Town of Burlington

Community Resilience Building

Summary of Findings

June 2019

Burlington Town Hall
Source: Town of Burlington

BSC GROUP

PREPARED AND PRESENTED BY

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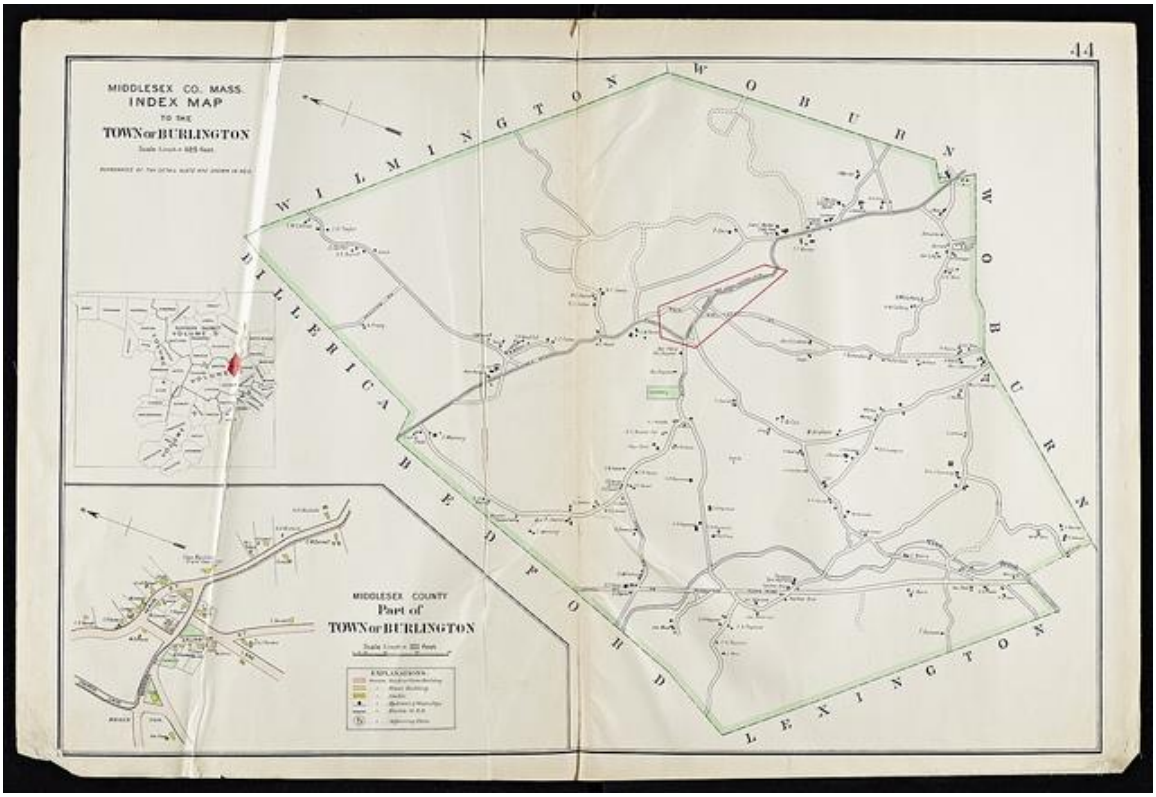
Grandview Farm
Source: Town of Burlington

EXECUTIVE SUMMARY

In accordance with Executive Order 569, which seeks to build resilience and adapt to the impacts of climate change, the Town of Burlington, Massachusetts is pleased to submit this Summary of Findings Report. In 2018, the Town of Burlington applied for and received a Municipal Vulnerability Preparedness (MVP) program planning grant from the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) to complete a vulnerability assessment and action oriented resilience plan (Findings Report). This planning effort followed the Community Resilience Building (CRB) framework developed by The Nature Conservancy. The CRB framework uses a community-driven workshop process to identify climate-related hazards, community strengths and vulnerabilities, and develop solutions to address these considerations. Completion of the CRB process enables the Town to achieve MVP community designation status from the EEA and receive preference for future state grants under the MVP program or other participating funding entities. As climate change continues to alter the way municipalities evaluate risk and manage resources, it is important to evaluate the effects of climate change and the solutions to address these challenges in a manner that assesses the interdependency of Burlington's infrastructural, societal, and environmental features. This Findings Report provides an important first step to establish climate resilience within the community.



Town of Burlington, Massachusetts c. 1906
Source: Town of Burlington

COMMUNITY RESILIENCE BUILDING PLANNING AND WORKSHOPS

The CRB process began with the establishment of a Core Team comprised of municipal staff members. The Core Team held strategic planning sessions on September 11, 2018 and November 13, 2018. Core Team meetings involved developing a broad understanding of the Hazards, Vulnerabilities, and Strengths that characterize the Town of Burlington, and to identify a list of Preliminary Resilience Actions that the community may consider at the CRB Workshops. Core Team meetings were also used to identify the goals of the workshop within the context of community interests and needs. The Core Team decided that it was important to use the workshops as a mechanism to engage with the community using interactive media platforms such as a GIS community data viewer prepared specifically for the workshop and an interactive demonstration of the Massachusetts Data Clearinghouse Website, resilientma.org.

Three Community Resilience Building Workshops were held on the following dates: January 22, 2019, March 6, 2019, and May 14, 2019. Workshop participants included a diverse set of community stakeholders from municipal departments, local businesses, non-government entities, and local interest groups. Workshop #1 included an expanded core team working group and involved a refinement of preliminary planning efforts. Workshop #2 involved a group presentation, two engagement and education Adaptation Action Stations, and workshop breakout groups. Information gathered during these Adaptation Action activities were integrated into previous planning efforts. Additionally, solutions derived from the breakout groups were integrated in the CRB Planning Matrix. Workshop #3 involved a group planning effort where participants drew upon local institutional knowledge to exchange ideas and expand upon previous CRB planning efforts to prioritize actions. Workshop #3 concluded with a brainstorming effort intended to identify interdependent project types that may be eligible for funding under the MVP program or other Massachusetts grant sources.

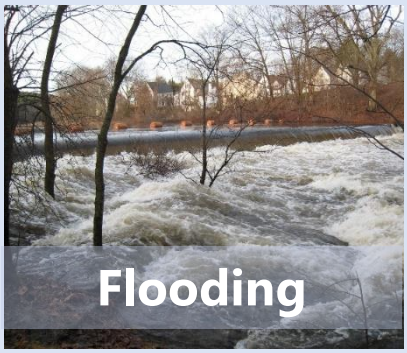
Climate resilience planning requires an ongoing effort by community stakeholders. Workshop attendees and other interested stakeholders are encouraged to provide comments, corrections, updates, or additional information of findings transcribed in this report to Josh Morris at jmorris@burlington.org. The success of climate resilience planning in Burlington is contingent upon ongoing participation of community stakeholders.

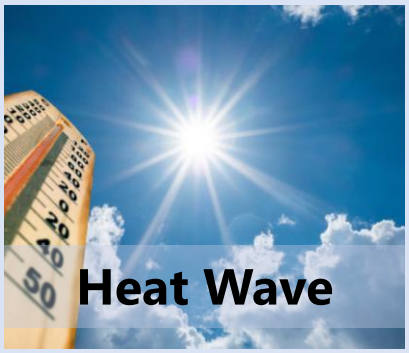
DEFINING HAZARDS

The Town of Burlington has several challenges related to establishing resilience to the effects of climate change. For example, between 1996 and 2015, Burlington experienced 76 extreme weather flood-related events that caused over $40 million in damages. Climate change is expected to increase the occurrence and intensity of weather related events. Identifying and preparing for the hazards most prevalent within Burlington is the first step to prepare for the effects of climate change.

During the Core Team and CRB planning efforts, stakeholders identified the top natural hazards for the Town of Burlington. Inland riverine flooding from extreme precipitation events was identified as the top hazard among most participants. Extreme temperatures, extreme snow events, and drought represented additional climate exposure hazards and were highlighted as significant concerns for the Town. Collectively, it was agreed upon by the group that the Town of Burlington's top hazards present ongoing and cumulative adverse impacts on the community's most important infrastructural, societal, and environmental resources.

TOP HAZARDS WITHIN BURLINGTON





CHARACTERIZING A CLIMATE RESILIENT BURLINGTON MUNICIPAL VULNERABILITIES AND STRENGTHS

The CRB process involves a robust stakeholder engagement effort and can be used to characterize the vulnerabilities and strengths unique to a given community. The Burlington CRB process revealed important characteristics that broadly represent the identity and culture of the community. Collectively, these characteristics provide a *snapshot* of the community's vulnerabilities and strengths and is an important starting point to identify community features most at risk to the effects of climate change.

