features	Location	Ownership	V or S					H - M - L	Short Long Ongoing
Infrastructural									
Societal									
Environmental									

Which of the following is Melrose most vulnerable to as the result of climate change?

Compromises to transportation infrastructure (roads, rail, bridges, trails, etc.)	6.29
Availability of utilities (water, wastewater, energy, communications, etc.)	6.76
Access to critical facilities (schools, libraries, emergency shelters, medical facilities, etc.)	5.59
Human injury, illness, or loss of life	4.24
Business interruptions (closures, economic losses, etc.)	3.59
Ability to maintain order and/or provide public amenities	3.35
Damage, contamination, or loss of ecosystems and natural resources (forests, wetlands, waterways, etc.)	4.24
Damage or loss of cultural resources (i.e. museums, historic properties, etc.)	1.94



Collective priorities: rank the importance of each statement to your department / organization



Community Resilience Building Workshop Risk Matrix

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

Top 4 Hazards (tornado, floods, wildfire, hurricanes, snow/ice, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	Coastal Flooding SLR/Storm Surge	Inland Flooding and Rain Events	Ice and Snow	Wind	Priority H - M - L	Time Short Long Ongoing
Infrastructural									
Town Campus	Specific	Town	V						
Evacuation Routes - Roads	Town-wide	Town/State	V						
Electrical Distribution System	Multiple	CL&P/Town	V						
Dams (inland and coastal)	Multiple	Private	V						
Railway and State Bridges	Multiple	Amtrak/State	V						
Societal									
Elderly Citizens (facilities)	Multiple	Private	V						
Neighborhood Cooperation	Town-wide	Private	V						
Faith-based Organizations	Multiple	Private	V						
Homeless Population	Town-wide	Town	V						
Vulnerable Neighborhoods	South side	Town/Private	V						
Coordinated Evacuation Plan	Town-wide	Town/State	V						
Sheltering Facility (upgrades)	Town/Region	Town/State	V						
Shelter Management Plan	Town-wide	Town	S						
Lower Household Expenses (flood insurance)	Town-wide	Town	S						
Environmental									
Beaches & Dunes	Multiple	State-Town-Private	V/S						
Forest (uniform age structure)	Town-wide	Town/State	V						
Salt Marsh	Multiple	State/Private	V/S						
Open Space Acquisition (for flood impact reduction)	Town-wide	Town-State-Private	V						
State Parks	Specific	State	V						
Rippowam River	Specific	State/Town	V						
Drinking Water Reservoir	Multiple	State-Private	V						
Protected Open Space	Multiple	State-Town-Private	S						

Introduction to Workshop #2

Workshop #2 Agenda

<u>Wednesday April 11, 2018</u>

- Workshop goals and desired outcomes
- Review Findings from Workshop #1
- Small Team Exercise (Led by the table facilitators)
  - Identify actions to address community vulnerabilities and reinforce strengths for infrastructure, society, and environment
  - Prioritize actions
  - Report out to the full group
- Finalize top priorities
- Wrap up and Next Steps

Melrose
Municipal Vulnerability Preparedness

Agenda: Community Resilience Building Workshop #2

April 11, 2018

8:45 – 9:00 Registration and Refreshments

9:00 – 9:05 Welcome and Introductions

9:05 – 9:15 Workshop goals and desired outcomes

9:15 – 9:30 Review Findings from Workshop #1

9:30 – 11:30 Small Team Exercise (Led by the table facilitators)

- Team introductions / identify a spokesperson
- Revisit Small Team hazards, vulnerability, and strengths from Workshop #1
- Identify actions to address community vulnerabilities and reinforce strengths for infrastructure, society, and environment
- Prioritize actions

11:30 – 11:45 Break / Collect lunch

11:45– 12:15 Small Team report out – present findings to the full group

12:15 – 12:45 Finalize top priorities

12:45 - 1:00 Wrap up and Next Steps

Melrose
Municipal Vulnerability Preparedness

CDM Smith

Community Resilience Building Workshop #2

April 11, 2018

Small Team Exercise Instructions

1. Identify the spokesperson (not the facilitator or scribe)
2. Revisit team findings from Workshop #1 **15 minutes**
    - TOP 4 the hazards in Melrose
    - Community Vulnerabilities and Strengths" for infrastructure, society, and environment
3. Identify actions to address community vulnerabilities and reinforce strengths for in each category of infrastructure, society, and environment. **1 hour (20 minutes on each category)**
4. Prioritize actions for each feature; Includes mapping and identifying timeframe (Short, Long, Ongoing). **30 minutes (10 minutes on each category)**
5. Identify the top 3-4 priority actions for the Report Out **15 minutes**

New defintions:

- **Actions** reduce vulnerability or reinforce strengths.
- **Prioritized actions** take into account the importance of addressing the vulnerability / reinforcing the strength to the community

A *hazard* is like the sun. The *risk* is sunburn. The *vulnerability* includes the length of *exposure* to the sun, how *sensitive* the skin is to it.

