City of Cambridge
Community Development Department

Climate Resilience Zoning Task Force

Presentation to the Health and Environment Committee
September 11, 2019

Agenda

- Progress report
- Summary review: heat
- Principles and objectives
- Q&A
- Zoning considerations
- Discussion

Progress Report

Introduction to the CRZTF

Purpose

- Discuss climate change vulnerabilities identified in the CCVA;
- Review recommendations from the ongoing CCPR planning effort and other related initiatives;
- Recommend development standards to incorporate into Cambridge's Zoning Ordinance.

Focus Areas

- Anticipated flooding from sea level rise, storm surge, and precipitation;
- Anticipated rise in temperatures exacerbated by the urban heat island effect.

Task Force Members

Category	Name	Title
Residents	Doug Brown (co-chair) Conrad Crawford Ted Cohen Mike Nakagawa	West Cambridge East Cambridge/CRA North Cambridge/Planning Board North Cambridge
Union/Trades Representative	Louis Bacci, Jr.	Laborers Local 151/East Cambridge/Planning Board
Institutional/Non-Profit Representatives	Brian Goldberg Tom Lucey Margaret Moran Craig Nicholson	MIT Office of Sustainability Harvard University Cambridge Housing Authority Just-a-Start
Business Representatives/ Property Owners	Jason Alves Nancy Donahue Joe Maguire Tom Sullivan Mike Owu	East Cambridge Business Assoc. Cambridge Chamber of Commerce Alexandria Divco West MITIMCo
Subject Matter Experts	Tom Chase Lauren Miller Jim Newman	Energy & Resilience Consultant, New Ecology Climate Consultant, CDM Smith Resilience Consultant, Linnaean Solutions
City Staff	John Bolduc Iram Farooq (co-chair) Kathy Watkins	Environmental Planner Assistant City Manager for Community Development City Engineer/Assistant Commissioner

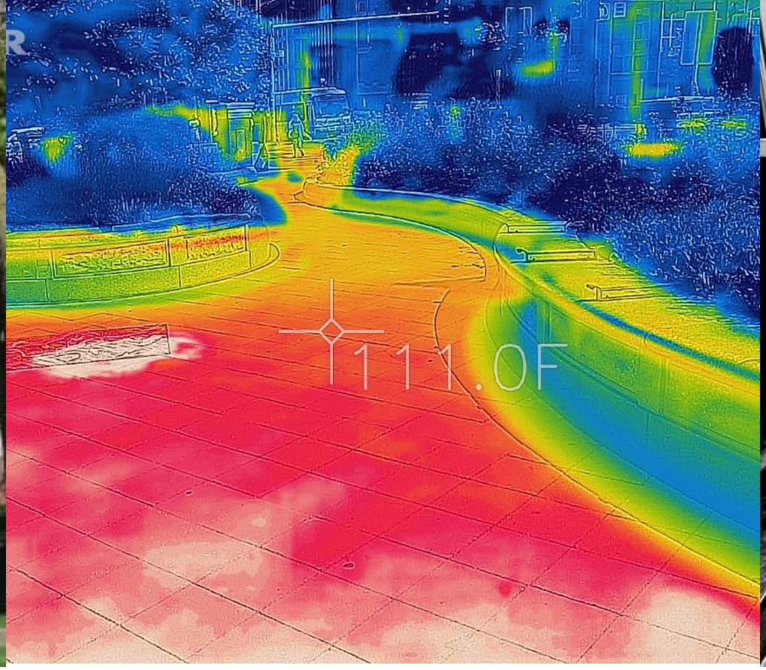
Work to Date

Date	Purpose
Meeting #1 – January 23	Introduction; review purpose and scope
Meeting #2 – February 27	Recap of CCPR/CCVA work; review of regulatory tools
Meeting #3 – March 21	Walking tour and discussion
Meeting #4 – April 24	Focus on flooding
Meeting #5 – May 29	***Joint meeting with Health and Environment Committee***
Meeting #6 – June 26	Focus on heat resilience; recap priority issues
Meeting #7 – July 31	Synthesize flooding and heat resilience discussions; develop combined framework of objectives

Future Discussions

Date	Purpose
Meeting #8 – September 11	***Joint meeting with Health & Environment Committee*** Recap work to-date; begin to discuss specific zoning considerations
Meeting #9 – October 10	Discuss zoning recommendations
Meeting #10 – November 6	Review/revise zoning recommendations
Meeting #11 –November 21 (to be confirmed)	***Joint meeting with Health & Environment Committee***
Meeting #12 – December 11	Finalize zoning recommendations

