CLIMATE CHANGE PREPAREDNESS & RESILIENCE

PREPAREDNESS HANDBOOK

City of Cambridge

11.15.2017

Acknowledgments

CITY OF CAMBRIDGE

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http://www.cambridgema.gov/CDD/Projects/Climate/climatechangeresilianceandadaptation.aspx#tabs-6

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Introduction

The objective of the Climate Change Preparedness and Resilience (CCPR) Plan is to mitigate the risks identified in the Climate Change Vulnerability Assessment (CCVA), and contribute to enhanced well-being of the Cambridge community. The Plan integrates the built, natural and social environments such that they are resilient to the effects of climate change.

WHAT IS THE ALEWIFE PREPAREDNESS HANDBOOK?

The Alewife Preparedness Handbook is a companion document to the Draft Alewife Preparedness Plan. It describes a range of resiliency strategies using a consistent, easy-to-read format for a broad audience. The Handbook is a practical guide of specific strategies for different stakeholders within Cambridge. The City expects that the collective implementation of these will reap greater benefits compared to implementation of individual strategies. The resilience strategies are organized into the following four (4) categories:

- **Prepared Community** providing for increased social and economic resilience.
- **Adapted Buildings** protecting against projected climate-change impacts and/or designing for a speedy return to normal operation.
- **Resilient Infrastructure** ensuring continued service and/or a swift recovery from climate shocks and stresses.
- **Resilient Ecosystems** integrating the built environment with green infrastructure, the urban forest, and natural areas to support a resilient ecosystem.

The Handbook is organized by the above four categories with specific strategies and actions described in succinct resiliency cards that can be used as stand-alone documents for implementation and can also be regrouped under different themes. For example, the strategies may be sorted by the risk addressed, such as flooding or extreme heat, or can be sorted by the key proponents/jurisdiction such as the City, residents, developers, private institutions or government agencies.

WHY WAS THE HANDBOOK DEVELOPED?

The Handbook provides guidance on how the proposed strategies and actions can be implemented. It provides a toolbox of specific actions for each strategy to achieve preparedness and resiliency. The format of each strategy is consistent so that the reader can directly compare its effectiveness across the four broad categories. Although this first draft has been developed for the Alewife Neighborhood, the City intends to have a Citywide Resiliency Handbook at the completion of the CCPR Plan.

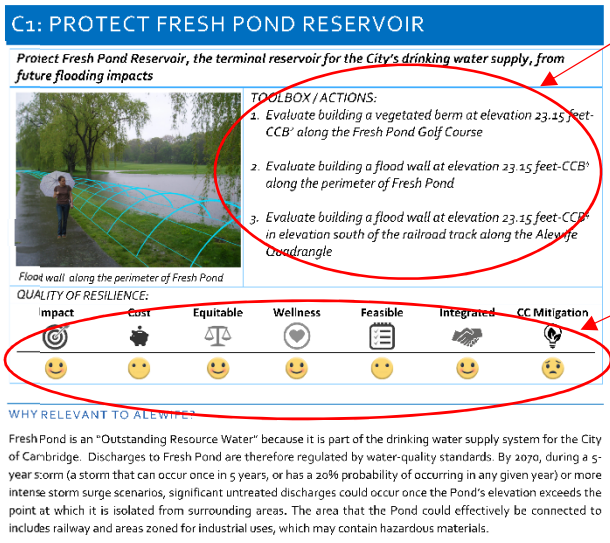
HOW CAN THE HANDBOOK BE USED?

The strategies included in the Alewife Preparedness Handbook target actionable measures that could be adopted in the short- to medium-term, plus a set of ideas and guiding principles for continuing to inform the Cambridge community's understanding of climate change vulnerability and resiliency as a basis for longer-term planning. Each strategy is presented by documenting a subset of actions, why these actions are relevant to mitigate the City's climate change risks, and anticipated effectiveness of each strategy. The Handbook assesses the qualities of resiliency, and introduces a possible path for implementation.

The City has researched best practices and the most relevant to Cambridge are documented in the Handbook. They are reported in the introduction section for each of the four categories of strategies.

HOW TO READ THE TEMPLATES FOR EACH STRATEGY

This section provides instructions on how to read the template provided per specific strategy and related actions. The top of the page lists the name of the strategy and describes its main intent. The sub-headings provide more detailed information as outlined below.



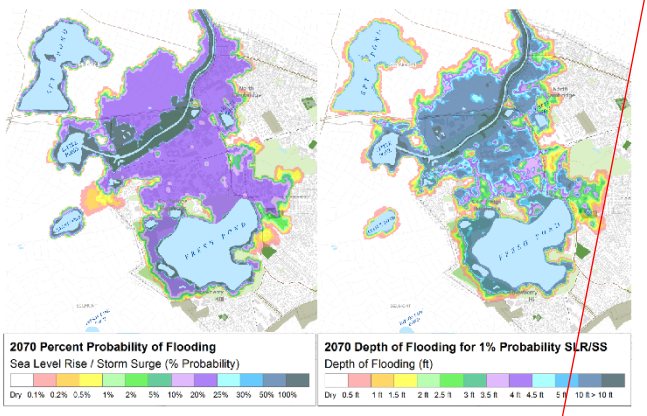
1. Toolbox / Actions: The Toolbox lists specific actions to achieve the strategy. Its purpose is to be as specific as possible, leading towards achieving an implementable strategy. The toolbox actions may be concurrent or in some cases, mutually exclusive.

2. Quality of Resiliency: Quality of resiliency can be defined as a measure of effectiveness in terms of resiliency by considering the following criteria: impact, cost, equitability, wellness, feasibility, integration, and climate change mitigation. The definition for each of these criterion is included in the sub-heading 4 under "Key Considerations."

When assessing the qualities of resiliency for each strategy, the Handbook makes a high-level assessment regarding the anticipated effectiveness of that strategy without necessarily assigning the qualities of resiliency for each toolbox action related to that strategy. Each strategy is scored for the quality of resiliency using the three symbols on the following page:

- = The strategy is *effective* in adressing this quality of resiliency. (For cost, this symbol would indicate a low cost.)
- = The strategy is *neutral* to this quality of resiliency.
- = The strategy is *not effective* or harder to achieve. (For cost, this symbol would indicate a high cost.)

3. **Relevance to Alewife:** This section identifies why the strategy is relevant to Cambrdige as informed by the vulnerabilities and risks for Alewife identified in the CCVA and which at-risk priority area from the CCVA is addressed by the strategy.



Percent Probability of Flooding (%, left) and Depth of Flooding (ft, right) in year 2070 for the Cambridge Alewife Neighborhood. Source: CCVA – Part 2

KEY CONSIDERATIONS

- *Impact:* These strategies would effectively protect the Fresh Pond Reservoir for up to the 2070 100-year sea-level rise/ storm surge storm event. The flood wall along the railroad track would also protect the neighborhood in the Alewife Quadrangle
- *Equitable:* These strategies help to preserve water-quality standards in Fresh Pond, which serves as the drinking water supply to the City of Cambridge
- *Feasible:* The berm and the flood wall around the Fresh Pond seem most feasible options. The flood wall along the railroad tracks would pose some permitting issues due to a portion of it being in the present FEMA 100-year flood zone, as well as its proximity to the railroad
- *Integrated:* Protecting the Fresh Pond Reservoir from future climate change impacts is aligned with Envision Cambridge, as it would effectively make the City more resilient. It also preserves the water quality of the City, which is a primary public-health benefit to the community

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4. **Key Considerations:** This section provides a more detailed narrative to support the scores assigned for each "Quality of Resiliency" as reported on page 1. The reasoning behind the preliminary assessment for the quality of resiliency is provided along with information regarding specific toolbox actions listed on page 1. Below is a brief description of each quality of resiliency:

Impact: Level of impact that implementation of the proposed strategy will have on mitigating the risks on critical infrastructure assets, services and vulnerable population groups.

Cost: Preliminary cost assessment for implementing the strategy using best and readily available knowledge on order-of-magnitude cost or, if available, cost per unit. This preliminary assessment is not based on a cost-benefit analysis, but cost only.

Equitable: Preliminary assessment of whether implementing the strategy benefits preparedness and resilience to all members of the community irrespective of income, age, level of education or English language proficiency. It indicates a strategy's effectiveness to provide equal protection and meaningful involvement of all people and community groups with respect to climate change.

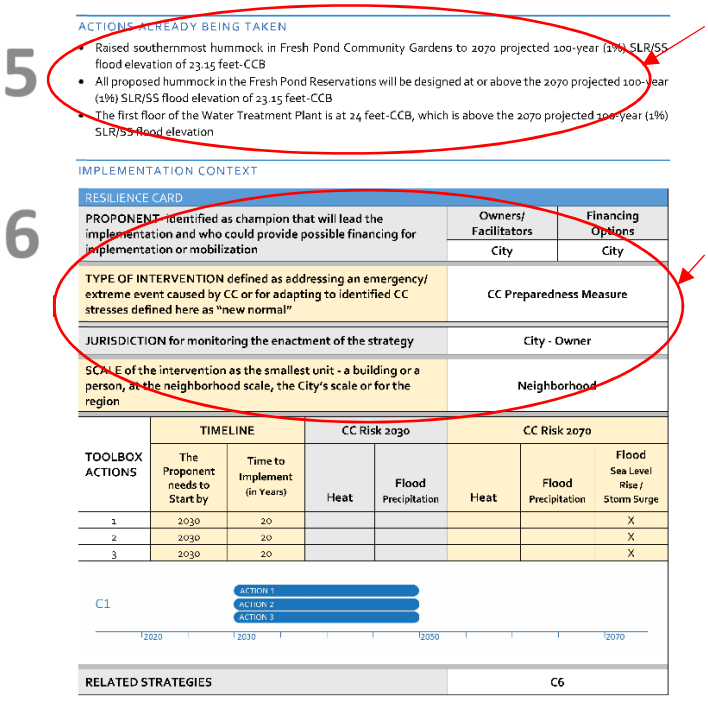
Wellness: How the strategy helps to build healthy and safe community environments. It addresses projected public health impacts due to climate change, if proposed action will improve livelihoods, provide for job opportunities, preserve business continuity, or promote an enhanced quality of life in the neighborhood.

Feasibility: Preliminary assessment of the technical, regulatory, and political feasibility of the strategy.

Integrated: How the strategy complements other strategies or ongoing City initiatives such as the Envision Cambridge, Net Zero Plan, and the Climate Action Plan.

Climate Change Mitigation: The City of Cambridge does not consider mitigation and adaptation as mutually exclusive, and instead views these as a two-pronged approach to manage the short-

and long-term disturbances of climate. This quality assesses to what extent a strategy also contributes to mitigate climate change by reducing greenhouse gas (GHG) emissions.



ACTIONS ALREADY BEING TAKEN

- Raised southernmost hummock in Fresh Pond Community Gardens to 2070 projected 100-year (1%) SLR/SS flood elevation of 23.15 feet-CCB
- All proposed hummock in the Fresh Pond Reservations will be designed at or above the 2070 projected 100-year (1%) SLR/SS flood elevation of 23.15 feet-CCB
- The first floor of the Water Treatment Plant is at 24 feet-CCB, which is above the 2070 projected 100-year (1%) SLR/SS flood elevation

IMPLEMENTATION CONTEXT

RESILIENCE CARD

PROPONENT identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	Owners/ Facilitators	Financing Options
	City	City
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	CC Preparedness Measure	
JURISDICTION for monitoring the enactment of the strategy	City - Owner	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	Neighborhood	

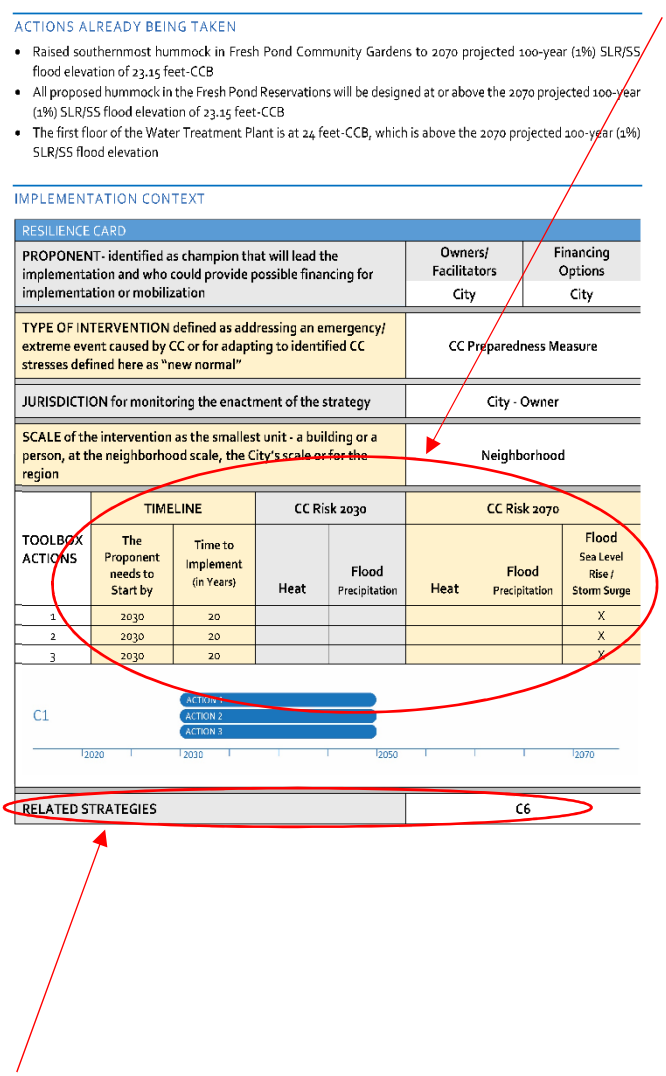
TOOLBOX ACTIONS	TIMELINE		CC Risk 2030		CC Risk 2070		
	The Proponent needs to Start by	Time to Implement (in Years)	Heat	Flood Precipitation	Heat	Flood Precipitation	Flood Sea Level Rise / Storm Surge
1	2030	20					X
2	2030	20					X
3	2030	20					X

RELATED STRATEGIES	C6

5. Actions Already Being Taken: There are many *actions already being taken* by the City's stakeholders and partners. We wish to avoid duplication, or confusion with existing policies, regulations, and programs or initiatives that address climate change identified risk(s).

6. Implementation Information: This section provides preliminary information that would contribute towards developing a complete implementation plan for that strategy. As a first step, the following key components have been identified:

- *Proponent* identifies a possible "champion" who could lead the implementation and provide possible financing. These two are not necessarily the same. Options include City, Government (other than City), Institutions/Not-for-Profit Organizations, Private Corporations, Private Residents, and Partnerships.
- *Type of Intervention* is defined as whether the intervention is an emergency response to address an extreme event caused by climate change such as a hurricane, or a preparedness measure to address a "new normal" caused by climate change, such as higher average summer temperatures compared to present.
- *Jurisdiction* defines who implements and monitors the enactment of the strategy. Options include the City as the owner, regulation or policy at the municipal level (under the jurisdiction of the City); the State as an owner, or regulation and policy at the State level; beyond State level (mainly for strategies at the federal government level), and finally; voluntary measures.
- *Scale of the intervention* can range from a single building or person to the neighborhood scale, City scale, or regional scale. Options include Parcel/Building/Owner/Resident, Neighborhood, City, and Regional.



ACTIONS ALREADY BEING TAKEN

- Raised southernmost hummock in Fresh Pond Community Gardens to 2070 projected 100-year (1%) SLR/SS flood elevation of 23.15 feet-CCB
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IMPLEMENTATION CONTEXT

RESILIENCE CARD

PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	Owners/ Facilitators: City	Financing Options: City
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	CC Preparedness Measure	
JURISDICTION for monitoring the enactment of the strategy	City - Owner	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	Neighborhood	

TOOLBOX ACTIONS	TIMELINE: The Proponent needs to Start by	TIMELINE: Time to Implement (in Years)	CC Risk 2030: Heat	CC Risk 2030: Flood Precipitation	CC Risk 2070: Heat	CC Risk 2070: Flood Precipitation	CC Risk 2070: Flood Sea Level Rise / Storm Surge
1	2030	20					X
2	2030	20					X
3	2030	20					X

C1

ACTION 1
ACTION 2
ACTION 3

2020 2030 2050 2070

RELATED STRATEGIES: C6

7

8

7. Timeline: The City is assessing possible timelines for implementation to start discussion. Strategies are sorted according to the following:

- *Near future:* to be initiated soon (start by 2020 or within the next 10 years).
- *Midterm:* to be initiated between 10-30 years (start between 2030 and 2050).
- *Distant future:* to be initiated after 30 years (start by or after 2050).

Length of time to implement: Some of the proposed strategies might require continuous work—for example, retrofitting existing buildings—and these strategies will be shown as ongoing with no targeted date for completion. On the other hand, some strategies need to be implemented and complete by a certain year. For example, the Fresh Pond Reservoir needs to be protected from SLR/ SS flooding by 2050, since the Reservoir is likely to flood if the Amelia Earhart Dam is overtopped by 2055 from a 100-year flood.

Based on the CCVA report, risks addressed include heat and flooding from precipitation or sea level rise/storm surge. It is also identified if the risk is most likely to occur by 2030 or by 2070.

8. **Related Strategies:** This section lists the strategies that share similar action(s) in the Toolbox.

NEXT STEPS

The Handbook is a companion document to the Alewife Preparedness Plan and is a practical compendium of specific preparedness and resiliency strategies and best practices focused on Alewife. Next steps for CCPR include: considering options for broader climate change risks, quantification of cost and economic opportunities, further technical analyses, and continued robust stakeholder engagement. The strategies developed for Alewife will be reviewed for applicability in other neighborhoods and will also inform the citywide plan.

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STRATEGIES A:
PREPARED COMMUNITY

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STRATEGIES A:
PREPARED COMMUNITY

OVERVIEW

Strategies for Prepared Community range from public-health approaches focusing on outreach and education to protection of critical facilities assuring their accessibility under "new normal" conditions due to repeated flooding, storm surges, and heat waves. Some strategies are focused on how best to enhance neighborhood services – e.g. cooling centers and networks supporting vulnerable populations. Other strategies are focused on protecting the facilities providing communication services and critical facilities such as local hospitals or ambulance services. Finally, some strategies propose a more comprehensive approach to strengthen current emergency plans and social networks. Table A.1 lists the proposed strategies for Alewife.

Table A.1 List of Strategies for Prepared Community

STRATEGY	TITLE	DESCRIPTION
A1	NEIGHBORHOOD RESILIENCE HUB	Establish a neighborhood resilience hub to foster community networks on a daily basis and increase preparedness and resilience among residents and businesses through education, training, planning, and implementation of resilience and sustainability measures.
A2	"COOL" COOLING CENTERS	Establish one or more "cool" cooling centers that would be attractive enough to be used during short periods of heat emergencies.
A3	SUPPORT SYSTEMS FOR VULNERABLE POPULATIONS	Establish a program to pre-identify and support individuals who are more vulnerable due to health conditions, addiction, homelessness or social isolation, and develop community support and emergency response systems to ensure their safety and well-being.
A4	EMERGENCY COMMUNICATION SYSTEMS	Develop neighborhood-scale communication systems that are redundant to normal communications systems to provide back-up during outages of telephone, cellular, cable and internet services.
A5	BUSINESS AND ORGANIZATIONAL PREPAREDNESS	Increase business and organizational continuity planning and preparedness including support services such as daycare.
A6	CRITICAL COMMUNITY FACILITIES RESILIENCE	Increase resilience of critical community facilities to climate shocks, prioritizing those with high vulnerabilities identified in the CCVA.

A7	EMERGENCY RESPONSE PLANS	Strengthen existing emergency response plans to include the potential impacts of climate change, including strategies to enable sheltering in place and evacuation when appropriate.
A8	HEALTHCARE CONTINUITY AND ACCESS	Work locally with key healthcare service providers and with the regional health and medical coalition to ensure capacity, continuity and access to medical services including pharmacies, dialysis, mental health, and addiction treatment.
A9	STRONGER SOCIAL NETWORK	Develop a neighborhood resiliency social network in partnership with community leaders and organizations.

BEST PRACTICES

The City gleaned best practices and model strategies for community resiliency and preparedness from research conducted over the summer of 2016 by the JSI Research & Training Institute, Inc. (JSI). Peer-reviewed studies, guidance from agencies including the Centers for Disease Control's Building Resilience Against Climate Effects (BRACE) framework, as well as reports from other communities were reviewed. The review focused primarily on the health impacts of extreme heat and flooding. Descriptions of the following best practices and models are provided in the following section:

- Heat-health action plan
- Emergency medical services support
- Preparedness and climate resiliency education
- Safe and pleasant shelters
- Accessible medical services

Heat-health Action Plan

Heat vulnerability, in both people and infrastructure, is an underappreciated risk. High heat leads to an increase in mortality across age groups. Causes vary from no access to air conditioning (AC), lack of awareness of heat warnings, and vulnerable individuals staying home in hot weather. For example, the death toll for the 1995 Chicago heat wave consisted mostly of victims who were elderly or poor residents of the inner city who could not afford air conditioning and did not open windows or sleep outside for fear of crime. Further epidemiological analysis showed that African Americans were more likely to die than whites, and that Hispanics had an unusually low death rate due to the heat. One explanation given is that many African Americans lived in isolated areas of sub-standard housing, while Hispanics lived in areas with higher population density and more social cohesion[1].

The implementation of a Heat-Health Action Plan (HHAP), with a focus on educating medical providers and developing recommendations for patient care, is suggested as effective at

[1] Case Study: Deadly Chicago Heat Wave of 1995 - AdaptNY , https://www.adaptny.org/2016/07/21/case-study-deadly-chicago-heat-wave-of-1995

preventing excess mortality.[2] The U.S. EPA advises that healthcare workers should educate patients on heat-health risks, work with their patients to develop prevention tactics, and educate their patients on when to seek help during a heat wave[3].

Emergency Medical Services Support

Best practices include preparing for higher demands on Emergency Medical Services (EMS) and the healthcare system. It is reported that EMS call volume and ambulance transports increase dramatically with temperature rise. The city's public health services in many states are now planning for projected heat waves.

Preparedness and Climate Resiliency Education

The City of Portland, Oregon, has organized an ambitious and popular disaster preparedness and climate resiliency education program called Planning for Resilience and Emergency Preparedness (PREP). Courses offered include the following:

- *Your Resilient Neighborhood* – focuses on citizen stormwater and heat management strategies
- *Should I Stay or Should I Go?* –examines real-time disaster survival, management and recovery scenarios. This is designed to encourage heads of households, institutional leaders, and business owners to develop contingency plans to address specific disaster threats.

Figure 1. City of Portland (OR) education program PREP [Source: Source: http://www.preporegon.org/]

Safe and Pleasant Shelters

Citizens often resist going to shelters during climate-related emergencies. This was evidenced in California where mandated evacuations were often ignored during wild fires in 2016. Officials speculated that this was partially driven by looting concerns. To address this resistance, one opportunity is to provide safe and pleasant places for sheltering. For example, there are some attractive City libraries that could be made available so people are more amendable to temporarily leaving their homes.

[2] Heudorf, U.; Schade, M. Heat waves and mortality in Frankfurt Am Main, Germany, 2003-2013: What effect do heat-health action plans and the heat warning system have? Zeitschrift fur Gerontologie und Geriatrie 2014, 47, 475-482.

[3] Excessive Heat Events Guidebook EPA 430-B-16-001 | June 2006 Updated Appendix A | March 2016. https://www.epa.gov/sites/production/files/2016-03/documents/eheguide_final.pdf

Accessible Medical Services

The experience with superstorm Sandy in New York City showed that the needs of people on kidney dialysis were often unknown to neighbors, and those residents were not helped when dialysis centers were closed. There is a need to identify medical services that are typically delivered outside of hospitals - e.g. methadone treatment, chemotherapy – that need to be prepared and resilient.

Effective Communication

Effective communication is a key element for a resilient community, as described in the following examples:

Community Resiliency Centers, Berkeley, California

Building upon a series of successful block parties promoting climate preparedness, Berkeley, California, in partnership with key stakeholders, established a network of Community Resiliency Centers where city staff work with local institutional leaders to identify vulnerable populations. These teams carry out resiliency research, education, and programming and pre-position emergency equipment and supplies in anticipation of likely disaster events.

Evacuteer Program, New Orleans, Louisiana

The City of New Orleans contracted with a local non-profit: Evacuteer, which recruits, trains, and manages evacuation volunteers who assist New Orleans' emergency response services. This helps in getting vulnerable individuals and families to safety in the event of a major climate-related disaster. This partnership between the non-profit and the City was tested during Hurricane Gustav in 2008, and is credited with helping to move more than 18,000 vulnerable New Orleanians out of harm's way.

Figure 2. City of New Orleans Evacuteer Program. [Source: http://www.evacuteer.org/, New Orleans]

PrepHUB model by the MIT Urban Risk Lab, Cambridge, Massachusetts

Personal electronic devices also could remain in operation with access to off-grid charging stations. These could be installed in public spaces to provide post-emergency services to citizens. An example in Cambridge is the PREPHub model developed by the MIT Urban Risk Lab, a disaster readiness structure where a pedaled generator enables people to recharge batteries and cellphones. An embedded webcam will let people take "selfies" and send those snapshots to relatives and social services as evidence they are safe; and an announcement system can alert people to dangers or direct them to a shelter (http://prephub.org/).

Figure 3. PrepHUB model in Cambridge, MA
[Source: MIT Urban Risk Lab]

RELEVANCE TO ALEWIFE

Table A.2 below provides a summary of how the best practices inform the development of specific strategies for Prepared Community.

Table A.2 List of Strategies and Related Best Practices

STRATEGY	TITLE	RELATED BEST PRACTICE	DESCRIPTION/ RELEVANCE TO ALEWIFE
A1	NEIGHBORHOOD RESILIENCE HUB	***Network of Community Resiliency Centers, Berkeley, California***	A network of Community Resiliency Centers where city staff work with local institutional leaders to identify vulnerable populations and carry out resiliency research, education, and programming. Positions emergency equipment and supplies in anticipation of likely disaster events.
A2	"COOL" COOLING CENTERS	*To be documented*	To be documented
A3	SUPPORT SYSTEMS FOR VULNERABLE POPULATIONS	***Planning for Resilience and Emergency Preparedness (PREP), City of Portland, Oregon***	Ambitious and popular disaster preparedness and climate resiliency education program offering courses on stormwater and heat management strategies, real-time disaster survival, and management and recovery scenarios.

A4	EMERGENCY COMMUNICATION SYSTEMS	***PrepHUB model by the MIT Urban Risk Lab, Cambridge, MA***	Small structures that can be installed in public spaces where a pedaled generator enables people to recharge batteries or cellphones to provide post-emergency services to citizens during disasters. An embedded webcam will let people take "selfies" and send those snapshots to relatives and social services as evidence they are safe.
A5	BUSINESS AND ORGANIZATIONAL PREPAREDNESS	***Planning for Resilience and Emergency Preparedness (PREP), City of Portland, Oregon***	Ambitious and popular disaster preparedness and climate resiliency education program offers courses on stormwater and heat management strategies, real-time disaster survival, and management and recovery scenarios.
A6	CRITICAL COMMUNITY FACILITIES RESILIENCE	*Refer to Table B.2 in section B: Adapted Buildings*	Refer to best practices recommended for strategies B1, B2, B3 and B4 for resiliency to flooding and heat for existing and new development.
A7	EMERGENCY RESPONSE PLANS	***Evacuteer Program, New Orleans, Louisiana***	Partnership between the City of New Orleans and a local non-profit. The non-profit recruits, trains, and manages evacuation volunteers who assist New Orleans' emergency response services. During Hurricane Gustav in 2008, credited with helping to move more than 18,000 vulnerable New Orleanians out of harm's way.
A8	HEALTH CARE CONTINUITY AND ACCESS	***Guidance from the Centers for Disease Control's Building Resilience Against Climate Effects (BRACE) framework***	The City's Human Services and Cambridge Health Alliance to develop guidance with key stakeholders adapted to the city's health care providers and populations.
A9	STRONGER SOCIAL NETWORK	*As informed by strategies above*	Tap on existing City's initiatives to enhance measures for addressing climate change.

The draft strategies are described in detail in the following pages.

A1: NEIGHBORHOOD RESILIENCE HUB

Establish a neighborhood resilience hub to foster community networks on a daily basis and increase preparedness and resilience among residents and businesses through education, training, planning, and implementation of resilience and sustainability measures

TOOLBOX / ACTIONS:

1. *Establish Disaster Support Hubs where local community leaders can obtain resources and meet with Emergency Management and Public Health Preparedness officials. Coordinate the structure and engagement opportunities with existing Local Emergency Planning Committees (LEPC), for example by forming a Climate Change subcommittee with expanded membership that fully integrates preparation for climate change events*
2. *Recruit, train, and manage evacuation volunteers to assist with City's public evacuations. Use established Cambridge Community Response Network (CCRN), or similar systems, to reach out to volunteers*
3. *Help residents, business owners and institutional leaders from "high risk" communities to complete and implement individualized disaster readiness and response plans based on MA's Know, Plan, Prepare while applying the community-driven approach FEMA's Whole Communities Program. Coordinate with local business associations and the Cambridge Economic Opportunity Center*
4. *Organize a disaster preparedness and climate resiliency education program and offer courses on resilience and emergency preparedness*

QUALITY OF RESILIENCE:

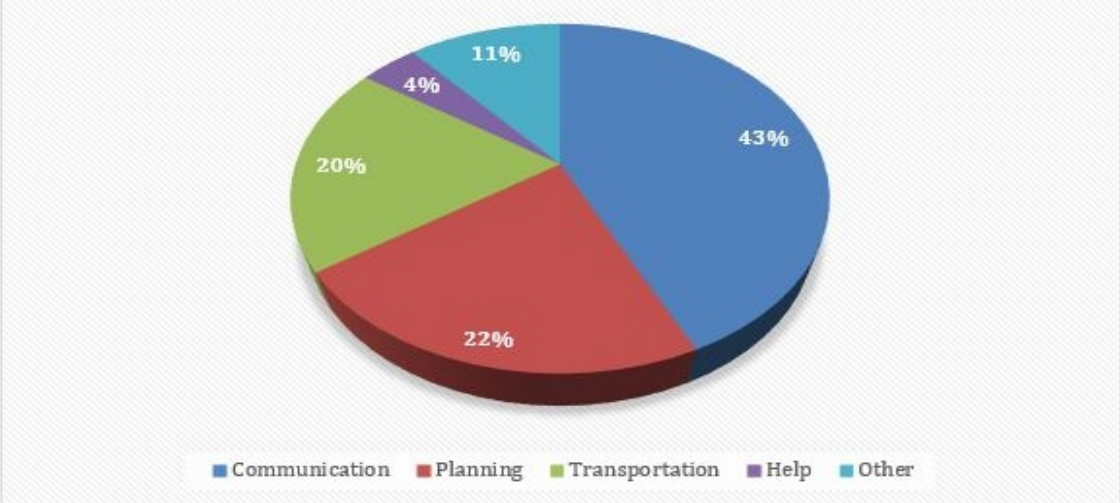
Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
						
						

WHY RELEVANT TO ALEWIFE?

Residents in the Fresh Pond-Alewife area are at relatively higher risk due to the higher probability, larger extent, and greater depths of flooding in this area. The area is also subject to the Urban Heat Island effect due to limited vegetation and urbanization patterns.

Cambridge is fortunate to have a rich network of civically-minded organizations engaged with first responders through LEPC in disaster preparedness, management, and recovery activities.

A Neighborhood Resilience hub organized via a climate change subcommittee of the LEPC would help organizations and citizens to develop protocols and procedures to address the full range of possible climate-related disasters they are likely to confront in the near future. The resilience hub should be established in the near future and be used on a regular basis to create a habit for its use.



In your opinion, what steps could the City of Cambridge take to better support you and your neighbors in the event of a future climate-related disaster?