The *actions* to address vulnerability of a sunburn include staying in the shade or wearing sunblock.

Prioritizing Considerations

- Funding availability and terms
- Agreement on outstanding impacts from recent hazard events
- Necessity for advancing longer-term outcomes
- Contribution towards meeting existing local/regional planning objectives

Timeframe/Urgency Examples

- Current projects to reduce flooding = **ongoing (O)**
- Update the Hazard Mitigation Plan = **short term (S)**
- Reducing housing stock in high-risk areas = **long term (L)**

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.com

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

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

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

Step 1 (Review). 15 minutes

Step 2. 20 minutes on each section (1 hour total)

Step 3. 45 minutes

Melrose Municipal Vulnerability Preparedness

Workshop #2

April 11, 2018

Welcome and Introductions

Agenda

- 9:00 – 9:05 Welcome and Introductions
- 9:05 – 9:15 Workshop goals and desired outcomes
- 9:15 – 9:30 Review Findings from Workshop #1
- 9:30 – 11:30 Small Team Exercise (Led by the table facilitators)
  - *Team introductions / identify a spokesperson*
  - *Revisit team findings from Workshop #1*
  - *Identify actions to address community vulnerabilities and reinforce strengths*
  - *Prioritize actions and identify timeframes*
- 11:30 – 11:45 Break / Collect lunch
- 11:45 – 12:00 Small Team report out
- 12:00 – 12:30 Finalize top priorities
- 12:30 - 12:45 Wrap up / Next Steps

Workshop Goals and Desired Outcomes

GOAL of the MVP Workshops:

"The Workshops are a new initiative to immediately integrate community-derived priorities into a natural hazard mitigation process and identify actions to build resilience in the community."

<u>This will allow Melrose to:</u>

1. Become a "Massachusetts Municipal Vulnerability Preparedness (MVP)" rated City
2. Incorporate findings into Natural Hazards Mitigation Plan

- *Funding availability/implications*

At Today's Workshop, we will:

- **Develop and prioritize actions** and clearly delineated next steps.
- **Identify opportunities to advance actions** that further reduce the impact of hazards and increase resilience across and within Melrose.
- **Finalize top priorities**

Review Findings from Workshop #1

Definitions

- **Hazard:** A physical process or event (hydro-meteorological or oceanographic variables or phenomena) that can harm human health, livelihoods, or natural resources.
- **Risk:** The potential for consequences where something is at stake and where the outcome is uncertain.
- **Exposure**: The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by a hazard.
- **Sensitivity**: The degree to which a system, asset, or species may be affected, either adversely or beneficially, when exposed to climate variability or change or geophysical hazards.
- **Vulnerability or Strength:** The potential effects of hazards on human or natural assets and systems. These potential effects, which are determined by both exposure and sensitivity, may be beneficial or harmful.

Source: World Bank: https://climatescreeningtools.worldbank.org/content/key-terms-0

- **Actions** reduce vulnerability or reinforce strengths.
- **Prioritized actions** take into account the importance of addressing the vulnerability / reinforcing the strength to the community

A *hazard* is like the sun. The *risk* is sunburn. The *vulnerability* includes the length of *exposure* to the sun, how *sensitive* the skin is to it.

The *actions* to address vulnerability of a sunburn include staying in the shade or wearing sunblock.

Review of Climate Data

- Summarized by the MA Executive Office of Energy and Environmental Affairs
- Regardless of geographic scale, rising temperatures, changing precipitation, and extreme weather will continue to affect the people and resources of the Commonwealth throughout the 21st century.