Burlington Mall Commercial District

The Burlington Mall and its surrounding commercial district is known as a shopping and entertainment destination. Situated at the junction of Route 128 and Route 3, the district's large office and industrial parks, restaurants, and retail chains make Burlington an important economic center within the region. Various types of state and critical infrastructure exist within the commercial district including roadways and municipal buildings. An estimated 37,000 workers commute to Burlington each day, many of whom are non-residents. Natural resources exist within the district which provide important naturalized space, and water quality and quantity benefits, but also increase the vulnerability of surrounding built infrastructure. For example, multiple public water supply wells are located within direct proximity of commercial development. The vulnerability of this area to the effects of flooding present a particularly significant threat to Burlington because of the important economic assets to the region and the large population of daytime non-residents that commute to Burlington for work, recreation, or shopping. The district is also a significant source of Urban Heat Island Effect because of the built environment that includes buildings, roadways, stormwater management infrastructure, parking lots, and traffic congestion. The community recognizes the district as an important source of strength and vulnerability within the community because of the resources it provides and the challenges it presents, particularly with emergency preparedness and communication.

Burlington Mall and Surroundings
Source: Town of Burlington

Emergency Preparedness and Response – Drawing Upon Established Processes as a Foundation for Climate Resilience

Emergency preparedness and response operations are managed by an established and collaborative effort between the Police Department, Fire Department, and the Health Department. The Town of Burlington has a well-defined and established operational procedure to prepare for the effects of natural hazards and associated response. Emergency preparedness and response systems in Burlington consist of a variety of communication procedures that that have proven effective in past emergency situations. The community recognizes these systems as adequate and effective but agree that improvements to these systems are both appropriate and necessary in the face of changing climate-related hazards. Upgrades to systems such as code-red, Connect 5, or Reverse 911 was mentioned as an important first step. Proactive approaches that draw upon emergency coordination resources or capacity across municipal departments to increase the "buy-in" from other town departments was mentioned as a necessary preliminary planning effort. Continuing to build upon established decision-making processes and operations is an important aspect of ongoing climate resilience efforts.

Ecological Resilience – Opportunity for Co-Benefits

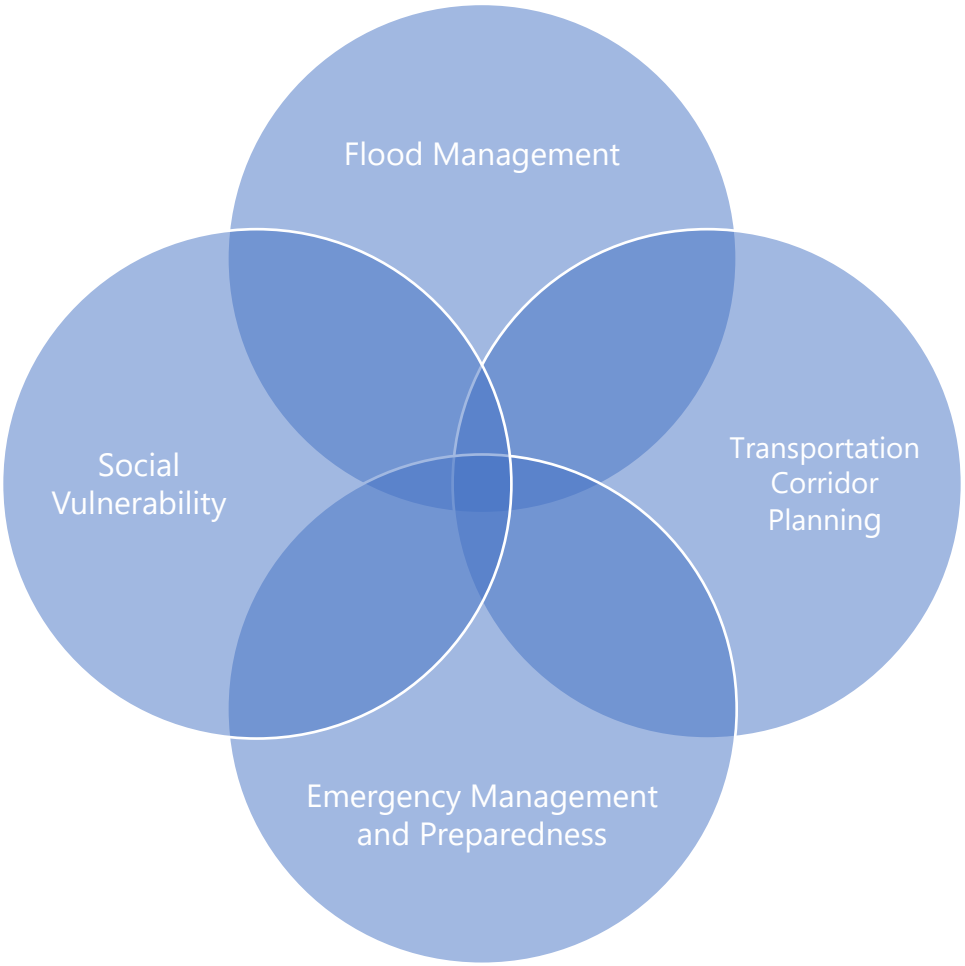
The Town of Burlington has developed in a manner that blends significant commercial development and residential development, while maintaining an important network of open space, conservation and recreational land. Burlington recognizes a deficiency of permanently protected town-owned open space/conservation land and the need to prioritize the acquisition of open space and enhance the ecological integrity of existing open space. As described within the *2019 Open Space and Recreation Plan, Burlington, MA – DRAFT* the Town is committed to enhancing the quality of life for all residents by sustainably meeting the needs of the community through a safe, healthy and high-quality open space and recreational opportunities.

Mill Pond, view from the dam
Source: StartBiking

To achieve these goals, Burlington has explicitly adopted the *Metrofuture* Regional Master Plan of the Massachusetts Area Planning Council with a focus on Protecting Natural Landscapes and Conserving Natural Resources. Burlington is committed to better understanding the threats of flooding throughout the community, an issue that is already prevalent across various locations in the town. Efforts to address flooding issues through infrastructural and natural approaches to ecosystem management was discussed.

CATEGORIZING CONCERNS AND CHALLENGES

Workshop participants used the CRB process to collaborative identify action-oriented solutions to address the climate vulnerabilities faced by the Town of Burlington. These actions are organized into four categories based on a combination of community characteristics (i.e. strengths and vulnerabilities) and solutions identified by workshop participants. During the workshops, an emphasis was placed on the interdependence of these categories that allowed for the development of climate resilience solutions that span infrastructural, societal, and environmental features. Through this lens, overlapping solutions that provide co-benefits were identified and prioritized.



Flood Management

Flooding in Burlington is primarily a result of high groundwater and low, flat topography. Under extreme precipitation conditions the system becomes overburdened and street and property flooding result. The built infrastructure within Burlington is characterized by an interdependent network of roads, bridges, dams, municipal buildings, and privately-owned buildings. State and local roadways within Burlington are often subject to flooding, some of which are located along important emergency evacuation routes or provide access to community shelters. There was a great deal of support for initiatives that promote the use of green infrastructure, low-impact design, or nature-based solutions throughout the built environment to improve flooding conditions. Efforts to establish regulatory mechanisms to promote the use of flood management strategies was also encouraged by most workshop participants. Town-wide flooding issues was recognized by most workshop participants and it was agreed that a better understanding of the vulnerabilities and risks associated with increased flooding within Burlington must be understood. Studies of Vine Brook and Sandy Brook were identified as important areas of assessment and should include hydro-geomorphologic study focused on steam flow characteristics, carrying capacity, water quality, sediment accumulation, and culvert elevations. Additionally, assessments should occur for locations where green infrastructure or nature-based solutions may be applied along the Vine Brook and Sandy Brook river corridor. The Town identified the importance of identifying flood storage within areas of existing protected open space (e.g. Landlocked Forest) or within areas where future open space may be feasible.