From interviews section in Appendix C: "Local Perceptions of Disaster Preparedness in the Alewife District of Cambridge, MA", January 23, 2017. Report by the MS in Urban Planning Program and Urban Harbors Institute, University of Massachusetts Boston

KEY CONSIDERATIONS

- *Impact*: can be measured by the number of individuals that these proposed hubs will be able to serve annually and by the number of Alewife-based public agencies, non-profit organizations, housing developers and management, and business organizations that have prepared and regularly update their own disaster preparedness, management, and recovery plans in coordination with the LEPC new hubs
- *Cost:* can be kept at minimum by locating the Disaster Support Hubs in buildings owned by the City or managed by LEPC partners and by the LEPC engaging volunteers in the education and training activities
- *Equitable:* can be measured by the number of vulnerable residents engaged annually in resiliency education and planning activities organized by Alewife-based community organizations. Vulnerable residents are defined using these social indicators: poverty, low education level, language isolation, and elderly living alone
- *Integrated:* The Hub will integrate and coordinate community preparation for events associated with climate change into the existing emergency planning activities of the LEPC, and also partner with the Cambridge Mayor's Summer Youth Employment Program to provide opportunities for youth to work with city agencies (e.g., Public Health, CDD) to develop and pilot educational outreach programming

ACTIONS ALREADY BEING TAKEN

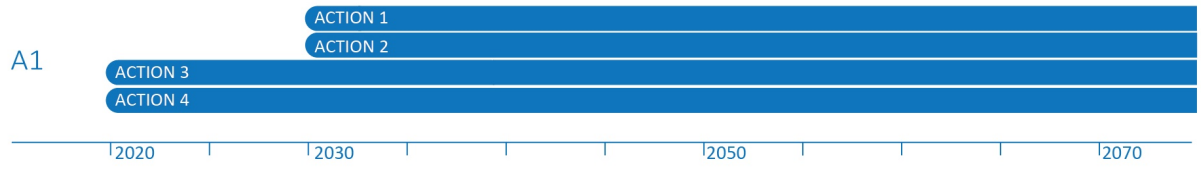
- The City has been informing residents and the leaders of local institutions about the general climate-related risks they might face through the Climate Change Vulnerability Assessment
- The City has been hiring consultants to perform interviews and inspect buildings to assess vulnerability and risk
- The Cambridge Public Health Department interacts with residents in vulnerable populations through their everyday programming, partnership with community service providers, and citywide events (e.g., Public Health Preparedness and Community Resilience Program, Healthy Homes Program, Pathways Program for new immigrant families, literacy program, Men's Health program and Men of Color Health Initiative, Injury and Violence Prevention Program, door knocking campaigns, Substance Abuse Prevention Program, Supplemental Nutrition Assistance Program promotion, Hoops N' Health event, school health program, membership in the Cambridge Community Response Network, seasonal flu clinics)

- Cambridge has an existing structure for Emergency Management and Public Health Emergency Preparedness that engages in "disaster preparedness, management, and recovery activities." The primary mechanism for organizational engagement is through the Local Emergency Planning Committee (LEPC). Many larger businesses who participate in the LEPC have Continuity of Operations Plans (COOP) that apply to all hazard preparedness, including power outages, winter storms, flooding, and hurricanes

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Partnership	**Partnership**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Emergency Response**	
JURISDICTION for monitoring the enactment of the strategy	**City - Policy**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Neighborhood**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2030	ongoing	X	X	X	X	X
2	2030	ongoing	X	X	X	X	X
3	2020	ongoing	X	X	X	X	X
4	2020	ongoing	X	X	X	X	X



RELATED STRATEGIES	**A4, A9**

A2: "COOL" COOLING CENTERS

Establish one or more "cool" cooling centers that would be attractive enough to be used during short periods of heat emergencies

TOOLBOX / ACTIONS:

1. *Align Cambridge Heat Emergency Plan with the Mass Care/Shelter Operation Plans*
2. *Create "cool" cooling centers; i.e., places where people would want to go to and hang out. Use existing buildings such as libraries, malls, cinemas as cooling centers where people can find shelter and amusement in case of an extreme heat event (3 days in a row over 90°F) that does not require overnight sheltering (triage for those needing more sheltering or support). Provide discounts and day and evening extended hours*
3. *Promote the initiative to local and senior housing groups. Vulnerable populations such as (but not limited to) older adults and public housing residents are more at risk*
4. *Provide a shuttle service to affordable housing, senior housing, and for people with limited mobility*
5. *Review options for community-approved or designed overnight shelters and services in collaboration with public and private members of the Cambridge Local Emergency Planning Committee to address more extreme scenarios with electrical system or telecommunication system outages*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	😐	🙂	🙂	🙂	🙂	😐

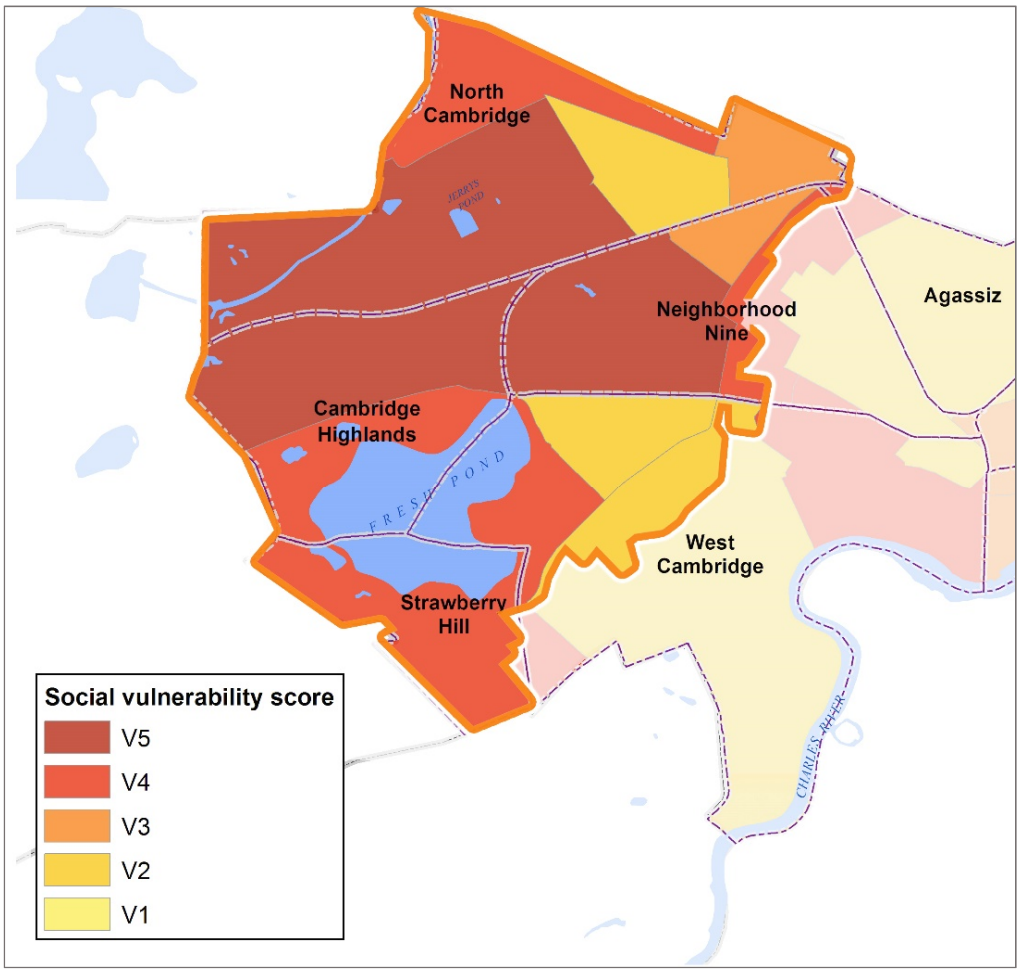
WHY RELEVANT TO ALEWIFE?

The number of days over 90 degrees Fahrenheit are projected to nearly triple by 2030, from an average of 11 days a year presently to about 31 days a year. This means there will be more heat waves (3 days in a row over 90 degrees F) and that longer heat waves will occur.

Urban areas like Cambridge will s2ee heat vulnerability exacerbated because of the "urban heat island effect" which is caused by the dense buildings and pavement that absorb heat. The Alewife Quadrangle is one of the most severe urban heat islands in the city.

Presently, hot days pose limited risks to human health because days over 90 degrees F don't occur often, and long heat waves are unusual. People with chronic respiratory and heart problems are more vulnerable to the effects of heat. As heat waves occur more frequently, we will enter temperature ranges on the hottest days that are

dangerous to public health. Heat waves contribute to a rapid deterioration of air quality and increased physiological stress, so the effects on the health of vulnerable residents are likely to get worse each day a heat wave persists.



Vulnerable populations per census tracts in the Alewife Neighborhood. Final Vulnerability Scoring (Low – High Vulnerability: Score 1 -5) (Source: Kleinfelder, May 2015)

KEY CONSIDERATIONS

- *Impact:*
  - Mortality impact – the strategy would lower the probable mortality risk associated with extreme heat and the demand on EMS and healthcare system (EMS call volume and ambulance transports increase dramatically with temperature increase). The City estimates an additional 1 to 2 transports per month in Cambridge per 1-degree increase[4]
  - Overall morbidity and mortality
  - Old and young are the most vulnerable; also, others who don't heed warnings and put themselves at risk by continuing their normal routines at home such as construction workers or athletes. The cooling center ensures that residents have access to cool environments by installing energy-efficient air conditioning and creating cooling spaces that people will want to use

[4] The numbers were calculated as informed by a study published by Li, T., R.M. Horton, D.A. Bader, G. Huang, Q. Sun, and P.L. Kinney, 2015: Heat-related mortality projections for cardiovascular and respiratory disease under the changing climate in Beijing, China. *Sci. Rep.*, 5, 11441, doi:10.1038/srep11441;

- *Cost:* The cost would be minimal if using existing facilities that already have AC. There might be an economic benefit to extending hours at shopping malls and movie theaters during heat waves. At the same time, operational costs should be considered
- *Equitable:* Need to make cooling centers places people want to go to remove stigma. The word "shelter" adds to this stigma. The cooling center must be able to accommodate pets, as people reluctant to leave pets are often part of a vulnerable population
- *Wellness:* Decrease in morbidity and death, less demand for hospitalization and emergency services due to heat exposure
- *Feasible*: Establish a resident-driven design event or contest on how best to achieve. A possible cooling center incentive could be free movie night, shopping mall extended hours or community events that bring people together for heat wave evenings. There would be a required change in regulation for extended business hours. The shelters will be effective for short heat waves
- *Integrated:* Work with the Teen Media Services program to develop public-service announcements to spread the reach of climate change messaging and promote cooling centers
- *CC Mitigation:* fewer individual AC units and a centralized system would save energy

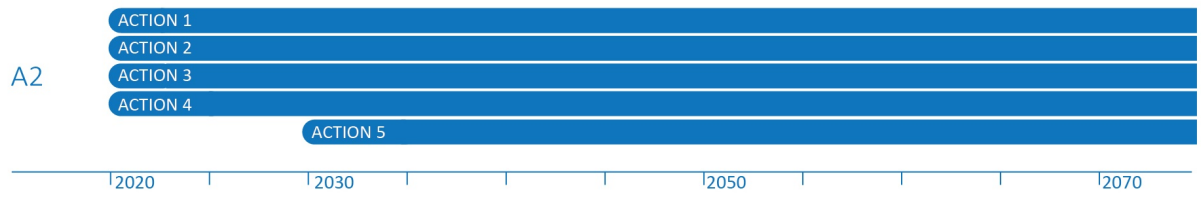
ACTIONS ALREADY BEING TAKEN

- The City is providing extended pool hours during heat waves
- Citywide Senior Center is a cooling center
- Mass care/shelter operations in Cambridge have typically included the Fire Department, Cambridge Public Health Department, Region 4AB Medical Reserve Corps and American Red Cross to open the shelter, staff it, track inventory and entry, provide medical triage and referral, and arrange for food provision and sanitation management

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Partnership	**Private Corporation**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Emergency Response**	
JURISDICTION for monitoring the enactment of the strategy	**City - Owner**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Neighborhood**	

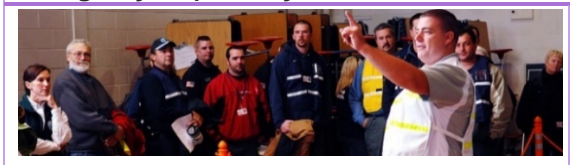
TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2020	ongoing	X		X		
2	2020	ongoing	X		X		
3	2020	ongoing	X		X		
4	2020	ongoing	X		X		
5	2030	ongoing	X		X		



RELATED STRATEGIES	**A3, A4, A6, A7, B2, B4**

A3: SUPPORT SYSTEMS FOR VULNERABLE POPULATIONS

Establish a program to pre-identify and support individuals who are more vulnerable due to health conditions, addiction, homelessness or social isolation, and develop community support and emergency response systems to ensure their safety and well-being



TOOLBOX / ACTIONS:

1. *Identify and reach out to vulnerable populations -- including homeless population and people with addiction or mental health issues -- and their leaders to validate/select preparedness, communications, and resiliency-building strategies that work for their communities. Ensure that high-risk employee groups (e.g., construction, day laborers) are included when considering vulnerable populations*
2. *Educate vulnerable populations, employers, providers, and in-home caregivers of medically-vulnerable populations on heat and flooding risk and recognizing danger signs. For example, consider implementing action plans such as a Heat-Health Action Plan (HHAP), with a focus on educating medical providers and developing recommendations for patient care*
3. *Schedule home visit/assessments for vulnerable residents (e.g., older adults) during heat emergencies or after flooding events*
4. *Develop a database of facilities and locations with concentrations of vulnerable individuals to assist with response activity prioritization*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
☺	☺	☺	☺	☺	☺	☺

WHY RELEVANT TO ALEWIFE?

Cambridge is home to large numbers of people who may be more vulnerable to impacts from climate-driven emergencies. For example, we know that people who are older, in financial stress, or with limited English are up to four times more likely to experience negative physical or mental health impacts from flooding disasters[5]. Recent experience from heat waves shows that older people who live at home, those with limited mobility or serious health conditions, as well as those with developmental challenges tend to require additional support. Identifying these

[5] Lowe D, Ebi KL, Forsberg B. Factors Increasing Vulnerability to Health Effects before, during and after Floods. International Journal of Environmental Research and Public Health. 2013;10(12):7015-7067. doi:10.3390/ijerph10127015.

vulnerable populations and anticipating their risks and needs due to climate-driven disasters can have a significant positive impact.

Alewife Neighborhood	% below poverty line (2014)	% >65 Years	% Elderly Alone	% Language Isolation
Strawberry Hill	16%	16%	14%	6%
Cambridge Highlands	10%	14%	10%	12%
Neighborhood Nine	10%	13%	11%	7%
North Cambridge	10%	10%	10%	8%

Source: Kleinfelder, May 2015 for CCVA

KEY CONSIDERATIONS

- *Impact:*
  - Improves human health: Has direct positive human-health impacts, reducing morbidity and mortality from climate-related emergencies
- *Cost:* Some activities may save healthcare costs and reduce burden on city. The cost may be negligible when working with organizations who already have a roster of people they serve
- *Equity:*
  - Addresses existing inequities
  - Addresses differential climate change impacts
- *Wellness:*
  - Has direct positive human-health impacts, promotes preventive services through multi-stakeholder engagement
- *Feasible:* Partners exist to implement
- *Integrated:* Aligns with U.S. Mayors Climate Protection Agreement, Heat Plan, Emergency Response plans.
- *CC Mitigation*: This strategy has no impact on mitigating CC

ACTIONS ALREADY BEING TAKEN

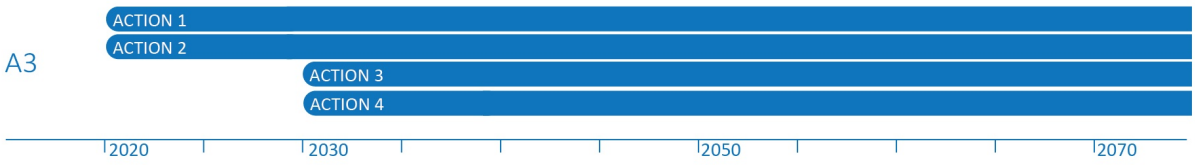
- The City and the Cambridge Public Health Department are coordinating with key stakeholders on the health risk caused by CC, focusing on extreme heat and flooding. An August 2016 workshop focused on CC and health risk

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Partnership	**Partnership**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Policy**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Neighborhood**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood** Precipitation	**Heat**	**Flood** Precipitation	**Flood** Sea Level Rise / Storm Surge
1	2020	ongoing	X	X	X	X	X
2	2020	ongoing	X	X	X	X	X
3	2030	ongoing	X	X	X	X	X
4	2030	ongoing	X	X	X	X	X

A3



RELATED STRATEGIES	**A1, A7, A8, A9**

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A4: EMERGENCY COMMUNICATION SYSTEMS

Develop neighborhood-scale communication systems that are redundant to normal communications systems to provide back up during outages of telephone, cellular, or internet services

Solar 1, located along New York City's East River, was able to provide much-needed power to its neighboring community after Superstorm Sandy. Source: Solar One.

TOOLBOX / ACTIONS:

1. *The City intends to engage the telecom providers to review the risks and request a preparedness and resilience plan to ensure continuous service during emergencies and to protect critical telecommunications infrastructure that supports service for cellular phones, landlines, cable television and internet*
2. *Ensure that residents have continued access to communication systems in case of emergency by securing the network and avoid:*
   - *Physical destruction of network components that are exposed to climate change hazards*
   - *Disruption of the supporting network infrastructure such as to the electrical distribution system*
   - *Network congestion*
3. *Consider solar panels and energy storage to power the backup system to limit GHG emissions*
4. *Provide Emergency Charging Stations in public areas to recharge personal devices in case of electrical outage*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	🙂	🙂	🙂	🙂	😐	😟

WHY RELEVANT TO ALEWIFE?

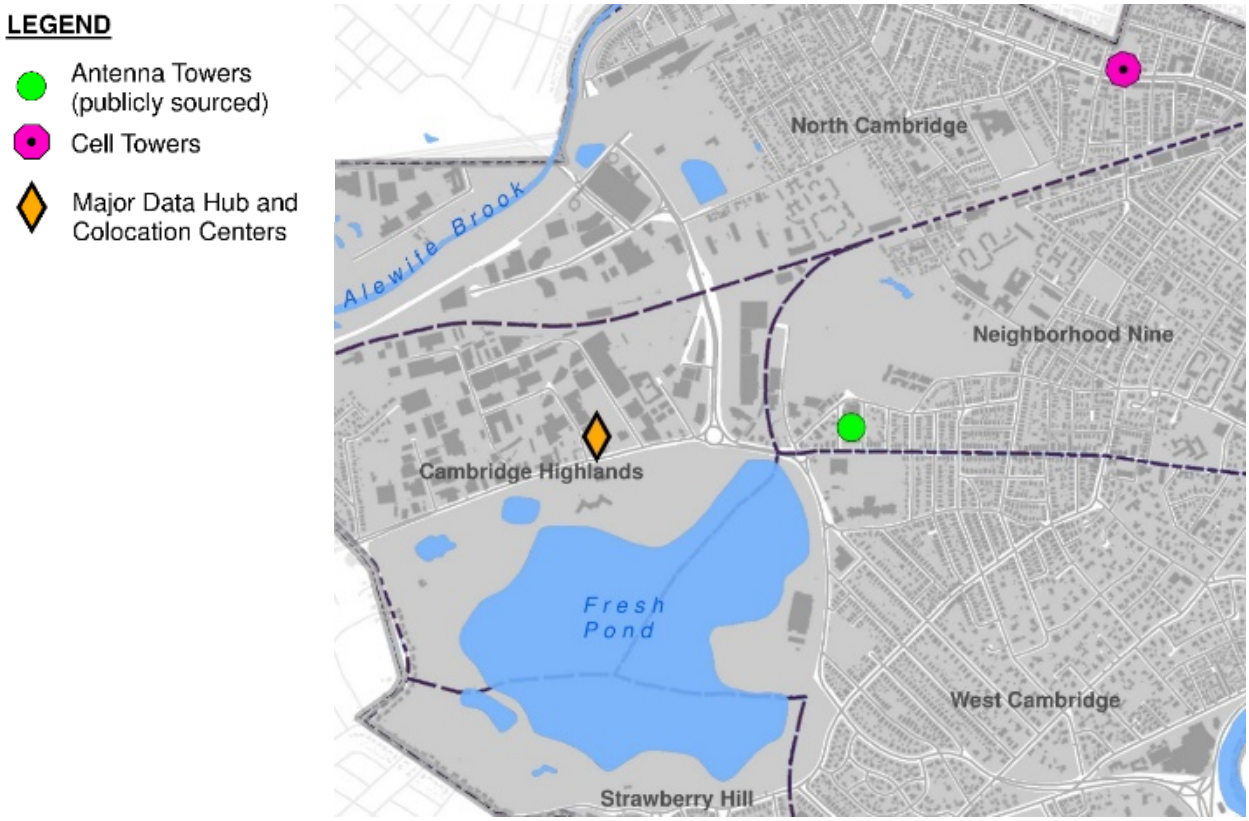
Telecommunication networks are instrumental for information exchange and serve as crisis communication networks during a disaster. Local government and first responders were alerted to the criticality of wireless phone and data networks for disaster recovery during Hurricane Sandy in New York City, when emergency services provision hinged on the relay of information to responders for health, public safety and support of vulnerable populations. As part of the CCVA, the telecommunication data hub in the Quadrangle was identified as the most at-risk infrastructure component. Protecting all infrastructure components is a safety priority and, in the recovery phase, key for business continuity. The priority for short- to medium-term actions is to protect the telecom system from flooding by elevating it, and to create an emergency communication system that can provide back-up if the normal communications system fails during outages of telephone, cellular, or internet services.

KEY CONSIDERATIONS

- *Impact:* The City will work with utility providers to set up an emergency plan and to secure the distribution Telecom system. This will have an important safety impact during emergencies, assuring communication between populations in need and first responders. In the recovery phase, a resilient telecommunication network is critical to assure business continuity. Providing personal-device charging stations completely off-grid is also an important safety measure
- *Cost:* Cost for creating a risk management plan, and securing Telecom assets is assumed to be marginal if integrated with operational and capital-improvement costs. The public emergency hubs are likely to be more expensive as this is a specific cost to its proponent or the entity who will install it
- *Equitable:* Offer emergency phones and emergency charging stations in public areas to provide access to all.
- *Wellness:* As a key component of public health and safety, this is considered a key strategy for wellness.
- *Feasible:* All proposed actions are feasible from a technology perspective
- *Integrated:* It is integrated with comprehensive efforts focused on business continuity
- *CC Mitigation:* Solar panels should be used to power the backup system and energy should be stored for later use in the emergency telecom hubs. This will consequently reduce some GHG impact for the City

ACTIONS ALREADY BEING TAKEN

- As part of CCVA, the City engages telecommunication companies to join a Technical Advisory Group to learn about CC and advise the City on how best to provide for resilient infrastructure
- The City is installing "Soofa benches" in public spaces. A Soofa bench (developed by Changing Environments, a MIT Media Lab spin-off) is a solar-powered bench that can charge up to two electronic devices at a time. In the Alewife neighborhood they can be found in Danehy Park and around Fresh Pond

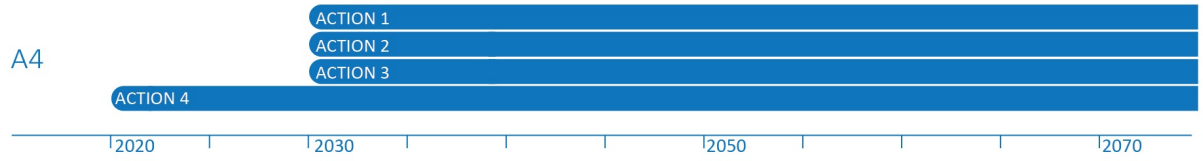


CCVA Part 1, Telecommunication Infrastructure in Alewife (Source: Kleinfelder, November 2015)

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**Private Corporation**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Emergency Response**	
JURISDICTION for monitoring the enactment of the strategy	**Partnership**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Neighborhood**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2030	ongoing		X		X	X
2	2030	ongoing		X		X	X
3	2030	ongoing		X		X	X
4	2020	ongoing		X		X	X



RELATED STRATEGIES	**A2, D3**

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A5: BUSINESS AND ORGANIZATIONAL PREPAREDNESS

Increase business and organizational continuity planning and preparedness including support services such as daycare

Source: Envision Cambridge, May 2017

TOOLBOX / ACTIONS:

1. *Large companies, institutions, and business associations to prepare and regularly update a disaster preparedness, management, and recovery plan*
2. *Large companies, institutions, and business associations to participate in a bi/tri-annual disaster simulation training exercise organized by local, state, and federal disaster management agencies*
3. *Provide contingency plans for all employees, both at work and at home, to adjust to extreme events and "new normal" for business continuity and to avoid loss of employment due to CC stresses.*
4. *Provide for resilient infrastructure supporting business continuity including resilient transportation systems for accessibility (Refer to C3)*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	🙂	🙂	🙂	🙂	🙂	🙂

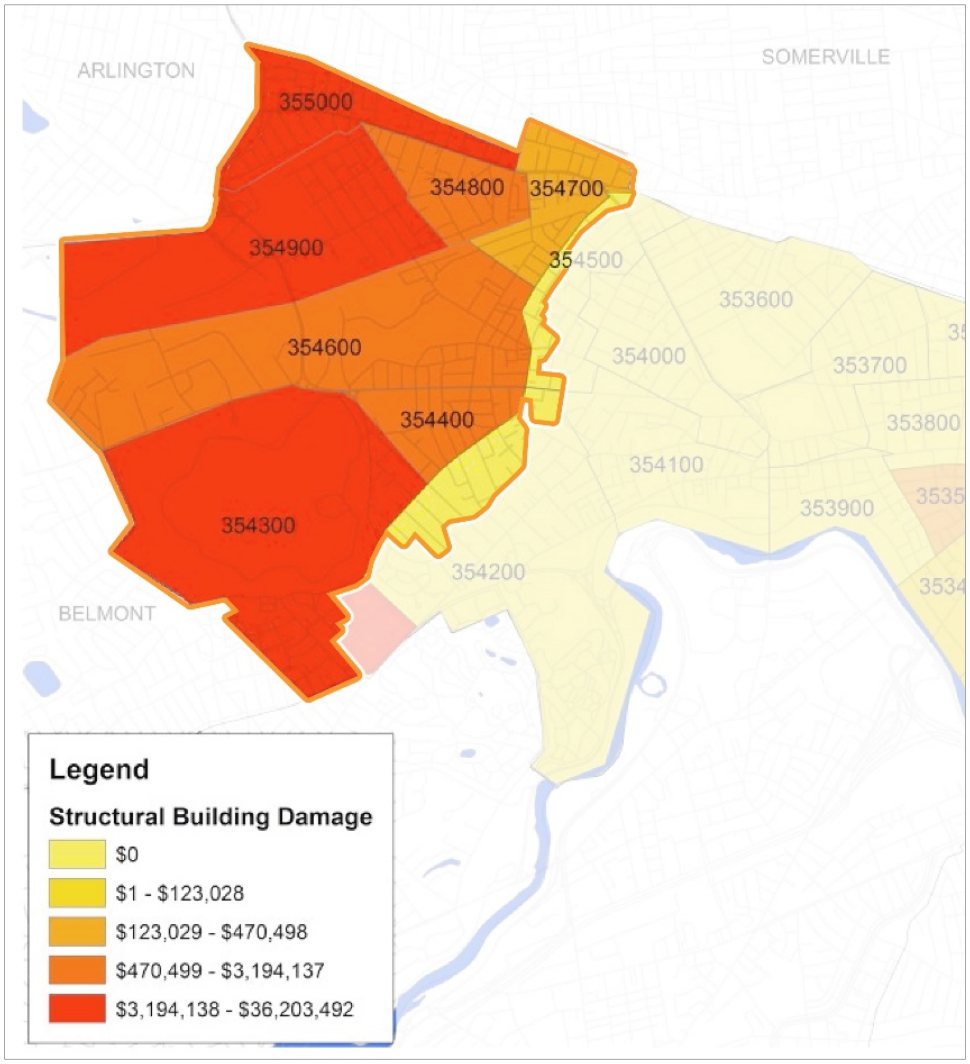
WHY RELEVANT TO ALEWIFE?

One of the CCVA key findings was that roughly $16.1 million per day and as much as 25% of U.S. annual GDP could be affected by extreme precipitation or extended heat waves[6]. This is based on the highest estimated impact that as many as 30,000 jobs or nearly one-quarter of the City's 2012-slevel employment could be disrupted.

The Alewife neighborhood—zip codes 02138 and 02140—is a major source of employment that contributes greatly to the City's overall economic prosperity. Preserving business continuity in the neighborhood is critical for the neighborhood and the City.

Another key aspect which is critical for continuity of business operation is continuity in providing for support services, such as day care, to allow workers from vulnerable populations to maintain their employment with minimal disruption.

[6] CCVA economic analysis
http://www.cambridgema.gov/cdd/projects/climate/~/media/8A81573575EB440BA0DBE9421B6AB1B1.ashx



Estimate of structural damage to buildings by census tracts from 24-hour 100-year rainfall event in 2030 (Source: Catalysis Adaptation Partners, February 2015)

KEY CONSIDERATIONS

- *Impact:*
  - *Disaster Preparedness and Climate Resiliency Planning* – As measured by the number of Alewife-based public agencies, non-profit organizations, housing developers and management, and business organizations that have prepared and regularly update their own disaster preparedness, management, and recovery plans.
  - *Disaster Simulation Exercise* – As measured by the number of Alewife-based public agencies, non-profit organizations, housing developer and management, and business organizations that participate in a bi/tri-annual disaster simulation training exercise organized by local, state, and federal disaster management agencies.
  - *Business continuity* – As measured by calculated cost of lost productivity per extreme events.
- *Cost:* Would be marginal if integrated with operation costs.
- *Equitable:* Contingency plans for all employees are equitable.
- *Wellness:* Economic stability is a key element of wellness and health.

- *Feasible:* Highly feasible to develop preparedness and contingency plans.
- *Integrated:* Aligned with Envision business development vision.
- *CC Mitigation:* Not significantly contributing to the reduction of GHG emissions.

ACTIONS ALREADY BEING TAKEN

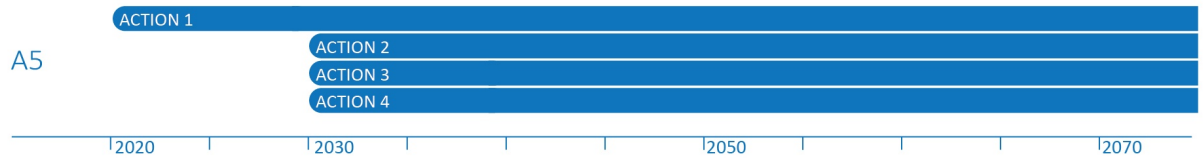
- Post-flood inspectional services (*Source: Cambridge Inspectional Services Department):*
  - Best practices after a flood: how to sanitize, food and goods to discard/keep
- Continuity of operations after a flood for laboratories (*Source: Cambridge Inspectional Services Department).*
- MAPC/City small business continuity toolkit by the Community Development Department documenting measures and available resources for preparedness to extreme events[7]

[7]www.cambridgema.gov/CDD/econdev/resourcesforbusinesses/smallbusiness/emergencypreparednessforbusinesses

IMPLEMENTATION CONTEXT

RESILIENCY CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**Private Corporation**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Regulation**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Parcel/Building/Resident**	

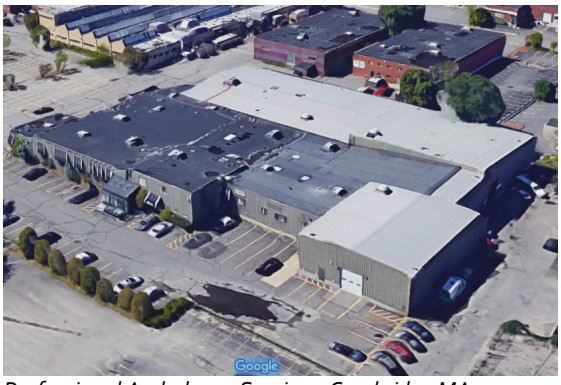
TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2020	ongoing	X	X	X	X	X
2	2030	ongoing	X	X	X	X	X
3	2030	ongoing	X	X	X	X	X
4	2030	ongoing	X	X	X	X	X



RELATED STRATEGIES	**A1, B1, B2, B3, B4**

A6: CRITICAL COMMUNITY FACILITIES RESILIENCE

Increase resilience of critical community facilities to climate shocks, prioritizing those with high vulnerabilities identified in the CCVA



Professional Ambulance Services, Cambridge MA

TOOLBOX / ACTIONS:

1. *Build/protect critical community facilities to the 2070 10-yr flood elevation from precipitation or SLR/storm surge, whichever is higher (Refer to strategies B1 and B3 outlining the toolbox/actions to protect)*
2. *Design community facilities to recover to the 2070 100-yr flood elevation from precipitation or SLR/storm surge, whichever is higher (Refer to strategies B1 and B3 outlining the toolbox/ actions to recover)*
3. *Provide for new and existing critical community facilities to be resilient to future heat risks identified for the neighborhood (Refer to strategies B2 and B4 outlining the toolbox/action for heat resiliency)*
4. *Provide for continuity of operations during extreme events and under new normal focusing on all employees to have contingency plans both at work and at home (Refer to A5)*
5. *Maintain a resilient transportation and transit infrastructure to ensure mobility and evacuation routes during and after climate shocks and stresses (Refer to C3)*

QUALITY OF RESILIENCE:

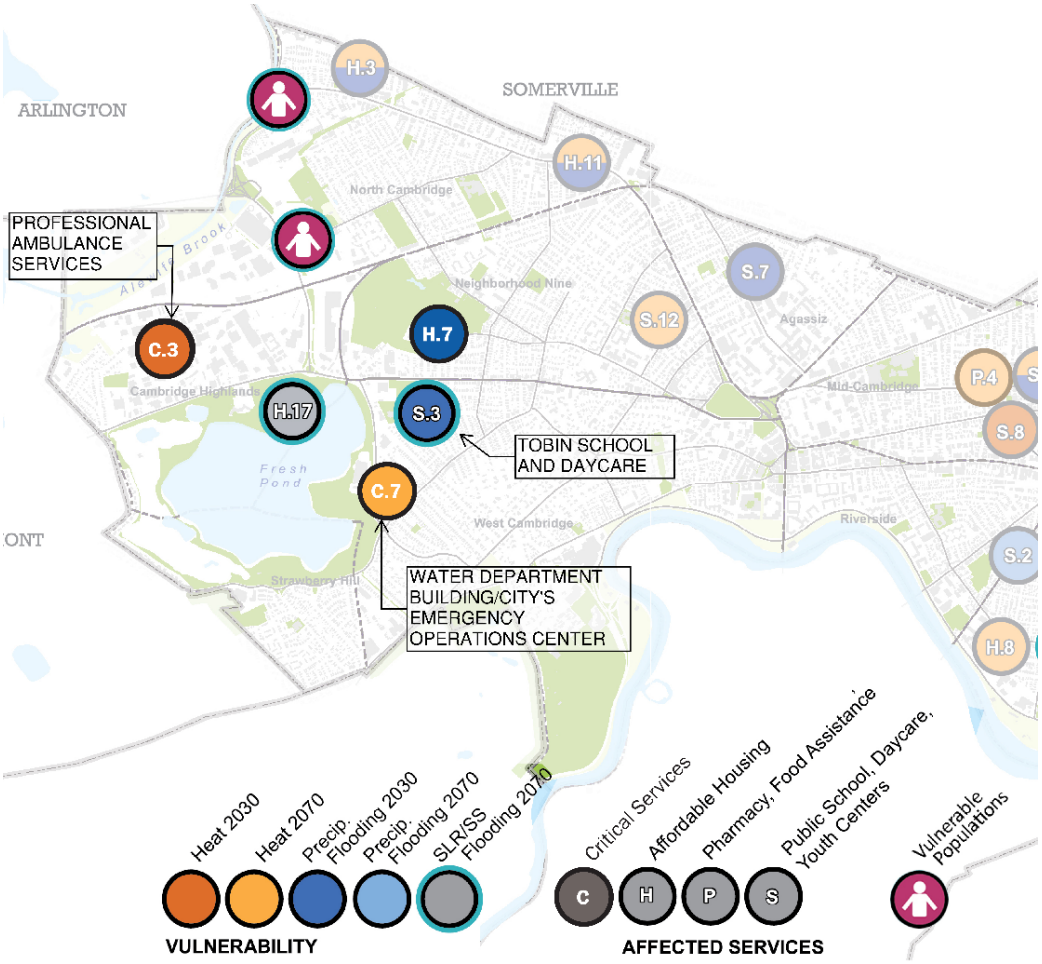
Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	😐	🙂	🙂	🙂	🙂	😟

WHY RELEVANT TO ALEWIFE?

Cambridge's critical services (e.g. fire stations, ambulance services) and community services (e.g. affordable housing, public schools, daycare and youth centers, pharmacies, and food pantries) provide important support services that need to be operational when climate stressors impact the City. These services provide critical places for residents to connect, therefore impacting public health when in danger. Some of the City's key resources are in the Alewife neighborhood and were identified as most at-risk to extreme heat and flooding in CCVA:

- Professional Ambulance Services–this asset was found to be one of the most at-risk as it had the highest risk scores (R4) in both Heat and Inland Flooding in the 2030s scenarios
- Water Department building / City's Emergency Operations Center (R3) – Heat risks under the 2070 scenario
- Tobin Elementary School & Daycare –Flood risks under the 2030 and 2070 climate scenarios

Assuring continuity of services and access to these key services during extreme events and "new normal" is a key component for the City's overall resiliency.