Summary Review: Heat

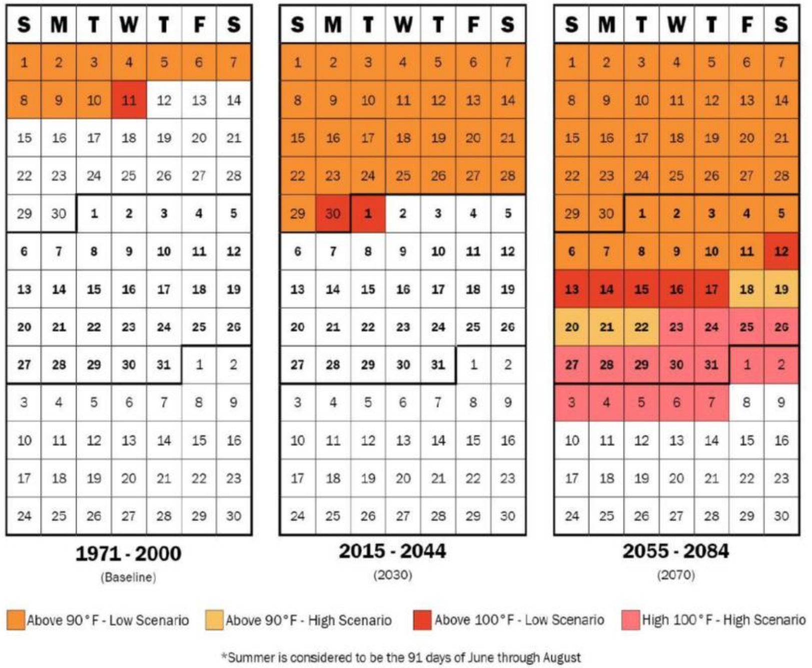



Climate Change & Urban Heat in Cambridge

City of Cambridge
September 11, 2019

Climate Resilience Zoning Task Force

Warmer Averages, Greater Extremes, More Heat Waves



By 2070, the number of days above 90º F could triple

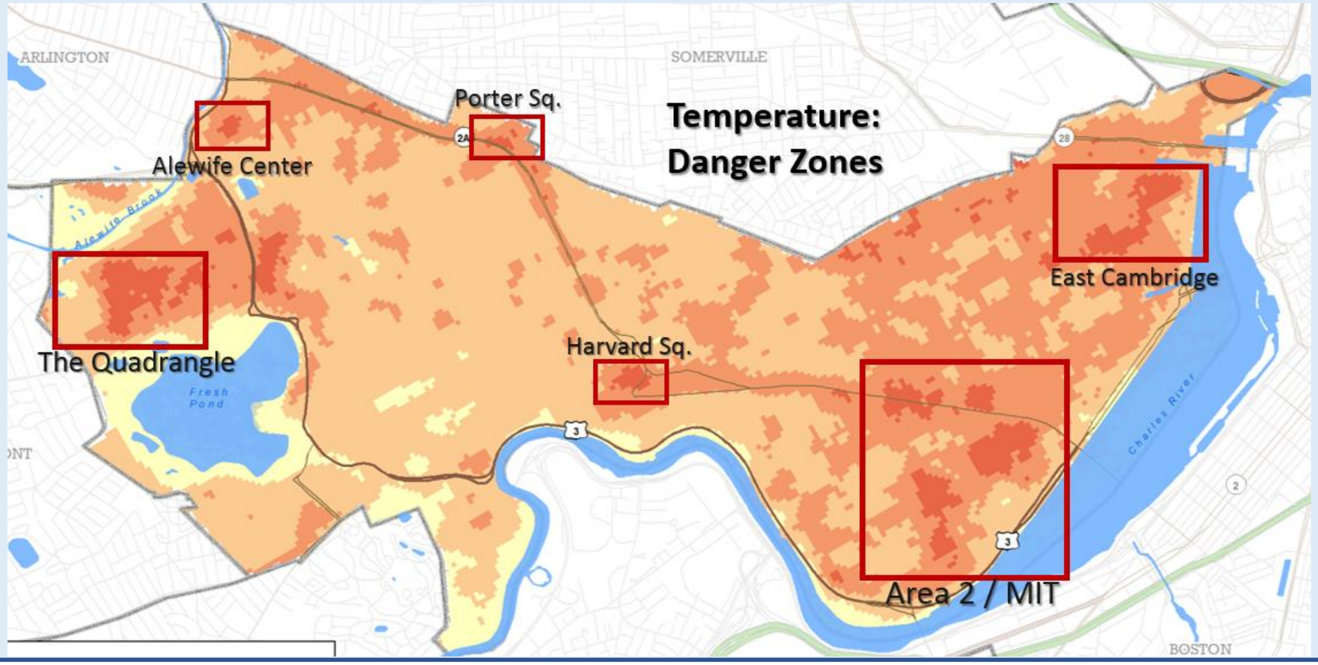
Objectives:

1. Identify vulnerabilities to increasing heat if no changes made

2. Understand better how Cambridge's urban form influences temperatures and how it could be modified

Urban Heat Island Effect Magnifies Ambient Temperature

- Darker impervious surfaces – pavement & roofs -- absorb heat
- Areas with large amounts of impervious surface and lacking tree canopy tend to be heat islands



Translating Heat Index to Human Health Impacts

NOAA National Weather Service: Heat Index

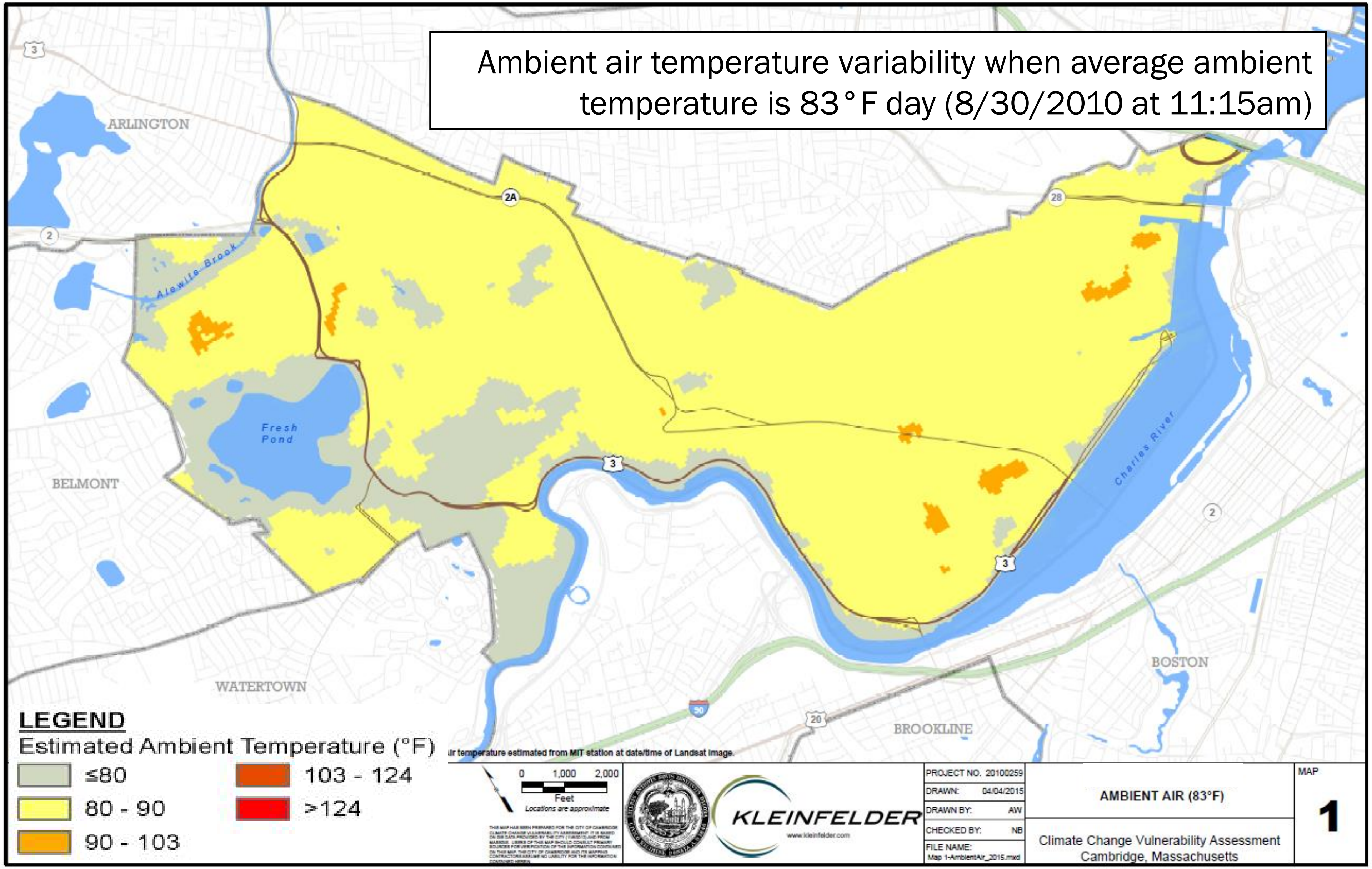
TEMPERATURE (°F)