Flood Management

- Flood Vulnerabilities
- Vulnerable Roads and Infrastructure
- Evacuation Routes
- Critical Buildings
- Hydro Geomorphologic Assessments
- Vine/Sandy Brook
- Open Space

Transportation Corridor Planning

A key planning feature identified by Workshop participants is the interdependent sources of vulnerability and strengths that exist within the primary transportation corridor within Burlington. Characterized by Burlington Mall Road and Middlesex Turnpike (bounded by Route 128 and Route 3), this area represents the primary traffic route through the Burlington Mall Commercial District. Workshop participants agreed that the planning scope of traffic and transportation improvements within this area should explicitly address the concerns of climate change related to carbon dioxide emissions, air quality, public health, and urban heat island effect. Identified solutions included promoting multimodal transportation (public transit, bicycle, walking) and green infrastructure options to address anticipated issues related to climate change. Workshop participants emphasized the need to coordinate with state agencies (MassDOT) and grant funding agencies (Safe Routes to School) to

Transportation Corridor Planning

- Traffic Management
- Carbon Mitigation
- Urban Heat Island Mitigation
- Evacuation Routes
- Critical Buildings
- Multimodal Transportation

finance these projects while maintaining a focus on climate mitigation and adaptation efforts. Community engagement and outreach efforts were also noted as an important aspect of this initiative. Identifying ways to address the lack of awareness by non-resident daytime populations that utilize this transportation corridor that may not be aware of vulnerabilities or evacuation procedures was an identified vulnerability.

Emergency Management and Preparedness

The Town of Burlington has an established emergency management plan that municipal stakeholders feel adequately addresses the needs of the community in an emergency. The Police Department, Fire Department, and the Burlington Board of Health work in close coordination to implement emergency management and preparedness for the community. Current emergency management procedures include preparation, mitigation, response, and recovery actions, activation and operation of the Burlington Emergency Operations Center, activation and operation of shelters, and municipal emergency preparedness training. Workshop participants agreed that increased capacity for emergency preparedness is among the most important action items the town can implement to improve resilience to the effects of a changing climate. Stakeholders indicated a need for additional "buy-in" from all town departments regarding the importance of improving the capacity of the town's emergency preparedness operations. The town has in place various systems to notify the community of important information (e.g. town website, social media, Connect 5, Reverse911), but participants felt these resources lack overall awareness in the community. Participants felt strongly that an informational outreach/network should be developed within the community to plan for climate change preparedness and response. Technology such as a town web-based application should be developed to convey information. Regional coordination should also occur within neighboring communities, and the Town should draw upon the capacity provided by state agencies to enhance its overall climate preparedness and resilience. The need to improve the capacity of existing shelters/cooling centers to function during a storm event was also acknowledged. Increasing the number of shelters within

Emergency Management and Preparedness

Community Outreach

Community Networks and Education

Evacuation Routes

Regional Coordination

Coordination with State Agencies

Municipal Communication Networks

Non-Resident Daytime Populations

Emergency Shelter/Assembly Areas

3rd Avenue, Burlington MA
Source: Town of Burlington

the community was also emphasized and participants expressed a need to increase the awareness of these resources at a town-wide scale. Understanding the needs and limitations of socially vulnerable populations (e.g. elderly population, environmental justice population, non-resident daytime population) should also be explicitly addressed within future planning efforts.

Social Vulnerability

Workshop participants expressed a diverse set of viewpoints pertaining to the need to address the considerations of socially vulnerable populations in response to the anticipated effects of climate change. Social vulnerability in Burlington is characterized by two Environmental Justice communities, but also other populations of social vulnerability exist such as the elderly or daytime non-residents. As such, stakeholders agreed that a central feature of climate adaptation planning within the community must ensure planning efforts do not reinforce existing sources of vulnerability. Participants agreed that future climate change planning should draw upon local resources such as the Council on Aging, Food Pantries, or Faith-Based organizations to increase Burlington's capacity to address the needs of the most vulnerable. Community outreach and education initiatives were recommended and alignment with ongoing efforts to improve emergency management, response, and communication was identified as an opportunity to reach groups that may otherwise be neglected during hazard mitigation planning. Efforts to identify socially vulnerable populations (e.g. elderly groups) was encouraged while efforts to promote shelter-in-place programs for individuals or groups that may not have the capacity to get to emergency shelters was recommended. Incentive programs to facilitate shelter-in-place programs, for example renewable energy tax credits, home air conditioning units, or neighborhood watch programs, were identified as possible climate resilient action items.

Social Vulnerability

Environmental Justice Populations

Elderly Residents

Daytime Non-Resident Populations

Community Outreach, Education & Preparedness

Shelters/Assembly Areas

Shelter-in-Place

Burlington High School has the potential to be an important emergency shelter resource for the community

Climate Resilience Actions to address these concerns were prioritized through workshop activities and coordination with Core Team leadership. These Climate Resilience Actions are organized by High Priority, Medium Priority, and Low Priority Actions.

High Priority Actions

Category	Action
Flood Management	Conduct a town-wide assessment for floodplain vulnerabilities and identify opportunities to implement nature-based solutions and green infrastructure.
	Conduct a Culvert Assessment Study and evaluate water drainage systems for Structural Deficiencies. Coordinate with state agencies (e.g. MassDOT) to assess heat stress on asphalt and other transportation infrastructure; Identify locations to conduct pilot programs using resilient transportation infrastructure materials. Coordinate with state agencies (e.g. MassDOT) to assess freeze-thaw effects on asphalt and other transportation infrastructure; Identify locations to conduct pilot programs using resilient transportation infrastructure materials. Identify roadways within the community that are within the floodplain that present risks for emergency response or evacuation. Formally map these areas. Evaluate existing and potential evacuation routes for vulnerabilities such as areas located within the floodplain or where critical facilitates may exist in the community. Consider non-resident "daytime" population when evaluating evacuation routes.
	Update floodplain regulations in accordance with findings. Identify locations where stream daylighting may occur; Consider locations for bank restoration projects;
	Draw upon results of hydro-geomorphologic study at Vine Brook and Sandy Brook. Develop a community outreach program to educate the population on stormwater management/flood reduction measures on private property. Draw upon Conservation Commission capacity to facilitate this effort.
	Coordinate with the private sector to develop solutions to improve flood issues within the community; promote regulatory changes to facilitate this effort.
	Conduct a hydro-geomorphologic study to assess stream flow characteristics and changing conditions associated with sediment buildup, temperature changes, carrying capacity, culvert elevations, etc. Assess Vine Brook for changes/environmental impacts when community well pumping stops. Identify locations to promote green infrastructure and nature-based solutions along Vine Brook corridor. Evaluate locations adjacent to Vine Brook and Sandy Brook for constructed wetlands/nature-based solutions to accept runoff and increase flood storage capacity.
	Acquire land along Sandy Brook; Install stormwater management devices; Implement stream cleaning and drainage repair. Evaluate for the use of nature-based solutions (e.g. constructed wetlands) along roadway corridor.

Transportation Corridor Management	Expand the planning scope of traffic/transportation improvements to address climate change issues. Evaluate the commercial district corridor (Burlington Mall Road/ Middlesex Turnpike) for measures to reduce greenhouse gas emissions associated with traffic congestion, reduce urban heat island effect, improve air quality, and promote multimodal transportation options (e.g. public transportation, bicycles, walking). Apply for Complete Streets Program; Implement Green Infrastructure; Increase public transit options; Improve computerized traffic signals; Identify regional partnerships to raise funds to address these issues; Expand upon Safe Routes to Schools Grant Program efforts; Establish a connection with the Minuteman Bike Trail and Employment centers; Draw upon data available from the private sector; Address dangerous road and sidewalk conditions on Cambridge Street. Develop a street tree planting plan following an assessment of existing trees or trees that may become vulnerable to the effects of climate change. Coordinate with MassDOT on these efforts along state owned roadways.
	Identify locations for infiltration/constructed stormwater wetlands; Assess whether infiltration areas can double as snow storage areas; Implement guidelines for drought-tolerant landscaping and site design measures; Increase Tree Planting within business districts. Consider revisions to Site Design requirements; Promote Green Building and Cool Roof Design; Engage with private business owners to promote community outreach and education initiatives for emergency preparedness and response. Consider the needs of daytime non-residents in this planning framework.
Emergency Management and Preparedness	Burlington's primary Emergency Shelter is the Human Services Building located at 61 Center Street. Conduct a community outreach effort to improve community wide understanding of shelter resources available during hazardous weather. Develop a plan to increase the number of shelters in the community for example at Burlington High School, Memorial Elementary School, and Marshall Simonds Middle School. Identify if these locations have existing vulnerabilities to climate change. Retrofit these buildings to serve as resilient shelter or assembly locations (e.g. backup/renewable energy generation, emergency lighting, cell service) during hazardous events. Consider implementing a "shelter-in-place" protocol for vulnerable populations. Provide incentives (e.g. renewable energy opportunities) for residents that may want/need to shelter-in-place during an event. Develop a branding effort that promotes the use of cooling locations/centers during extreme heat events to increase overall usage by the community.