Key resources located in the Alewife neighborhood that are most at-risk to extreme heat and flooding (Source: Critical services, selection from Fig 13 & Fig. 14, CCVA Part 2, November 2015)

KEY CONSIDERATIONS

- *Impact:*
  - Confirm that critical services and community service facilities are equipped, designed, or retrofitted to maintain full operation during emergency and "new normal" conditions
- *Cost:* As costs range for retrofitting existing buildings to developing an operational plan, this is too broad to assign for actions under this strategy
- *Equitable:* These services are for all members of the Cambridge community and also support the most-vulnerable populations
- *Wellness:* Ensuring operation of first responders and community services to vulnerable populations during extreme events and CC stresses is a key component of a comprehensive public health plan
- *Feasible:* It is feasible to upgrade buildings and develop operational plans resilient to CC stresses
- *Integrated:* This strategy relies on the implementation of many other strategies for "Prepared Buildings and Resilient Infrastructure"
- *CC Mitigation:* Limited impact on GHG emissions

ACTIONS ALREADY BEING TAKEN

- Post-flood inspectional services (Source: Cambridge Inspectional Services Department)
- DPW municipal facilities improvement plan is addressing CCVA findings

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	City	**Institutional/Non -for profit**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Emergency Response**	
JURISDICTION for monitoring the enactment of the strategy	**City - Policy**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Parcel/Building/Resident**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood** Precipitation	**Heat**	**Flood** Precipitation	**Flood** Sea Level Rise / Storm Surge
1	2020	ongoing		X		X	X
2	2020	ongoing		X		X	X
3	2020	ongoing	X		X		
4	2030	ongoing	X	X	X	X	X
5	2030	ongoing		X		X	X

RELATED STRATEGIES	**A5, B1, B2, B3, B4, B5, C3**

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A7: EMERGENCY RESPONSE PLANS

Strengthen existing emergency response plans to include the potential impacts of climate change, including strategies to enable sheltering in place and evacuation, when appropriate

TOOLBOX / ACTIONS:

1. *Update and strengthen City of Cambridge's existing Heat Emergency Response Guide, potentially including:*
   - *Incorporating health surveillance data into activation triggers;*
   - *Automatic notification of partners triggered by heat index; and*
   - *Increasing outreach to homeless individuals*
2. *Plan to address enhanced aggravation of health conditions specific to heat wave and flood*
3. *Public Health could provide public guidance on reducing risks from home-prepared food, including proper sanitizing techniques, guidance on spoilage, and common-sense information on when to discard food and other perishables*
4. *Public-health officials and food inspectors could be available during emergency periods to assess and advise on damage to perishable goods, proper handling and appropriate mold remediation practices*
5. *Food inspectors could inspect establishments permitted to serve and sell food after flooding or loss of power*
6. *Housing inspectors could be available to assess and advise on general hygiene, habitability, trash and rodent control, as well as hazardous building and utility conditions. They could also determine if there is live electricity that could pose a hazard, and request utility companies to repair and restore service*
7. *The Cambridge Inspectional Services Department (ISD) could provide a list of qualified contractors to remove water damage and restore labs to full operational status*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
						
						

WHY RELEVANT TO ALEWIFE?

While Cambridge has already developed plans to respond to emergencies impacting the city, climate change will result in different and expanded challenges than the city has previously planned for, including increased regional flooding and extreme heat events. Incorporating concerns regarding climate change into these existing plans will help to ensure the City is ready for future emergencies and disasters.

KEY CONSIDERATIONS

- *Impact:* Helps ensure the City is ready for future emergencies and disasters
- *Cost:* An investment in preparedness could decrease the cost of response and recovery in the event of an emergency or disaster
- *Equity:* An effective emergency response is more likely to benefit more vulnerable populations that are more likely to rely on the City's services (e.g., those without access to transportation, individuals lacking a social safety net)
- *Wellness:* Promotes healthy environments and preventive services, while addressing health and economic impacts of climate change through strong governance and multi-stakeholder engagement
- *Feasible:* Partners exist to implement
- *Integrated:* Improving upon existing resources; other related initiatives (e.g., A2, A4) would be built into the plan

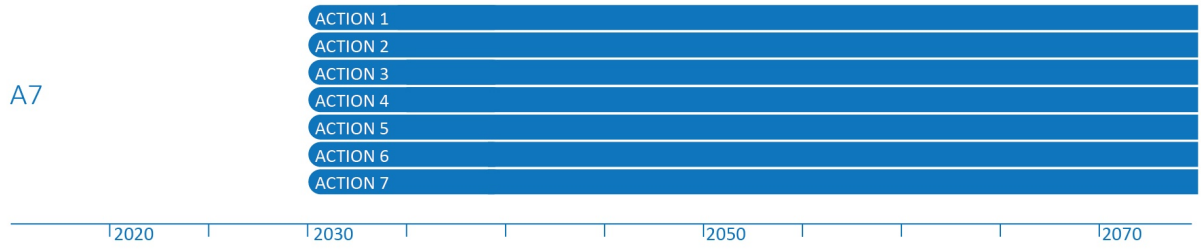
ACTIONS ALREADY BEING TAKEN

The City has strong, regionally coordinated emergency preparedness plans, leadership, and staffing. It has projected vulnerabilities through the Cambridge Climate Change and Vulnerabilities Assessment.

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	City	**City**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Emergency Response**	
JURISDICTION for monitoring the enactment of the strategy	**City - Owner**	
SCALE of the intervention as the smallest unity- a building or a person, at the neighborhood s ale, the City's scale or for the region	**City**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2030	ongoing	X	X	X	X	X
2	2030	ongoing	X	X	X	X	X
3	2030	ongoing	X	X	X	X	X
4	2030	ongoing	X	X	X	X	X
5	2030	ongoing	X	X	X	X	X
6	2030	ongoing	X	X	X	X	X
7	2030	ongoing	X	X	X	X	X



RELATED STRATEGIES	**A2, A4**

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A8: HEALTHCARE CONTINUITY AND ACCESS

Work locally with key healthcare service providers and with the regional health and medical coalition to ensure capacity, continuity and access to medical services including pharmacies, dialysis, mental health, and addiction treatment

TOOLBOX / ACTIONS:

1. *Engage the workforce to identify vulnerabilities and educate patients about the risk of Climate Change impacts, (e.g. heat, flooding) and add measures to prepare for it. The City's Human Services Department could work on this with the Cambridge Health Alliance and other Fresh Pond providers*
2. *Plan temporary centers in the Alewife Neighborhood to assess individuals for heat impact. Assess potential locations close to vulnerable populations such as in existing health care centers, senior centers, schools and affordable housing*
3. *Coordinate with pharmacy owners and managers to inform them of the CC risks and possible resiliency measures to limit disruption of services due to CC impacts and also provide measures for residents to have longer supply of medications*
4. *Update current emergency measures to better integrate identified CC threats to ensure adequate health and behavioral response resources in the event of a disaster. The City, with the Fire Department and other emergency providers, to work on this. For example, review evacuation roads to consider revised flooding projections; extreme heat wave planning that includes potential violence and mental-health exacerbations*
5. *Advocate for supportive state policies and programs (E.g. Allow patients to store an emergency excess supply of medications)*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	😐	🙂	🙂	🙂	😐	😐

WHY RELEVANT TO ALEWIFE?

Like other cities in the Northeastern US, Cambridge is vulnerable to adverse health impacts of heat and flooding. Heat has been the largest single weather-related cause of death in the US since NOAA began reporting data for heat in 1988. In addition, heat impacts on health are the most well understood, measurable, and yet preventable impacts of climate change. Healthcare workers should educate patients on heat-health risks and mold risks, work

with their patients to develop prevention tactics, and educate their patients on when to seek help during a heat emergency and after flood damage.

It is also important to ensure that residents have continued access to medical care and that the services are comprehensive, including behavioral health and substance use; adequate to manage higher demands, and accessible. Also critical is continuity in services for needed medications and medical supplies. Interruptions in medication and medical technologies can exacerbate underlying conditions and increase the risk of morbidity and mortality.

KEY CONSIDERATIONS

- *Impact:*
  - Improves human health and ability to meet other City goals
- *Cost:* Some activities may save healthcare costs and reduce burden on City
- *Equity:*
  - Selected with stakeholder engagement
  - Addresses differential climate change impacts
- *Wellness:*
  - Improves public health
  - Addresses vulnerabilities due to demographic factors
  - Expands quality preventive services in both clinical and community settings
- *Feasible:* Partners exist to implement, need to coordinate with state policies and programs
- *Integrated:* Aligns with U.S. Mayors Climate Protection Agreement, Heat Plan, Emergency Response plans

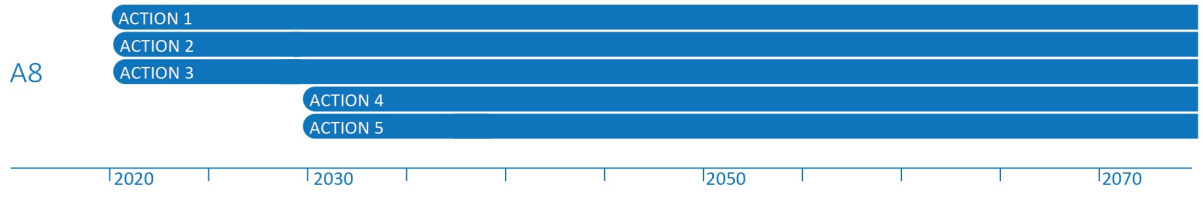
ACTIONS ALREADY BEING TAKEN

- Healthcare and multi-stakeholder public health collaborations
- Heat Plan
- Emergency response planning

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Partnership	**Partnership**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Emergency Response**	
JURISDICTION for monitoring the enactment of the strategy	**City - Regulation**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Neighborhood**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood** Precipitation	**Heat**	**Flood** Precipitation	**Flood** Sea Level Rise / Storm Surge
1	2020	ongoing	X	X	X	X	X
2	2020	ongoing	X	X	X	X	X
3	2020	ongoing	X	X	X	X	X
4	2030	ongoing	X	X	X	X	X
5	2030	ongoing	X	X	X	X	X



RELATED STRATEGIES	**A1, A8**

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A9: STRONGER SOCIAL NETWORK

Develop a neighborhood resiliency social network in partnership with community leaders and organizations

Family day care providers trained on environmental health

TOOLBOX / ACTIONS:

1. *Identify and reach out to vulnerable populations directly and through informal community leaders, the faith community, and community service providers to validate/select preparedness, communications and resiliency-building strategies and systems that work for their communities. Ensure that homeless, students, and high-risk employee groups are included when considering vulnerable populations*
2. *Design asset-based climate change engagement campaigns that*
   - *Address existing concerns among vulnerable populations (e.g. safety, comfortable heating and cooling, health disparities, job security)*
   - *Build on strengths and capacity of neighborhood residents, workers, students, workplaces, and community-based organization (e.g. social, faith-based, educational, advocacy)*
3. *Compile resource listings and design culturally and linguistically appropriate educational and outreach materials with tailored messages. Disseminate locally via neighbors, peers and other trusted channels of communication to increase family, school, workplace, and neighborhood mutual support for advocacy and preparedness*
4. *Engage in activities to build social connections between neighborhood residents to foster neighborhood cohesion and resilience, such as block parties and volunteer projects to address climate change, and to build community voice and power to advance community-driven climate solutions*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
						
						

WHY RELEVANT TO ALEWIFE?

Collaboration with leaders of vulnerable populations to build social cohesion and resiliency is among top near-term priorities voiced by Cambridge stakeholders engaged in public health and climate change preparedness planning. Cambridge and the Fresh Pond area are home to many highly vulnerable populations such as seniors at Neville Place, newborns, the homeless, low-income persons, those with limited English proficiency or literacy, and persons with pre-existing health conditions housed at Fresh Pond Apartment section 8 housing. Cambridge and the Fresh Pond area are renowned for civic and neighborhood engagement among their richly diverse populations.

Extreme heat is a risk factor for students engaged in demanding sports at area public and private schools such as Tobin and Fayerweather. It also presents an occupational hazard for construction workers, day laborers, and others who work outside or in uncooled environments. These populations, and those who create policies and supervise them - from employers to school coaches, need to be engaged. Increasing awareness and resiliency through culturally appropriate community-led peer outreach, coupled with mutual support and volunteerism that addresses climate-related risk factors, can be effective in preparing and strengthening both individuals and neighborhoods. Equity-focused climate change frameworks further emphasize fostering decision-making power of those most impacted. "The opportunity for increasing community resilience is in the very process of developing a plan when those who are most vulnerable are at the heart of society's efforts to build a resilient future." (Source: Community-Driven Climate Resilience Planning). As informed by best practices and the stakeholder engagement process for the project, it is critical for members of the Alewife community to become aware of, and connected to, climate-related community systems and programs.

KEY CONSIDERATIONS

- *Impact:*
  - Improved social cohesion, collaboration, improved infrastructure for community participation in decision-making
- *Cost:* Some activities may save healthcare costs and burden on individuals, employers, and the City
- *Equitable:*
  - Addresses existing inequities including root causes of vulnerabilities such as structural racism
  - Addresses differential climate change impacts through comprehensive resident-driven solutions
- *Wellness:*
  - Evidence that improved action to address climate change improves individual resiliency, promoting adoption of adaptation measures and long-term mental health
- *Feasible:* Partners exist to implement
- *Integrated:* Aligns with U.S. Mayors Climate Protection Agreement, Heat Plan, Emergency Response plans, and City public-health programming
- *CC Mitigation:* Residents may be engaged in mitigation

ACTIONS ALREADY BEING TAKEN

- The Cambridge Community Response Network (CCRN) has been created to help build a more resilient city by creating a strong community in which neighbors feel connected to and responsible for each other[8]
- Recognizing the power of grassroots and locally-based connections, the Cambridge Peace Commission organizes a Meet Your Neighbor Day cosponsored by the Citizen's Committee on Civic Unity for a Cambridge-specific approach to building connections and community[9]
- The Cambridge Climate Protection Action Committee, Community Engagement Teams, Cambridge Health Alliance Volunteer Health Advisors, Literacy Ambassadors, "Food-for-Free," the Cambridge Men's League, area aging agencies, and school, workplace, and faith community networks and activities can be expanded upon

[8] www.cambridgema.gov/Departments/peacecommission/CCRN

[9] www.cambridgema.gov/Departments/peacecommission/meetyourneighborday

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Partnership	**Partnership**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Policy**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Neighborhood**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood** Precipitation	**Heat**	**Flood** Precipitation	**Flood** Sea Level Rise / Storm Surge
1	2020	ongoing	X	X	X	X	X
2	2020	ongoing	X	X	X	X	X
3	2020	ongoing	X	X	X	X	X
4	2020	ongoing	X	X	X	X	X

RELATED STRATEGIES	**A1 - A8**

STRATEGIES B:
ADAPTED BUILDINGS

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STRATEGIES B:
ADAPTED BUILDINGS

OVERVIEW

The overall benefit of the strategies for adapted buildings is to develop a resilient neighborhood that is protected from climate change impacts and designed for a speedy return to normal. Strategies for flood and heat resiliency have been developed separately for new and existing buildings because different approaches and means are needed for each. Table B.1 lists the proposed strategies.

Table B.1 List of Strategies for Adapted Buildings

STRATEGY	TITLE	DESCRIPTION
B1	FLOOD PROTECTION FOR NEW BUILDINGS	Establish regulations and design guidelines for new buildings and re-developments to be resilient to future flood risks identified for the neighborhood.
B2	HEAT PROTECTION FOR NEW BUILDINGS	Establish regulations and design guidelines for new buildings and re-developments to be resilient to future heat risks identified for the neighborhood.
B3	FLOOD PROTECTION FOR EXISTING BUILDINGS	Establish a program to support retrofitting of existing buildings and re-developments to be resilient to future flood risks.
B4	HEAT PROTECTION FOR EXISTING BUILDINGS	Establish a program to support retrofitting of existing buildings and re-developments to be resilient to future heat risks.
B5	BUILDING MANAGEMENT FOR FLOOD AND HEAT PROTECTION	Develop a program to enable building residents and occupants to effectively manage and operate resilient buildings.
B6	SITE GREEN INFRASTRUCTURE	Implement green infrastructure (GI) at the parcel level to improve water management and reduce heat-island effect.
B7	ADAPTED ZONING, POLICIES AND REGULATIONS	Revise zoning to factor in Climate Change risks, such as flooding and extreme heat and adjust building requirements to take into account new constraints such as revised flood elevation.

BEST PRACTICES

As many cities are experiencing the impacts of climate change and working to recover after the disaster, there are many best practices from around the United States and internationally. The best practices summarized below serve as examples in building design, programming and changes in regulations and standards to integrate climate change projections. They have been selected for their possible applicability in the context of City of Cambridge.

Flood Protection for New and Existing Buildings

American Copper Buildings, New York City, New York

The American Copper Buildings are two residential buildings with a total of 760 apartments along the East River in New York City. The buildings were designed with flood resiliency. The lobby walls were constructed of stone to prevent flood damage and there is a stormwater detention pit under the basement floor. The mechanical systems are on the 2nd floor, and there are five natural gas emergency generators on the 48th floor.

Figure 1. American Copper Building, NYC [Source: New York Times, Curbed NY]

HafenCity, Hamburg, Germany

HafenCity, Hamburg, built a series of mixed-use buildings fully elevated from the street level for flood protection and improved neighborhood resilience. Buildings facing the lower street are more prone to flooding and have flood control measures such as flood gates. Garages and common lobby spaces are good examples of areas that can be designed and operated to recover from flood events.

Figure 2a. Flood Protection Shutters [Source: City of Hamburg, Germany]

Figure 2b. Flood Protection Gates to achieve a Flood Protection Level [Source: HafenCity, Hamburg, Germany]

Heat Protection for New and Existing Buildings

Cornell Tech's Residential Tower, Roosevelt Island, New York

Cornell Tech's 26-story residential tower is the first high-rise building to meet the Passive House standard, which prioritizes building design principles that meet thermal resilience goals. The tower is projected to use 60 to 80 percent less energy than other similarly sized buildings by using LEED, Net Zero and Passive House principles, such as tighter building envelope, and well-insulated exterior window and wall systems. This will help maintain habitable interior temperatures during power failure from extreme heat events, which allows people to shelter-in-place.

Figure 3. Cornell Tech's 26-story residential tower, NYC [Source: Cornell University]

New York City Cool Roofs Program, New York City, New York

New York City's CoolRoofs™ Program was launched in 2009. The initiative is a partnership between the NYC Department of Small Business Services, the Mayor's Office of Sustainability, the Mayor's Office of Recovery and Resiliency, and Sustainable South Bronx, a division of The HOPE Program[1]. Through the program, building owners have applied approximately 6 million square feet of white, reflective coating on more than 600 building roofs. The program offers cool roof installations at no cost or low cost to select buildings (e.g., community centers, schools, hospitals, cultural buildings) with priority given to non-profits and affordable housing. Building owners are provided discounted rates for the coating, as well as labor, technical assistance, and materials (e.g. paint brushes, rollers, gloves). Private building owners who share the electricity cost savings are also eligible. The program reduces the urban heat-island effect, reduces GHG emissions and provides savings of 10 to 30 percent on cooling costs.

Figure 4. Buildings commissioner cools a roof in Long Island City [Source: NYC CoolRoofs]

[1] https://www1.nyc.gov/nycbusiness/article/nyc-coolroofs

The City of Toronto's Eco-Roof Incentive Program, Environment and Energy Division, City of Toronto, Canada

Figure 5. Green roof system [Source: Toronto.ca – Green Roofs - Green Roof at Ryerson University]

The City of Toronto launched its Eco-Roof Incentive Program in 2009 to provide incentives to support the adoption of green roofs and cool roofs on new and existing buildings. As part of this incentive program, green-roof projects receive a grant of $100 per square meter, while cool-roof projects receive a grant of $2 to $5 per square meter. This program compliments the Toronto Green Roof Bylaw (adopted by the Toronto City Council in May 2009), which requires the construction of green roofs on new residential, commercial and institutional buildings with a minimum floor area of 20,000 square feet. The Bylaw is supported by a green roof screening tool to determine applicability to the developer. As a result of the Program and the Bylaw, there are over 2.5 million square feet of green roofs installed on approximately 500 roofs across the City.

Building Maintenance Plans for Resiliency

Building maintenance plans are preventative measures that reduce damage and failure of systems during events. For example, protection of structural elements and electrical systems will require special procedures before and during flood events. After the event, swift removal of waterborne materials is essential. Methods include pumping standing water, hosing down flood deposits or debris, and removing wet or damaged materials before they develop mold. Establishing positive drainage away from the building with a slope greater than 2 percent and high-pressure water supply connections can assist in hosing down debris to catch basins after an event, before deposits harden and require more mechanical means of removal. The ability to maintain power to critical systems is also important. Components such as energy management systems can localize and reduce energy consumption, as well as communicate to the grid when needed. In addition, installing backup power systems or the ability to quickly connect to emergency power systems is essential. New York State and Austin, Texas provide good models for smart building management to reduce the stresses brought by climate change.

New York State Generator Connections

New York State requires disaster preparedness plans for nursing homes and assisted living facilities. Part of the plan requires emergency generators or access to temporary emergency generators through a contract with a supplier. In addition, the plan requires retrofitting these buildings with pre-connections for temporary generators during outages.

Figure 6. Emergency Generator [Source: Powertron Solutions]

Austin Energy Smart Thermostats, Austin, Texas

Austin Energy, a municipal utility in Austin, TX, has a goal to achieve 900 megawatts (MW) in savings through increased energy efficiency and demand-side management, and a renewable energy goal of 55 percent by 2025, including 200 MW in local solar.

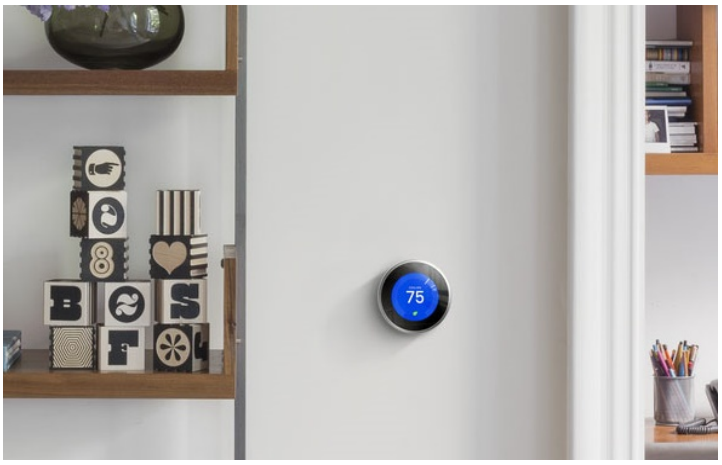


Figure 7. Smart Thermostat [Source: Austin Energy]

As part of this energy management goal, Austin Energy provides the Power Partner[SM] Thermostats rebate program, in which they first provided free thermostats to customers and then subsidized the program via a rebate to purchase the smart thermostat. Austin Energy pays thermostat vendors a one-time fee to enter the program and an annual fee (per thermostat) to manage the demand-response events. There are several demand-response vendors and over 10 models of thermostats provided by different manufacturers available through the Smart Thermostat Program. The Smart Thermostat allows the utility company to adjust temperatures during peak demand and also send messages, pricing signals, and critical usage information to customers. Demand-response to reduce peak electricity usage through smart thermostats reduces the stress on the electrical distribution system and the possibility of outages.

Building Standards and Regulations

Climate change requires predicting future impacts for communities to be prepared. Building standards and regulations have been established based on past events and historic storms. The building and construction industry, including professional associations, municipalities and government regulatory agencies, is in the process of revising standards and regulations to factor in climate change projections. Best practices for new standards and regulations have been documented for their applicability to the City of Cambridge and the Commonwealth of Massachusetts. Possible regulatory approaches include the following:

Flood Resistant Design and Construction (24-14) [2]***:***

The ASCE/SEI 24-14 published by the American Society of Civil Engineers (ASCE) is a referenced standard in the International Codes® (I-Codes®). It states the minimum requirements and expected performance for the siting, design and construction of buildings and structures in flood hazard areas that are subject to building code requirements. Buildings and structures designed according to ASCE 24 are better able to resist flood loads and flood damage. Types of buildings and structures include commercial, residential, industrial, educational, healthcare, critical facilities, and other occupancy types. FEMA deems ASCE 24 to meet or exceed the minimum National Flood Insurance Program (NFIP) requirements for buildings and structures. ASCE 24 includes additional specificity, some additional requirements, and some limitations that are not in NFIP regulations[3].

Figure 8. Flood Resistant Design and Construction (24-14) Reference standard [Source: American Society of Civil Engineers

[2] https://www.fema.gov/media-library-data/1436288616344-93e90f72a5e4ba75bac2c5bb0c92d251/ASCE24-14_Highlights_Jan2015_revise2.pdf

[3] https://www.fema.gov/media-library/assets/documents/14983

New Orleans Municipal Code, New Orleans, Louisiana:

Section78-80 of the New Orleans' Municipal Code requires a Certificate of Elevation for building permit applications to insure accuracy in compliance with regulations. Specifically, all building permits issued for new construction or substantial improvement must be imprinted with the lowest floor elevation (including basement), referenced with respect to the mean sea level[4]. The process of raising structures has been streamlined to avoid the need for plan review for structural renovation permits which may be obtained by licensed elevation or shoring companies where the entire structure is proposed to be raised[5].

Section 78-80 of the New Orleans' Municipal Code requires a Certificate of Elevation for all building permits issued for new construction or substantial improvement must be imprinted with the required mean sea level elevation of the lowest floor (including basement).

New York City Building Code: Flood Resistant Construction:

The New York City Building Code references the American Society of Civil Engineers, ASCE 24 but also has special requirements that apply to post-Flood Insurance Rate Map (FIRM) construction and substantial improvements located within A Zones as defined by FEMA. References to ASCE 24 include using freeboard requirements by category of buildings. According to the ASCE 24 guidelines, residential dwellings and most other buildings are required to have a 1-foot freeboard above the FIRM Base Flood Elevation (BFE)[6], where was certain essential facilities, such as hospitals, fire and police stations, emergency shelters, etc. are required to have 2-3 feet of freeboard above the BFE. Other design guidelines include those related to design for hydrostatic pressure of below-grade structures, design of foundation structures, mechanical, heating, ventilation and air conditioning elements, use of flood damage resistant materials, as well as, appropriate design consideration for utilities and service equipment to prevent from water intrusion. Additional provisions, for example, apply to relief vents and fresh-air intakes serving building traps that shall be carried above-grade and shall terminate in a screened outlet. All applications involving utility or mechanical work shall include a separate certification by the applicant that work will conform to ASCE 24.

In New York, some retroactive provisions require improvements to be made regardless of whether building permits are being considered. For example, existing nursing homes of similar occupancy types in flood zones would require installing connections for temporary external generators to be in place by 2030 to ensure backup power for vulnerable populations. At the same time, new

[4] Mean sea level (MSL) (often shortened to sea level) is an average level of the surface of one or more of Earth's oceans from which heights such as elevations may be measured. MSL is a type of vertical datum – a standardized geodetic reference point.

[5] New Orleans, Louisiana - Code of Ordinances, Chapter 78 – Floods Article II. – Flood Damage Prevention, Division 4 – Flood Hazard Reduction. https://library.municode.com/la/new_orleans/codes/code_of_ordinances

[6] Base Flood Elevation is the computed elevation to which floodwater is anticipated to rise during the base flood, which is referred to as the 100-year flood, or a flood that has a 1 percent annual chance of exceedance in any given year.

hospital buildings will be required to meet construction code standards for flood-resistant construction [7].

Regulatory and Zoning Measures

EPA Recommendations for Climate Change

The EPA published a report recommending the adoption of flexible zoning, which could include dynamic zoning or a floating zone. Dynamic zoning allows a community to pass regulations that fit its current conditions but will change based on some empirical future condition[8]. Two key ideas that could inform the Cambridge CCPR follow:

- *Adopt elements of dynamic zoning, or building flexibility into codes to cope with changing conditions.* With dynamic zoning, the zoning code includes "triggers" that, when activated, change the code requirements automatically. The nature of dynamic zoning might be particularly helpful for climate-change-related impacts. One legal expert notes that, "gradual and adaptive regulations can minimize harm and takings compensation requirements" while giving property owners some certainty about how they can expect to use their property once certain thresholds are passed. It should be noted that this is a new approach to zoning that has yet to be tested in "real life" conditions.

The nature of dynamic zoning might be particularly helpful for climate-change-related impacts. Dynamic provisions would let a community pass regulations that fit its current conditions but will change based on some empirical future condition.

- *Green Infrastructure at Parcel Level.* Green infrastructure (GI) and low-impact development (LID) rainwater management strategies improve the environmental conditions by mimicking a site's natural hydrology. They limit the amount of impervious cover on a site, and infiltrate, filter, store, evaporate, or detain rainwater runoff at or close to its source. GI also contributes to reduction of urban heat-island impacts by lowering temperatures.

[7] As recommended in http://www.nyc.gov/html/sirr/downloads/pdf/final_report/Ch_8_Healthcare_FINAL_singles.pdf

[8] https://www.epa.gov/smartgrowth/smart-growth-fixes-climate-adaptation-and-resilience.

New York City Flood Resilience Zoning Text

The Flood Resilience Zoning Text[9] (the "Flood Text") is one part of a wide range of efforts by the City of New York to recover from Hurricane Sandy, promote rebuilding, and increase the City's resilience to climate-related events, including coastal flooding and storm surge. The Flood Text encourages flood-resilient building construction throughout designated floodplains by removing regulatory barriers that hinder or prevent the reconstruction of storm-damaged properties.

It also enables new and existing buildings to comply with new, higher flood elevations issued by the Federal Emergency Management Agency (FEMA), and to comply with new requirements in the New York City Building Code ("Building Code") [10].

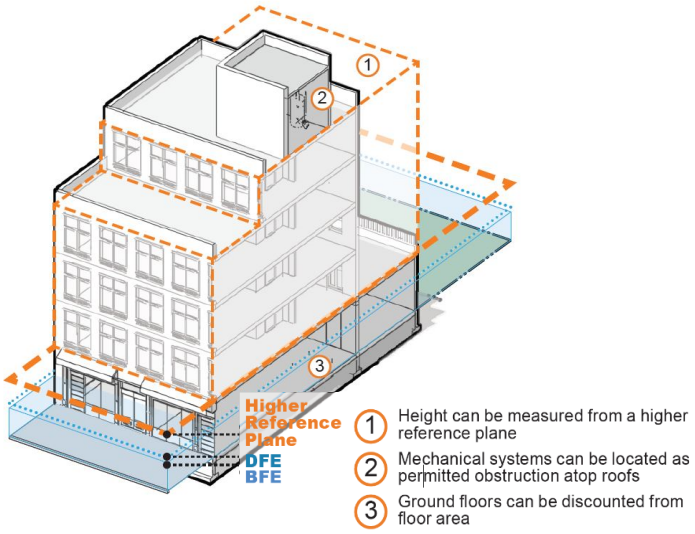


Figure 9. New Dry Floodproofed Mixed-Use Building. [Source: NYC Flood Resilience Zoning, Executive Summary]

[9] Source: NYC Flood Resilience Zoning, Executive Summary https://www1.nyc.gov/assets/planning/download/pdf/zoning/districts-tools/flood-test/flood-text-overview.pdf

[10] this is a proposed revision in the process of being evaluated: http://www1.nyc.gov/site/planning/zoning/districts-tools/flood-text.page

RELEVANCE TO ALEWIFE

Table B.2 below provides a summary of how the best practices inform the development of specific strategies for Adapted Buildings.

Table B.2 List of Strategies and Related Best Practices

STRATEGY	TITLE	RELATED BEST PRACTICE	DESCRIPTION/ RELEVANCE TO ALEWIFE
B1	FLOOD PROTECTION FOR NEW BUILDINGS	***American Copper Buildings, New York City, New York***	Residential buildings (760 apartments) in a flood-prone area in New York City that adopted a series of resiliency measures including: lobby walls in stone to prevent flood damage, stormwater detention pit under the basement floor, mechanical systems elevated to the 2nd floor and five natural gas emergency generators on the 48th floor.
B2	HEAT PROTECTION FOR NEW BUILDINGS	***Cornell Tech's 26-Story Residential Tower, Roosevelt Island, New York***	The residential tower meets the Passive House standard, which prioritizes building design principles that meet thermal resilience goals. Adopted measures include a tighter building envelope, and well-insulated exterior window and wall systems. The building can also maintain habitable interior temperatures during power failure from extreme heat events, which allows people to shelter-in-place while using 60 to 80% less energy than similar buildings.
B3	FLOOD PROTECTION FOR EXISTING BUILDINGS	***HafenCity, Hamburg, Germany***	Series of mixed-use buildings that implemented flood measures such as: flood gates for buildings facing the lower street, garages and common lobby spaces designed and operated to recover from flood events.
B4	HEAT PROTECTION FOR EXISTING BUILDINGS	***New York City Cool Roofs Program, New York City, New York***	CoolRoofs™ offers cool roof installations at no cost or low cost to select buildings (e.g., community centers, schools, hospitals, cultural buildings) with priority given to non-profits and affordable housing.
B5	BUILDING MANAGEMENT FOR FLOOD AND HEAT PROTECTION	***New York State Generator Connections***	New York State requires disaster preparedness plans for nursing homes and assisted living facilities. Part of the plan requires emergency generators or access to temporary emergency generators through a contract with a supplier.

		Austin Energy Smart Thermostats, Austin, Texas	Austin Energy provides the Power Partner[SM] Thermostats rebate program, in which they first provided free thermostats to customers to purchase the smart thermostat. It allows for managing demand-response events during peak demand and also sends messages, pricing signals, and critical usage information to customers.
B6	SITE GREEN INFRASTRUCTURE	***The City of Toronto's Eco-Roof Incentive Program, Environment and Energy Division, City of Toronto, Canada***	Eco-Roof Incentive Program provides financial incentives (in dollars or in increased development rights – FAR) to support the adoption of green roofs and cool roofs on new and existing buildings.
B7	ADAPTED ZONING, POLICIES AND REGULATIONS	***Flood Resistant Design and Construction (24-14)*** [11]	Published by the American Society of Civil Engineers (ASCE); states the minimum requirements and expected performance for the siting, design and construction of buildings and structures in flood-hazard areas that are subject to building code requirements. ASCE 24 includes additional specificity, some additional requirements, and some limitations that are not in NFIP regulations[12].
		New Orleans Municipal Code, New Orleans, Louisiana	Section 78-80 of the New Orleans' Municipal Code requires a Certificate of Elevation for all building permits issued for new construction or substantial improvement must be imprinted with the required mean sea level elevation of the lowest floor (including basement).
		New York City Flood Resilience Zoning Text	The Flood Text encourages flood-resilient building construction throughout designated floodplains by removing regulatory barriers that hinder or prevent the reconstruction of storm-damaged properties. It also enables new and existing buildings to comply with new, higher flood elevations issued by the Federal Emergency Management Agency (FEMA), and to comply with new requirements in the New York City Building Code.

[11] https://www.fema.gov/media-library-data/1436288616344-93e90f72a5e4ba75bac2c5bb0c92d251/ASCE24-14_Highlights_Jan2015_revise2.pdf

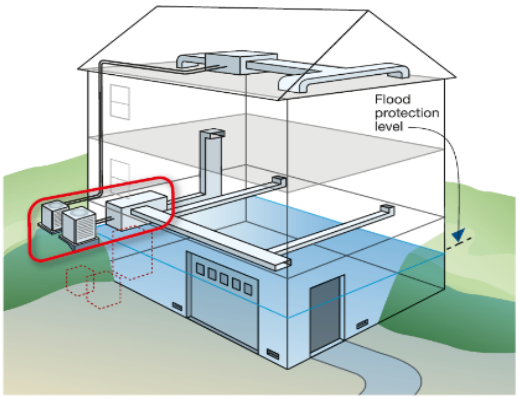
[12] https://www.fema.gov/media-library/assets/documents/14983

		EPA Recommendations for Climate Change	*Adopt dynamic zoning to cope with changing conditions.* The zoning code could include "triggers" that, when activated by a special event, change the code requirements automatically.