TEMPERATURE KEY TAKE-AWAY

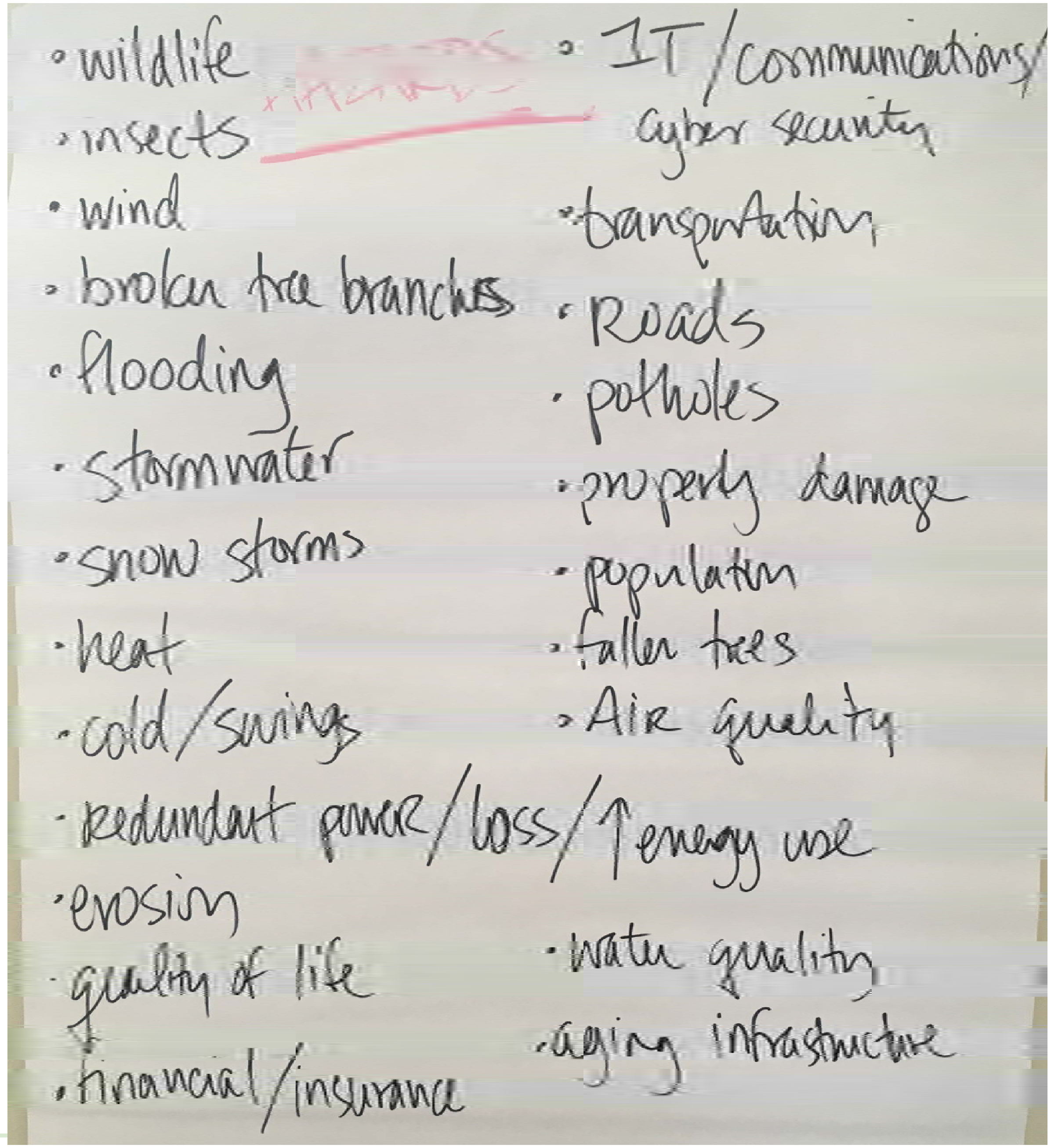
- Average, maximum, and minimum temperatures are expected to increase
- Seasonally, maximum summer and fall temperatures are expected to see the highest projected increase

PRECIPITATION KEY TAKE-AWAY

- Precipitation will be more variable. “Extreme” precipitation events are likely to occur more often.

Hazards in Melrose

- Extreme temperatures
- Heat
- Flooding
- Major storms (rain and snow)
- Wind
- Power loss
- Disease



Vulnerabilities and Strengths in Melrose

Infrastructure	V or S
Roadways – Evacuation routes, Melrose St. Bridge	V
Technology – Backup Phones/Public Safety/Servers	V
Drainage infrastructure / Stormwater – Parking lots	V/S
Sewer system / pump stations / MWRA	V
Power outages / power provider	V
City Buildings / School facilities	V/S
New development	V/S
Generator capacity	V/S
Senior Center	V/S
Transportation network	V/S
Places of worship	S
Elderly and low income housing	V