	Maintain, update, improve emergency response/communication systems; Develop a Community Outreach Plan to increase users; Develop a Community Education/Education Plan for community-wide emergency response; Integrate climate vulnerabilities into Emergency Response Plan. Identify where additional emergency coordination resources may exist across municipal departments (e.g. population data). Increase "buy-in" of the importance of improving emergency management provisions from town departments; Identify and document sources of backup energy within the community; Prioritize locations such as shelter areas for backup energy sources (diesel). Identify whether diesel delivery truck routes must pass through flooded areas and identify alternative routes. Evaluate the use of microgrids for backup energy. Develop a neighborhood watch/Emergency Check-In Program.
Social Vulnerability	Vulnerable populations such as low-income, minority, children, and elderly people (among others) are particularly vulnerable during long-term power outages. Assist vulnerable populations by identifying specific at-risk populations; establish actions to diminish this vulnerability. Coordinate with local institutions/organizations such as faith-based groups (e.g. Islamic Center of Burlington), public shelters, assembly areas, cooling centers, and food pantries to increase the capacity to address the needs of socially vulnerable populations. Identify opportunities to strengthen the capacity of community groups/partnerships to build social resilience to climate change. Draw upon the resources of Council on Aging to better understand the needs of socially vulnerable populations within the community. Draw upon Council on Aging transportation resources.
	Coordinate with the Town Council on Aging to update the list of elderly and disabled individuals within the community. Develop an outreach plan to improve the notification process during hazardous weather conditions.
	Engage in a community outreach and educational initiative for socially vulnerable populations.
	Develop a public-private partnership to educate and inform daytime non-residents working within the commercial district areas of the community. This initiative should be conducted as a community education and outreach effort for climate change impacts, emergency preparedness and response, and emergency communication efforts; Identify and label evacuation routes. Consider the use of code-red or explicit signage to ensure daytime population of non-residents has appropriate information in an emergency event. Draw upon the business community (data) to facilitate this effort.

Medium Priority Actions

Category	Action
Flood Management	Assess Fire Station #2 property for climate resilient solutions to address flooding issues. Promote green infrastructure or nature-based solutions into design implementation where appropriate.
	Conduct a flood study to integrate climate vulnerability into the Emergency Action Plan for the Mill Pond Reservoir Dam spillway area every 2 years; Assess water availability under drought conditions; develop a water conservation community outreach initiative for use during drought conditions; Develop an outreach program initiative for dam safety. Coordinate regionally (e.g. Wilmington) on dam safety initiatives.
	Continue to promote robust open space protection efforts within the community. Evaluate Emergency Access at Landlocked Forest. Organize fire department tours to show town officials and residents the most vulnerable areas for brush fires. Conduct open space trail management outreach. Identify opportunity within the Landlocked Forest to develop flood storage/slow/detain water.
Transportation Corridor Management	Impervious surfaces such as pavement contributes to urban heat island effect. Improve regulatory mechanisms to require infiltration, Low Impact Development (LID), Green Infrastructure, & Shade/Cooling requirements. Develop an incentive program that can facilitate the reduction of impervious surface within the community. Conduct an urban heat island study within the community and identify locations where green infrastructure/nature-based solutions may be applied.
Emergency Management and Preparedness	Evaluate public buildings for green infrastructure or Energy Efficient building practices; Evaluate public buildings for ability to withstand snow loads and retrofit public buildings where necessary. Develop an outreach program with private building owners to integrate green-infrastructure, Low-Impact Development, and Energy Efficient building practices. Draw upon past successes (e.g. green roofs on public buildings) to encourage private building owners to implement these practices. Consider updates to building codes to increase the resilience to extreme climate events and promote retrofits/upgrades. Establish a bylaw committee that may provide assistance, education, outreach for green infrastructure, BMP's or climate resilient development standards within the community.
	Assess the viability of establishing cooling centers throughout the community to serve as an additional emergency preparedness resource to existing shelter areas/assembly areas during hazardous weather events. Conduct a community outreach effort to inform the community of this resource. Develop public-private partnerships at locations where electrical redundancy may exist (e.g. Wegmans, Burlington Mall). Develop a more robust communication system to respond to emergency conditions and make the public aware of sheltering and or cooling center resources. Develop a branding effort to increase usage among community members.

	Engage in public education initiatives and utilize capacity of existing resources within the community. Continue to draw upon the capacity of these organizations and/or regulatory mechanisms to enhance public climate change awareness and education. Engage with the local business community to advance these awareness/engagement efforts.
	Add Climate Change Adaptation to current/future Master Plan and Hazard Mitigation Plan updates. Identify strategies to improve the implementation of various municipal regulatory mechanisms; enhance coordination among municipal departments; Coordinate across municipal, state, regional agencies to address local vulnerability and identify resources to implement climate resilient solutions. Promote the need for Sustainability Leadership within the community. Find champions of Sustainable Leadership through existing municipal and non-municipal organizations (non-profits, Burlington Reserve Corps) as well. Consider the development of an Information database to residents to understand the hazards faced by the community in response to climate change. Develop welcome packets for new residents. Consider the implementation of a "buy-back" program for vulnerable properties/parcels. Convert these properties into important nature-based solutions to increase the resilience of the community.
Social Vulnerability	Encourage solar energy production throughout the community. This should occur as part of public and private efforts through regulatory mechanisms and private development commitments. Natural gas should be evaluated as a transition energy source. Apply for Green Communities Designation and reduce energy consumption at municipal facilities and expand out to the residential community. Consider burying utility infrastructure where appropriate.
	Engage in a community outreach and educational initiative for socially vulnerable populations located within the mapped Environmental Justice area located north of Rt. 95 and South of the Mill Pond Conservation Area.

Low Priority Actions

Category	Action
Flood Management	Evaluate water treatment facility property for future use, notably for flood storage or green infrastructure opportunities. Identify potential water quality issues that may arise when transition to MWRA infrastructure may occur. Utilize the transition to MWRA watery supply to develop a public education campaign regarding water use and conservation. Draw upon Conservation Commission resources as part of this effort.
	Assess pump stations for vulnerabilities associated with increased flooding and drought conditions across the community.
	Continue to implement the Conservation Department Stream Cleaning program; Improve this program as necessary to achieve climate resilience goals.
Emergency Management and Response	No Low Priority Emergency Management and Response Actions Identified in this Category.
Social Vulnerability	Evaluate important historical and cultural resources within the community for specific vulnerabilities to climate change. Coordinate with local historical commissions or municipal resources to conduct this effort. Include natural resource areas as part of this assessment (e.g. Mill Pond, Sawmill Brook, Little Brook, and Vine Brook), Cultural Resources include but are not limited to, John Wynn House, Isaiah Reed House, Major General John Walker House, Old Burying Ground, Marian Tavern and Grandview Farm, and Francis Wyman House, pre-historic archaeological sites, Public Cultural Resources include Burlington Public Library, Town Hall and Annex, and the Town Commons.
	Identify locations where unused public or private spaces (e.g. transmission line corridors) may be used to establish important cultural or environmental community features such as habitat connectivity, parks, open space, recreational space, nature-based solutions, resilient spaces. Draw upon state level resources to facilitate this effort, but promote as a bottom-up community driven effort.

Community Workshop Participants

Name	Affiliation
Christa Brown	Town Resident
Elliot Brown	Town Meeting Members (TMM)
Ernest R. Zabolotny	TMM
John Mangino	Lahey Hospital
Dave Miller	TMM
Jack Kelly	Planning Board
Larry Cohen	Conservation Commission
Mollie Nash	TMM
Brendan Egan	Parks and Recreation
Ernie Covino	Planning Board
Jon Sachs	TMM
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Thomas Hayes	DPW
Michael Patterson	Fire Department
Patrick O'Brien	TMM
Michael Wick	Library
Andy Wells-Bean	TMM
Christine Mathis	Board of Health
Susan Lumenello	Board of Health
Bob Cunha	School Department
Monte Pearson	Town Manager
Josh Morris	Planning Department
Liz Boneventre	Planning Department
Jane Lynch	BPS Teacher
Marge McDonald	Council on Aging
Eileen Coleman	Conservation
Katie Moniz	BSC Group
John G. Sanchez	DPW
Anthony Reppucci	DPW/Engineering
Olivia Virgin	Board of Health
Gerard McDonough	Police Department
John Petrin	Administrator
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Glen Mills	Police Department

Citation

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Susan Lumenello, Board of Health
Christine Mathis, Board of Health
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Thank you to the community leaders within Burlington who attended the Burlington CRB Workshops. The institutional knowledge provided by workshop participants was essential to the success of this process.

Thank you to the Metropolitan Area Planning Council (MAPC) for providing background data and community maps that were used during workshop breakout engagement activities.