The draft strategies are described in detail in the following pages.

B1: FLOOD PROTECTION FOR NEW BUILDINGS

Establish regulations and design guidelines for new buildings and re-developments to be resilient to future flood risks identified for the neighborhood



Source: FEMA, "Protecting Building Utility Systems from Flood Damage"

TOOLBOX / ACTIONS:

1. *Build/protect to the 2070 10-year flood elevation from precipitation or sea level rise/storm surge, whichever is higher*
2. *Recover to the 2070 100-year flood elevation from precipitation or sea level rise/storm surge whichever is higher*
3. *Establish requirements for all vulnerable utilities to be located above the determined flood elevation based on building use type*
4. *Require the American Society of Civil Engineers (ASCE) 24-14 Flood Resistant Design and Construction below 2070 100-yr flood elevation*
5. *Locate electrical shut-off to building at or above grade level, not in basement*

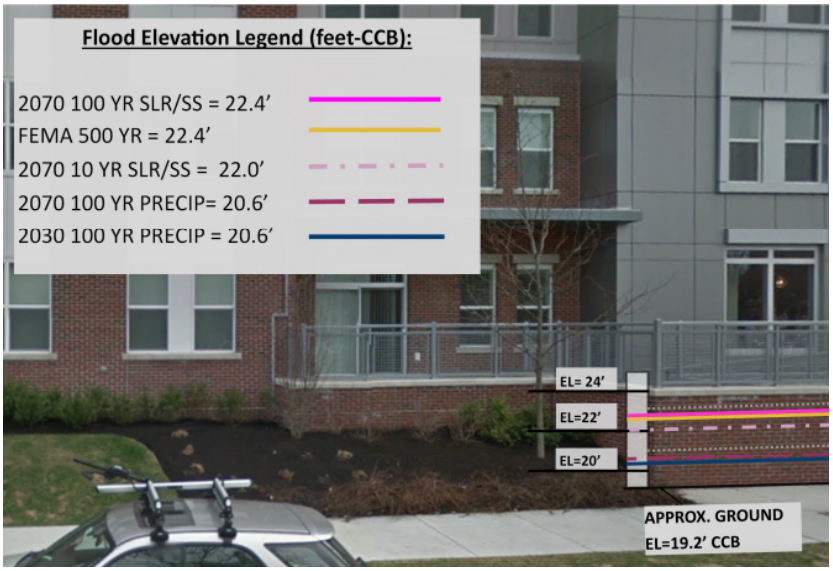
QUALITY OF RESILIENCE:

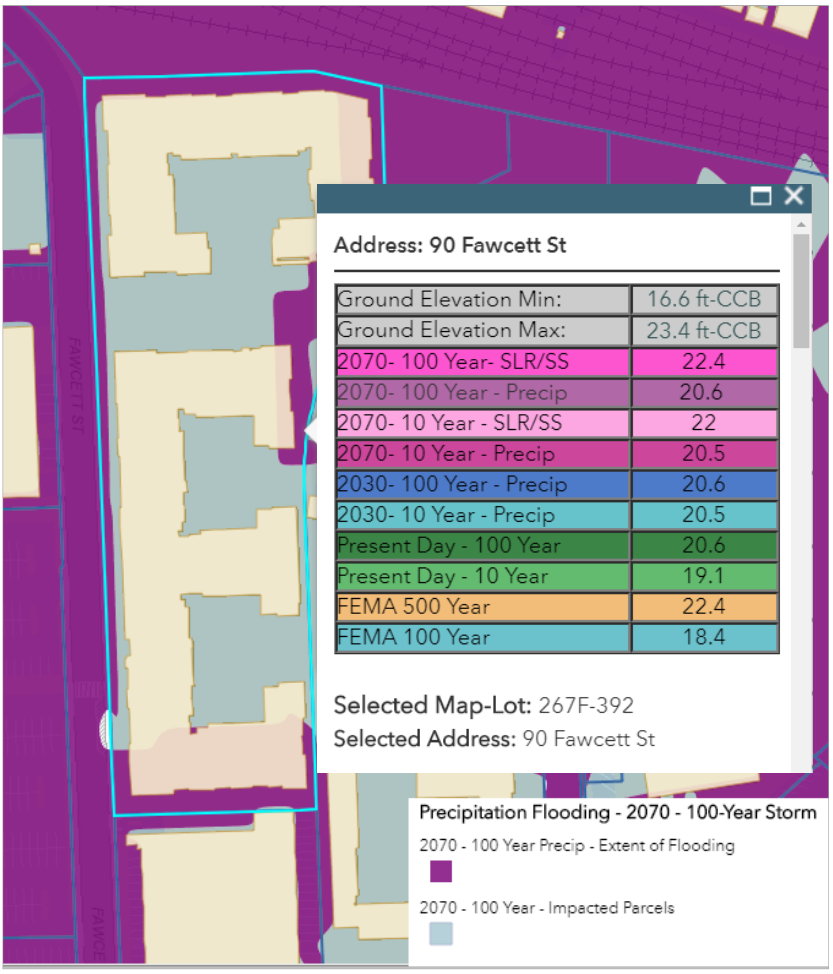
Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	😟	😟	🙂	🙂	🙂	😶

WHY RELEVANT TO ALEWIFE?

By 2070, storm surge modeling shows that large swaths of the Alewife-Fresh Pond area could be subject to annual probabilities of flooding up to 20 percent or once every five years. Flooding can carry contaminants such as fuel from vehicles and homes into buildings and create conditions for indoor mold growth with negative impacts on indoor air quality. Flooding from storm surges may involve salt water and will pose risks to buildings and infrastructure.

The City of Cambridge has created a database where it is possible to asess projected flood elevations at a parcel level. The database will be publicly available to inform residents about the risk and vulnerability of specific buildings and facilities. New buildings in the Alewife Area should be informed by current understanding of Climate Change and flooding risk to the City, to protect new development and contribute to making the neighborhood more resilient.





Draft Visualization tool documenting possible flood elevations per parcel in the Alewife Neighborhood.
Source: (Kleinfelder)

KEY CONSIDERATIONS

- *Impact:*
  - Adapted buildings protected from flooding for the 2070 10-year storm (10% probability). Reduced cost for repair and recovery after the projected 2070 100-year event (1% probability)
  - Reduced impact of dislocation of business or residents and economic impacts resulting from loss of housing or business activity
  - Reduced lost revenue and tax generation
- *Cost:*
  - Cost for new construction can range from marginal to high according to projected flood elevation
  - Consider cost of repairs, displacement or permanent damage to property
- *Equitable:*
  - Preferentially benefits new residents and new affordable housing units
- *Wellness:*
  - Reduces risk of environmental damage (e.g. contamination, mold) caused to buildings by substantial or repeated flooding
  - Reduce risk of spills and contamination from floodwater and debris
- *Feasible:*
  - Tested in other communities and uses national standards
  - If flood elevations are higher than 4 feet, it might negatively impact the public realm and be poorly received by stakeholders
  - Not feasible if zoning or height requirements are not adjusted to allow for limited use of areas below set flood elevations
- *Integrated:*
  - Yes, if coordinated with City infrastructure improvements
  - Yes, contributes to "A Prepared Community" by limiting disruption to extreme events
- *Climate Change Mitigation:*
  - Neutral, does not impact reduction for greenhouse gases
  - Could have a negative impact if pumps to remove flooding water are powered with fossil fuel

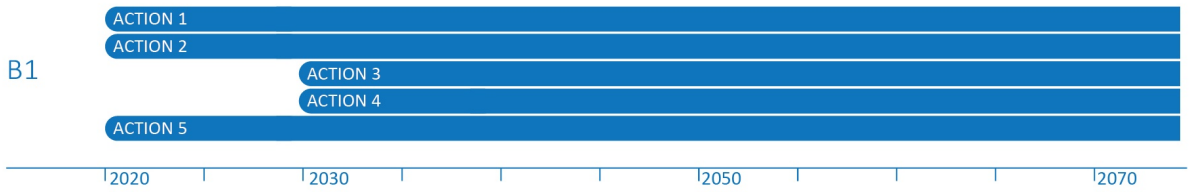
ACTIONS ALREADY BEING TAKEN

- The City is coordinating with developers for new construction to adapt to projected flood elevation for 2070
- The City requires backflow preventers
- Flooding brochure to inform residents

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**Private/Residents**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Regulation**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Parcel/Building/Resident**	

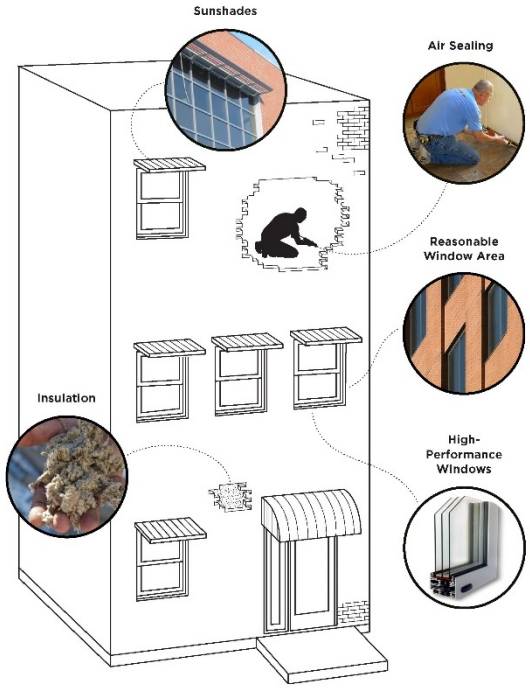
TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood** Precipitation	**Heat**	**Flood** Precipitation	**Flood** Sea Level Rise / Storm Surge
1	2020	ongoing		X		X	X
2	2020	ongoing		X		X	X
3	2030	ongoing		X		X	X
4	2030	ongoing		X		X	X
5	2020	ongoing		X		X	X



RELATED STRATEGIES	**A5, A6, B7, D3**

B2: HEAT PROTECTION FOR NEW BUILDINGS

Establish regulations and design guidelines for new buildings and re-developments to be resilient to future heat risks identified for the neighborhood



High-performance building practices and materials (Source: Urban Green Council)

TOOLBOX / ACTIONS:

1. *Design buildings with passive strategies including building orientation, high-performance insulation and windows, shading and natural ventilation, and white or green roofs*
2. *Require all new buildings to design with a high-performance building envelope (e.g., R-20 minimum wall insulation and R-40 minimum roof insulation, U-0.3 maximum glazing) and limit air leakage (less than or equal to 3 ACH at 50 pascals)*
3. *Design buildings to meet the Passive House Institute US Certification, aiming to design for the projected Climate Zone 3, or to meet the LEED Pilot Credit for Resiliency*
4. *Require buildings to have mixed-mode ventilation systems, which include passive cooling, and install ceiling fans where applicable. Require reflective rooftops with a minimum solar reflectance index (SRI) of 82 (for rooftop slopes less than 10 degrees) and 39 (for rooftops over 10 degrees), non-roof surfaces with a minimum solar reflectance of 0.33, or install green roofs (structural capacity dependent) and green infrastructure*
5. *Maintain mature trees in private and public property. Plant new trees where possible to shade buildings. Advocate for trellises and other site features with vegetative grown shading buildings*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	🙂	😟	🙂	🙂	🙂	🙂

WHY RELEVANT TO ALEWIFE?

Cambridge weather could feel like Northern Virginia by mid-century and South Carolina by end-of-century assuming business-as-usual operation. Average temperatures in the area would increase and annual days over 90

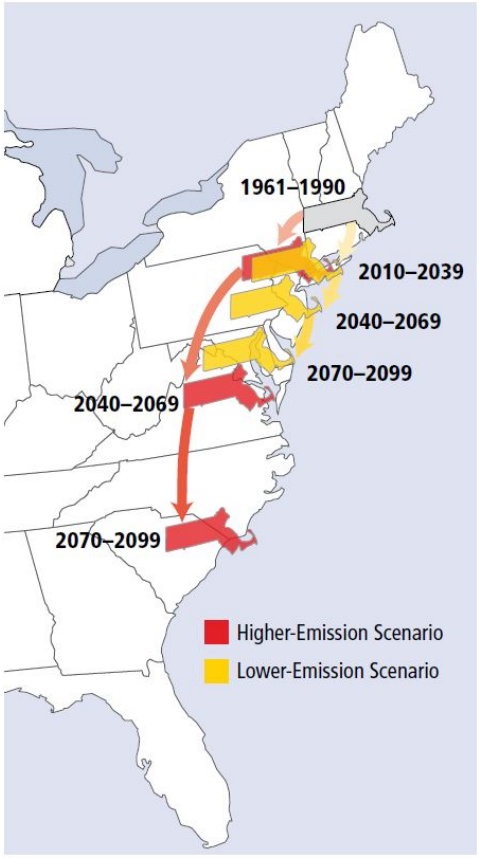
degrees Fahrenheit would increase significantly (several months over 90 degrees Fahrenheit compared with less than two weeks per year, in present day).

More robust building envelopes will help to prevent buildings from falling victim to drastic changes in weather. With a stronger thermal barrier, buildings will be able to more easily maintain comfortable living conditions without increased energy input. Currently, residential buildings have a minimum R-value requirement of R-13 for wall construction (R-12.5 for commercial buildings). For roofing, residential buildings must have a minimum R-value of R-38 and commercial, R-26. The City recommends all buildings to be built with at least R-20 walls and R-40 roofing. In general, exterior continuous insulation (minimum 1" thick) that is well-installed and taped at all seams is a best practice for creating a more robust envelope.

As for window glazing, buildings are currently built with U-values of at most U-0.35 – U-0.45. The City recommends new buildings meet ENERGY STAR qualifications and U-factors of at most U-0.30.

In addition to improving building envelopes, SRI should be considered in building construction. The SRI is a measure of a surface's ability to stay cool in the sun by reflecting solar radiation and emitting thermal radiation. A high reflectivity from cool, white roofs or green roofs will help to reduce the urban heat-island effect. In general, buildings should be designed to meet the Passive House Institute US Certification or meet the LEED Pilot Credit for Resiliency. Passive House considerations should be made based on Climate Zone 3 requirements, as this is the projected future climate zone for Cambridge. Both programs are widely accepted leaders in sustainability and are a good step towards building resilient and efficient buildings.

As additional building heat protection, the City recommends proper maintenance of mature trees in public and private property, planting more trees to provide shade to buildings, and to advocate for vegetative-grown shading. Improved building shading will help to reduce the cooling load on the building. Additional benefits to increased tree coverage are trees' ability to reduce heat-island effects, improve air quality, and increase evapotranspiration.



Projected climate "migrations" for Massachusetts illustrating that average temperature could be compared to South Carolina by 2070. [Source: Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS)].

KEY CONSIDERATIONS

- *Impact:* Designing these systems into new buildings will ensure passive survivability, adaptation to extreme temperatures over time and reduce energy and indoor temperatures, however these measures will not impact the existing building stock
- *Cost:* The recommended systems are minor premiums on new buildings for Massachusetts code and will provide significant savings in energy and the impact on the grid during extreme temperature events. R-40 insulation will have a 10% premium compared to R-25, and green roofs (4") have a $15-20/sf premium

compared to white roofs and low-e glazing up to 30% premium. Passive House Buildings could increase costs approximately 5-15%. Green infrastructure costs vary: $10-18/sf for rain gardens, $9-22/sf for bioswales, $7-16/sf for permeable pavers and $0.10-2/sf for trees

- *Equitable:* The recommended actions will only impact new buildings but will not have an impact on existing, vulnerable communities
- *Wellness:* The reduction of urban heat island and adaptation to extreme temperatures will improve health
- *Feasible:* The recommended strategies are feasible for any new buildings in Cambridge
- *Integrated:* The recommended strategies can integrate with the existing grid and green infrastructure (GI) will be integrated with stormwater management plans
- *CC Mitigation:* The new building strategies will help the City meet other goals such as Net Zero Energy

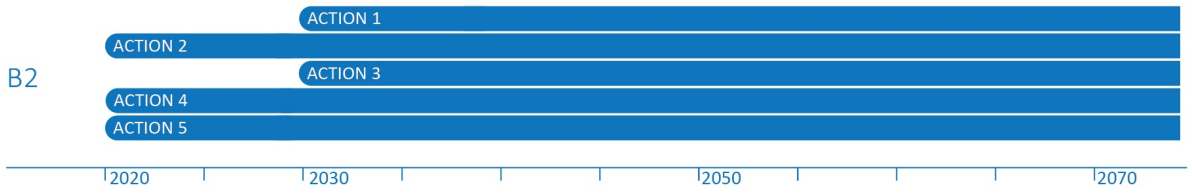
ACTIONS ALREADY BEING TAKEN

- Guidelines and recommendations established for new development including implementing passive strategies, high-performance building envelopes, mixed-mode ventilation with passive cooling, reflective rooftops, and improved tree and vegetation coverage for building shading. These guidelines are in the context of aiming for official certifications such as Passive House or LEED
- Public building capital costs are underway, to revitalize public buildings to meet all proposed requirements
- Massachusetts Energy Stretch Code
- Alewife Overlay District Zoning to preserve and enhance the capacity to store floodwater, recharge groundwater and manage the collection and disposal of stormwater
- Energy-related initiatives (e.g., LEED requirements, energy codes)
- Cooperation with the State and utilities for solar energy and storage

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**Private/Residents**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Regulation**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Parcel/Building**	

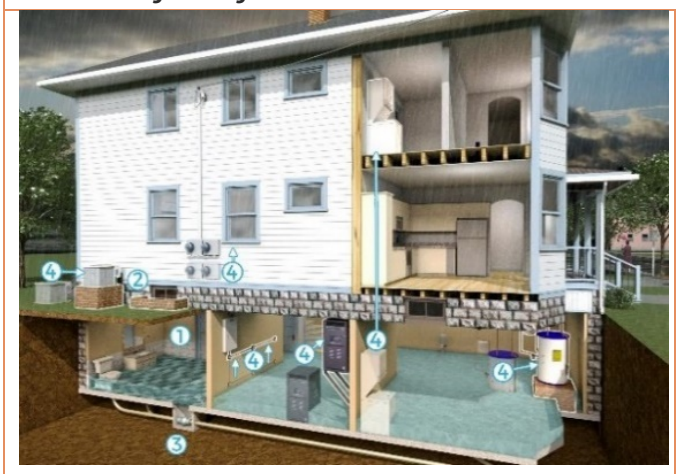
TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2030	ongoing	X		X		
2	2020	ongoing	X		X		
3	2030	ongoing	X		X		
4	2020	ongoing	X		X		
5	2020	ongoing	X		X		



RELATED STRATEGIES	**A2, A5, B4, B5**

B3: FLOOD PROTECTION FOR EXISTING BUILDINGS

Establish a program to support retrofitting of existing buildings and re-developments to be resilient to future flood risks



① Use Flood Resistant Materials
② Build Exterior Floodwalls
③ Install Backwater Valves
④ Elevate/Relocate Utilities

Source: Kleinfelder for the City of Cambridge

TOOLBOX / ACTIONS

1. *Retrofit/protect to the 2070 10-year flood elevation from precipitation or sea level rise/storm surge, whichever is higher*
2. *Retrofit to recover to the 2070 100-year flood elevation from precipitation or sea level rise/storm surge, whichever is higher*
3. *Elevate or protect vulnerable utilities such as fuel storage, furnaces, and electrical panels above 2070 10-year flood elevation*
4. *Use flood resilient construction materials below the 2070 10-year flood elevation*
5. *Relocate electrical panels and main shut-off at or above grade level, not in basement, if substantial renovation being considered*

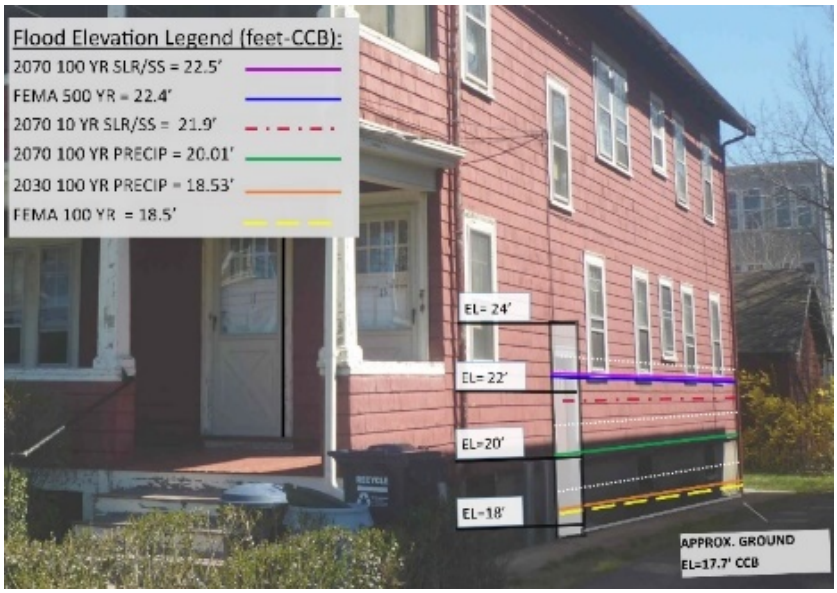
QUALITY OF RESILIENCE:

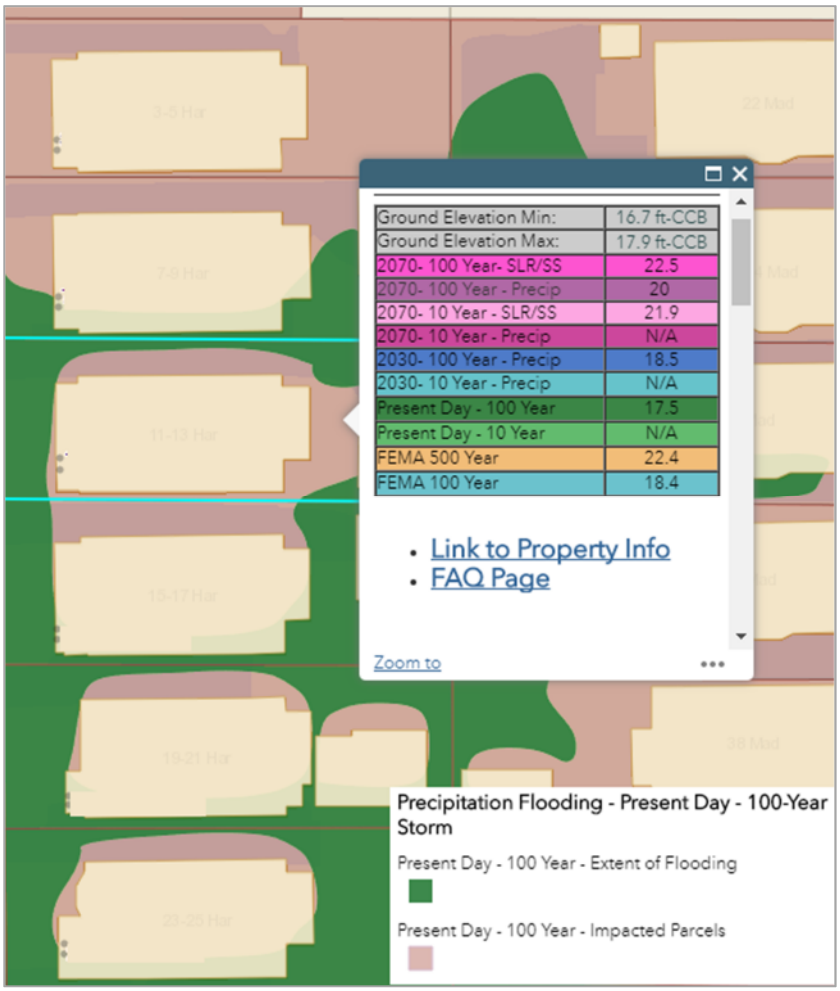
Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	🙂	🙂	🙂	🙂	🙂	🙂

WHY RELEVANT TO ALEWIFE?

By 2070, storm surge modeling shows that large swaths of the Alewife-Fresh Pond area could be subject to annual probabilities of flooding up to 20 percent, or once every five years. The City's Alewife-Fresh Pond area will be the most impacted area by flooding from sea level rise and storm surge. Flooding can carry contaminants into buildings and create conditions for indoor mold growth with negative impacts on indoor air quality. Flooding may involve salt water and will pose risks to populations, buildings, and infrastructure.

The City of Cambridge has created a database where it is possible to assess projected flood elevation at a parcel level. The database will be publicly available to inform residents and businesses about the possible risk and vulnerability of specific buildings and facilities. Many of the buildings in the Alewife Area will need to be upgraded to become resilient to the new climate change threat of flooding caused by extreme events.





Draft Visualization tool documenting possible flood elevations per parcel in the Alewife Neighborhood.
Source: (Kleinfelder)

KEY CONSIDERATIONS

- *Impact:*
  - Reduced cost for repair and recovery
  - Reduced waste of damaged materials to be replaced
  - Reduced lost revenue and tax generation
  - Scalable to avoid dislocation or inequitable cost burdens
- *Cost:*
  - Low to high depending on specific triggering actions
  - Consider cost of repairs, displacement or permanent damage to property
- *Equitable:*
  - May impact lower income homeowners and landlords with disincentive to reinvest
- *Wellness:*
  - A focus on environmental safety has community-wide benefits
- *Feasible:*
  - Needs a sliding-scale approach to ensure compliance and reinvestment
- *Integrated:*
  - Provide for a prepared community
  - Increase wellness by limiting potential exposure to flooding and mold
- *CC Mitigation:*
  - Limited

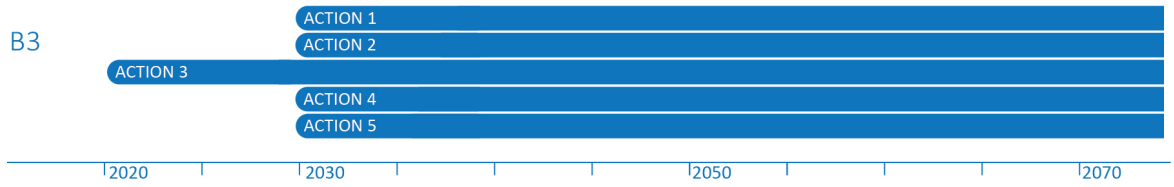
ACTIONS ALREADY BEING TAKEN

- Guidelines and recommendations established for homeowners for flooding strategies to protect facilities
- City requires backflow preventers

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**Private/Residents / City Funds**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**State - Regulation**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Parcel/Building/Resident**	

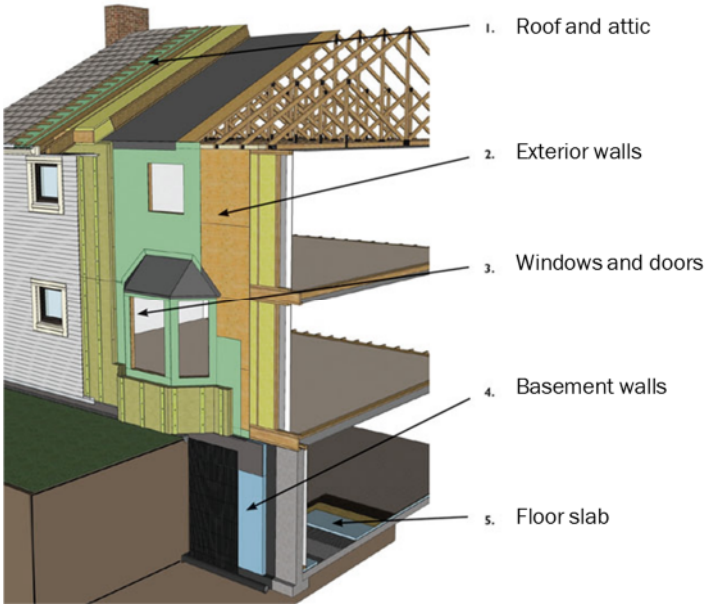
TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2030	ongoing		X		X	X
2	2030	ongoing		X		X	X
3	2020	ongoing		X		X	X
4	2030	ongoing		X		X	X
5	2030	ongoing		X		X	X



RELATED STRATEGIES	**A5, A6, D1**

B4: HEAT PROTECTION FOR EXISTING BUILDINGS

Establish a program to support retrofitting of existing buildings and re-developments to be resilient to future heat risk



Source: Canada Mortgage and Housing Corporation

TOOLBOX / ACTIONS:

1. *Maximize opportunities for natural ventilation and upgrading building mechanical systems and install ceiling fans (where applicable) for improved passive survivability*
2. *Install backup solar energy and storage power systems and separate circuits for critical building loads including AC in "selected cool zone"*
3. *Retrofit rooftops with a minimum Solar Reflectance Index (SRI) of 82 (for rooftop slopes less than 10 degrees) and 39 (for rooftops over 10 degrees), non-roof surfaces with a minimum solar reflectance of 0.33 or install white or green roofs (structural capacity dependent) and green infrastructure in place of grey infrastructure*
4. *Replace windows with low-e glass windows with a U-value maximum of U-0.03*
5. *Encourage temperature control setpoints to maintain higher temperatures during the summertime*
6. *Encourage LEED certification for existing buildings*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	😟	😶	🙂	🙂	🙂	🙂

WHY RELEVANT TO ALEWIFE?

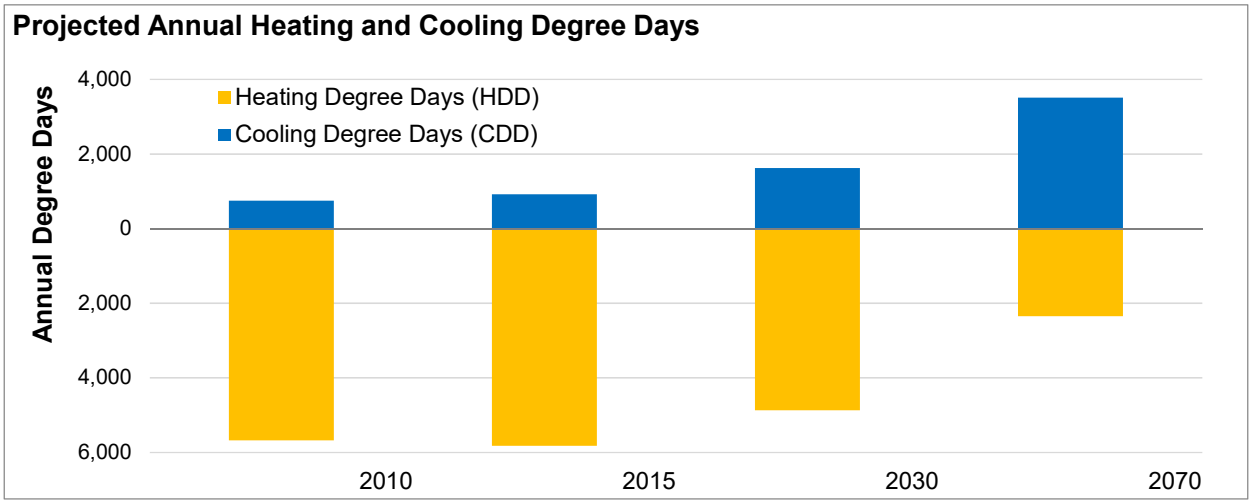
Building weatherization offers proven measures that will save energy and lower energy costs and also help existing homes adapt to days of extreme heat and cold. Examples include re-insulation and air sealing of envelopes to bring the envelope up to current code requirements, window replacements with low-e windows and maximum U-values of U-0.03, and exterior shading and reflective roofing materials. Taking into account project climate stresses, upgrading buildings for Heating Ventilation and Air Conditioning (HVAC) systems will improve ventilation, save energy and adapt to fluctuating temperatures. Additionally, thermostats and temperature control setpoints should

be increased, within the ASHRAE comfort temperature range of 67 – 82°F, to reduce energy consumption and cooling load during the summer.

Existing homes and businesses will be more resilient to CC stresses with access to alternative energy sources such as solar and storage, or natural gas backup generators, in tandem with circuits dedicated to critical equipment. This will reduce possible energy-supply disruption due to increased demand or shortage caused by extreme events.

As additional building heat protection, we recommend proper maintenance of mature trees in public and private property, planting more trees to provide shade to buildings, and to advocate for vegetative grown shading. Improved building shading will help to reduce the cooling load on the building. Additional benefits to increased tree coverage are trees' ability to reduce heat-island effects, improve air quality, and increase evapotranspiration.

By implementing the suggested measures, Cambridge buildings will increase their passive survivability, allowing buildings to maintain a comfortable environment in the case of emergency or lack of power.