Realative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Category	Health impact
Caution	**Fatigue**
Extreme Caution	**Heat exhaustion possible**
Danger	**Heat exhaustion likely; heat stroke possible**
Extreme Danger	**Heat stroke likely (death or permanent damage)**

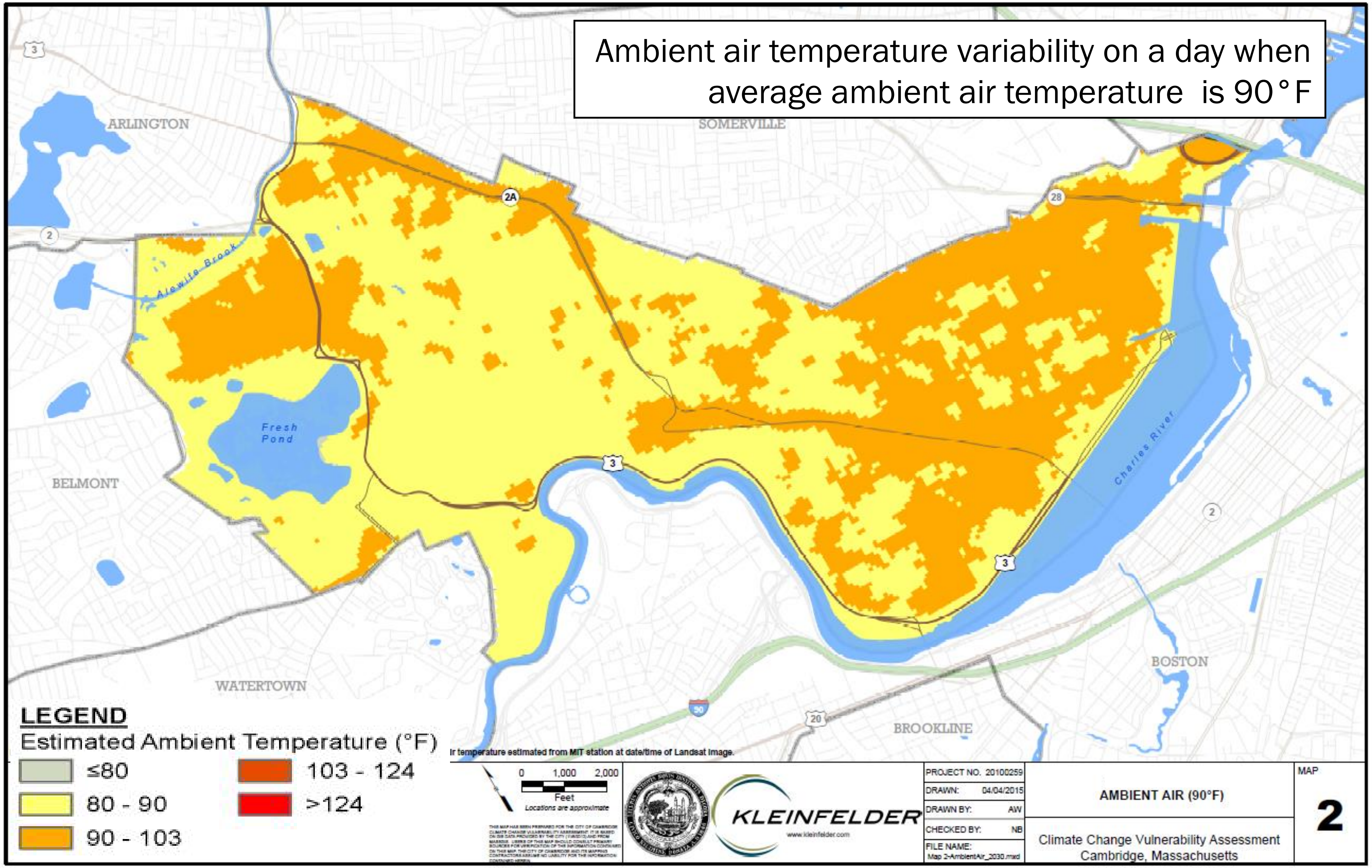
Humidity Exacerbates Heat Impact on Human Health