CLIMATE CHANGE INFOGRAPHIC

CLIMATE CHANGE

Burlington, Massachusetts
Shawsheen Watershed Basin

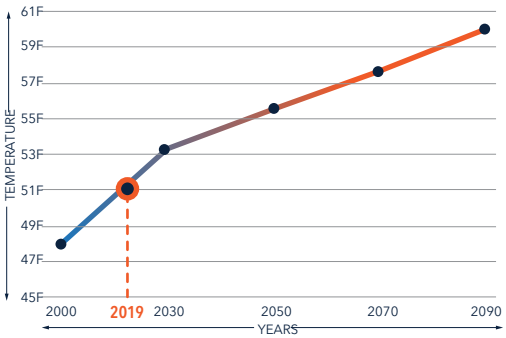
Andover, Bedford, Billerica, Burlington, Concord, Lawrence, Lexington, Lincoln, North Andover, Tewksbury, Wilmington, and Woburn

*PORTIONS OF BURLINGTON ALSO FALL WITHIN THE BOSTON HARBOR BASIN AND IPSWICH BASIN

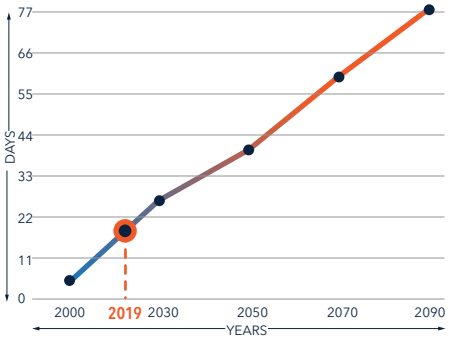
Global warming is caused by the accumulation of greenhouse gases within the atmosphere. Gases that contribute to the greenhouse effect include water vapor, carbon dioxide, methane, and nitrous oxide. On earth, human activities such as burning fossil fuels and land deforestation have altered the delicate balance of atmospheric conditions that regulate our climate. The effect of these changes cause global climate change that are likely to be significant and to increase over time.

EXTREME TEMPERATURES

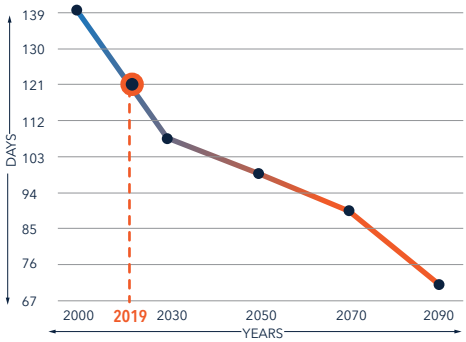
Average Temperatures



Days with Maximum Temperature over 90˚F



Fewer Days Below Freezing

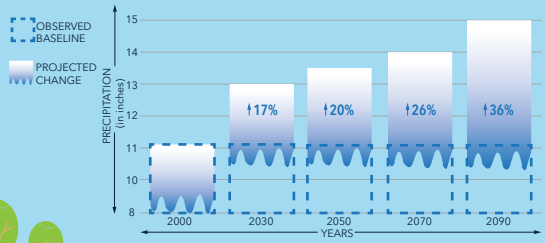


What can BURLINGTON expect as CLIMATE CHANGES?

Climate change has already had observable effects on the environment. Rising temperatures, changes in precipitation patterns, droughts and heat waves, sea-level rise, and extreme storm events have **altered the distribution of risk and how resources are managed.**

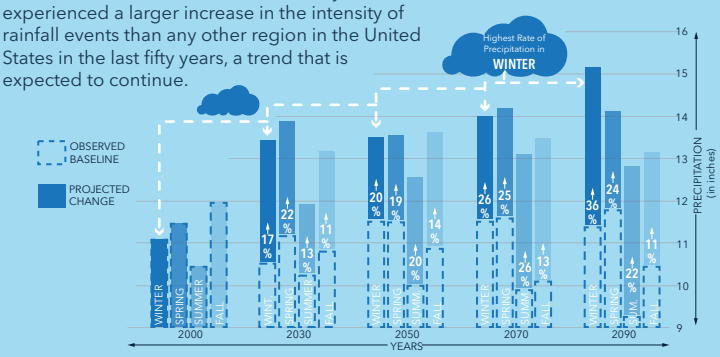
Extreme Snow And Ice Events

Total Annual Precipitation is expected to increase within the Shawsheen Basin over the remainder of the century. Most of this increase is expected to occur during winter months where precipitation will fall as either rainfall or extreme snow or ice events.



More Annual Precipitation and Inland Flooding

The Northeast United States has already experienced a larger increase in the intensity of rainfall events than any other region in the United States in the last fifty years, a trend that is expected to continue.



Blizzards, Nor'Easters and Hurricanes

Storm events fueled by higher temperatures, increased evaporation, and atmospheric moisture leads to stormy weather of increased duration and intensity.

Wind / Microbursts

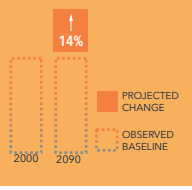
Hazardous wind conditions most commonly accompany extreme storm events. High winds and microburst conditions present unique hazards to infrastructure, public safety and important natural resources.

Heatwaves

Extreme heat events are expected to become more frequent and intense. Socially vulnerable populations are particularly vulnerable to the dangers related to extreme temperature conditions.

Drought Conditions

Due to the combined effects of higher temperatures, reduced groundwater recharge from extreme precipitation events, earlier snowmelt, summer and fall droughts may become more frequent.



Sources: Massachusetts Executive Office of Energy and Environmental Affairs; ResilientMA.org

BSC GROUP

COMMUNITY RESILIENCE BUILDING MATRIX

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

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

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

Features	Location	Ownership	V or S	Flooding	Drought	Heatwave	Snow	Priority H - M - L	Time Short Long Ongoing
Infrastructural									
Business Districts •Burlington Mall Commercial District	town-wide	public/private	V/S	Identify locations for infiltration/constructed stormwater wetlands; Assess whether infiltration areas can double as snow storage areas; Implement guidelines for drought-tolerant landscaping and site design measures; Increase Tree Planting within business districts. Consider revisions to Site Design requirements; Promote Green Building and Cool Roof Design; Engage with private business owners to promote community outreach and education initiatives for emergency preparedness and response. Consider the needs of daytime non-residents in this planning framework.				H	Ongoing
Transportation Corridor through Commercial District Management	commercial district	public/private	V	Expand the planning scope of traffic/transportation improvements to address climate change issues. Evaluate the commercial district corridor (Burlington Mall Road/ Middlesex Turnpike) for measures to reduce greenhouse gas emissions associated with traffic congestion, reduce urban heat island effect, improve air quality, and promote multimodal transportation options (e.g. public transportation, bicycles, walking). Apply for Complete Streets Program; Implement Green Infrastructure; Increase public transit options; Improve computerized traffic signals; Identify regional partnerships to raise funds to address these issues; Expand upon Safe Routes to Schools Grant Program efforts; Establish a connection with the Minuteman Bike Trail and Employment centers; Draw upon data available from the private sector; Address dangerous road and sidewalk conditions on Cambridge Street. Develop a street tree planting plan following an assessment of existing trees or trees that may become vulnerable to the effects of climate change. Coordinate with MassDOT on these efforts along state owned roadways.				H	Ongoing
Water Treatment Plant Infrastructure	specific location	public	V/S	Evaluate water treatment plant property for future use, notably for flood storage or green infrastructure opportunities. Identify potential water quality issues that may arise when transition to MWRA infrastructure may occur. Utilize the transition to MWRA watery supply to develop a public education campaign regarding water use and conservation. Draw upon Conservation Commission resources as part of this effort.				L	Long
Roadways and Intersections	town-wide	MassDOT/ public	V	Conduct a Culvert Assessment Study and evaluate water drainage systems for Structural Deficiencies. Coordinate with state agencies (e.g. MassDOT) to assess heat stress on asphalt and other transportation infrastructure; Identify locations to conduct pilot programs using resilient transportation infrastructure materials. Coordinate with state agencies (e.g. MassDOT) to assess freeze-thaw effects on asphalt and other transportation infrastructure; Identify locations to conduct pilot programs using resilient transportation infrastructure materials. Identify roadways within the community that are within the floodplain that present risks for emergency response or evacuation. Formally map these areas. Evaluate existing and potential evacuation routes for vulnerabilities such as areas located within the floodplain or where critical facilitates may exist in the community. Consider non-resident "daytime" population when evaluating evacuation routes.				H	Ongoing
Fire Station #2	specific location	public	V/S	Assess property for climate resilient solutions to address flooding issues. Promote green infrastructure or nature-based solutions into design implementation where appropriate.				M	Long