Calculations based on Boston, MA, historical and future annual HDD and CDD normals [Source: BuroHappold 2016 for CCPR]

KEY CONSIDERATIONS

- *Impact:* Designing these systems into existing buildings will have a major impact on passive survivability, adaptation to extreme temperatures over time, and reduction of energy and indoor temperatures
- *Cost:* The strategies have very high costs and will be difficult to finance but will yield large energy savings. A weatherization program for a single-family home could cost approximately $5,000 and costs will increase as the size of the building increases. Mechanical upgrades vary in cost depending on the systems in the building. Backup solar and battery storage unit for a single-family home costs approximately $30,000 and costs will increase based on the size of the building. The premium for green roofs on existing buildings could range from $20 per sf (extensive) to $30 per sf if it requires structural retrofits
- *Equitable:* Improvement of existing buildings to survive during heat events will require financing options beyond a home or building owner, to address the most vulnerable populations
- *Wellness:* The reduction of urban heat island and adaptation to extreme temperatures will improve health and wellness
- *Feasible:* The approach to retrofitting existing buildings will need to be planned to determine the most vulnerable and the types of systems to be installed. It will also require coordination with the homeowners and utilities

- *Integrated:* The recommended strategies can integrate with the existing grid as well as the City's stormwater management plans
- *CC Mitigation:* Existing building retrofit will have a major positive impact on GHG emission reductions

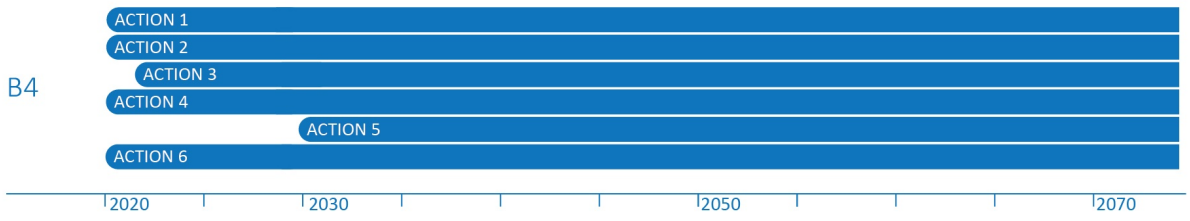
ACTIONS ALREADY BEING TAKEN

- Guidelines and recommendations established for homeowners such as promoting and incentivizing weatherization, improved building envelopes and shading, rooftop reflectivity and low-e windows with improved U-values, encouraging HVAC system replacement and improved ventilation systems and strategies, improved space temperature control and setpoints, and backup solar energy and storage power systems
- Public building capital costs underway to revitalize public buildings to meet all proposed requirements
- Substantial renovations required to comply with new regulations

IMPLEMENTATION CONTEXT

RESILIENCY CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**Partnership**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Policy**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Parcel/Building/Resident**	

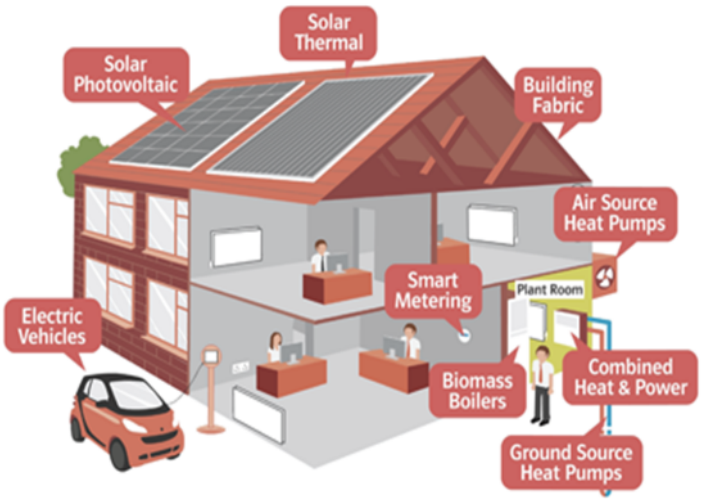
TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2020	ongoing	X		X		
2	2020	ongoing	X		X		
3	2022	ongoing	X		X		
4	2020	ongoing	X		X		
5	2030	ongoing	X		X		
6	2020	ongoing	X		X		



RELATED STRATEGIES	**A2, A5, B2, B5**

B5: BUILDING MANAGEMENT FOR FLOOD AND HEAT PROTECTION

Develop a program to enable building residents and occupants to effectively manage and operate resilient buildings



Source: E.ON Energy

TOOLBOX / ACTIONS:

1. *Require all commercial and multi-family residential buildings over ten units to have a maintenance plan and emergency plan for maintaining, at a minimum, basic service for flood and heat events*
2. *Revisit salt water incursion risk at ten-year intervals*
3. *Require new buildings to include building management systems/smart thermostats and energy management systems*
4. *Ensure all new buildings are "generator ready" and there are transfer switches and quick-connect outlets for existing buildings*
5. *Encourage distributed energy systems (on-site generation) that allow autonomy in new buildings during outages*
6. *Encourage increased tree and vegetative cover and maintenance throughout the city to help buffer heat and flooding*

QUALITY OF RESILIENCE:

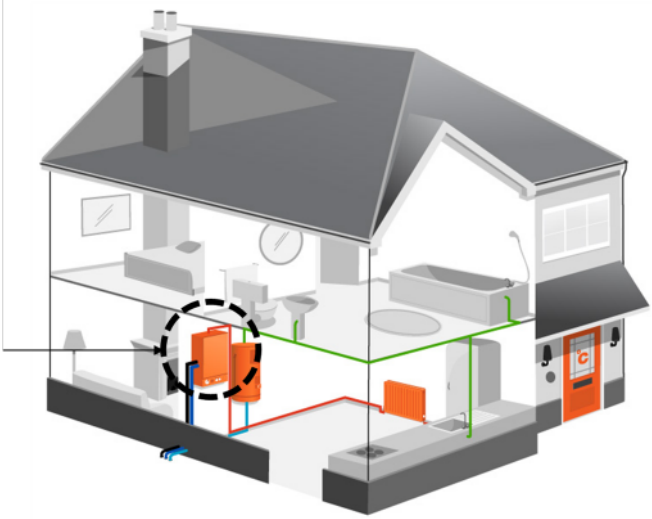
Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	😐	😐	🙂	😐	🙂	🙂

WHY RELEVANT TO ALEWIFE?

Some neighborhoods will inevitably experience regular or episodic flooding, leaving portions of buildings subject to damage. Increasing temperatures similar to current-day Virginia and increasing heat days will potentially leave infrastructure and buildings without power. This will require active management techniques before, during and after events to ensure public safety and reduce damage. Professionally managed buildings can use technology and institute procedures to reduce damage and continue operation. Examples include erecting temporary flood barriers, removing vehicles from floodable areas, elevating or shutting off systems in floodable zones, and managing power to prevent outages and powering critical systems during outages. Even Cambridge's small-scale

buildings can adopt resiliency efforts such as installing back-up generators or solar thermal or photovoltaic (PV) systems, installing smart thermostats and devising emergency plans.

Building maintenance plans are preventative measures that will reduce damage and failure of systems during events. After the event, swift removal of waterborne materials is essential such as pumping standing water, hosing down flood deposits or debris and removing wet or damaged materials before they develop mold. The ability to maintain power to critical systems is also important. Components such as building management systems and energy management systems can localize or reduce energy consumption, as well as communicate to the grid when needed. In addition, installing backup power systems or the ability to quickly connect to emergency power systems is essential.



Micro-CHP for residential and small commercial buildings: Reduces electricity need during normal operation, provides backup heat and power for critical loads (*Source US EPA Combined Heat and Power Partnership)*

Garages and lobbies are a good example of areas that can be managed to recover from flooding events with proper management. Protection of structural elements and electrical systems will require special procedures before and during flood events. In some cases, building entrances and lobbies subject to flooding and can be flooded and quickly recover with small efforts by management. Elevators can be designed to withstand flooding by removing all equipment to upper levels and waterproofing controls within the flood zone.

As additional building heat protection, the City recommends to maintain mature trees in public and private property, plant more trees to provide shade to buildings, and to advocate for vegetative grown shading. Improved building shading will help to reduce the cooling load on the building. Additional benefits to increased tree coverage are trees' ability to reduce heat-island effects, improve air quality, and increase evapotranspiration.

KEY CONSIDERATIONS

- *Impact:* High impact by preventing damage and loss of power, and achieving business continuity without significantly reducing quality of life
- *Cost:* Reduced cost for repair and recovery; low capital costs to put together maintenance and emergency plans, however, higher costs associated with control and backup generation equipment; reduced lost revenue and tax generation. BMS systems could cost approximately $2-10/sf for buildings and smart thermostats could cost $300-700 per customer. Emergency natural gas generators cost approximately $200-300/kW (not including a 20-50% premium for installation including transfer switch). Transfer-switch installation cost approximately $100-300 for a home (depending on type of installation and type/size of generator). Solar and battery-storage systems for single-family homes cost approximately $30,000
- *Equitable:* Upfront capital costs for backup generation may limit residents and small businesses from purchasing equipment without subsidies, and maintenance and emergency plans should be very localized
- *Wellness:* Reduced damage, increased maintenance and clean emergency power reduces waste, improves indoor and outdoor air quality

- *Feasible:* Emergency and maintenance plans and installing smart thermostats are feasible to new and existing buildings however integrating backup power sources to existing buildings could be difficult due to cost and space issues
- *Integrated:* Emergency and maintenance plans are operational measures and controls and backup power are physical measures that integrate solutions that cover building, parcel and infrastructure systems
- *CC Mitigation:* Controls will reduce energy consumption in buildings which will reduce greenhouse gases; PV and battery storage systems are clean emergency power systems that will also provide renewable energy when the grid is connected

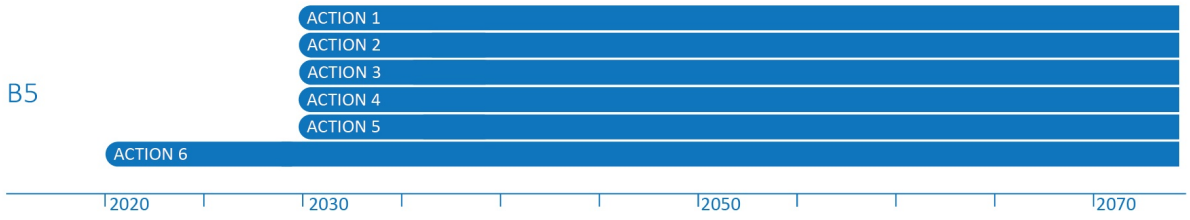
ACTIONS ALREADY BEING TAKEN

- Guidelines and recommendations established for homeowners such as requiring maintenance and emergency plans, revisiting salt water incursion risk at ten-year intervals, requiring building management systems and smart thermostats, ensuring all buildings are "generator ready" and encouraging distributed energy systems

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**Private/Residents**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Regulation**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Parcel/Building/Resident**	

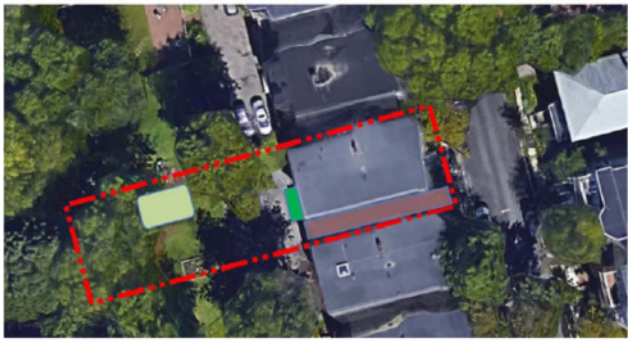
TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2030	ongoing	X	X	X	X	X
2	2030	ongoing		X	X	X	X
3	2030	ongoing	X	X	X	X	X
4	2030	ongoing	X	X	X	X	X
5	2030	ongoing	X	X	X	X	X
6	2020	ongoing	X	X	X	X	X



RELATED STRATEGIES	**D1**

B6: SITE GREEN INFRASTRUCTURE

Implement Green Infrastructure (GI) at parcel level to improve water management and reduce the heat-island effect



LEGEND

Bioretention Basin

Porous Paving – Driveway

Above-ground Planter

GI opportunities on existing parcel (Appendix B: Green Infrastructure Analysis & Urban Heat Island Modeling)

TOOLBOX / ACTIONS:

1. *Implement on-site store/retain/delay strategies for stormwater. Refer to LEED* "Sustainable Sites" and "Water Efficiency" sections for guidelines and implementation. Possible approaches or technologies:*
   - *Use porous (pervious) pavement for driveways and parking stalls*
   - *Install bioretention basins: rain gardens, tree boxes, infiltration planters*
   - *Install green roofs*
   - *Harvest rainwater*
2. *Preserve and Increase tree and vegetative coverage – plant roots absorb water; foliage protects against heat. Revegetate when possible*

*[*LEED refers to the Leadership in Energy and Environmental Design Green Building Rating System as developed and revised by the United States Green Building Council (USGBC)]*

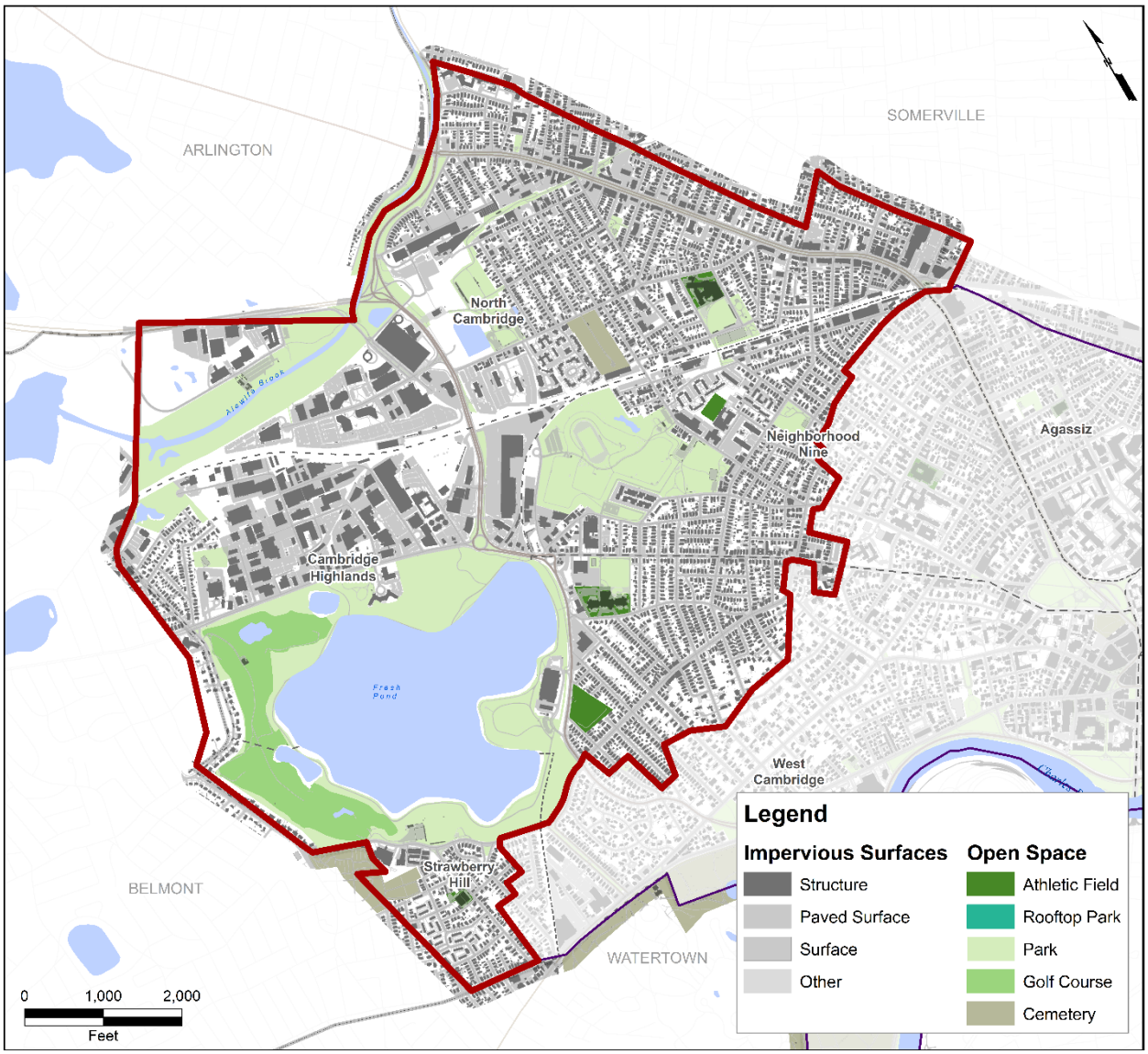
QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	😟	🙂	🙂	😶	🙂	😶

WHY RELEVANT TO ALEWIFE?

The many impervious surfaces – defined as constructed surfaces including buildings, roads, parking lots, brick, asphalt and concrete – in the Alewife area are a significant contributor to surface run-off, thereby impacting stormwater management. Close to 50 % of the urban land in Alewife – excluding the Fresh Pond Reservation – is impervious. Green infrastructure (GI) can supplement the grey infrastructure already in place in Cambridge to increase storage capacity.

Green infrastructure is also proven to be effective in reducing the urban heat-island effect. Urban areas such as Cambridge will see heat vulnerability exacerbated.



Impervious Surfaces and Open Space in the Alewife Neighborhood. Source: City of Cambridge, 2012

The number of days over 90 Fahrenheit are projected to nearly triple by 2030. Such temperature increases are dangerous to public health. GI can reduce the levels of excess energy through absorption and the evaporation of water, and can thus be used to reduce the outdoor temperature in urban areas.

KEY CONSIDERATIONS

- *Impact:* GI and low-impact development (LID) rainwater management strategies provide limited flood storage for the 2030, 10-year storm, and are proven to be effective in reducing the urban heat-island effect
- *Cost:* For the various GI, cost depends on the type of system (thickness, vegetation and use). Costs for green roofs in the United States are estimated to average between $15 to $20 per square foot. These costs include all aspects of green roof development, from the waterproofing membrane to soil substrate creation to planting [Source: Low Impact Development Center, Inc.]. On the other hand, homeowners who choose to incorporate

green roof systems, for example, will find that they quickly pay for themselves due to the resulting reduction in heating and cooling costs as they provide a natural "coat" which improves the building's energy balance

- *Equitable:* Implementing GI, particularly on the parcel scale, would require stricter regulations on new and existing development
- *Wellness:* During the summer months, many urban environments become true "heat islands." GI can reduce the levels of excess energy through absorption and the evaporation of water, and their cooling effect can thus make the city climate more bearable. At the same time dust and toxic particles are filtered out, leading to improvements in the air quality. The view over landscaped roofs and parks on underground garages increases the quality of life. Even a few blooming islands can help to break up the monotony of concrete and asphalt-grey and can thus improve the living environment
- *Feasible:* Work with the project's civil engineer, landscape architect, hydrologist, or other qualified professional to determine design strategies and perform stormwater management calculations. The feasibility can be assessed by identifying the total hardscape area and total applicable roof area inside the project boundary, calculating runoff volume to be managed on site (using rainfall data for the site) and choosing the right approaches or technologies from the toolbox list
- *Integrated:* This strategy addresses GI at parcel level and its implementation would enhance the effects of the Cambridge Envision goals of "Sustainability & Resilience" and "Community Health & Wellbeing"
- *CC Mitigation:* Green infrastructure at parcel level can contribute to a reduction in the household's CO_2 emissions

ACTIONS ALREADY BEING TAKEN

- The City requires buildings of at least 25,000 sf of gross floor area to meet the requirements of the most current applicable LEED building rating system, which includes site GI requirements [Source: The Green Building Requirements, Article 22 "Sustainable Design and Development" of the Zoning Ordinance]
- The City is giving Floor Area Exemptions for Functional Green Roof Area (Zoning Ordinance Article 22, Subsection 22.30)

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**City**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Regulation**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Parcel/Building/Resident**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2020	ongoing	X	X	X		
2	2020	ongoing	X	X	X		

RELATED STRATEGIES	**B7, D1, D3, D4**

B7: ADAPTED ZONING, POLICIES AND REGULATIONS

Revise zoning to factor in Climate Change risks, such as flooding and extreme heat and adjust building requirements to take into account new constraints such as revised flood elevation

The Metro Mayors' Coalition is a groundbreaking coalition made up of 14 communities in Greater Boston. It is a voluntary forum where members exchange information and create solutions to common problems

TOOLBOX / ACTIONS

1. *Amend Cambridge Flood Protection Overlay Districts (20:70) to include projected 2070 10-year events*
2. *Update City of Cambridge Zoning (Article 5.0) dimensional standards to include building height exceptions to factor in flood elevation requirements*
3. *Adopt, in the zoning code, a model "resiliency district" that describes the characteristics that a prepared community would like to see in new developments*
4. *Advocate for the Massachusetts building code 780 CMR to modify definition of base flood elevation to anticipate 2070 flood elevation*
5. *Create tools and resources to enforce the energy code, especially for commercial buildings; advocate for State policies that encourage on-site renewables and zoning barriers such as the ability to serve residents in multiple buildings and ground-mounted solar*
6. *Encourage insurance companies to provide discounts for basic resiliency improvements as recommended in strategies B1 & B3*
7. *Identify funding sources for home owners to incentivize utility improvements (B3)*
8. *Promote and incentivize programs to weatherize, upgrade envelope and shade buildings for improved passive survivability (B4)*
9. *Create incentives for catchment overlay districts for encouraging and supporting implementation of GI in strategic locations where they will have most impact (B6)*

QUALITY OF RESILIENCE:

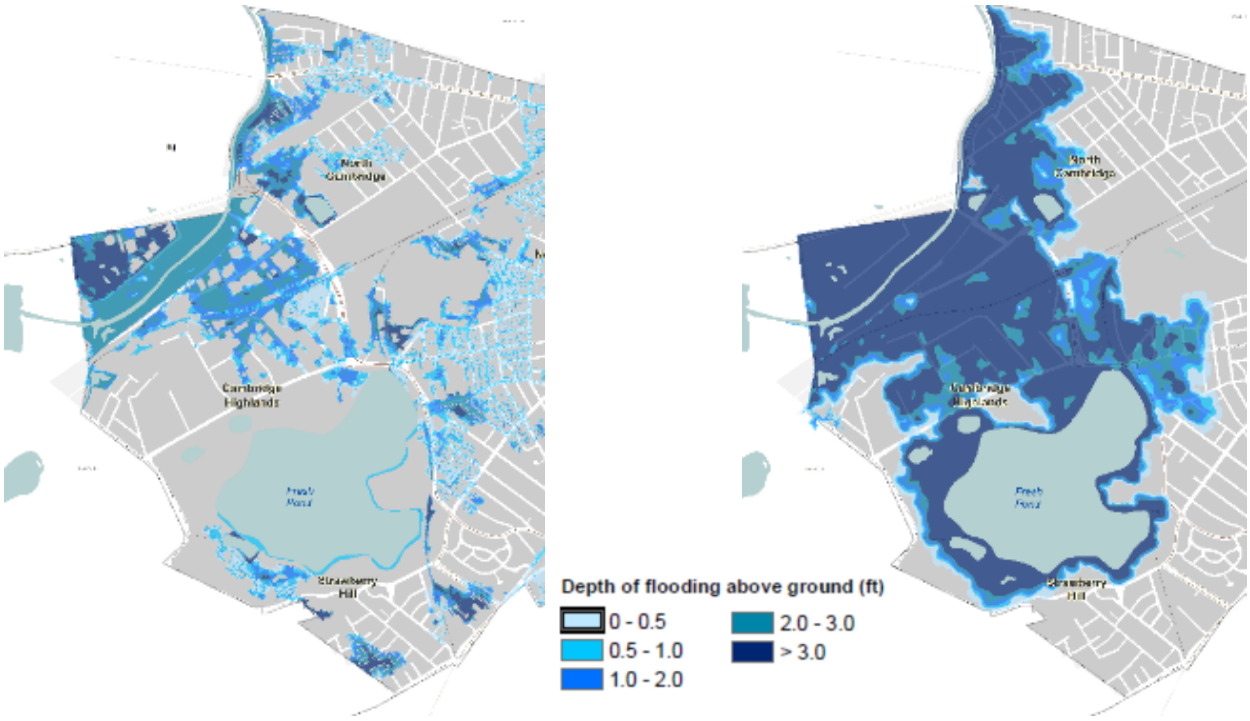
Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
☺	☺	☺	☺	☺	☺	☺

WHY RELEVANT TO ALEWIFE?

The detailed analyses of flooding risks for Cambridge, performed as part of the Climate Change Vulnerability Assessment, demonstrate that risk is not the same within the City. Some areas, such as Alewife, have greater probability of experiencing severe flooding with climate change. As allowed by the City's detailed information, flooding requirements can be targeted to most at-risk areas on a parcel-by-parcel basis, to adapt to projected flood elevations. The advantage of expanding the definition of the flood overlay district to include projected flood levels to 2070, is to provide for a concerted, long-term, urban design approach to develop an enjoyable public realm while protecting buildings from flooding. Establishment of TIFF or TID district or impact fees on new development could target readiness and resiliency efforts to low-income homeowners.

The City will advocate for updating state and model building codes to support climate readiness.

While the energy code proposes more strict requirements, there are gaps between what is required and what gets built, due to inadequate enforcement tools. To complement the energy code, tools and resources should be created to enforce the code, especially for commercial buildings.



2070 100-Year Precipitation **2070 1% probability Sea Level Rise /Storm Surge**

Depth of flood above ground for the Alewife Neighborhood
(Source: Kleinfelder for CCVA Part 1 Revision, 02-2017 & CCVA Part 2)

KEY CONSIDERATIONS

- *Impact:*
  - Adapted areas within Alewife neighborhood protected from flooding for the 2070 10-yr storm (10% probability) and reduced cost for repair and recovery after the projected 2070 100-yr event (1% probability)
  - Reduced impact of dislocation of business or residents and economic impacts resulting from loss of housing or business activity
  - Reduced lost revenue and tax generation
  - District approach allows for minimizing the negative impacts of flood requirements on the public realm
  - Adjusted zoning/height requirements mitigate impact of revised/higher flood elevations
- *Cost:*
  - Change in zoning to adapt to new flood requirements and adjust building heights would decrease the cost impact of proposed measures
- *Equitable:*
  - Control on cost impact and affordable insurance would benefit all residents and businesses
- *Wellness:*
  - Reduced risk of environmental damage (e.g. mold) caused to buildings by substantial or repeated flooding
  - Reduced risk of spills and contamination from floodwater and debris
- *Feasible:*
  - Increased height to allow for revised flood elevations might raise stakeholder concerns
  - Coordinating with insurers even post-Sandy has proven to be difficult
- *Integrated:*
  - The Climate Change Resiliency measures are being tested/integrated in the Citywide Envision plan
- *Climate Change Mitigation:*
  - Reduction of waste, transport and landfill use after storm events

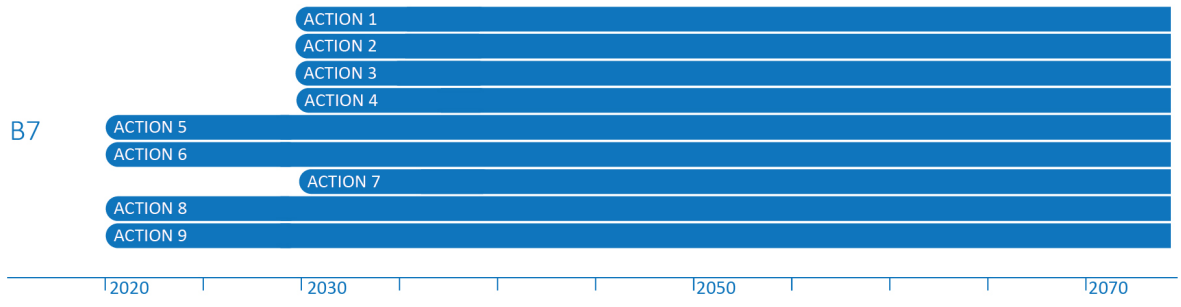
ACTIONS ALREADY BEING TAKEN

- The City is coordinating with developers for new construction to adapt to projected flood elevation for 2070
- Measures developed in the CCPR Alewife Draft Report are being tested in the Envision plan for Alewife
- The City is coordinating with the Metro Mayors' Coalition

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT - identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Partnership	**Partnership**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**State - Regulation**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**City**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2030	ongoing		X		X	X
2	2030	ongoing		X		X	X
3	2030	ongoing		X		X	X
4	2030	ongoing		X		X	X
5	2020	ongoing		X		X	X
6	2020	ongoing	X		X		
7	2030	ongoing		X		X	X
8	2020	ongoing	X		X		
9	2020	ongoing		X		X	



RELATED STRATEGIES	**A5, A8, A9, B1, B2, B3, B4, D5**

STRATEGIES C:
RESILIENT INFRASTRUCTURE

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STRATEGIES C:
RESILIENT INFRASTRUCTURE

OVERVIEW

Strategies for resilient infrastructure range from parcel- to regional-scale solutions for protection of critical infrastructure and mitigation of the negative impacts from both SLR/SS flooding and precipitation flooding. Table C.1 lists the proposed strategies.

Table C.1 List of Strategies for Resilient Infrastructure

STRATEGY	TITLE	DESCRIPTION
C1	PROTECT FRESH POND RESERVOIR	Protect Fresh Pond Reservoir, the terminal reservoir for the City's drinking water supply, from future flooding impacts.
C2	RESILIENCY OF ELECTRICAL DISTRIBUTION SYSTEM	Engage with Eversource and the Massachusetts Public Utilities Commission to increase the resiliency of the electricity distribution system, particularly the Alewife substation.
C3	RESILIENCY OF THE TRANSPORTATION SYSTEM	Engage the MBTA and MassDOT to increase the resiliency of major transportation and transit infrastructure to ensure mobility and access to evacuation routes. Complete street grid by adding new local roads for better connectivity to the Alewife train station.
C4	REGIONAL FLOOD RESILIENCY AT AMELIA EARHART DAM AND OTHER SITES	Collaborate regionally and with the State on structural and operational improvements at the Amelia Earhart Dam. Plan, design and implement storm-surge barriers, "smart" flood prevention systems and conveyance improvements at appropriate sites.
C5	WATERSHED SCALE FLOOD STORAGE	Collaborate regionally to plan and implement watershed-scale flood storage at appropriate sites in the Mystic River watershed.
C6	SUB-NEIGHBORHOOD SCALE FLOOD PROTECTION	Create a neighborhood solution for sea level rise/storm surge flooding for the extended Quadrangle area and Fresh Pond.
C7	COMBINED SEWER SEPARATION	Continue combined sewer separation in the Alewife area to reduce adverse public-health impacts during flood events and to protect water quality.

C8	STORMWATER STORAGE	Evaluate the collective benefits of adopting updated stormwater storage requirements at the parcel scale to mitigate flooding at the sub-neighborhood scale.
C9	CLEAN ENERGY FACILITY	Establish a neighborhood-scale clean energy facility in the Alewife Quadrangle area.

BEST PRACTICES

Resilient infrastructure is being used in many U.S. cities already experiencing the impact of climate change. These models provide a library of possible strategies informing the City's approach toward preparedness and resiliency. Best practices documented in this section address flood control, innovative street design, an enhanced approach to energy production and distribution, and integrating clean energy.

Flood Control

The Big U, New York City, New York

The Big U is a $500M resiliency project in New York City, New York, that proposes to protect Manhattan from flooding. This project involves installing flood barriers around 3 sections of the City including East River Park (Figure 1), Two Bridges and Chinatown, and Brooklyn Bridge to the Battery. This project also aims to make protective measures one of the City's attractions by offering waterfront access for leisure along one berm, constructing an educational facility where visitors can observe tidal variations and sea level rise behind another berm, and adding artwork to deployable floodwalls.

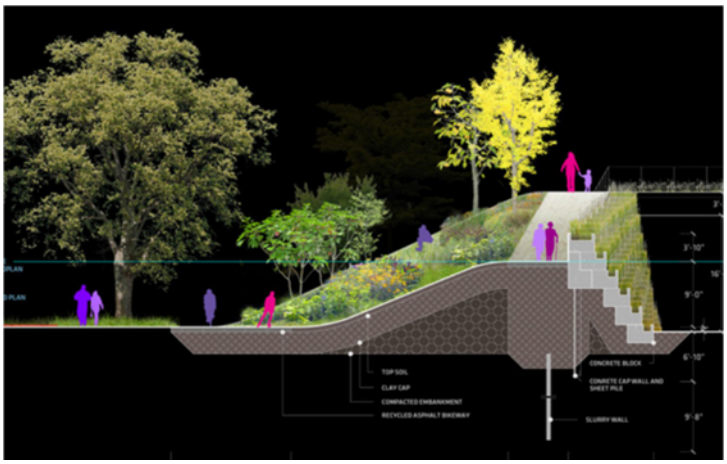

Figure 1. Raised berm for flood protection [Source: Rebuild By Design]

EcoRoof Incentives, Portland, Oregon

The City of Portland, Oregon, offers incentives for EcoRoofs, more commonly known as green roofs (Figure 2). Buildings with 60% or more green roof coverage are allowed to have higher development rights or Floor Area Ratio (FAR). The formula is for an additional three square feet of development for any additional square foot of green roof – above the 60% threshold. The City of Austin, Texas, adopted a similar program by adopting a Green Roof Density Bonus, which can give a density bonus of up to eight square feet for every square foot of green roof installed.

Figure 2. Portland Green Roof [Source: Portland Environmental Services, Portland, Oregon]

Park Designed for Stormwater Storage, Pittsburg, Pennsylvania

The City of Pittsburgh, Pennsylvania, has implemented "The Vision Plan for Pittsburgh's River Fronts" (Figure 3). One of the goals of the plan is to integrate sustainability into the design of riverfront development. Strategically designing parks and other vegetation along the riverfront allows for stormwater storage during heavy rainfall events and helps to preserve the water quality of the river through this intended buffer. The open space is used efficiently for stormwater storage during extreme events.

Figure 3. Open space planning in North Shore, Pittsburgh. The park was designed to collect and cool stormwater before release into river habitat [Source: Riverlife Task Force, Pittsburgh, PA]

Innovative Street Design

Canal Streets, Copenhagen, Denmark

Some streets in Copenhagen, Denmark, are designed as "canal streets." Canal streets use lowered street profiles (Figure 4) that form a flood pathway or corridor, directing stormwater away from public spaces. Abutting open spaces and bio-retention basins aligned with streets also contribute to store some excess stormwater if the corridors overflow due to a heavy rainfall event.

Before *After*

Figure 4. Integrated green and grey infrastructures to maximize the public realm for flood resiliency [Source: City of Copenhagen]

Raised Streets, Miami, Florida

Miami, Florida, is making efforts to elevate streets (Figure 5) to protect the community from rapidly increasing sea-level rise/storm surge impacts. This approach protects the roadways and requires redesigning buildings' accesses to adjust to the higher street elevations.

Figure 5. Raised street and sidewalk, Sunset Harbour, Miami, FL [Source: The Miami Herald]

Buildings as Flood Walls

HafenCity, Hamburg, Germany

In HafenCity, on the exposed windward sides, the external perimeter will actually lie at 8 to 9 meters above sea level[1]. It is the responsibility of the private developers of buildings to put these artificial compacted bases in place, so their number is growing as the number of buildings increases. This has dispensed for premature financing of flood-protection measures years - or even decades – ahead of the sale and deployment of the sites concerned.

Figure 6. Flood Protection Gates to achieve a Flood Protection Level [Source: HafenCity, Hamburg, Germany]

[1] [Source: http://www.hafencity.com/en/concepts/flood-secure-bases-instead-of-dikes-safe-from-high-water-in-hafencity.html]

Enhanced Energy Systems

Off-the-Grid Solar Array, New York City, New York

New York City provides residents with 3.5 kW of power through an off-the-grid solar array with battery storage. The array is elevated and uses air-tight construction. It was able to generate electricity for small uses such as mobile-device charging after Hurricane Sandy in 2012 while the surrounding areas lost power.

Figure 7. Solar panels on the rooftop of a building in Brooklyn, New York City, NY. [Source: Reuters]

Microgrids

Microgrids are small-scale distribution systems that link multiple distributed energy resources (DERs) into a network that can generate, store and control its own power. Microgrids can operate in tandem with the main power grid during normal conditions but can disconnect and function as independent "islands" if the main grid fails.

Microgrids founding program, State of Connecticut

In July 2012, Connecticut's Governor Dannel Malloy passed legislation demanding an improvement to the state's emergency preparedness and response efforts. In turn, Connecticut became the nation's first state to develop a program that funds the development of microgrids at critical facilities. Critical facilities eligible for the program are: hospital, police station, fire station, water treatment plant, sewage treatment plant, public shelter, correctional facility, municipal center, telecommunications equipment, gas station, pharmacy and grocery store. The Town of Fairfield was among the first recipients of a grant award as a result of the new law[2].

Figure 8. Fairfield Town and Connecticut State officials at the unveiling of the municipal microgrid system on October 29, 2015. [Source: Fairfield Daily Voice]

[2] http://se-enable.com/wp-content/uploads/MG_Fairfield-Case-Study_Digital.pdf

The City constructed a 310-350 kW hybrid microgrid that serves three critical facilities (Police Headquarters, Fire Headquarters, and Operations Hope) over 2.5 acres. The project included the following elements: upsizing a 50-kW natural gas-fired generator to 60-kW generator by computer adjustment, replacing the diesel-fired emergency generator at the Police Headquarters with a natural-gas generator installed above the 100-year floodplain, and interconnecting all three buildings for electric service. The City installed a 20-kW photovoltaic system on Operation Hope's roof, a 27-kW Photovoltaic generator was placed on the Fire Headquarters roof, and a state-of-the-art controls system was installed at the Police Headquarters to insure that the correct amount of electricity is delivered to each facility as needed, with green power having preference.

Hardened Electrical System, Averne, New York

Efforts in Arverne, New York, are making the electrical distribution system more resilient in response to damages due to Hurricane Sandy. Electrical lines are hardened by burying them underground to prevent damage from extreme weather. Additionally, transformers have been made waterproof and elevated. All mechanical systems are required to be on upper floors to prevent flooding.