Ambient Air Temperatures with UHI Effect - 83°F day

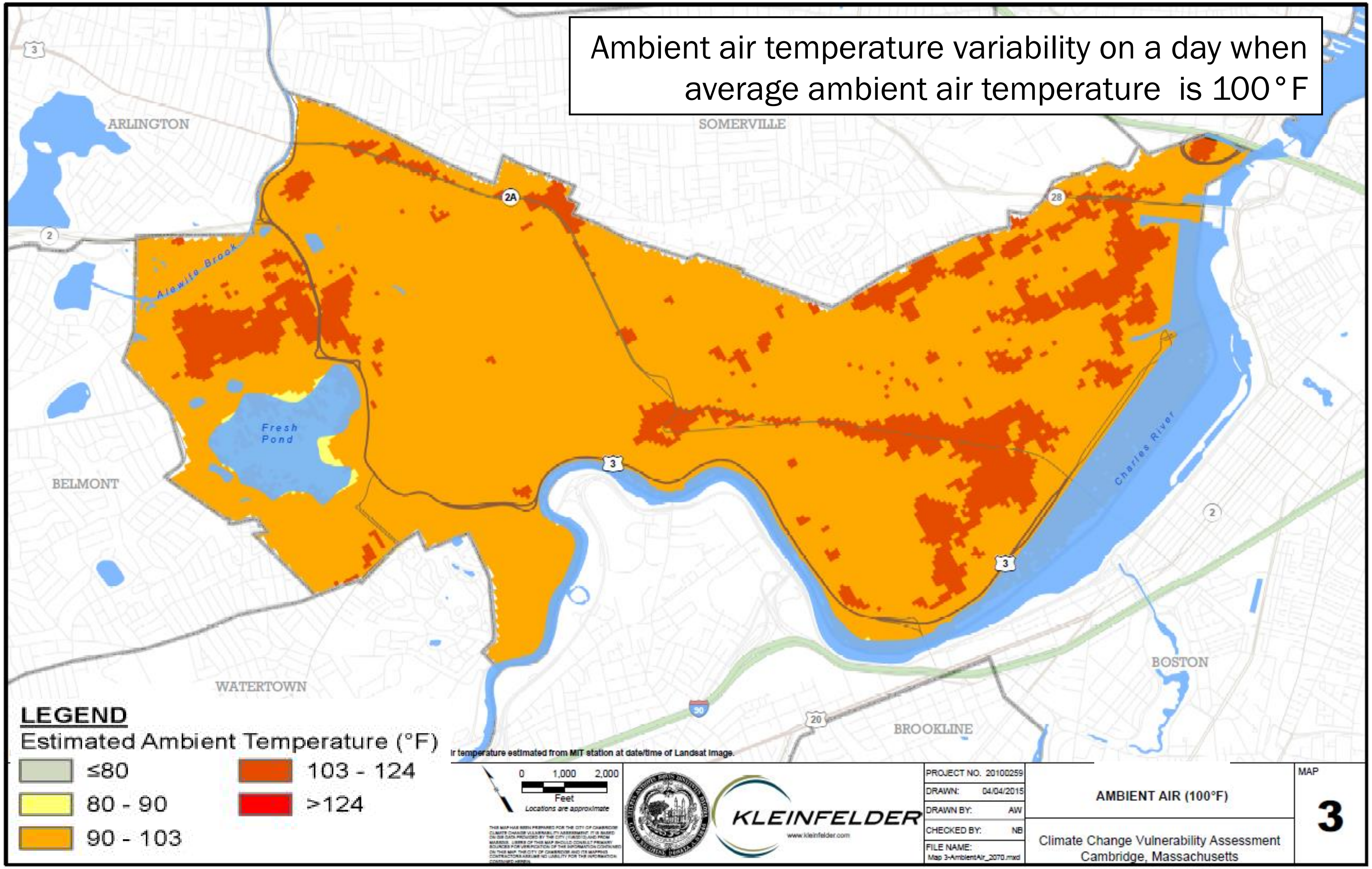


Colors keyed to NOAA Heat Index

Ambient Air Temperature with UHI Effect – 90°F Day



Ambient Air Temperature with UHI Effect - 100°F Day



Energy Use in Buildings Shifting – More Cooling, Less Heating

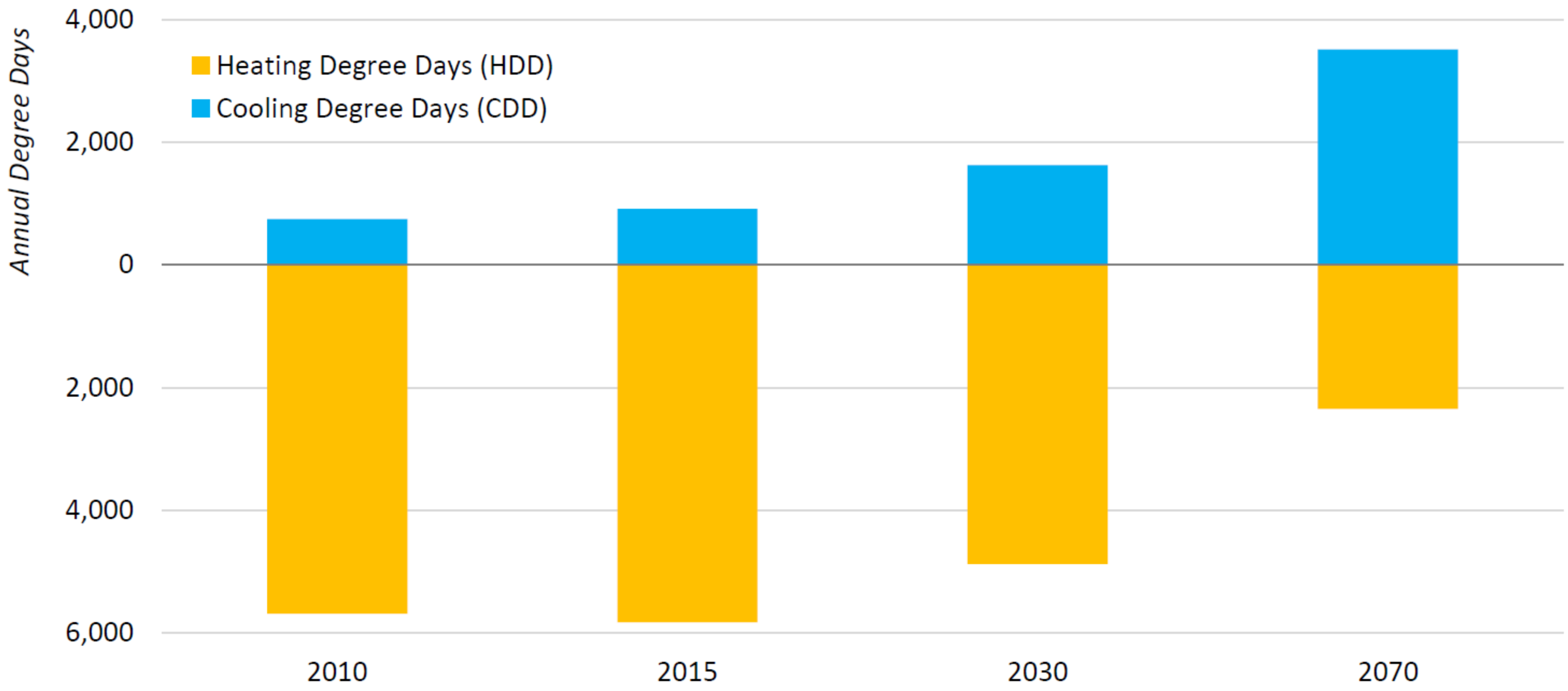


Figure 4 – Historic and projected annual heating and cooling degree days[24]

NOAA data shows Cooling Degree Days have increased by 1.5 times since 2000 compared to 1970-2000.

Cooling impact of:

Building Envelope

White roofs

Converting impervious surfaces to vegetation

Expanding urban forest canopy

Resiliency Planning Objectives for Heat

Cooling impact of:

Building Envelope

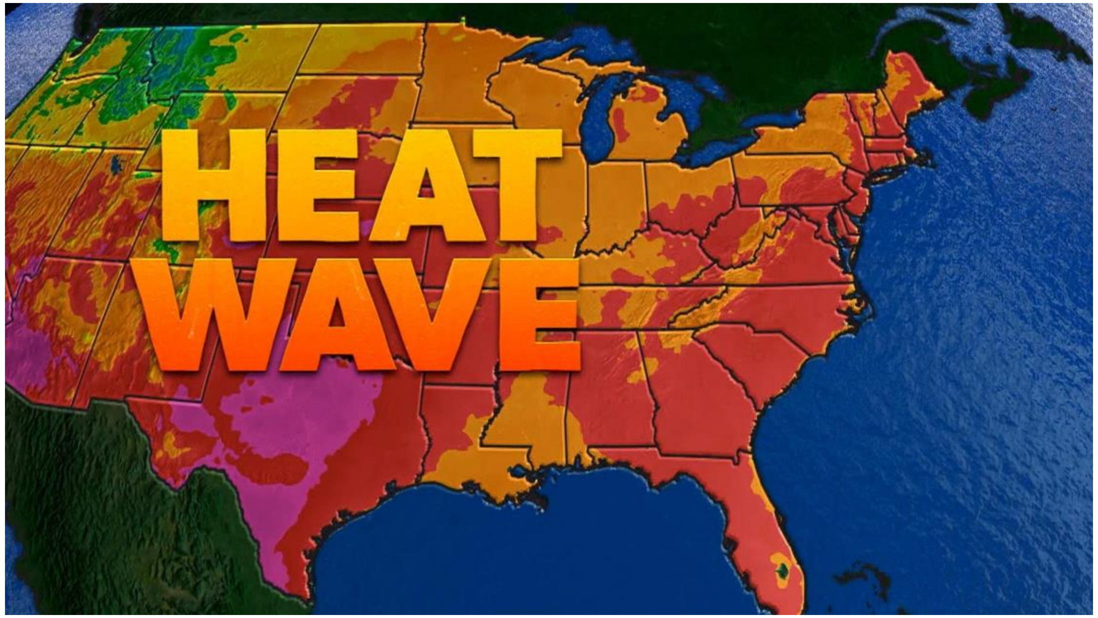
White roofs

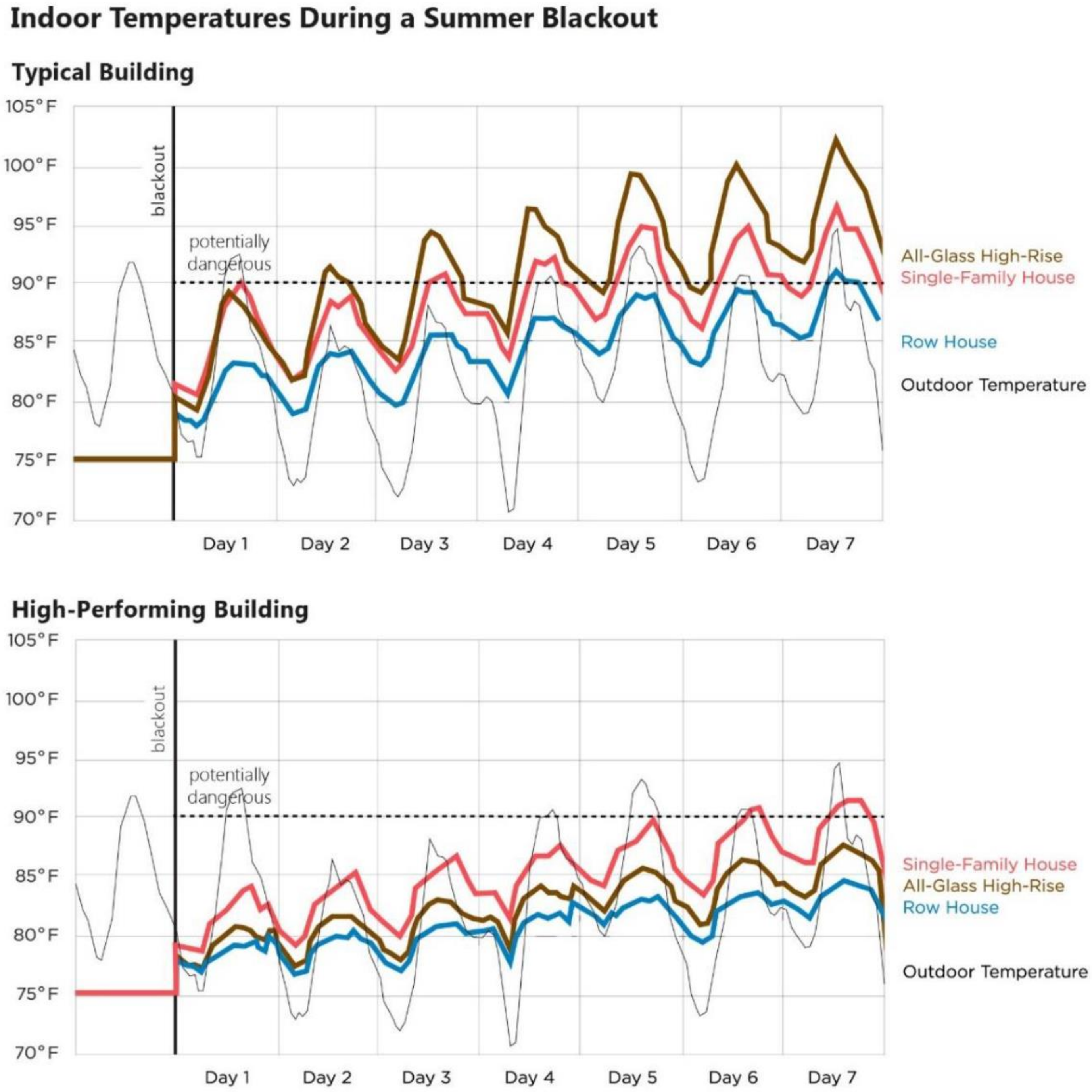
Converting impervious surfaces to vegetation