Mill Pond Dam Infrastructure	Mill Pond Reservoir	public	V/S	Conduct a flood study to integrate climate vulnerability into the Emergency Action Plan for the Mill Pond Reservoir Dam spillway area every 2 years; Assess water availability under drought conditions; Develop a water conservation community outreach initiative for use during drought conditions; Develop an outreach program initiative for dam safety. Coordinate regionally (e.g. Wilmington) on dam safety initiatives.	M	Long
Pump Stations	town-wide	public	V	Conduct an Assessment of pump stations for vulnerabilities associated with increased flooding and drought conditions across the community.	L	Long
Parking Lots/Impervious Surfaces	town-wide/commercial district	public/private	v	Impervious surfaces such as pavement contributes to urban heat island effect. Improve regulatory mechanisms to require infiltration, Low Impact Development (LID), Green Infrastructure, Shade/Cooling requirements. Develop an incentive program that can facilitate the reduction of impervious surface within the community. Conduct an urban heat island study within the community and identify locations where green infrastructure/nature-based solutions may be applied.	M	Ongoing
Alternative/Renewable Energy	town-wide	public/private	V/S	Encourage solar energy production throughout the community. This should occur as part of public and private efforts through regulatory mechanisms and private development commitments. Natural gas should be evaluated as a transition energy source. Apply for Green Communities Designation and reduce energy consumption at municipal facilities and expand out to the residential community. Consider burying utility infrastructure where appropriate.	M	Long
Buildings (Public and Private)	town-wide	public/private	V/S	Evaluate public buildings for green infrastructure or Energy Efficient building practices; Evaluate public buildings for ability to withstand snow loads and retrofit public buildings where necessary. Develop an outreach program with private building owners to integrate green-infrastructure, Low-Impact Development, and Energy Efficient building practices. Draw upon past successes (e.g. green roofs on public buildings) to encourage private building owners to implement these practices. Consider updates to building codes to increase the resilience to extreme climate events and promote retrofits/upgrades. Establish a bylaw committee that may provide assistance, education, outreach for green infrastructure, BMP's or climate resilient development standards within the community.	M	Ongoing

Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.org

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

Features	Location	Ownership	V or S	Flooding	Drought	Heatwave	Snow	Priority **H** - **M** - **L**	Time **S**hort **L**ong **O**ngoing
Environmental									
Protected Open Space •Mill Pond Conservation Area	town-wide	public	V/S	Engage in a community outreach and educational initiative for socially vulnerable populations located within the Mill Pond Conservation Area.				M	Long
Protected Open Space •Landlocked Forest	town-wide	public	V/S	Continue to promote robust open space protection efforts within the community. Evaluate Emergency Access at Landlocked Forest. Organize fire department tours to show town officials and residents the most vulnerable areas for brush fires. Conduct open space trail management outreach. Identify opportunity within the Landlocked Forest to develop flood storage/slow/detain water.				M	Long
Unprotected Open Space	town-wide	public/private	V/S	Identify locations where unused public or private spaces (e.g. transmission line corridors) may be used to establish important cultural or environmental community features such as habitat connectivity, parks, open space, recreational space, nature-based solutions, resilient spaces. Draw upon state level resources to facilitate this effort, but promote as a bottom-up community driven effort.				L	Long
Vine Brook and Sandy Brook (Flooding)	town-wide	public	V	Conduct a Hydro-geomorphologic study to assess stream flow characteristics and changing conditions associated with sediment buildup, temperature changes, carrying capacity, culvert elevations, etc. Assess Vine Brook for changes/environmental impacts when community well pumping stops. Identify locations to promote green infrastructure and nature-based solutions along Vine Brook corridor. Evaluate locations adjacent to Vine Brook and Sandy Brook for constructed wetlands/nature-based solutions to accept runoff and increase flood storage capacity.				H	Short
Sandy Brook Road (Flooding)	specific location	private	V	Acquire land along Sandy Brook; Install stormwater management devices; Implement stream cleaning and drainage repair. Evaluate for the use of nature-based solutions (e.g. constructed wetlands) along roadway corridor.				H	Short
Conservation Department Stream Cleaning Program	town-wide	public	V/S	Continue to implement the Conservation Department Stream Cleaning program; Improve this program as necessary to achieve climate resilience goals.				L	Long
Town Wide Floodplain	town-wide	public	V	Conduct a town-wide assessment for floodplain vulnerabilities and identify opportunities to implement nature-based solutions and green infrastructure. Update floodplain regulations in accordance with findings. Identify locations where stream daylighting may occur; Consider locations for bank restoration projects; Draw upon results of Hydro-geomorphologic study at Vine Brook and Sandy Brook. Develop a community outreach program to educate the population on stormwater management/flood reduction measures on private property. Draw upon Conservation Commission capacity to facilitate this effort. Coordinate with the private sector to develop solutions to improve flood issues within the community; promote regulatory changes to facilitate this effort.				H	Short

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

Features	Location	Ownership	V or S	Flooding	Drought	Heatwave	Snow	Priority **H** - **M** - **L**	Time **S**hort **L**ong **O**ngoing
Societal									
Social Vulnerability - Elderly Communities	town-wide	private	V	Coordinate with the Town Council on Aging to update the list of elderly and disabled individuals within the community. Develop an outreach plan to improve the notification process during hazardous weather conditions.				H	Ongoing
Social Vulnerability - Environmental Justice Communitieis	town-wide/regional	N/A	V	Engage in a community outreach and educational initiative for socially vulnerable populations.				H	Ongoing
Social Vulnerability - Daytime Population of Non-Residents	Commercial District	N/A	V	Develop a public-private partnership to educate and inform daytime non-residents working within the commercial district areas of the community. This initiative should be conducted as a community education and outreach effort for climate change impacts, emergency preparedness and response, and emergency communication efforts. Identify and label evacuation routes. Consider the use of code-red or explicit signage to ensure daytime population of non-residents has appropriate information in an emergency event. Draw upon the business community (data) to facilitate this effort.				H	Ongoing
Vulnerable Populations - General	town-wide	public/private	V	Vulnerable populations are particularly vulnerable during long-term power outages. Assist vulnerable populations by identifying specific at-risk populations; establish actions to diminish this vulnerability. Coordinate with local institutions/organizations such as faith-based groups (e.g. Islamic Center of Burlington), public shelters, assembly areas, cooling centers, and food pantries to increase the capacity to address the needs of socially vulnerable populations. Identify opportunities to strengthen the capacity of community groups/partnerships to build social resilience to climate change. Draw upon the resources of Council on Aging to better understand the needs of socially vulnerable populations within the community. Draw upon Council on Aging transportation resources.				H	Ongoing
Sheltering - Schools/Businesses (Private) •Francis Wyman School •Primrose •Daycares •Wegmans •Burlington Mall	town-wide	public	V/S	Assess the viability of establishing cooling centers throughout the community to serve as an additional emergency preparedness resource to existing shelter areas/assembly areas during hazardous weather events. Conduct a community outreach effort to inform the community of this resource. Develop public-private partnerships at locations where electrical redundancy may exist (e.g. Wegmans, Burlington Mall). Develop a more robust communication system to respond to emergency conditions and make the public aware of sheltering and or cooling center resources. Develop a branding effort to increase usage among community members.				M	Long
Shelters/Assembly Areas	town-wide	public	V/S	Burlington's primary Emergency Shelter is the Human Services Building located at 61 Center Street. Conduct a community outreach effort to improve community wide understanding of shelter resources available during hazardous weather. Develop a plan to increase the number of shelters in the community for example at Burlington High School, Memorial Elementary School, and Marshall Simonds Middle School. Identify if these locations have existing vulnerabilities to climate change. Retrofit these buildings to serve as resilient shelter or assembly locations (e.g. backup/renewable energy generation, emergency lighting, cell service) during hazardous events. Consider implementing a "shelter-in-place" protocol for vulnerable populations. Provide incentives (e.g. renewable energy opportunities) for residents that may want/need to shelter in place during an event. Develop a branding effort that promotes the use of colling locations/centers during extreme heat events to increase overall usage by the community.				H	Short