Figure 9. Arverne, NY [Source: Arverne by the Sea, NY. September, 2014. ULI]

Cogeneration Plant, New York University, New York

Cogeneration (cogen) uses a heat engine or power station to simultaneously generate electricity and useful heat (Figure 10). Like microgrids, cogen plants can operate as independent "islands" in the event of a grid failure.

During and after Hurricane Sandy in 2012, when Con Edison's electrical grid shut down in Manhattan below midtown, New York University (NYU) benefited from its cogen plant, which was built in 2011. The plant at NYU produces electricity, hot water, heat, and chilled water. Once the plant's controls sensed that power was not flowing from the grid, the plant automatically isolated itself and began operating independently.

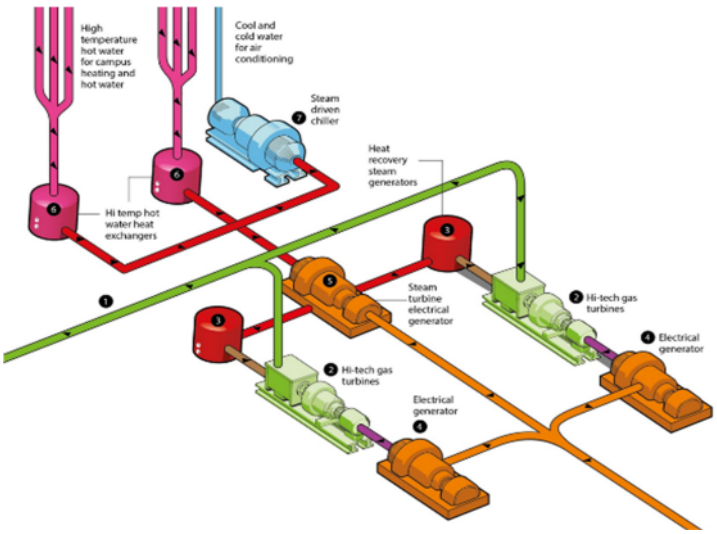

Figure 10. Gas-fired cogeneration plant [Source: New York University]

The 22 buildings connected to NYU's cogen plant for electricity continued to have power, heat and hot water, then reconnected to the grid once Con Edison was able to restore power.

Smart Power, Salem, Oregon

The City of Salem, Oregon, provides backup power for the regional grid via a 5-MW lithium-ion battery capable of storing 1.25 MWh of energy. The center is designed to test how to better integrate renewable energy with inconsistent supply, such as solar and wind power, into the electrical grid. It utilizes stored renewable energy during peak energy loads and helps to stabilize the grid during power outages. The Smart Power Center has demonstrated the ability to access power from third-party generators to create a microgrid that can serve about 500 business and residential customers in southeast Salem.

RELEVANCE TO ALEWIFE

Table C.2 below provides a summary of how the best practices inform the development of specific strategies for Resilient Infrastructure.

Table C.2 List of Strategies and Related Best Practices

STRATEGY	TITLE	RELATED BEST PRACTICE	DESCRIPTION/ RELEVANCE TO ALEWIFE
C1	PROTECT FRESH POND RESERVOIR	***The Big U, New York City, New York***	The Big U provides for resiliency infrastructure measures by combining amenities for recreational uses along berms also protecting from flooding.
C2	RESILIENCY OF ELECTRICAL DISTRIBUTION SYSTEM	***Hardened Electrical System, Averne, New York***	Arverne, New York is making its electrical distribution system more resilient in response to damages due to Hurricane Sandy by evaluating a series of measures. E.g. transformers to be made waterproof and elevated and for mechanical systems to be on upper above projected flood elevations.
		Smart Power, Salem, Oregon	Smart Power integrates renewable energy with inconsistent supply, such as solar and wind power, into the electrical grid to be able to use stored renewable energy to peak energy loads and helps to stabilize the grid during power outages.
C3	RESILIENCY OF THE TRANSPORTATION SYSTEM	***Raised Streets, Miami, Florida***	The raised streets protect from flooding and maintain accessibility. This approach requires redesigning buildings' accesses to adjust to the higher street elevations.
		Canal Streets, Copenhagen, Denmark	The Canal Streets form a flood pathway corridor, directing stormwater away from public circulation. The abutting open spaces and bio retention basins are also contributing to store some excess stormwater if the corridors were to overflow due to a heavy rainfall event.
C4	REGIONAL FLOOD RESILIENCY AT AMELIA EARHART DAM AND OTHER SITES	***The Big U, New York City, New York***	The Big U is proposing different approaches for flood protection adapted to different urban conditions in 3 sections of New York City: the East River Park, Two Bridges and Chinatown, and Brooklyn Bridge to the Battery.

C5	WATERSHED SCALE FLOOD STORAGE	***Park Designed for Stormwater Storage, Pittsburg, Pennsylvania***	The open space system is maximized for stormwater storage during extreme events and helps preserve the water quality of the river through this intended buffer.
C6	SUB-NEIGHBORHOOD SCALE FLOOD PROTECTION	**Buildings as Flood Wall. *HafenCity, Hamburg Germany***	Building facades are designed as a continuous flood wall.
C7	COMBINED SEWER SEPARATION	*Recognized Best Practice*	*Recognized Best Practice*
C8	STORMWATER STORAGE	***EcoRoof Incentives, Portland, Oregon***	The EcoRoof (green roof) incentives allow for the implementation of stormwater storage at the parcel-scale that are intended to benefit the neighborhood.
C9	CLEAN ENERGY FACILITY	***Off-the-Grid Solar Array, New York City, New York***	The City provided power to residents through an off-the-grid solar array with 3.5 kW of power and battery storage.
		Microgrids founding program, State of Connecticut	Connecticut became the nation's first state to develop a program that funds the development of microgrids at three critical facilities (Police Headquarters, Fire Headquarters, and Operations Hope).
		CoGen Plant, New York University, New York	During and after Hurricane Sandy in 2012, when Con Edison's electrical grid shut down, New York University (NYU) benefited from its cogen plant. The plant operated independently. The 22 buildings connected to NYU's cogen plant for electricity continued to have power, heat and hot water, then reconnected to the grid once Con Edison was able to restore power.

The draft strategies are described in detail in the following pages.

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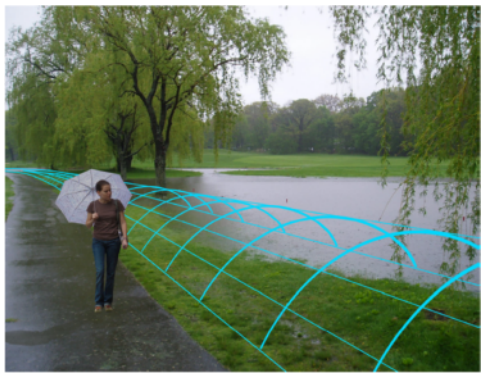
C1: PROTECT FRESH POND RESERVOIR

Protect Fresh Pond Reservoir, the terminal reservoir for the City's drinking water supply, from future flooding impacts



Option for flood wall along the perimeter of Fresh Pond

TOOLBOX / ACTIONS:

1. *Evaluate building a vegetated berm at elevation 23.15 feet-CCB[3] along the Fresh Pond Golf Course*
2. *Evaluate building a flood wall at elevation 23.15 feet-CCB[3] along the perimeter of Fresh Pond*
3. *Evaluate building a flood wall at elevation 23.15 feet-CCB[3] in elevation south of the railroad track along the Alewife Quadrangle*

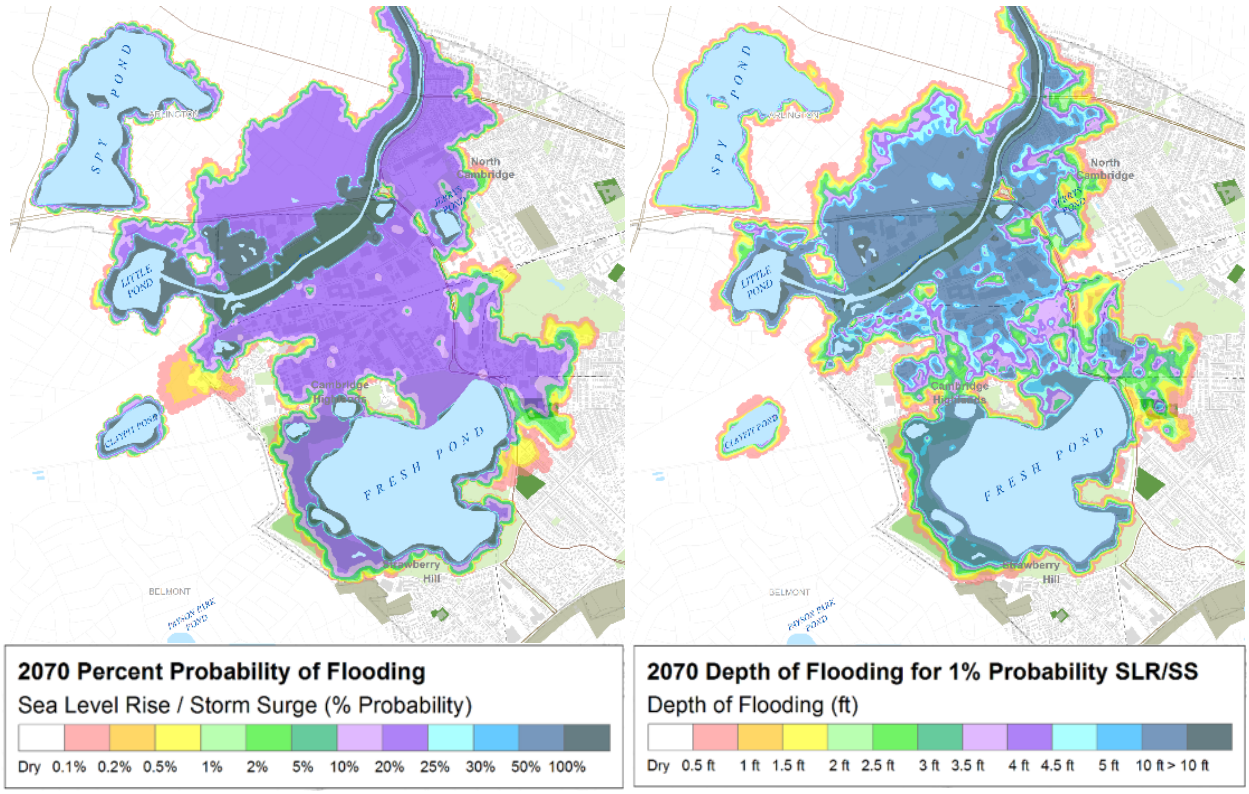
QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	😶	🙂	🙂	😶	🙂	😟

WHY RELEVANT TO ALEWIFE?

Fresh Pond is an "Outstanding Resource Water" because it is part of the drinking water supply system for the City of Cambridge. Discharges to Fresh Pond are therefore regulated by water-quality standards. By 2070, during a 5-year storm (a storm that can occur once in 5 years, or has a 20% probability of occurring in any given year) or more intense storm surge scenarios, significant untreated discharges could occur once the Pond's elevation exceeds the point at which it is isolated from surrounding areas. The area that the Pond could effectively be connected to includes railway and areas zoned for industrial uses, which may contain hazardous materials.

[3] CCB stands for Cambridge City-base datum, which is vertical reference datum that the City uses. The CCB datum is 11.35 feet below the mean sea level in Boston, MA



Percent Probability of Flooding (%, left) and Depth of Flooding (ft, right) in year 2070 for the Cambridge Alewife Neighborhood. Source: CCVA – Part 2

KEY CONSIDERATIONS

- *Impact*: These strategies would effectively protect the Fresh Pond Reservoir for up to the 2070 100-year sea-level rise/ storm surge storm event. The flood wall along the railroad track would also protect the neighborhood in the Alewife Quadrangle
- *Equitable*: These strategies help to preserve water-quality standards in Fresh Pond, which serves as the drinking water supply to the City of Cambridge
- *Feasible*: The berm and the flood wall around the Fresh Pond seem most feasible options. The flood wall along the railroad tracks would pose some permitting issues due to a portion of it being in the present FEMA 100-year flood zone, as well as its proximity to the railroad
- *Integrated*: Protecting the Fresh Pond Reservoir from future climate change impacts is aligned with Envision Cambridge, as it would effectively make the City more resilient. It also preserves the water quality of the City, which is a primary public-health benefit to the community

ACTIONS ALREADY BEING TAKEN

- Raised southernmost hummock in Fresh Pond Community Gardens to 2070 projected 100-year (1%) SLR/SS flood elevation of 23.15 feet-CCB
- All proposed hummock in the Fresh Pond Reservations will be designed at or above the 2070 projected 100-year (1%) SLR/SS flood elevation of 23.15 feet-CCB
- The first floor of the Water Treatment Plant is at 24 feet-CCB, which is above the 2070 projected 100-year (1%) SLR/SS flood elevation

IMPLEMENTATION CONTEXT

RESILIENCE CARD							
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization					**Owners/ Facilitators**	**Financing Options**	
					City	**City**	
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"					**CC Preparedness Measure**		
JURISDICTION for monitoring the enactment of the strategy					**City - Owner**		
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region					**Neighborhood**		
TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2030	20					X
2	2030	20					X
3	2030	20					X

RELATED STRATEGIES	**C6**

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C2: RESILIENCY OF ELECTRICAL DISTRIBUTION SYSTEM

Engage with Eversource and the Massachusetts Public Utilities Commission to increase the resiliency of the electricity distribution system, particularly the Alewife substation

Transmission lines

TOOLBOX / ACTIONS:

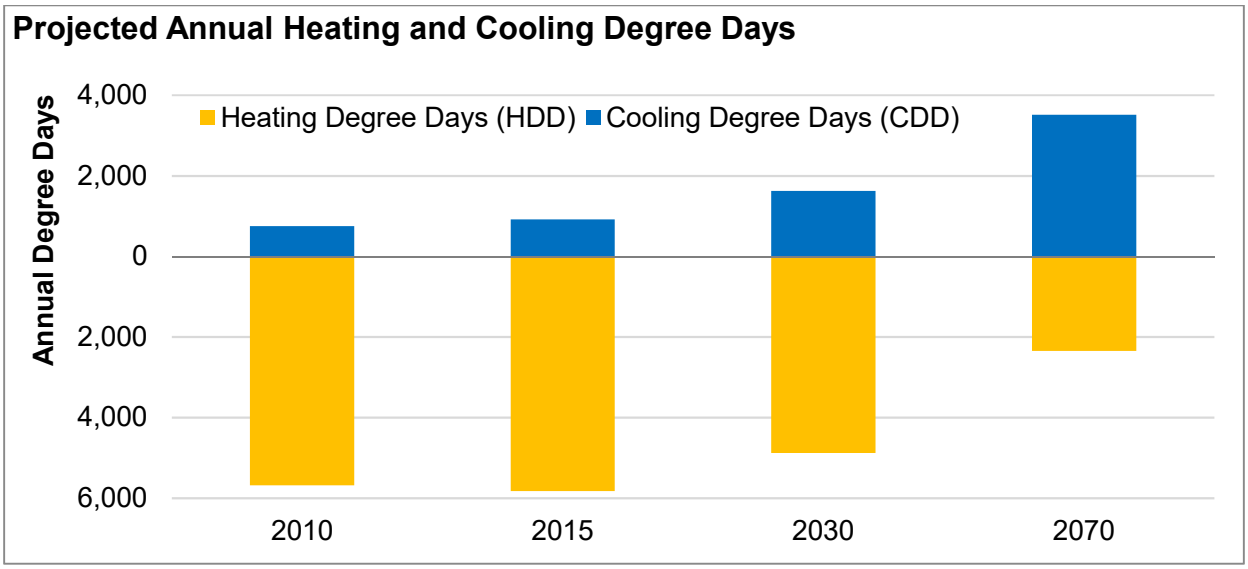
1. *Evaluate hardening overhead lines*
2. *Analyze sectionalizing and increasing redundancies in the distribution system*
3. *Evaluate elevating and protecting the North Cambridge substation*
4. *Evaluate the implementation of "Smart Grid" technology*
5. *Advocate for State to develop a program that funds the development of microgrids at critical facilities*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
						
						

WHY RELEVANT TO ALEWIFE?

A resilient electrical distribution system is important for the welfare of a city. The North Cambridge substation powers all of North Cambridge, exposing this area to power outages. Strain on Cambridge's electrical grid will continue to increase if resiliency measures are not taken, as increased energy demands from extreme heat will impact peak energy loads. The Alewife area is also one of the most vulnerable areas of Cambridge, with a relatively high population of elderly, and lower socioeconomic status. Power outages will affect this vulnerable population most severely. Seniors who do not have access to air conditioning due to a power outage are more likely to experience negative health impacts. Additionally, power outages have an economic impact as they put the community at risk from economic loss due to disruption of business.



Source: Petri, Y. and Caldeira, K. **Impacts of global warming on residential heating and cooling degree-days in the United States (2015)**, and BuroHappold analysis

KEY CONSIDERATIONS

- *Cost:* The cost for hardening overhead lines and sectionalizing the distribution systems is likely prohibitive. Cost may be mitigated by using a targeted approach. Elevating the North Cambridge Substation would have the most widespread cost-effective benefit for the community. Smart Grid technology is in the initial stages of development, and there is minimal data regarding relative cost
- *Wellness:* A resilient electrical system will provide uninterrupted cooling, and in return, mitigate negative health impacts caused by extreme heat
- *CC Mitigation:* Hardening overhead lines, elevating substations and transformers, and sectionalizing the distribution system will not mitigate climate change. However, implementing Smart Grid Technology will help to mitigate climate change, as it allows for the integration of renewable energy systems that produce less greenhouse gas emissions

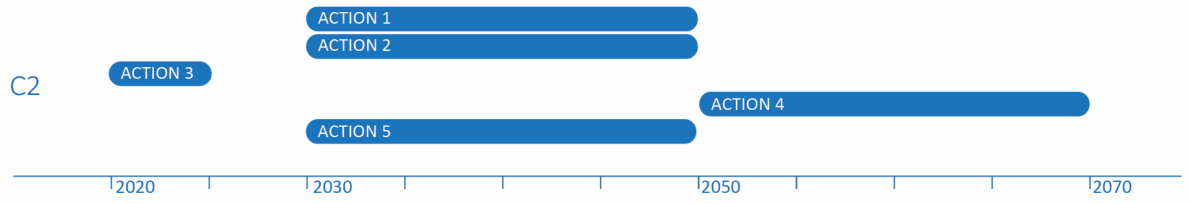
ACTIONS ALREADY BEING TAKEN

- Coordination with Eversource Electric to ensure power needs are met and engaging Eversource as part of stakeholder discussions so that future climate risks are appropriately communicated and potential solutions are determined collaboratively
- Eversource is making significant investments in the local electric grid to harden and make it resilient to extreme storms
- Transmission redundancy among Prospect Substation and un-impacted generation within the City (e.g. at the Veolia-Kendall Cogeneration Station)

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**Private Corporation**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Owner**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**City**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2030	20	X	X	X	X	X
2	2030	20	X		X		
3	2020	5		X		X	X
4	2050	20	X		X		
5	2030	20	X	X	X	X	X



RELATED STRATEGIES	**A4, A5, A6**

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C3: RESILIENCY OF THE TRANSPORTATION SYSTEM

Engage the MBTA and MassDOT to increase the resiliency of major transportation and transit infrastructure to ensure mobility and access to evacuation routes. Complete street grid by adding new local roads for better connectivity to the Alewife train station

Sand Barrier at Fenway Portal (Green Line) during heavy precipitation event, March 2010. (Source: Climate Change Resiliency at the MBTA, September 29, 2016)

TOOLBOX / ACTIONS:

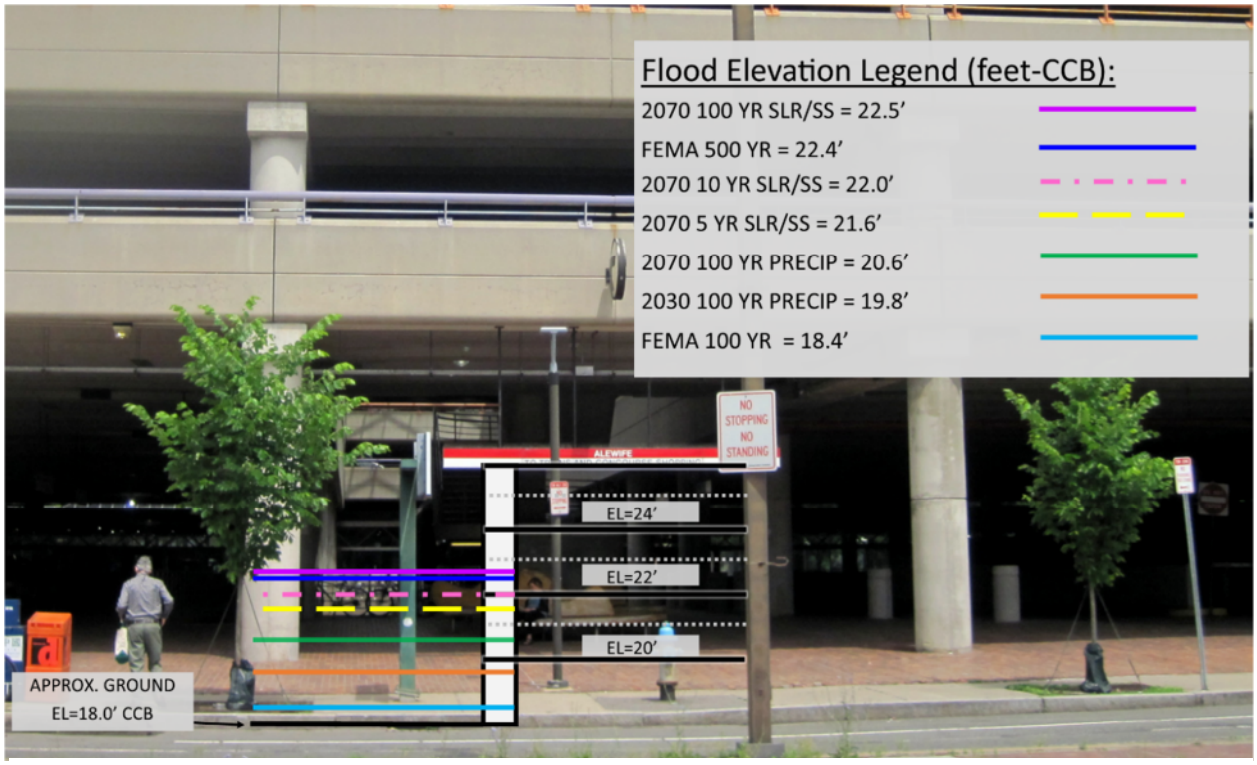
1. *Protect utilities serving the MBTA, such as energy, telecommunications, water*
2. *Plan for alternative evacuation routes*
3. *Evaluate a distributive, multi-modal transportation network by completing the street grid and making better connections and redundancies to the MBTA subway*
4. *Evaluate the installation of flood barriers around the MBTA station*
5. *Provide detour routes around flooded roadways*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
😐	😟	🙂	🙂	😐	🙂	🙂

WHY RELEVANT TO ALEWIFE?

The subway lines take 10,000 riders to six Cambridge stations each day, and 33 Cambridge public bus routes carry 85,000 passenger trips every week. Approximately 25% of residents who do not own cars rely on public transit as their primary means of transportation. Impacts to any part of the subway have potential to affect the entire system, as there is little redundancy within the subway lines. Alewife is the only Cambridge subway station with commuter parking (which currently exceeds demand), accommodating 2,733 motor vehicle spaces and 174 bicycle spaces. Alewife is also at risk for 2030s inland flooding. Transit systems in Cambridge were not designed or adapted to cope with significant exposure to inland flooding. Pumping stations are likely inadequate, and there are few, if any, barriers to limit the penetration of flood waters into sensitive areas. Additionally, equipment may not be sufficiently raised off the ground. The rail used in MBTA subway lines is conditioned to operate optimally at around 80°F, above which, the risk of buckling increases as heat rises. Additionally, many roadways and intersections in the Alewife area are at risk from flooding in the 10-year, 24-hour rainfall event. Roadway flooding has the cascading impact of restricting law enforcement and public safety in Cambridge.



Alewife Garage Flood Elevations. Source: Kleinfelder

KEY CONSIDERATIONS

- *Impact:* Providing detours, and planning for alternate evacuation routes are not effective long-term strategies, as they do not offer a solution to roadway or transit failure. Additionally, creating distributive, multi-modal transportation networks will make system failure less widespread, but does not prevent the tracks from buckling under extreme heat or prevent exposure to inland flooding. Protecting utilities, and designing flood barriers have the most significant impacts on transportation and transit infrastructure
- *Cost:* The cost of creating distributive, multi-modal transportation networks will be substantial and disruptive to the community during construction
- *Feasible:* The cost of creating distributive, multi-modal transportation networks will not be as feasible as other toolbox options due to high cost, disruption to the community, and permitting challenges
- *Integrated:* Improving the resiliency of major transportation and transit infrastructure is aligned with Envision Cambridge's vision to support substation transportation with access to daily needs
- *CC Mitigation:* the creation of a distributive, multi-modal transportation system will mitigate the GHG impact

ACTIONS ALREADY BEING TAKEN

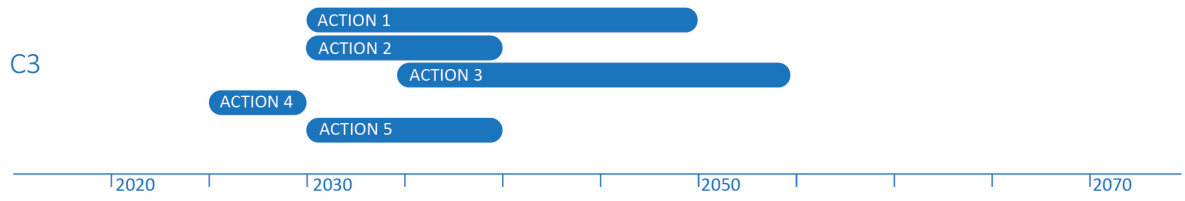
- Enable trains to safely cross over lightly-buckled track sections by reducing speed while the ambient temperature is above 90°F
- Single track trains when a section of rail is shut down due to flooding or heat
- Provide shuttle buses when a section of rail is shut down due to flooding or heat
- Both MassDOT and MBTA are in the process of identifying their most vulnerable transportation and transit assets/infrastructure, as well as developing their resiliency plans

- MassDOT is completing its final design for installation of removable flood walls at three locations, completing construction of tide gates at vulnerable outfalls and assessing the conditions of stormwater outfalls and tide gates to understand their vulnerability to sea level rise and storm surge by 2030

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Government (other than City)	**Government (other than the City)**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Policy**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**City**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2030	20	X	X	X	X	X
2	2030	10		X		X	X
3	2035	20		X		X	X
4	2025	5		X		X	X
5	2030	10		X		X	X



RELATED STRATEGIES	**A6**

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C4: REGIONAL FLOOD RESILIENCY AT AMELIA EARHART DAM AND OTHER SITES

Collaborate regionally and with the State on structural and operational improvements at the Amelia Earhart Dam. Plan, design and implement storm-surge barriers, "smart" flood prevention systems and conveyance improvements at appropriate sites

Source: Google Earth

TOOLBOX / ACTIONS:

1. *Raise the top of the Amelia Earhart Dam (AED)*
2. *Modify pump operations at AED by adding a fourth pump and including real-time control and optimization*
3. *Evaluate building storm barriers at the storm pathway along the Mystic River downstream of the AED*
4. *Evaluate building a berm on the south side of the AED (Assembly Square area) to eliminate or reduce flanking*
5. *Evaluate building a berm on the north side of the AED to eliminate the point of entry between Alford Street and railroad track (near Wynn Casino site)*
6. *Analyze how and in which locations "smart" ocean backflow (flood) prevention systems can be installed*
7. *Evaluate improvements in existing bridges, culverts, and other hydraulic bottlenecks along the river flow path towards the dam*
8. *Evaluate building micro-berms at strategic locations along both sides of Alewife Brook at identified points of entry. This action has regulatory challenges considering the floodplains along the Brook, and therefore options of obtaining regulatory variances will need to be explored*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	😟	🙂	🙂	😶	😶	😟

WHY RELEVANT TO ALEWIFE?

The primary functions of the dam are to maintain the Mystic River basin and its associated sub-basins' elevation between 104.5 ft and 106.5, ft as well as to prevent sea water from entering the lower basin during high tides.

Because the Amelia Earhart Dam is critical for flood control operations in the Mystic River, including Alewife Brook, as well as in areas of North and West Cambridge (list other communities) that drain to the Alewife Brook, it is of vital importance to assess the extent of vulnerability of the dam to flooding impacts from both extreme precipitation events, as well as from sea level rise and storm surge impacts. The ability of the Amelia Earhart Dam to pump after a storm event will affect the duration of flooding in the Alewife area. The dam is expected to flank in the 2045-2050, 100-year storm and overtop in the 2055-2060, 100-year storm.

KEY CONSIDERATIONS

- *Impact:* Raising the dam would be the most effective option for preventing overtopping, but this does not prevent flanking. Adding a fourth pump at the dam will provide redundancy if one of the pumps stop working. Also, with the fourth pump in operation, the floodwaters can recede more quickly, and therefore aide in recovery operations. Berms on the north and south side of the Amelia Earhart Dam can reduce the flanking paths around the dam. Improvements in existing bridges and culverts along the Mystic River that serve as hydraulic bottlenecks along the river flow path towards the dam can alleviate precipitation flooding in the Alewife area. Implementing "smart" ocean backflow (flood) prevention systems at strategic locations upstream of the dam, which provide similar functions as a sluice gate (gate is open during heavy rainfall and closed when the storm surge advances up the Mystic River) have dual benefits of mitigating risks from both precipitation and sea level rise/storm surge flooding
- *Cost:* The cost for building storm barriers or berms, and improvement projects for hydraulic bottlenecks would be expensive, but if a combination of those could prevent the dam from overtopping without the need to raise the dam, these would be cost-effective options. The cost of raising the dam would be substantial
- Feasibility: Raising the dam or making other improvements at the dam are critical, and should be considered as priority. However, modifications at the *existing* dam may be less feasible considering extensive regional analysis and coordination that will be required for this action. On the other hand, building berms along the north and south side of the dam to reduce the flanking pathways may be more feasible since these will be part of new design, and may be easier to build once the regulatory challenges are solved

ACTIONS ALREADY BEING TAKEN

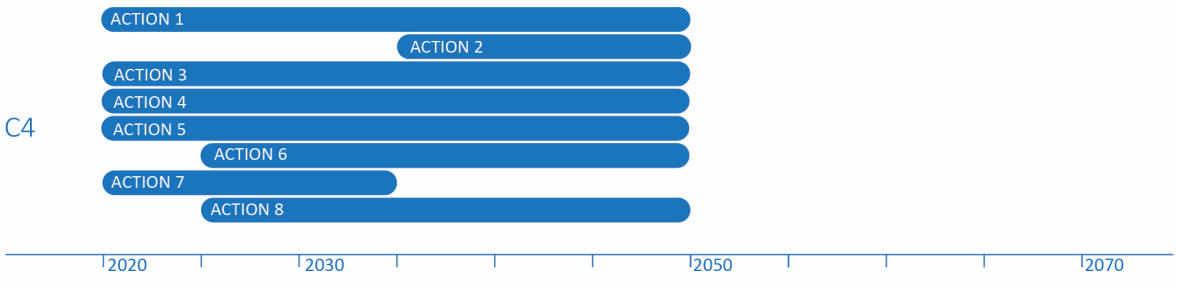
- City has applied for a NOAA grant in collaboration with MAPC, City of Boston and Chelsea and the Mystic River watershed association to evaluate resiliency strategies that include many of the toolbox items discussed above to mitigate both sea level rise and precipitation flooding in the lower Mystic River watershed
- City has incorporated the latest hydraulic improvements made at the Craddock Bridge in its hydraulic model to evaluate the flooding impacts as a result of these improvement(s)
- City has evaluated the benefits of additional pumping capacity at the Amelia Earhart Dam in terms of significant flood reduction in the Alewife area
- City is engaged in stakeholder discussions related to increased resiliency at the Amelia Earhart Dam and the Charles River Dam with local and state agencies, such as the Department of Conservation and Recreation (DCR), and Division of Capital Asset Maintenance and Management (DCAMM)

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**Government (other than the City)**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Owner**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Regional**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood** Precipitation	**Heat**	**Flood** Precipitation	**Flood** Sea Level Rise / Storm Surge
1	2020	30					X
2	2035	15				X	
3	2020	30					X
4	2020	30					X
5	2020	30					X
6	2025	25				X	X
7	2020	15				X	
8	2025	25				X	X

C4



RELATED STRATEGIES	**C5, C6**

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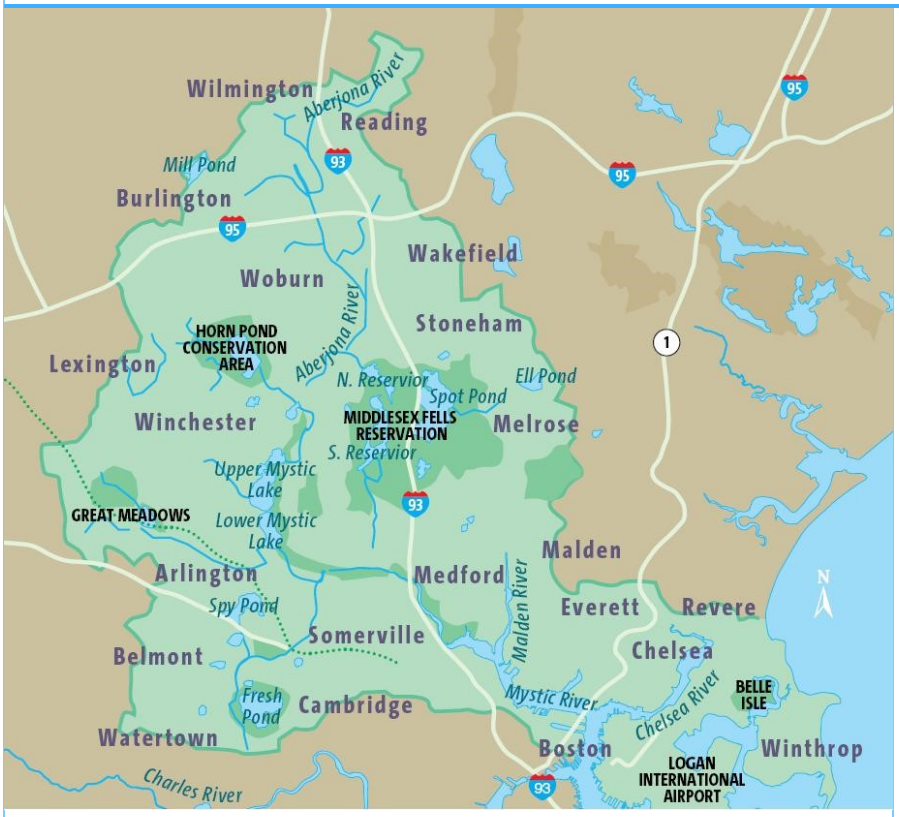
C5: WATERSHED SCALE FLOOD STORAGE

Collaborate regionally to plan and implement watershed scale flood storage at appropriate sites in the Mystic River watershed



Mystic Greenways [Source: https://mysticriver.org/atlas-maps]

TOOLBOX / ACTIONS:

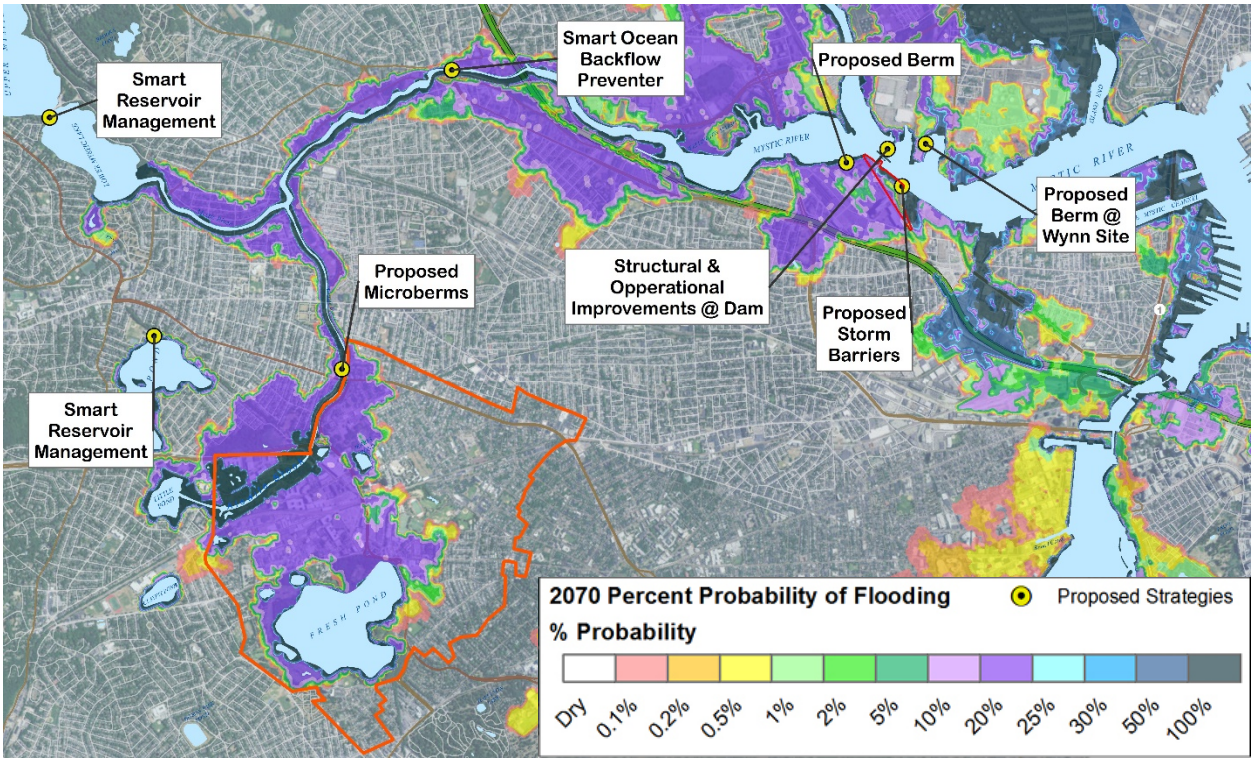
1. *Evaluate if existing reservoirs within the watershed can be pre-drained to maximize storage based on severe weather forecasts by NOAA*
2. *Create real-time decision trees based on available time, severity of the forecasted storm, and criticality of available reservoirs and existing infrastructure*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
😐	🙂	🙂	🙂	😐	🙂	😟

WHY RELEVANT TO ALEWIFE?