Vulnerabilities and Strengths in Melrose

Society	V or S
Emergency Responders	S
Evacuation Plans	V/S
MVP Community / Hazard Mitigation Plans	S
Public Facilities	V/S
Hospital	S
Bus/Transportation Access	V/S
Seniors/Aging Population	V/S
Essential Services to Vulnerable Populations	V
Communication (internal/to public)	V/S
Chronically ill/disabled	V
Managing public fear/anxiety	V
Security (cyber, physical, public safety)	V
Quality of Life	V/S
Shelter Management Plan / Shelters	S
Faith based organizations	S

Vulnerabilities and Strengths in Melrose

Environment	V or S
Water bodies (irrigation, storage capacity, flood management)	V/S
Parks/Open Space/Conservation Land/Fells/Mt. Hood/Trail Network	V/S
Trees/Canopy	V/S
Air Quality	V
Heat Islands	V
Local Agriculture	V/S
Rodents/Insects (vectors)	V
Mosquito Management	V/S
Wildlife habitat	V/S
Water quality	V/S
Sewer overflow	V
Erosion	V

Small Team Exercise Instructions

Small Team Exercise Instructions

1. Identify the spokesperson (not the facilitator or scribe)
2. Revisit team findings from Workshop #1 **15 minutes**
   - Top 4 the hazards in Melrose
   - Community Vulnerabilities and Strengths for infrastructure, society, and environment
3. Identify actions to address community vulnerabilities and reinforce strengths **1 hour (20 minutes on each category)**
   - For in each category of infrastructure, society, and environment.
4. Prioritize Actions for each feature **30 minutes (10 minutes on each category)**
   - Includes mapping and identifying timeframe (Short, Long, Ongoing).
5. Identify the top 3-4 Priority Actions for the Report Out **15 minutes**

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.com

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

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

Step 1 (Review). 15 minutes

Step 2. 20 minutes on each section (1 hour total)

Step 3. 45 minutes

Prioritizing and Timeframes

Prioritizing Considerations

- Funding availability and terms
- Agreement on outstanding impacts from recent hazard events
- Necessity for advancing longer-term outcomes
- Contribution towards meeting existing local/regional planning objectives

Timeframe/Urgency Examples

- Current projects to reduce flooding = **ongoing (O)**
- Update the Hazard Mitigation Plan = **short term (S)**
- Reducing housing stock in high-risk areas = **long term (L)**

Identifying/prioritizing actions - examples

H-M-L priority for action over the Short or Long term (and Ongoing)

V = Vulnerability S = Strength

Features	Location	Ownership	V or S	Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)				Priority	Time
				Flooding	ALL (Major storms/Extreme temps/wind /power loss)	Heat		H - M - L	Short Long Ongoing
Infrastructural									
City hall lot is subject to flooding	City Hall	City	V	-Repave with permiable pavement -Install "green infrastructure" features in parking lot				M	L
Societal									
Managing public fear/anxiety	Citywide	Public/ City	V		-Increase two-way preparedness communication to citizens -Host a series on emotional well-being			H	O/S
Environmental									
Air quality	Citywide	Public	S/V			-Increase the tree canpoy near vulnerable populations -Create an anti-idling campaign		M	S/L

Community Resilience Building Workshop Risk Matrix

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

Top 4 Hazards (tornado, floods, wildfire, hurricanes, snow/ice, drought, sea level rise, heat wave, etc.)