Public Education •Burlington Reserve Corps •Ongoing MS4 Updates	town-wide	N/A	S	Engage in public education initiatives and utilize capacity of existing resources within the community. Continue to draw upon the capacity of these organizations and/or regulatory mechanisms to enhance public climate change awareness and education. Engage with the local business community to advance these awareness/engagement efforts.	M	Ongoing
Hazard Communication Planning	town-wide	N/A	V/S	Maintain, update, improve emergency response/communication systems; Develop a Community Outreach Plan to increase users; Develop a Community Education/Education Plan for community-wide emergency response; Integrate climate vulnerabilities into Emergency Response Plan. Identify where additional emergency coordination resources may exist across municipal departments (e.g. population data). Increase "buy-in" of the importance of improveing emergency management provisions from town departments; Identify and document sources of backup energy within the community; Prioritize locations such as shelter areas for backup energy sources (diesel). Identify whether diesel delivery truck routes must pass through flooded areas and identify alternative routes. Evaluate the use of microgrids for backup energy. Develop a neighborhood watch/Emergency Check-In Program.	H	Short
Historical/Cultural Resources	town-wide	public	V	Evaluate important historical and cultural resources within the community for specific vulnerabilities to climate change. Coordinate with local historical commissions or municipal resources to conduct this effort. Include natural resource areas as part of this assessment (e.g. Mill Pond, Sawmill Brook, Little Brook, and Vine Brook), Cultural Resources include but are not limited to, John Wynn House, Isaiah Reed House, Major General John Walker House, Old Burying Ground, Marian Tavern and Grandview Farm, and Francis Wyman House, pre-historic archaeological sites; Public Cultural Resources include Burlington Public Library, Town Hall and Annex, and the Town Commons.	L	Long
Regualtory Planning/Master Planning				Add Climate Change Adaptation to future Master Plan and Hazard Mitigation Plan updates. Identify strategies to improve the implementation of various municipal regulatory mechanisms; enhance coordination among municipal departments; Coordinate across municipal, state, regional agencies to address local vulnerability and identify resources to implement climate resilient solutions. Promote the need for Sustainability Leadership within the community. Find champions of Sustainable Leadership through existing municipal and non-municipal organizations (non-profits, Burlington Reserve Corps) as well. Consider the development of an Information database to residents to understand the hazards faced by the community in response to climate change. Develop welcome packets for new residents. Consider the implementation of a "buy-back" program for vulnerable properties/parcels. Convert these properties into important nature-based solutions to increase the resilience of the community.	M	Ongoing

SHAWSHEEN BASIN CLIMATE PROJECTIONS

SHAWSHEEN BASIN

MUNICIPALITIES WITHIN SHAWSHEEN BASIN:

Andover, Bedford, Billerica, Burlington, Concord, Lawrence, Lexington, Lincoln, North Andover, Tewksbury, Wilmington, 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.

SHASHEEN BASIN

Shawsheen 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	48.85	+2.27 to +4.43	+2.94 to +6.36	+3.49 to +9.14	+3.80 to +11.03
	Winter	28.07	+2.36 to +5.04	+3.02 to +7.52	+3.77 to +9.36	+4.06 to +10.81
	Spring	46.8	+1.85 to +3.59	+2.62 to +5.48	+2.76 to +7.90	+3.40 to +9.69
	Summer	69.15	+2.16 to +4.39	+2.82 to +6.68	+3.23 to +9.84	+3.80 to +12.26
	Fall	51	+2.28 to +4.99	+3.68 to +6.79	+3.47 to +9.69	+3.95 to +12.08
Maximum Temperature	Annual	59.46	+2.13 to +4.15	+2.73 to +6.22	+3.21 to +9.15	+3.46 to +10.95
	Winter	37.65	+2.03 to +4.58	+2.64 to +7.02	+3.19 to +8.66	+3.59 to +10.04
	Spring	57.78	+1.69 to +3.49	+2.32 to +5.56	+2.70 to +8.13	+3.26 to +9.64
	Summer	80.26	+2.02 to +4.45	+2.74 to +6.61	+3.13 to +10.04	+3.60 to +12.44
	Fall	61.73	+2.40 to +4.87	+3.44 to +6.95	+3.37 to +9.99	+3.86 to +12.40
Minimum Temperature	Annual	38.25	+2.36 to +4.76	+3.20 to +6.49	+3.80 to +9.09	+4.15 to +11.10
	Winter	18.49	+2.64 to +5.50	+3.40 to +8.02	+4.37 to +10.05	+4.51 to +11.58
	Spring	35.81	+1.99 to +3.92	+2.86 to +5.79	+2.94 to +7.66	+3.53 to +9.55
	Summer	58.05	+2.30 to +4.42	+2.97 to +7.08	+3.32 to +9.63	+3.97 to +12.08
	Fall	40.28	+2.17 to +5.15	+3.56 to +6.70	+3.56 to +9.62	+4.06 to +11.80

- The Shawsheen 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 2.7 °F to 6.6 °F (3-8% increase); end of century increase of 3.6 °F to 12.4 °F (4-15% increase).
    - Fall mid-century increase of 3.4 °F to 7 °F (6-11% increase); end of century increase by and 3.9 °F to 12.4 °F (6-20% increase).
- Seasonally, minimum winter and fall temperatures are expected to see increases throughout the 21st century.
    - Winter mid-century increase of 3.4 °F to 8.0 °F (18-43% increase); end of century increase by 4.5 °F to 11.6 °F (24-63% increase).
    - Fall mid-century of 3.6 °F to 6.7 °F (9-17% increase); end of century increase of 4.1°F to 11.8 °F (10-29% increase).

SHAWSHEEN BASIN

Shawsheen 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	6.86	+7.12 to +19.09	+9.97 to +32.49	+11.78 to +54.36	+14.06 to +71.94
	Winter	0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00
	Spring	0.46	+0.19 to +0.80	+0.37 to +1.67	+0.44 to +2.83	+0.31 to +4.68
	Summer	6.09	+6.10 to +16.64	+8.27 to +27.05	+10.16 to +43.63	+12.29 to +56.36
	Fall	0.31	+0.51 to +2.48	+0.87 to +5.25	+0.85 to +9.31	+1.35 to +12.70
Days with Maximum Temperature Over 95°F	Annual	0.44	+2.21 to +7.69	+2.81 to +14.87	+3.96 to +29.90	+5.67 to +45.80
	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	+0.04 to +0.25	+0.03 to +0.42	+0.10 to +0.88	+0.07 to +1.85
	Summer	0.44	+1.93 to +7.09	+2.42 to +13.33	+3.43 to +26.26	+5.15 to +39.40
	Fall	0.00	+0.09 to +0.77	+0.15 to +1.85	+0.18 to +4.18	+0.42 to +5.83
Days with Maximum Temperature Over 100°F	Annual	0.03	+0.27 to +1.85	+0.34 to +4.38	+0.57 to +9.66	+0.68 to +18.80
	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 +0.03	+0.00 to +0.05	+0.00 to +0.21	+0.00 to +0.52
	Summer	0.03	+0.25 to +1.74	+0.27 to +4.15	+0.55 to +9.00	+0.64 to +17.12
	Fall	0.00	+0.00 to +0.12	+0.00 to +0.37	+0.00 to +0.93	+0.01 to +1.43

- Due to projected increases in average and maximum temperatures throughout the end of the century, the Shawsheen basin is also expected to experience an increase in days with daily maximum temperatures over 90 °F, 95 °F, and 100 °F.
    - Annually, the Shawsheen basin is expected to see days with daily maximum temperatures over 90 °F increase by 10to 32 more days by mid-century, and 14 to 72 more days by the end of the century.
    - Seasonally, summer is expected to see an increase of 8 to 27 more days with daily maximums over 90 °F by mid-century.
    - By end of century, the Shawsheen basin is expected to have 12 to 56 more days.

SHAWSHEEN BASIN

Shawsheen 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	5.13	-1.42 to -3.32	-1.68 to -3.72	-1.90 to -3.97	-1.93 to -4.07
	Winter	5.05	-1.35 to -3.03	-1.67 to -3.54	-1.88 to -3.83	-1.91 to -3.92
	Spring	0.05	-0.26 to +0.02	-0.01 to -0.28	-0.01 to -0.33	-0.01 to -0.29
	Summer	0.00	-0.00 to -0.00	-0.00 to -0.00	-0.00 to -0.00	-0.00 to -0.00
	Fall	0.03	-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	139.15	-12.22 to -30.06	-18.88 to -42.27	-22.01 to -56.63	-25.03 to -67.51
	Winter	81.49	-2.91 to -7.88	-3.86 to -13.86	-5.44 to -22.83	-6.91 to -29.08
	Spring	33.69	-4.29 to -11.03	-7.17 to -15.08	-7.86 to -19.41	-8.86 to -20.97
	Summer	0.00	-0.07 to -0.00	-0.07 to -0.00	-0.07 to -0.00	-0.06 to -0.00
	Fall	23.93	-5.02 to -10.54	-7.89 to -13.62	-8.10 to -17.02	-7.46 to -18.84

- Due to projected increases in average and minimum temperatures throughout the end of the century, the Shawsheen 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 4 to 14 fewer days by mid-century, and 7 to 29 fewer days by end of century.
    - Spring is expected to have 7 to 15 fewer days by mid-century, and 9 to 21 fewer days by end of century.
    - Fall is expected to have 8 to 14 fewer days by mid-century, and 7 to 19 fewer days by end of century.