The Amelia Earhart Dam currently provides adequate protections for flooding up to 2030. Precipitation-driven flooding is more of an immediate threat to the City of Cambridge than flooding due to sea-level rise/ storm surge flooding. However, by 2045 the 100-year flood could cause the Amelia Earhart Dam to flank and by 2055, it could cause the Dam to overtop. This would flood communities upstream of the Dam in the Mystic River Watershed, including Cambridge. Therefore, beyond mid-century, flooding impacts from sea-level rise and storm surge are expected to be profound for the City, with the Alewife area being among the first to be impacted. The Alewife Brook watershed is also at high risk from precipitation driven flooding. If storm surge flooding were to overtop the Amelia Earhart coupled with heavy rainfall, the Alewife area would experience a severe amplification of flooding stresses.



Map of potential regional joint actions for the Mystic River and Alewife Brook to overcome flooding stresses. MAPC NOAA Grant Application. [Source: Kleinfelder for the City of Cambridge, June 2017]

KEY CONSIDERATIONS

- *Impact:* Pre-draining the existing reservoirs based on severe weather forecasts by NOAA may not be effective, as these predictions may be inaccurate. The required volume to be drained from the reservoirs would also be difficult to determine
- *Feasible:* Pre-draining existing reservoirs based on severe weather forecasts by NOAA would likely meet with public resistance, as there is a lot of uncertainty in weather forecasts. There are potential losses for the City if the severity of flooding is either underestimated or overestimated

ACTIONS ALREADY BEING TAKEN

- City has applied for a NOAA grant in collaboration with MAPC, City of Boston and Chelsea and the Mystic River watershed association to evaluate resiliency strategies that include evaluation of the watershed scale storage to alleviate precipitation flooding from extreme storms
- City is part of the Arlington-Belmont-Cambridge (ABC) Tri-community flooding group that meets regularly to discuss ongoing and potential collaborative efforts related to stormwater flooding at the sub-watershed scale among the three communities
- City has ongoing discussions with the Mystic River Watershed Association on flood mitigation projects, such as the study on how best to use Spy Pond for flood protection in the Alewife area without increasing the flood risk for Spy Pond homeowners

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Government (other than City)	**Government (other than the City)**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**State - Owner**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Regional**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2050	ongoing		X		X	X
2	2050	ongoing		X		X	X

RELATED STRATEGIES	**C4**

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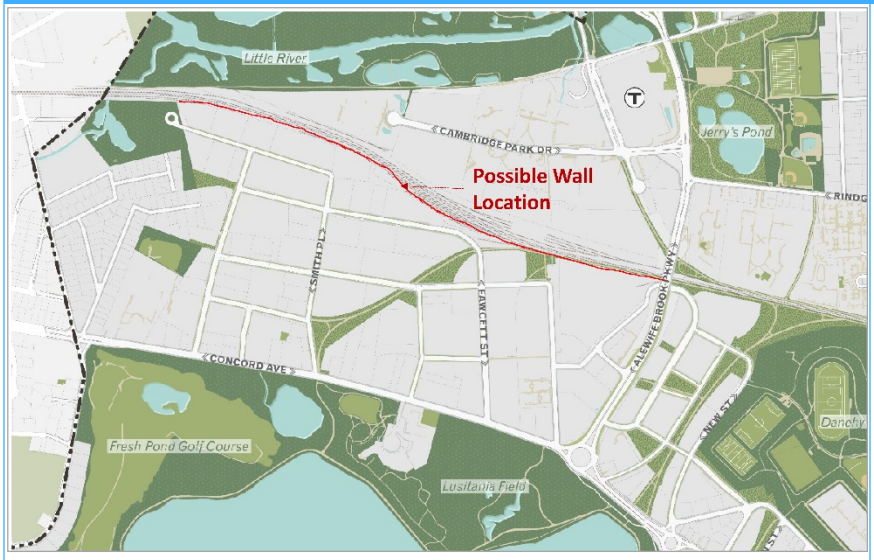
C6: SUB-NEIGHBORHOOD SCALE FLOOD PROTECTION

Create a neighborhood solution for sea-level rise/storm surge flooding for the extended Quadrangle area and Fresh Pond



Proposed Option for Location of the Flood Wall. Source: Kleinfelder,2016

TOOLBOX / ACTIONS:

1. *Evaluate building a flood wall at elevation 22.5 feet-CCB south of the railroad track along the Alewife Quadrangle*
2. *Evaluate if new buildings along the back of Concord/Alewife can incorporate a continuous flood wall (serving as a flood barrier) as part of the new construction*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	😐	😟	🙂	😐	😐	😟

WHY RELEVANT TO ALEWIFE?

The City of Cambridge is currently at risk for precipitation-driven flooding, particularly in the Alewife Brook sub-watershed, and many homes in the area already experience flooding. Beyond mid-century, flooding impacts from sea-level rise and storm surge are projected to be profound for the City. Fresh Pond is at risk for sea-level rise and storm surge flooding for the 2070, 5-year storm. Fresh Pond is part of the drinking water supply for the City of Cambridge. If the Pond's elevation exceeds the point at which it is isolated from surrounding areas, significant untreated discharges could occur, exposing the water supply to contamination. Neighborhood flood protection would not only prevent individual homes from experiencing flooding damage and stresses, it would also preserve the water quality of Fresh Pond.

In HafenCity, Hamburg, Germany, building facades are designed as continuous flood wall. [Source: http://www.hafencity.com/en/concepts/flood-secure-bases-instead-of-dikes-safe-from-high-water-in-hafencity.html]

KEY CONSIDERATIONS

- *Impact:* Installing a floodwall south of the railroad line along the Alewife quadrangle at an elevation of 22.5 feet-CCB would protect Fresh Pond from the 100-year, 2070 sea-level rise/ storm surge event. The net area of lost floodplain would be 12.6 acres, and the compensatory volume is estimated to exceed 3.0 MG
- *Equitable:* Installing a floodwall along the railroad line would provide sub-neighborhood scale flood protection for the Alewife Quadrangle, but will have no effect on the Triangle which includes the Alewife MBTA Station and Cambridgepark Drive
- *Feasible:* Installing a floodwall along the railroad line would pose some permitting issues due to a portion of it being in the present FEMA 100-year flood zone, as well as its proximity to the railroad

ACTIONS ALREADY BEING TAKEN

- For all new development, the City recommends designing to higher flood elevations (e.g. building to 2070 10-year flood elevation (precipitation or sea level rise/storm surge flooding, whichever is higher) and recovering from the 2070 100-year flood elevation (precipitation or sea level rise/storm surge flooding, whichever is higher)
- As part of the Envision Master Plan, the City proposes to require that the first habitable floor of new buildings be raised by four feet and all parking is proposed to be below the four-foot rise. The Plan proposes to install a 12-foot wide continuous platform at the four-foot elevation on streets with buildings used for business

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	City	**City**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Owner**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Neighborhood**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2030	20					X
2	2030	20					X

RELATED STRATEGIES	**C1, C5, B1, B3**

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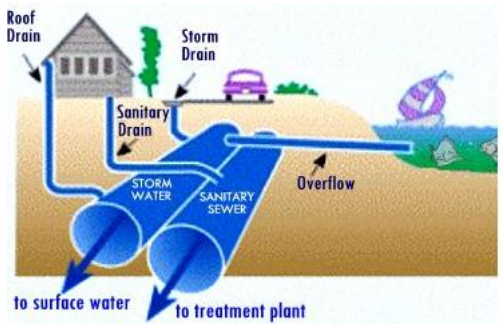
C7: COMBINED SEWER SEPARATION

Continue combined sewer separation in the Alewife area to reduce adverse public-health impacts during flood events and to protect water quality



Separated System, Source: Washington State Department of Ecology

TOOLBOX / ACTIONS:

1. *Evaluate implementation of sewer separation program in remaining combined sewer catchment area CAM001*
2. *Evaluate implementation of sewer separation program in remaining combined sewer catchment area CAM002*
3. *Evaluate implementation of sewer separation program in remaining combined sewer catchment area CAM401A/B*

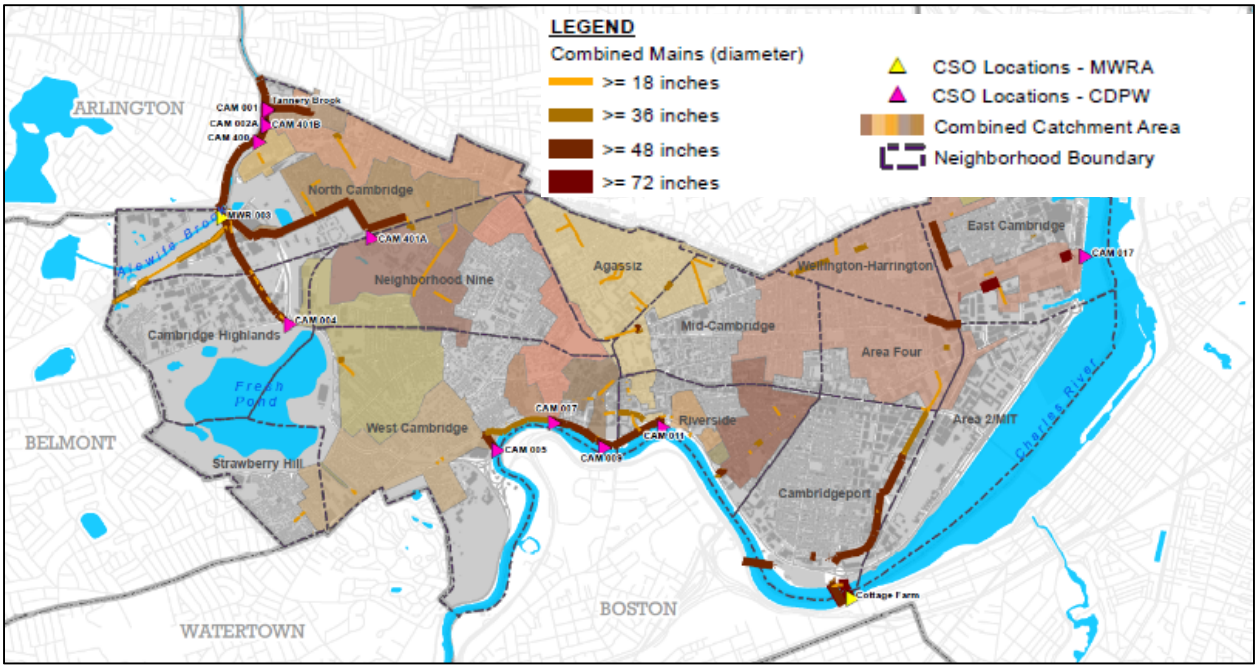
QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	😟	🙂	🙂	🙂	😶	😟

WHY RELEVANT TO ALEWIFE?

The City of Cambridge still has approximately 41 miles of combined sewer. The City also has 12 permitted CSO locations associated with 11 CSO regulator structures. The City's sewer separation projects and stormwater management efforts have addressed localized flooding problems and stormwater quality issues for existing conditions. However, the City's collection system may be subject to vulnerability considering predicted increase in heavy precipitation events and flooding from sea level rise and storm surge.

The stormwater outfalls associated with pipes greater than 18 inches in diameter are considered critical. The City is continuing separation efforts to improve water quality in Cambridge, reduce or eliminate combined sewer overflows and sanitary sewer backups, reduce flooding and prevent adverse public-health impacts.



Combined sewer mains in Cambridge, MA. Source: CCVA Part 1

KEY CONSIDERATIONS

- *Impact:* Combined sewer separation projects have been proven effective in improving water quality and reducing street flooding
- *Wellness:* During significant rainfall events, combined sewer overflows can occur and discharge untreated sewage to the Charles River or Alewife Brook. As flooding intensifies, so does the negative public-health impact. This strategy is effective in mitigating adverse health impacts from discharging raw sewage into surface water bodies
- *Cost:* The cost for separating combined sewer systems is substantial because it requires extensive construction. However, many sewer networks in Cambridge are over 150 years old and will need to be replaced regardless of other requirements

ACTIONS ALREADY BEING TAKEN

- Separation of the combined sewer system began in the 1930's. Separated systems are designed and constructed to convey only stormwater to the rivers and only sanitary waste to a treatment plant. Sewer separation continues today and the city's collection system currently include approximately 110 miles of sanitary sewer, 94 miles of stormwater drains, and 41 miles of combined sewer. Approximately 40% of the collection system owned and maintained by Cambridge has been separated[4]. The sewer separation for the CAM004 Area in Alewife was completed in December 2015, and was focused in the West Cambridge neighborhoods surrounding the Huron Avenue and Concord Avenue areas
- The City of Cambridge develops and maintains 5- and 10-year capital infrastructure program objectives for municipal storm sewer infrastructure
- The City performs remedial reconstruction of storm sewer and drainage infrastructure, a cleaning program for combined sewer overflows, and televised reviews to check on physical condition of structures

[4] https://www.cambridgema.gov/theworks/ourservices/stormwatermanagement/sewerseparation1

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	City	**City**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Regulation**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Neighborhood**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2020	ongoing		X		X	
2	2030	ongoing				X	
3	2020	ongoing		X		X	

RELATED STRATEGIES	**C8**

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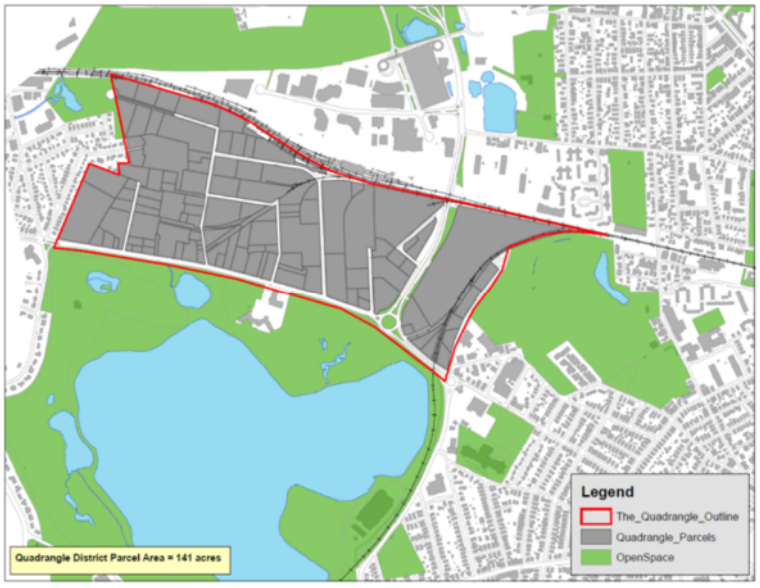
C8: STORMWATER STORAGE

Evaluate the collective benefits of adopting updated stormwater storage requirements at the parcel scale to mitigate flooding at sub-neighborhood scale



Legend:

- The Quadrangle Outline
- Quadrangle Parcels
- Open Space

Quadrangle District Parcel. Source: Envision Cambridge, 2017

TOOLBOX / ACTIONS:

1. *Evaluate updating the criterion for 25:2 compensatory stormwater storage requirement to use either 2030 or 2070 design storms for new development*
2. *Evaluate the use of combination of grey and green infrastructure for all new development to meet stormwater requirements*
3. *Evaluate the installation of a berm in Danehy Park and pre-draining adjoining wetlands. Evaluate pumping stormwater from Bellis Circle and CAM004 areas into the drained wetlands or Danehy Park*
4. *Evaluate the installation of a berm in the area behind Tobin School for surface stormwater storage*
5. *Evaluate the installation of an underground stormwater storage tank behind Tobin school*

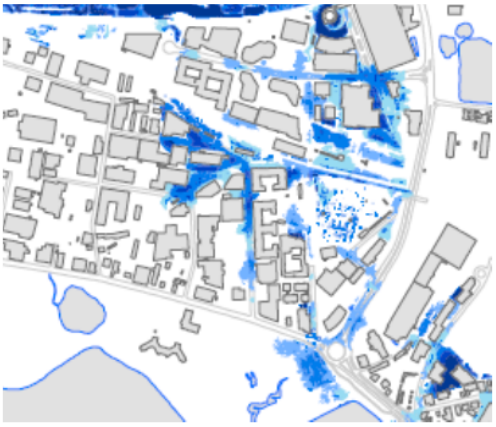
QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
😐	🙂	😐	🙂	🙂	😐	😟

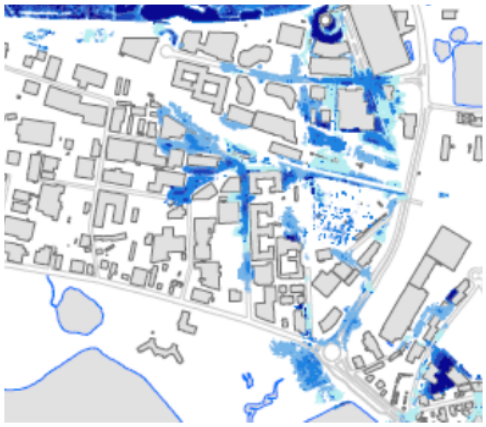
WHY RELEVANT TO ALEWIFE?

The City of Cambridge is at risk for inland flooding for the both the 2030 and 2070 10-year storm scenarios, particularly in the Alewife region. The Alewife area is also one of the most vulnerable areas of Cambridge with a relatively high population of elderly, and lower socioeconomic status. Flooding will affect these vulnerable populations most severely. There are many negative health impacts associated with inland flooding, especially in areas where sewer systems are still combined. It is important to implement stormwater storage strategies in the City of Cambridge, and there are several opportunities in the Alewife area for neighborhood-scale solutions. Additionally, stricter stormwater storage policy could be effective in less developed areas, such as the Alewife quadrangle.

Flood Reduction Benefits Evaluated using the 2070 10-year storm by Collective Implementation of the Revised 25:2 Stormwater Storage Criterion

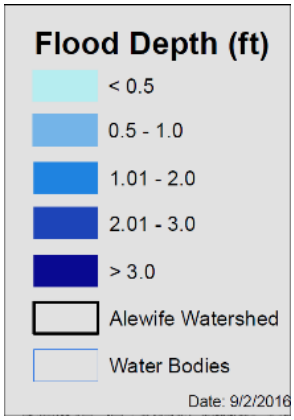


No action 10yr 2070



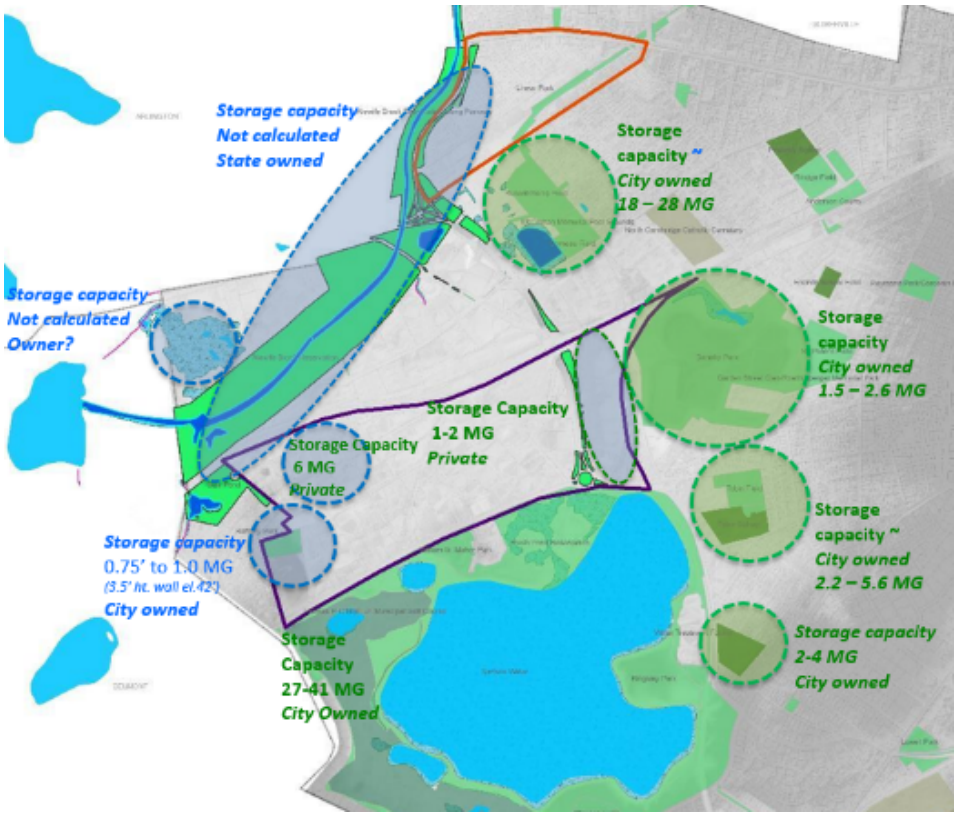
With "2030 25:2" in place for 50% parcels – 10yr storm by 2070

With "2030 25:2" in place for 75% parcels – 10yr storm by 2070



Source: Results from running the City's ICM-2D flood model, Stantec, September 2016.

Combined Flood Storage Obtained from the Collective Implementation of some of the Toolbox Actions of Stormwater Storage Criterion



Source: Storage volumes computed by Kleinfelder, Chester and Stantec, September 2016.

KEY CONSIDERATIONS

- *Impact:* At the highest level of intervention, neighborhood scale flood storage would only provide enough additional storage to account for the 2030, 10-year storm. A four-foot berm surrounding the area behind Tobin School would store 4.5 MG. An underground storage tank designed for the present day 50-year storm would hold 1.1 MG. Three, three-foot berms installed in Danehy Park in the soccer field, baseball field, and running track would store 6.3 MG. Ten percent of new development in Alewife adopting the present 100:5 compensatory storage requirement and implementing green roofs on all properties would provide 5.1 MG of storage
- *Cost:* The cost for implementing neighborhood flood storage is relatively small, and much of the cost could be absorbed by developers
- *Equity:* The updated 25:2 criterion disproportionately affects new developments, and does not require built-environment to adapt to more severe storm scenarios

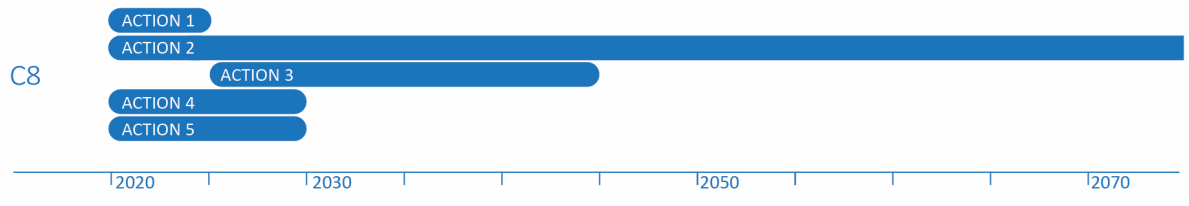
ACTIONS ALREADY BEING TAKEN

- Zoning ordinance, Article 22 incentivizes the implementation of green roofs by not counting them against a building's Gross Floor Area
- Zoning ordinance, Article 19 requires a special permit from the Planning Board for any structure that is constructed, expanded, or for dumping, filling, excavation within the floodplain
- The City requires that developments store the difference in volume between the present 2-year, 24-hour storm event pre-development runoff and the present 25-year, 24-hour storm event post-development runoff from the site through its stormwater policy

IMPLEMENTATION CONTEXT

RESILIENCY CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**Private/Residents**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Regulation**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Neighborhood**	

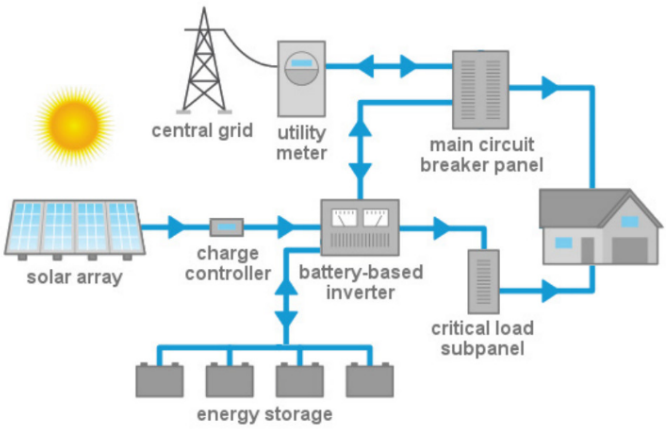
TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood** Precipitation	**Heat**	**Flood** Precipitation	**Flood** Sea Level Rise / Storm Surge
1	2020	5		X		X	
2	2020	ongoing		X		X	
3	2025	20				X	
4	2020	10		X		X	
5	2020	10		X		X	



RELATED STRATEGIES	**C1, C5, D4**

C9: CLEAN ENERGY FACILITY

Establish a neighborhood-scale clean energy facility in the Alewife Quadrangle area



Source: Solar Power Now (solar-power-now.com/solar-power-storage/)

TOOLBOX / ACTIONS:

1. *Evaluate updating requirements to include on-site solar photovoltaic (PV) and storage systems at critical facilities and residential developments*
2. *Investigate opportunities for small to medium sized combined heat and power (CHP) systems and district ground source heating and cooling systems*
3. *Evaluate building an Alewife microgrid consisting of generation, storage and a smart, controlled network*
4. *Enable community energy systems for individual households and businesses to invest in and benefit from distributed generation and energy storage assets*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	😐	😐	🙂	😐	🙂	🙂

WHY RELEVANT TO ALEWIFE?

Most of Cambridge's electricity is generated outside the City and is constrained due to transmission capacity issues and lack of redundancy. The powerplants located in or near the City use fossil fuels, including imported oil and gas. The vulnerabilities of the grid as well as the fuel supply chain will increase due to more flood events, storms and heat events, as well as increases in average temperature. These vulnerabilities and the potential to generate approximately 91 gigawatt hours per year of electricity (or 5.3 percent of the City's annual electricity use) through rooftop solar PV plus storage and CHP provides the opportunity to increase resilience and reliability while decreasing GHG emissions in Cambridge.

Solar Panels on pitched roof

KEY CONSIDERATIONS

- *Impact:* Localized, distributed generation such as solar, solar plus storage, CHP and microgrids will increase the resilience of Alewife, specifically during heat events. These systems could generate electricity (and cooling for CHP) during emergencies while reducing the impact on the grid
- *Cost:* The cost for solar has decreased significantly over the past 10 years (currently less than $4 per watt with incentives), however, the cost of solar plus storage systems are currently high, due to the cost of battery systems (~$30,000 for a typical single-family home). The cost of CHP systems is typically high but can vary depending on the type of system, installation, air controls and gas line (~$1,500-$5000 per kW). All of the recommended systems could be funded by third parties
- *Equitable:* CHP facilities are typically located in areas with cheaper land. Distributed energy may have an impact on energy prices. Specifically, the customers that do not benefit from the renewable energy may be impacted by higher electricity costs due to stranded power assets
- *Feasible:* Solar PV installations on rooftops are achievable although there are interconnection issues during outages. Siting and financing CHP and microgrids are typically difficult to achieve. In addition, microgrids with multiple owners create additional implementation issues
- *CC Mitigation:* The addition of renewable and clean energy will reduce grid GHG emissions

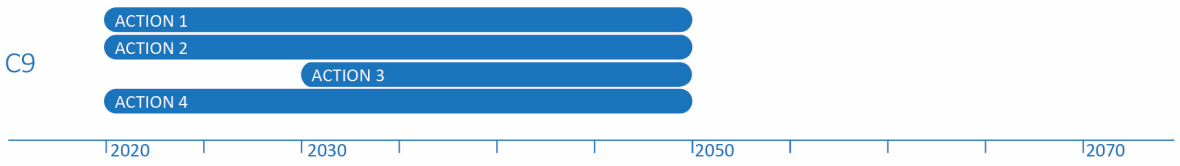
ACTIONS ALREADY BEING TAKEN

- Cambridge Green Building Requirements (CD Article 22) and MA Stretch Code
- Coordinating with Eversource Electric to ensure power needs are met

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**Partnership**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**State - Policy**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Parcel/Building/Resident**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2020	30	X	X	X	X	
2	2020	30	X	X	X	X	
3	2030	20	X	X	X	X	X
4	2020	30	X	X	X	X	



RELATED STRATEGIES	**A4, A5, A6**

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STRATEGIES D:
RESILIENT ECOSYSTEMS

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STRATEGIES D:
RESILIENT ECOSYSTEMS

OVERVIEW

Strategies for resilient ecosystems are closely aligned with each other and focus on mitigating the Urban Heat-Island (UHI) effect to protect vulnerable populations from the negative health impacts of extreme heat, improve water quality, and reduce flooding impacts from smaller storm events. Table D.1 lists the proposed strategies.

Table D.1 List of Strategies for Resilient Ecosystems

STRATEGY	TITLE	DESCRIPTION
D1	RESILIENT URBAN FOREST	Reduce the UHI effect by increasing the urban forest canopy, developing a comprehensive urban forest management plan, and continuing urban forest maintenance efforts.
D2	ENHANCED OUTDOOR THERMAL COMFORT	Develop "cool corridors" aligned with bike and pedestrian routes and MBTA bus stops to enhance outdoor thermal comfort for transit users.
D3	REDUCE IMPERVIOUS AREA	Reduce impervious area of upstream parcels to limit flooding at downstream parcels. Evaluate the implementation of a combination of grey and green infrastructure in parcels upstream of flood-prone areas to reduce runoff from impervious areas.
D4	GREEN INFRASTRUCTURE OPPORTUNITIES	Implement Green Infrastructure (GI) to improve water quality and reduce flooding impacts from smaller rainfall events and mitigate urban heat islands (UHI)

BEST PRACTICES

Resilient ecosystems are being used in many U.S. areas already experiencing the impact of climate change. These models provide a library of possible strategies informing the City's approach toward preparedness and resiliency. These best practices are helping to enhance conventional infrastructure projects and ecosystems via infrastructure projects, building projects and educational programs.

Infrastructure Projects

Park Designed for Stormwater Storage, Pittsburg, Pennsylvania

The City of Pittsburgh, Pennsylvania, obtains 90% of its drinking water from the City's three rivers. The rivers receive combined (sanitary and storm) sewer outfalls, as well as treated water discharged for the wastewater treatment plant. In an effort to preserve the water quality of the rivers, the City of Pittsburgh has included elements of green infrastructure in every major park improvement in the past 15 years. As part of the "The Vision Plan for Pittsburgh's RiverFronts," parks and other vegetation are placed alongside the rivers in the Ohio River Basin (Figure 1). This natural landscape allows stormwater to be retained, cleansed, and infiltrated before it reaches the river

Figure 1. Open-space planning in North Shore [Source: Rivers in Synergy, Pittsburgh, PA]

Green Streets Program, Portland, Oregon

A street that uses vegetated facilities to manage stormwater runoff at its source is referred to as a Green Street. This may include street trees, vegetation along sidewalks, swales, and rain gardens. In 2007, the Portland, Oregon City Council approved a policy to promote and incorporate the use of green street elements in public and private development. Under this policy, all development funded by the City of Portland must incorporate green street facilities, or 1% of their construction cost will go to a Green Street Fund. The City will assist in developing incentives and encouraging the private sector to implement green-street projects though planning, design, and funding. The policy also has a public outreach component to educate residents on the benefits of green streets. Lastly, the City must conduct ongoing monitoring of green street facility effectiveness.

Figure 2. Portland Green Street [Source: Environmental Services, City of Portland]

Building projects

Living Walls, various cities

Many cities have begun to implement green walls to preserve air quality and help to mitigate the urban heat-island effect.

Figure 3 (left) shows an example of a green wall on a high-rise building in the center of Concepción, Chile. This building has a vertical green wall constructed from locally-sourced wood shields the structure from the sun to the north, east, and west, and acts as a "double green skin" that insulates the interior. The structure's south wall features a high-performance facade constructed from locally-sourced corrugated metal that helps to insulate the interior and render it highly energy efficient.