Features	Location	Ownership	V or S	Coastal Flooding SLR/Storm Surge	Inland Flooding and Rain Events	Ice and Snow	Wind	Priority H-M-L	Time Short Long Ongoing
Infrastructural									
Town Campus	Specific	Town	V	Verify risk from flooding events; Identify alternative locations during peak flooding; Verify maintenance plan annually				H	S
Evacuation Routes - Roads	Town-wide	Town/State	V	Install highly visible signage for evacuation routes; Develop and implement communication program				H	S
Electrical Distribution System	Multiple	CL&P/Town	V	Within floodplain area, establish plan to address protection and long-term relocation of equipment		Upgrade transformers; Maintain power line protection zone (tree trimming)		H	O-L
Dams (inland and coastal)	Multiple	Private	V	Prevent possibility of catastrophic dam failure; Identify and remove dams to minimize downstream flooding due to failure				H	L
Railway and State Bridges	Multiple	Amtrak/State	V	Improve communications between parties; Expand green/gray infrastructure and improve bridge structures; Assess vulnerability and prioritize infrastructure improvement list				M	S
Societal									
Elderly Citizens (facilities)	Multiple	Private	V	Assess and identify vulnerabilities to determine residents needs during emergencies; Coordinate emergency planning efforts; Conduct routine evacuation drills				H	S
Neighborhood Cooperation	Town-wide	Private	V	Assist associations in identifying and conducting best practices to reduce risk; Advance a "Neighbor helping Neighbor" Program through Community Center training				H	S
Faith-based Organizations	Multiple	Private	V	Coordinate organizations in identifying and conducting best practices amongst members to reduce risk				H	S
Homeless Population	Town-wide	Town	V	Extreme weather flyers and communications about available services				M	S
Vulnerable Neighborhoods	South side	Town/Private	V	Identify level and location of vulnerable units; Develop longer term plan to reduce vulnerability				M	L
Coordinated Evacuation Plan	Town-wide	Town/State	V	Reconfigure evacuation routes; Update signage along critical routes				L	S
Sheltering Facility (upgrades)	Town/Region	Town/State	V	Conduct feasibility analysis for regional sheltering facility; Seek to construct over next 15 years.				L	L
Shelter Management Plan	Town-wide	Town	S	Review and update as needed on annual basis; More resources required (cots, shampoo, etc.)					Ongoing
Lower Household Expenses (flood insurance)	Town-wide	Town	S	Continue enrollment in FEMA Community Rating System (CRS);Reduced number flood insurance rate payers through volunteer buyouts/relocation					Ongoing
Environmental									
Beaches & Dunes	Multiple	State-Town-Private	V/S	Maintain existing beaches & dunes; Assess values and key locations relative to people and property				H	S
Forest (uniform age structure)	Town-wide	Town/State	V	Seeks management that diversifies the age structure of forests in Town; Assess and identify key vulnerabilities from tree fall				H	S
Salt Marsh	Multiple	State/Private	V/S	Maintain existing marsh; Consider additional regulatory protection (increased setbacks) to prevent impacts to resource; Assess risk reduction potential from existing and future wetlands				H	S
Open Space Acquisition (for flood impact reduction)	Town-wide	Town-State-Private	V	Secure state funding; Salt marsh advancement zones	Secure state/federal funding	Include land protection needs Master Plan		H	S-L
State Parks	Specific	State	V	Encourage the State to work more closely with Town to comprehensively maintain town-wide natural resources, amenities, and water quality; Coordinate with state regarding evacuation procedures				M	S
Rippowam River	Specific	State/Town	V		Improve risk reduction characteristics of waterway through natural infrastructure & riparian buffer enhancements			M	S-L
Drinking Water Reservoir	Multiple	State-Private	V	Conduct assessment to comprehensively identify vulnerabilities and develop action plans to increase resilience of natural resources and long term water quality/quantity; Implement improvements				L	L
Protected Open Space	Multiple	State-Town-Private	S	Maintain existing open space to help reduce risk to Town; Seek to increase open space with the highest risk reduction characteristics					Ongoing

Report Out / Final Priority Actions

Small Team Priority Actions (Top 3-5 per Team)

RED

1. Generator at City Hall
2. Dredge SW outfalls/universal permit/maintenance plan
3. Communication plan on hazards
4. Update MS4 permit
5. Water/sewer back-up pump stations (power and bypass capability) and elevation

GREEN

1. Generator at City Hall
2. Update emergency mgmt. plan (inc. Inventory/assessment of shelters
3. Public outreach on hazards
4. Green infrastructure and green buildings (zoning, BMP for developers, specific projects)
5. Water/sewer back-up pump stations (power and bypass capability)

ORANGE

1. Generator at other public buildings
2. Dedicated emer. Mgmt director /MOU for emergency response
3. Update evacuation plan/communication/drills
4. Mosquito mgmt – disease and flooding
5. Trees – warden position/P3 for funding and maintenance

Final Priority Actions (Goal: Top 3-5)

- City Hall generator
- Dredge stormwater outfalls/permit plan/maintenance plan/ mosquito management
- Emergency management:
  - plan update
  - outreach/communication
  - Emergency management director
- Green infrastructure and green buildings
  - Energy management (efficiency and renewable)
  - Stormwater management
  - Zoning/Regulatory
  - BMP
  - Communication

Next Steps

Next Steps

- Master Risk Matrix
- MVP Findings Report
- MVP listening session / Hazard mitigation plan public meeting – end of May/early June
- Natural Hazard Mitigation Plan (with climate change effects) – end of 2018

GREAT JOB!

THANK YOU!