SHAWSHEEN BASIN

Shawsheen 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	6457.27	-556.59 to -1157.37	-744.96 to -1578.96	-881.68 to -2104.05	-988.55 to -2493.48
	Winter	3341.25	-205.49 to -468.50	-268.38 to -687.75	-334.19 to -850.20	-375.33 to -994.01
	Spring	1696.91	-152.06 to -296.50	-214.82 to -450.18	-230.44 to -622.13	-297.82 to -732.12
	Summer	96.04	-34.42 to -58.95	-43.83 to -75.20	-52.54 to -85.37	-54.50 to -88.05
	Fall	1320.96	-157.39 to -362.74	-269.46 to -457.50	-256.40 to -646.06	-274.44 to -732.46
Cooling Degree-Days (Base 65°F)	Annual	553.74	+221.45 to +463.80	+297.69 to +760.97	+354.17 to +1182.91	+408.70 to +1536.06
	Winter	nan	+0.29 to +1.40	+0.21 to +4.11	+0.59 to +2.98	+0.84 to +4.11
	Spring	22.21	+14.12 to +33.56	+23.25 to +58.93	+25.76 to +101.49	+19.98 to +143.71
	Summer	478.25	+165.00 to +346.62	+205.73 to +544.78	+237.90 to +825.47	+285.55 to +1042.92
	Fall	46.51	+34.32 to +99.41	+52.73 to +178.08	+60.58 to +273.71	+86.88 to +353.61
Growing Degree-Days (Base 50°F)	Annual	2547.15	+425.51 to +829.02	+579.35 to +1257.57	+659.53 to +1979.30	+740.10 to +2479.76
	Winter	5.61	-0.03 to +13.65	+2.12 to +18.15	+5.46 to +29.22	+4.87 to +38.12
	Spring	299.4	+75.52 to +153.54	+101.19 to +257.20	+117.99 to +388.21	+130.73 to +507.39
	Summer	1762.28	+198.83 to +403.50	+258.88 to +614.39	+296.18 to +904.61	+348.82 to +1127.82
	Fall	470.48	+114.48 to +302.52	+188.90 to +433.24	+176.93 to +651.82	+229.10 to +816.40

- Due to projected increases in average, maximum, and minimum temperatures throughout the end of the century, the Shawsheen 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 8-21% (268 -688 degree-days) by mid-century, and a decrease of 11-30% (375 -994 degree-days) by the end of century.
    - The spring season is expected to decrease in heating degree-days by 13-27% (215 -450 degree-days) by mid-century, and by 18-43% (298 -732 degree-days) by the end of century.
    - The fall season is expected to decreases in heating degree-days by 20-35% (269 -458 degree-days) by mid-century, and by 21-55% (274 -732 degree-days) by the end of century.
- Conversely, due to projected increasing temperatures, summer cooling degree-days are expected to increase by 43-114% (206 -545 degree-days) by mid-century, and by 60-218% (286 -1043 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 15-35% (259 -614 degree-days) by mid-century, and by 20-64% (349 -1128 degree-days) by end of century.
- Spring is expected to see an increase by 34-86% (101 -257 degree-days) by mid-century and 44-169% (131 -507 degree-days) by end of century.
- Fall is expected to see an increase by 40-92% (189 -433 degree-days) by mid-century and 49-174% (223 -816 degree-days) by end of century.

SHAWSHEEN BASIN

Shawsheen 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	8.4	+0.15 to +2.14	+0.55 to +3.00	+1.07 to +2.99	+1.12 to +3.98
	Winter	2.13	-0.17 to +0.79	+0.07 to +1.15	+0.14 to +1.45	+0.30 to +1.87
	Spring	1.93	-0.11 to +0.74	+0.06 to +1.13	+0.17 to +1.26	+0.11 to +1.42
	Summer	1.75	-0.14 to +0.57	-0.08 to +0.75	+0.00 to +0.77	-0.16 to +0.65
	Fall	2.59	-0.31 to +0.65	-0.15 to +0.89	-0.33 to +0.80	-0.35 to +0.96
Days with Precipitation Over 2"	Annual	1.08	-0.06 to +0.64	+0.03 to +0.71	+0.09 to +0.77	+0.15 to +0.96
	Winter	0.13	-0.03 to +0.13	-0.05 to +0.19	-0.04 to +0.25	-0.01 to +0.28
	Spring	0.18	-0.07 to +0.20	-0.01 to +0.33	-0.05 to +0.31	+0.01 to +0.40
	Summer	0.37	-0.12 to +0.19	-0.04 to +0.26	-0.05 to +0.23	-0.08 to +0.23
	Fall	0.4	-0.09 to +0.38	-0.05 to +0.32	-0.01 to +0.31	-0.07 to +0.38
Days with Precipitation Over 4"	Annual	0.11	-0.04 to +0.12	-0.01 to +0.12	-0.04 to +0.13	-0.05 to +0.21
	Winter	0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.00	+0.00 to +0.01
	Spring	0.00	-0.01 to +0.04	-0.01 to +0.04	-0.01 to +0.06	-0.01 to +0.09
	Summer	0.06	-0.04 to +0.06	-0.02 to +0.06	-0.02 to +0.06	-0.04 to +0.11
	Fall	0.05	-0.04 to +0.11	-0.03 to +0.09	-0.03 to +0.08	-0.06 to +0.11

- The projections for expected number of days receiving precipitation over one inch are variable for the Shawsheen 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 an increase of 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 of an increase of 0- days by the end of century.

SHAWSHEEN BASIN

Shawsheen 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	45.01	+0.31 to +4.84	+0.23 to +6.51	+1.15 to +7.90	+1.20 to +8.27
	Winter	11.15	-0.57 to +1.89	+0.04 to +2.31	+0.25 to +2.90	+0.19 to +4.04
	Spring	11.42	-0.15 to +2.46	+0.08 to +2.19	+0.18 to +2.85	+0.31 to +2.78
	Summer	10.48	-0.14 to +1.44	-0.48 to +2.13	-0.49 to +2.70	-1.29 to +2.36
	Fall	11.99	-1.11 to +1.30	-1.17 to +1.67	-1.88 to +1.54	-1.56 to +1.29

- Similar to projections for number of days receiving precipitation over a specified threshold, seasonal projections for total precipitation are also variable for the Shawsheen basin.
    - The winter season is expected to experience the greatest change with an increase of 0-21% by mid-century, and of 2-36% 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 Shawsheen or basin could see a decrease of 0.5 to an increase of 2.1 inches by mid-century (decrease of 5% to increase of 20%) and a decrease of 1.3 to an increase of 2.4 inches by the end of the century (decrease of 12% to increase of 23%).
        - The fall season projections for the Shawsheen basin could see a decrease of 1.2 to an increase of 1.7 inches by mid-century (decrease of 10% to increase of 14%) and a decrease of 1.6 to an increase of 1.3 inches by the end of the century (decrease of 13% to increase of 11%).

Shawsheen 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	17.1	-0.66 to +1.99	-0.57 to +2.30	-0.48 to +2.79	-0.26 to +2.93
	Winter	11.77	-0.61 to +1.61	-0.45 to +1.30	-0.77 to +2.20	-0.79 to +1.89
	Spring	11.06	-1.15 to +0.89	-1.24 to +1.14	-1.31 to +0.93	-1.12 to +0.82
	Summer	13.19	-0.99 to +1.45	-0.91 to +2.09	-1.05 to +2.77	-1.16 to +2.21
	Fall	12.43	-0.12 to +2.04	+0.04 to +2.92	-0.34 to +3.85	-0.12 to +4.00

- 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 Shawsheen 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 0-4 days in consecutive dry days by the end of the century.

PUBLIC LISTENING SESSION - FEEDBACK

Comment No.	Participant Comment (summarized for clarity)
Comment 1	Flooding is the primary hazard we face in Burlington and should be our priority when evaluating resilience actions. The other three listed hazards in this report are secondary.
Comment 2	Many people still don't understand the science behind climate change, the risks and hazards associated with climate change, and the solutions that can be used to increase our resilience to climate change. Outreach and education should be a central feature of our resilience efforts.
Comment 3	Regional partnerships are important. Many of these issues are regional. Burlington should draw upon regional opportunities.
Comment 4	Regional listening exercises should be used as a form of community engagement.
Comment 5	Burlington should be focusing on projects that address mitigation (reduction of carbon emissions) and adaptation (resilience to the effects of climate change).
Comment 6	The public should be involved with these ongoing climate resilience initiatives.
Comment 7	Many of these Action Items identified involve many components for example addressing our flooding issues. Efforts to address these issues should be done in a phase approach, for example a culvert assessment paired with a hydro geomorphologic assessment, phased over time.