Figure 3. Green wall on a building in Concepción, Chile (left) and a green wall on a small business building on Shin Koenji street in Tokyo, Japan (right). [Sources: ihabitat.com/consorcio-headquarters-by; tokyogreenspace.com/tag/green-wall]

The third element is a cantilevered roof that provides shade to the structure's top floor balcony. Figure 3 (right) shows an example of a lush second floor garden on Shin Koenji shopping street in Tokyo. Tokyo Metropolitan Government's 10-year project for Green Tokyo has aimed to create a total of 400 hectares of green space by greening rooftops, wall surfaces, railroad areas, parking lots and all other possible urban spaces.

Chicago Green Roof Improvement Fund, Chicago, Illinois

The Chicago Green Roof Improvement Fund provides for a 50% grant match for the cost of placing a green roof on an existing building located in the Central Loop District up to a maximum grant amount of $100,000 per project. The Green Roof Grant Program, awards $5,000 grants for green roof projects on residential and small commercial projects. In addition, the city of Chicago currently requires all new, near-flat roofs meet the U.S. EPA ENERGY STAR cool roof standards as part of the Chicago Energy Conservation Code. A cool roof uses special materials to reflect the sun's heat instead of warming the building below.

Figure 4. Chicago Green Roof. Photo credit: Conservation Design Forum

The City of Chicago's Cool Roofs Grant Program provides up to $6,000 per project to help residents and small business owners install roofs that meet or exceed the cool roof standards.

Educational programs

Green Schools Program, Boston, Massachusetts

New rain gardens, bioswales and other green infrastructure are being designed to capture and filter stormwater runoff while serving as an educational tool for teachers and students of five Boston Public Schools. Construction and plantings are complete at the Irving School in Roslindale, and construction has begun at the Hernandez School in Roxbury. These projects are a collaboration between Boston Water and Sewer Commission (BWSC), Boston Public Schools (BPS), the Charles River Watershed Association (CRWA), Horsley Witten Group, Offshoots, and Kristin Metz. The new green school yards are educational, interactive, and offer some greenery to the urban landscape, and also serve as model schools for surrounding districts.

Figure 5. Tree planters and bioretention basin at parking lot of Irving School in Roslindale, Boston. [Source: Boston Water and Sewer Commission (BWSC) and Greenovate City of Boston]

Green Infrastructure Education, Philadelphia, Pennsylvania

West Philadelphia residents, middle schoolers and University of Pennsylvania students launched a citizen study of the Mill Creek portion of their watershed prompting neighbors to install flower boxes, rain barrels, green roofs and walls, street trees, and rain gardens. The study included incorporating green stormwater infrastructure into a new public school and establishing outdoor classrooms where students learn about natural features, the built environment, and how human behaviors interact to shape the quality of urban life. The study also encouraged municipal officials to “daylight” portions of a creek that was enclosed within a culvert. The creek was restored to its natural state to improve stormwater management and create a new public amenity.

RELEVANCE TO ALEWIFE

Table D.2 below provides a summary of how the best practices inform the development of specific strategies for Resilient Ecosystems.

Table D.2 List of Strategies and Related Best Practices

STRATEGY	TITLE	RELATED BEST PRACTICE	DESCRIPTION/ RELEVANCE TO ALEWIFE
D1	RESILIENT URBAN FOREST	*To be documented*	*To be documented*
D2	ENHANCED OUTDOOR THERMAL COMFORT	***Green Streets Program, Portland, Oregon***	Promote and incorporate the use of green street elements in public and private development. Under this policy, all development funded by the City of Portland must incorporate green street facilities, or 1% of their construction cost will go to a Green Street Fund.
D3	REDUCE IMPERVIOUS AREA	***Chicago Green Roof Improvement Fund, Chicago, Illinois***	The Chicago Green Roof Improvement Fund provides for a 50% grant match for the cost of placing a green roof on an existing building.
D4	GREEN INFRASTRUCTURE OPPORTUNITIES	***Park Designed for Stormwater Storage, Pittsburg, Pennsylvania***	The City of Pittsburgh has included elements of green infrastructure in every major park improvement in the past 15 years. This natural landscape allows stormwater to be retained, cleansed, and infiltrated before it reaches the river.
		Green Infrastructure Education, Philadelphia, Pennsylvania	West Philadelphia residents, middle schoolers and University of Pennsylvania students launched a citizen study of the Mill Creek portion of their watershed prompting neighbors to install flower boxes, rain barrels, green roofs and walls, street trees, and rain gardens.

The draft strategies are described in detail in the following pages.

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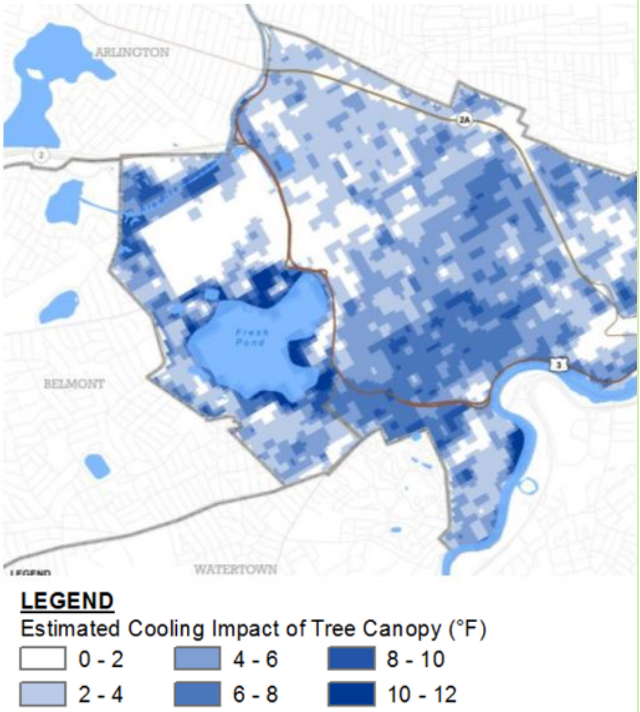
D1: RESILIENT URBAN FOREST

Reduce the urban heat-island effect and improve water quality by increasing the urban forest canopy, developing a comprehensive urban forest management plan, and continuing urban forest maintenance efforts

existing conditions **Cooling impact of tree canopy**



Source: CCVA Part 1

TOOLBOX / ACTIONS:

1. *Increase tree canopy in areas that lack trees, such as streets and parking lots*
2. *Develop a comprehensive urban forest management plan*
3. *Continue urban forest maintenance efforts*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	🙂	🙂	🙂	🙂	🙂	🙂

WHY RELEVANT TO ALEWIFE?

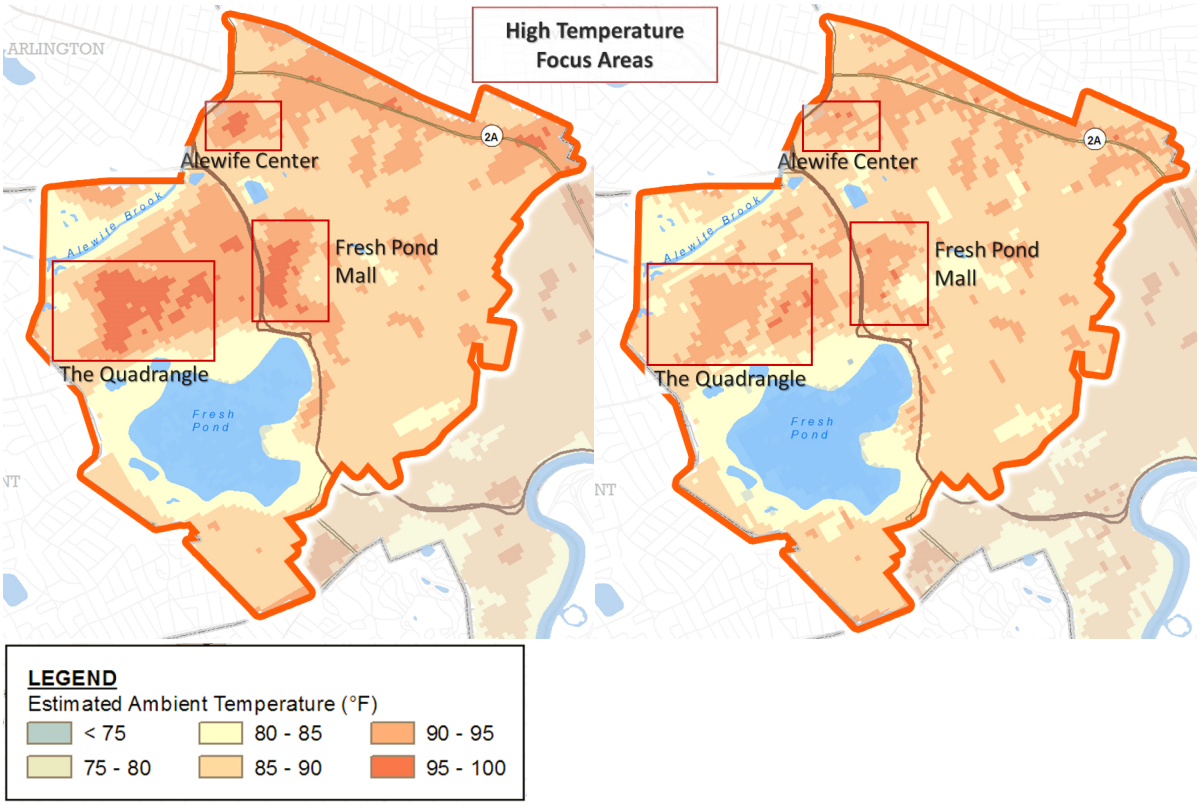
The number of days over 90° Fahrenheit are projected to nearly triple by 2030, from present conditions of approximately 11 days a year to around 31 days a year. Urban areas like Cambridge will see heat vulnerability exacerbated because of the urban heat island effect. The Alewife quadrangle in particular, is one of the worst urban heat islands in the city. People with chronic respiratory and heart problems are more vulnerable to the effects of heat. By the 2030s, we will experience increases in temperatures that are dangerous to public health. A 1° temperature increase yields an increase of 0.018 ambulance transports for heat stroke per 1,000 people (approximately 2 transports in Cambridge). Additionally, a similar increase in temperature can add 1.5-2% to peak electricity demand for air conditioning. This could cause outages, and have negative public-health and economic impacts on the residents of Cambridge.

KEY CONSIDERATIONS

- *Impact:* Increasing the urban forest canopy has proven effective in reducing the Urban Heat Island (UHI) effect
- *Cost:* Planting street trees, implementing green roofs, and installing vertical planters have a relatively low capital cost, but operations and maintenance costs need to be considered. Developers could absorb some of this capital cost for new development, and the operations and maintenance costs could be shared by the property owners and the City. The City may be able to provide incentives in the future for existing property owners to implement green roofs as part of retrofits. Also, many residents are willing to fund tree plantings for their aesthetics and increased property value
- *Integrated:* Increasing urban forest canopy would help the City to decrease energy demands which is aligned with Net Zero. Adding street trees improves the aesthetics of the neighborhoods and quality of life of residents, which is aligned with Envision Cambridge
- *Climate Change Mitigation:* Increasing urban forest canopy would absorb greenhouse gas emissions. Trees also provide shade for homes in the summer, reducing energy demands for the City

2030 urban heat island with existing tree canopy

2030 urban heat island with 40% tree increase in areas with less than 15% canopy coverage



Source: Appendix B- Green Infrastructure Analysis and Urban Heat Island Modeling.

ACTIONS ALREADY BEING TAKEN

- The Department of Public works has developed and maintains a comprehensive tree inventory of public street and park trees and continues to oversee tree plantings throughout the City. Residents may request trees in front of their property for a fee. Under the Urban Forestry Initiative, the City plans to plant 265 new trees in existing tree pits and new locations as part of roadway reconstruction projects by 2020

- The City of Cambridge is developing a comprehensive Urban Forest Master Plan. The Plan will provide for the review of the current and future threats to the urban forest specific to climate change and how threats will affect existing trees and the choice of species for future plantings

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	City	**City**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Regulation**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Parcel/Building/Resident**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2020	ongoing	X		X		
2	2020	5	X		X		
3	2020	ongoing	X		X		

RELATED STRATEGIES	**D2, D4**

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D2: ENHANCED OUTDOOR THERMAL COMFORT

Develop "cool corridors" aligned with bike and pedestrian routes and MBTA bus stops to enhance outdoor thermal comfort for of transit users

White Roof (Source: Earth Rangers Centre for Sustainable Technology)

TOOLBOX / ACTIONS:

1. *Continue planting street trees along the sidewalk in the public right-of-way and in parking lots*
2. *Add additional permanent or flexible shaded structures at outdoor bus waiting areas*
3. *Evaluate accessibility to water at waiting areas*
4. *Evaluate applying white coating to roofs*
5. *Evaluate replacing pavement with open spaces or surfaces with lower emissivity such as CoolSeal*
6. *Increase access to waterplay areas and public pools*
7. *Sprinkle water on streets during periods of extreme heat*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
🙂	🙂	🙂	🙂	🙂	🙂	🙂

WHY RELEVANT TO ALEWIFE?

Many Cambridge residents are exposed to heat through transit use. The Pedestrian network in Cambridge is extensive. All Cambridge streets have sidewalks and street lighting. Additionally, Cambridge has built a reputation as one of the best cities for bicycling in the U.S. There are 46 miles of bike routes which almost completely mirror the City's 48 miles of major roads. Cambridge has established the Hubway bike-share program which provides 27 bike-sharing stations in the City. Bike routes and pedestrian walkways are directly exposed to heat. Additionally, people using the bus system must wait outside, exposing these public transit users to heat impacts. Buses are important assets in the City's public transit network. Operating in or passing through Cambridge, 33 buses or trackless trolleys carry approximately 85,000 riders each weekday. In the MBTA system, 5 of the 20 bus routes with highest ridership are in Cambridge.

KEY CONSIDERATIONS

- *Impact:* Planting street trees, applying CoolSeal to pavement, and sprinkling water on pavement have each been shown to reduce the Urban Heat Island effect. In order to enhance outdoor thermal comfort, strategies will need to be applied on the parcel scale, including green roofs or applying a white coating to roofs. Preliminary analyses show that white roofs provide a greater benefit in reducing urban heat island compared to only green roofs. Though providing access to water at waiting areas and increasing access to waterplay

areas/ pool does little to combat the urban heat-island effect, these strategies could be effective short-term cooling options for residents

- *Wellness:* Enhancing outdoor thermal comfort is effective in alleviating negative health impacts due to extreme heat. Strategies that help to reduce the urban heat-island effect would bring down the ambient temperature and providing access to drinking water and waterplay areas/ pool could prevent dehydration and overheating during heat exposure
- *Feasible:* Enhancing outdoor thermal comfort is a feasible strategy. Cambridge has already taken steps to enhance thermal comfort, and increasing efforts is realistic

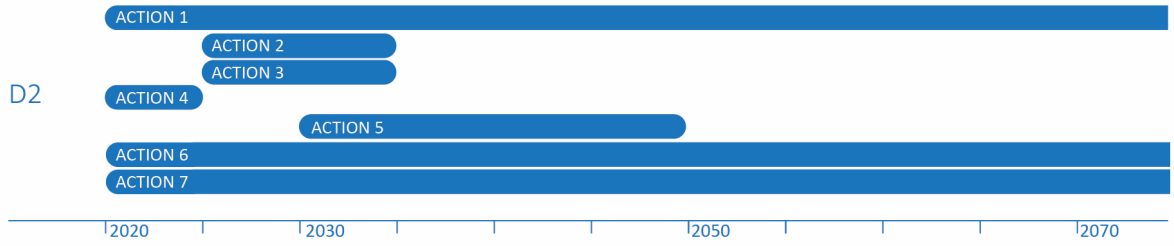
ACTIONS ALREADY BEING TAKEN

- MBTA provides online GPS tracking of buses that may be downloaded as an app on a smartphone to minimize outdoor wait times
- The Department of Public Works has developed and maintains a comprehensive tree inventory of public street and park trees and continues to prioritize tree plantings throughout the City. Under Urban Forestry Initiative, the City plans to plant 265 new trees in existing tree pits and new locations as part of roadway reconstruction projects by 2020
- The City of Cambridge has issued a request for qualifications for its comprehensive Urban Forest Master Plan, which includes elements such as baselining the current health and condition of the City's urban forest, assessing future threats from climate change and increased development, reviewing legal and regulatory factors pertaining to urban forest maintenance and expansion, reviewing existing management and emergency response procedures, and preparing a plan document to achieve the City's goals and objectives for its urban forest in the present and future
- The City provides free access to public pools and waterplay areas in many locations in Cambridge, including 2 pools and 1 waterplay area in the Alewife area

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Partnership	**Partnership**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Owner**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**City**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2020	ongoing	X		X	X	X
2	2025	10	X		X		
3	2025	10	X		X		
4	2020	5	X		X	X	
5	2030	20	X		X		
6	2020	ongoing	X		X		
7	2020	ongoing	X			X	



RELATED STRATEGIES	**D1, D4**

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D3: REDUCE IMPERVIOUS AREA

Reduce impervious area of upstream parcels to limit flooding at downstream parcels. Evaluate the implementation of a combination of grey and green infrastructure in parcels upstream of flood-prone areas to reduce runoff from impervious areas

Sample Quadrangle Parcel

TOOLBOX / ACTIONS:

1. *Evaluate revegetating paved areas*
2. *Evaluate reducing parking lot size or use porous pavement for parking lots*
3. *Evaluate installing green roofs on new buildings and in retrofitting existing buildings*
4. *Evaluate the implementation of a combination of grey and green infrastructure in parcels upstream of flood-prone areas to reduce runoff from impervious areas*
5. *Coordinate with surrounding communities to reduce impervious area in the greater watershed*

QUALITY OF RESILIENCE:

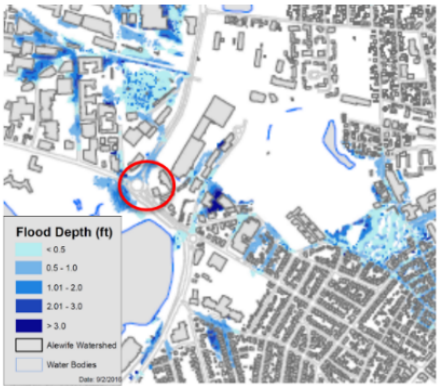
Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
😐	🙂	😐	🙂	😐	😐	🙂

WHY RELEVANT TO ALEWIFE?

The impervious surface coverage in the watershed is a significant contributor to surface runoff, thereby impacting stormwater management. Maximizing upstream stormwater storage alleviates downstream flooding. The Alewife area of Cambridge has capacity for reducing impervious surfaces for stormwater storage, particularly in the relatively underdeveloped Alewife Quadrangle. There are undeveloped impervious lots that could be revegetated, and several commercial buildings that could implement green roofs.

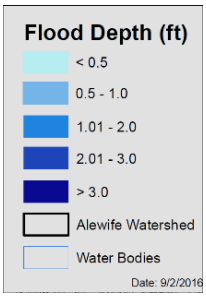
Flood Reduction Benefits by Reducing Impervious Area for 2030 10-year Storm

No Action



With 25% Reduction

With 50% Reduction



Source: Results from the City's ICM-2D flood model, Stantec, September 2016.

KEY CONSIDERATIONS

- *Impact:* Reducing upstream impervious surface has flood reduction benefits downstream. However, reducing impervious areas beyond 50% demonstrates negligible additional flood storage. A 25-50% reduction in impervious surface would diminish flooding for the 2030 10-year storm, but grey infrastructure (i.e. detention tanks) would be necessary for further storage capacity
- *Cost:* The cost of reducing impervious surfaces is relatively low but some measures will trigger higher operation costs
- *Feasible:* Solutions that do not reduce existing parking are likely to be most feasible
- *Equitable:* The proposed measures have an impact for capital cost and operation cost, so will impact affordability

ACTIONS ALREADY BEING TAKEN

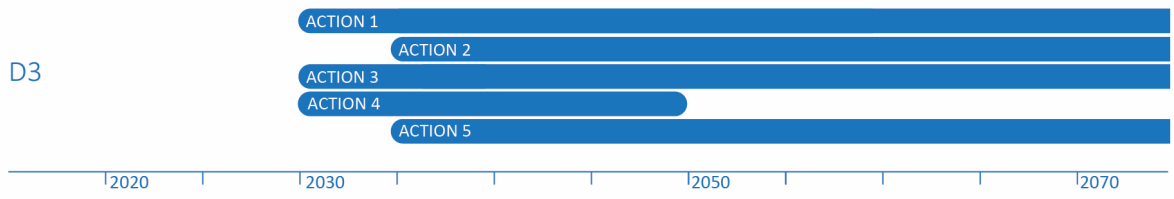
- The City requires that any new development reduces the post-development 25-year peak flow from the proposed site such that it is lower than the pre-development 2-year peak flow.
- Zoning ordinance, Article 22 incentivizes the implementation of green roofs by not counting them against a building's Gross Floor Area

- Zoning ordinance, Article 19 requires a special permit from the Planning Board for any structure that is constructed, expanded, etc., or for dumping, filling, excavation, etc., within the floodplain
- The City has designed and commissioned several green infrastructure projects such as porous pavement, rain gardens, bioretention basins–particularly as part of the Huron A, B, Concord Avenue and Western Avenue sewer separation projects
- The City designed and built a 3.4-acre constructed wetland, New England's largest constructed stormwater wetland, to meet stormwater storage requirements as part of the Alewife combined sewer separation project. This wetland area serves to store, attenuate and treat the separated stormwater before discharging to the Little River

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**Private/Residents**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**Make a Program**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Parcel/Building/Resident**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2030	ongoing	X		X	X	
2	2035	ongoing	X	X	X	X	
3	2030	ongoing	X		X		
4	2030	20	X	X	X	X	
5	2035	ongoing	X	X	X	X	



RELATED STRATEGIES	**D1, D4, C8**

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D4: GREEN INFRASTRUCTURE OPPORTUNITIES

Implement Green Infrastructure (GI) to improve water quality and reduce flooding impacts from smaller rainfall events and mitigate urban heat islands (UHI)

Western Avenue Cambrdige, MA. [Source: City of Cambridge]

TOOLBOX / ACTIONS:

1. *Evaluate installation of raised planters in medium-density residential parcels*
2. *Evaluate landscaping to include bioretention basins in retrofitting medium-density residential parcels and in new high-density residential parcels, new light industrial development, public open space and public right-of-way*
3. *Evaluate using porous pavement and permeable pavers for residential driveways, new streets and parking lots of commercial parcels*
4. *Evaluate installation of green roofs in retrofitting existing commercial buildings, new light industrial buildings, and new high-density residential development*
5. *Evaluate constructing water quality swales in public open space*
6. *Evaluate installation of subsurface infiltration chambers in new high-density residential development*
7. *Explore developing an education program for residents and public schools on local green infrastructure opportunities benefit the watershed*

QUALITY OF RESILIENCE:

Impact	Cost	Equitable	Wellness	Feasible	Integrated	CC Mitigation
😐	🙂	🙂	🙂	🙂	😐	🙂

WHY RELEVANT TO ALEWIFE?

The City requires 25:2 compensatory flood storage for all new development, and this policy may become more stringent as flooding increases. The Alewife area already has flooding problems caused by runoff during storms that exceed the ability of the Alewife Brook to convey water to the Mystic River. Additionally, the drainage network has limited capacity to take in stormwater runoff and convey those flows downstream. During larger storms, many properties are flooded. Green infrastructure allows for an increase in flood storage and improved water quality of the drinking water supply. Green infrastructure can supplement the grey infrastructure already in place in Cambridge to increase storage capacity. Green infrastructure is also proven to be effective in reducing the Urban Heat Island (UHI) effect. Urban areas such as Cambridge will see heat vulnerability exacerbated. The number of days over 90 Fahrenheit are projected to nearly triple by 2030. Such temperature increases are dangerous to public health.

KEY CONSIDERATIONS

- *Impact:* Green infrastructure is limited in terms of flood storage. Improvements in grey infrastructure would need to supplement this strategy in order to increase storage capacity for flood depths greater than the 2030, 10-year storm. The primary benefit of implementing green infrastructure over grey infrastructure is that this strategy mitigates the urban heat-island effect in addition to flooding.
- *Integrated:* Implementing green infrastructure, particularly on the parcel scale, would require stricter regulations on new and existing development.

Flooding from the 10-year 2070 storm with as-is infrastructure

Flooding from the 10-year 2070 storm with green infrastructure

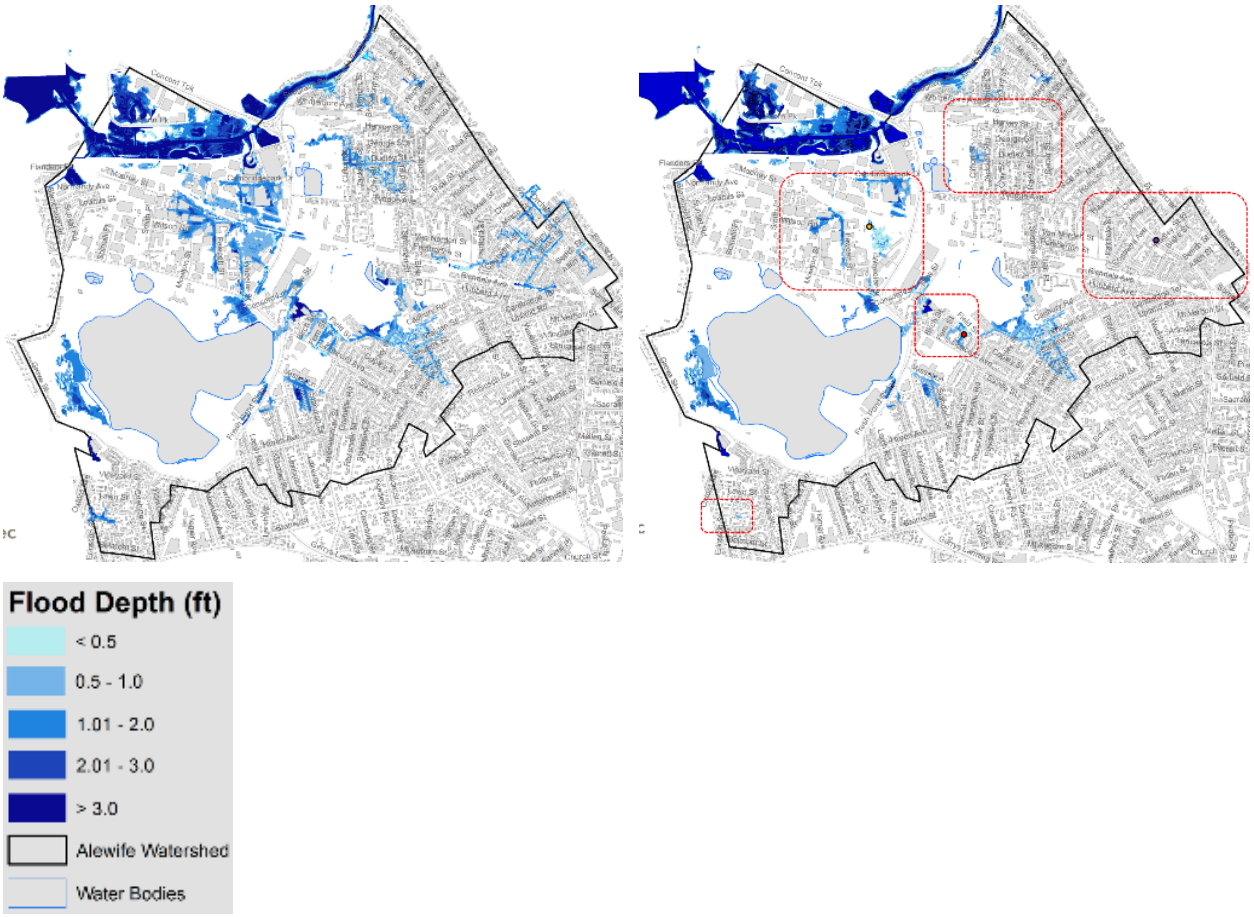
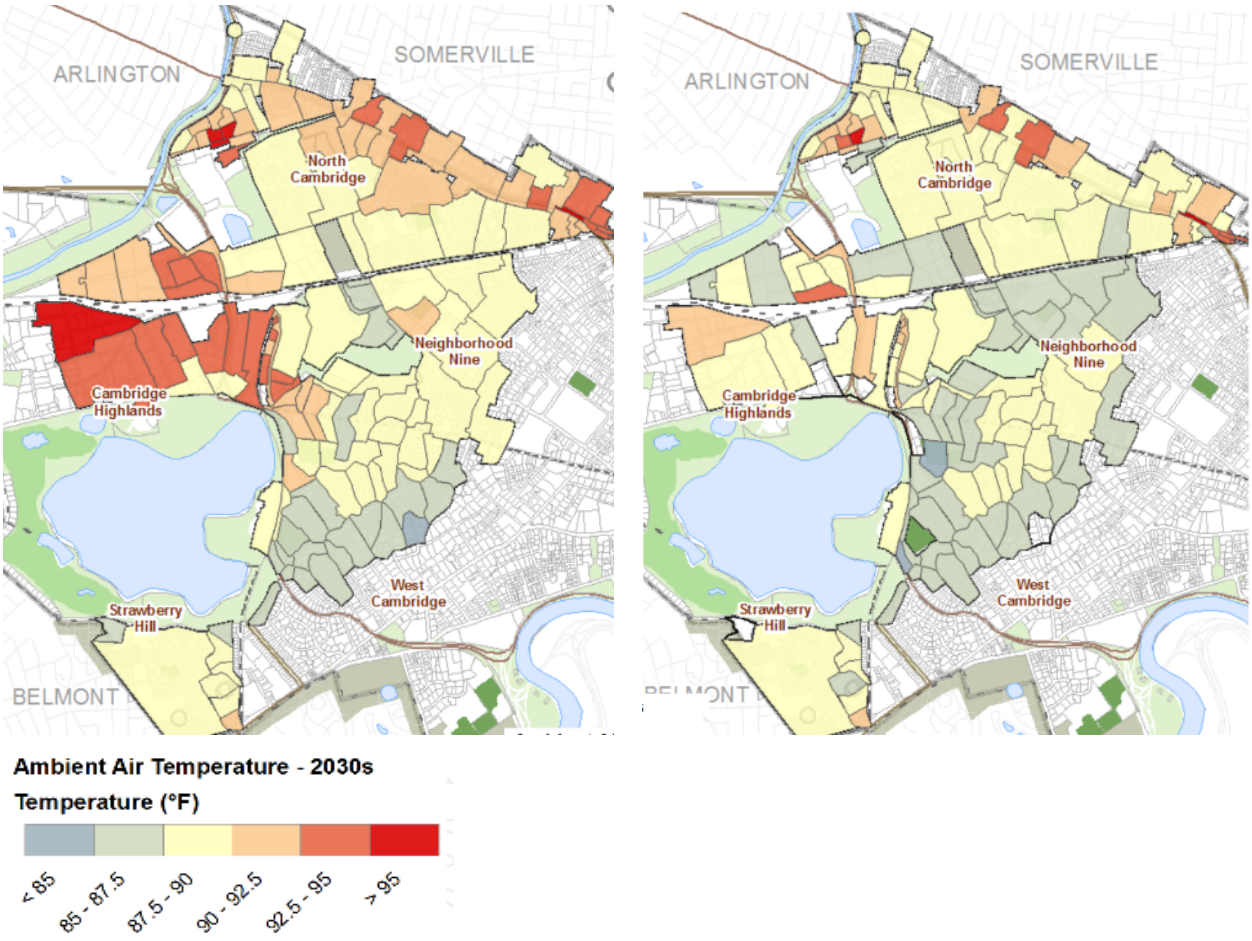


Illustration of reduced flooding – in areas highlighted with orange boxes —by the implementation of green infrastructure. Source: Results from the City's ICM-2D flood model[1]. October 2017

[1] Refer to Appendix B: Green Infrastructure Analysis and Urban Heat Island Modeling, for a detailed analysis.

Urban heat island in 2030 with as-is infrastructure

Urban heat island in 2030 with green infrastructure



Results from the City's Urban Heat Island Model. Source: Appendix D Green Infrastructure Analysis and Urban Heat Island Modeling, October 2017

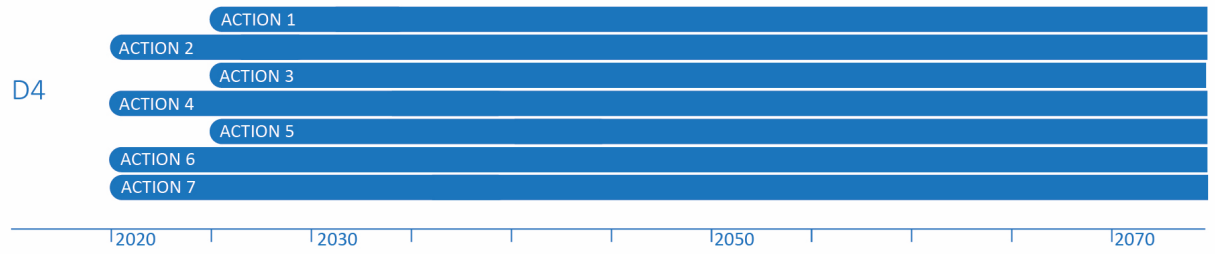
ACTIONS ALREADY BEING TAKEN

- The Department of Public Works has developed and maintains a comprehensive tree inventory of public street and park trees and continues to prioritize tree plantings throughout the City.
- Porous pavement and infiltrating catch basins have been installed in some streets in Cambridge.
- The City requires that developments store the difference in volume between the 2-year, 24-hour storm event pre-development runoff and post-development 25-year, 24-hour storm event runoff hydrograph through its stormwater policy.

IMPLEMENTATION CONTEXT

RESILIENCE CARD		
PROPONENT- identified as champion that will lead the implementation and who could provide possible financing for implementation or mobilization	**Owners/ Facilitators**	**Financing Options**
	Private	**City**
TYPE OF INTERVENTION defined as addressing an emergency/ extreme event caused by CC or for adapting to identified CC stresses defined here as "new normal"	**CC Preparedness Measure**	
JURISDICTION for monitoring the enactment of the strategy	**City - Regulation**	
SCALE of the intervention as the smallest unit - a building or a person, at the neighborhood scale, the City's scale or for the region	**Neighborhood**	

TOOLBOX ACTIONS	**TIMELINE**		**CC Risk 2030**		**CC Risk 2070**		
	The Proponent needs to Start by	**Time to Implement (in Years)**	**Heat**	**Flood Precipitation**	**Heat**	**Flood Precipitation**	**Flood Sea Level Rise / Storm Surge**
1	2025	ongoing	X	X	X	X	
2	2020	ongoing	X	X	X	X	
3	2025	ongoing	X	X	X	X	
4	2020	ongoing	X	X	X	X	
5	2025	ongoing	X	X	X	X	
6	2020	ongoing	X	X	X	X	
7	2020	ongoing	X	X	X	X	



RELATED STRATEGIES	**D1, D4, C7**

PRODUCED IN COLLABORATION WITH

Kleinfelder, Lead Consultant

Buro Happold for energy

Chester Engineers for green infrastructure

HR&A for financial expertise

John Snow Institute (JSI) for public health

Stantec for water modeling of piped infrastructure

NBBJ for architecture and planning

The Consensus Building Institute (CBI) for stakeholder engagement

UMass Boston for outreach and vulnerable populations