Expanding urban forest canopy

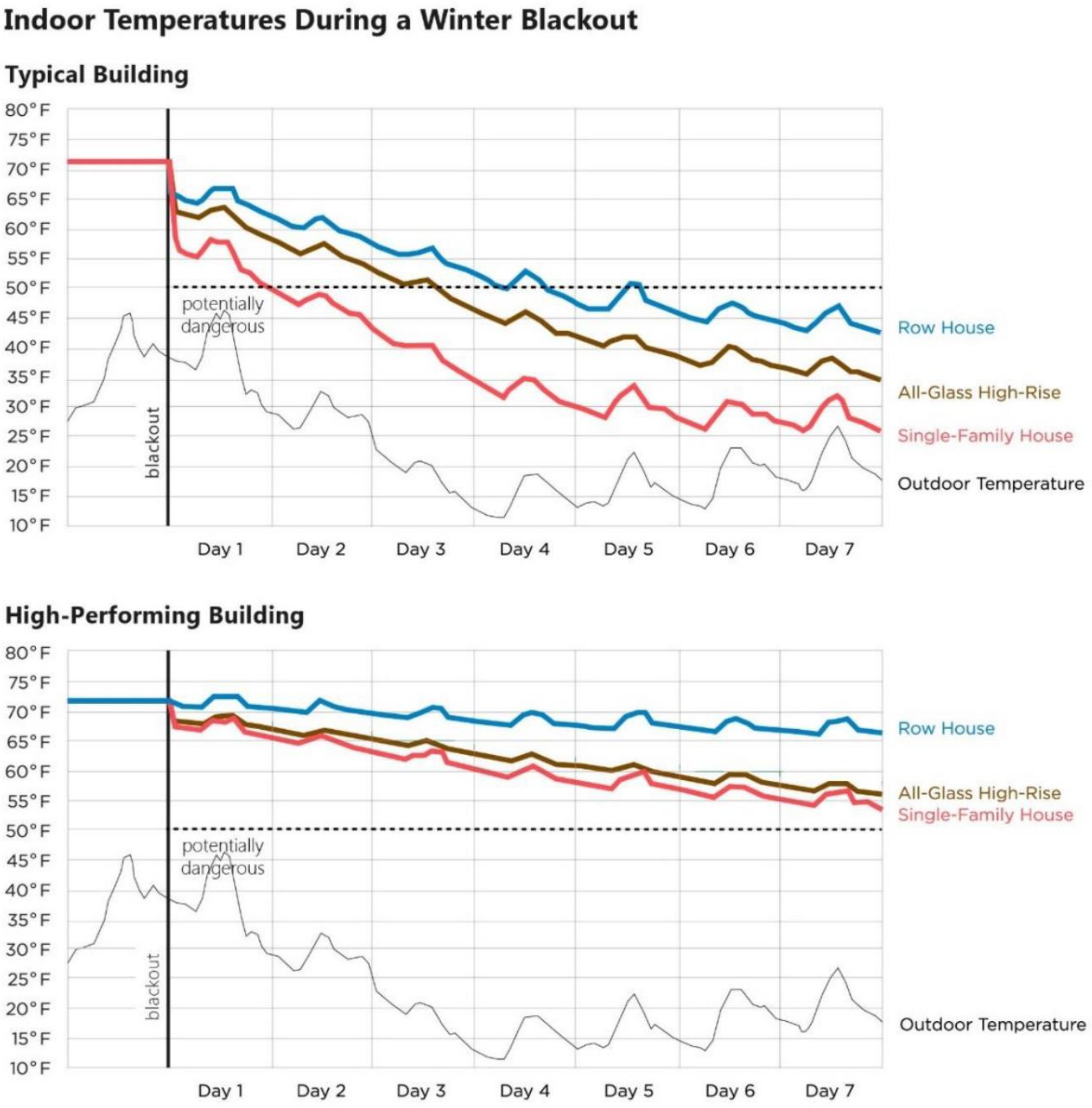
Resiliency Planning Objectives for Heat

How do High-Performing Buildings Perform in a Summer Blackout?





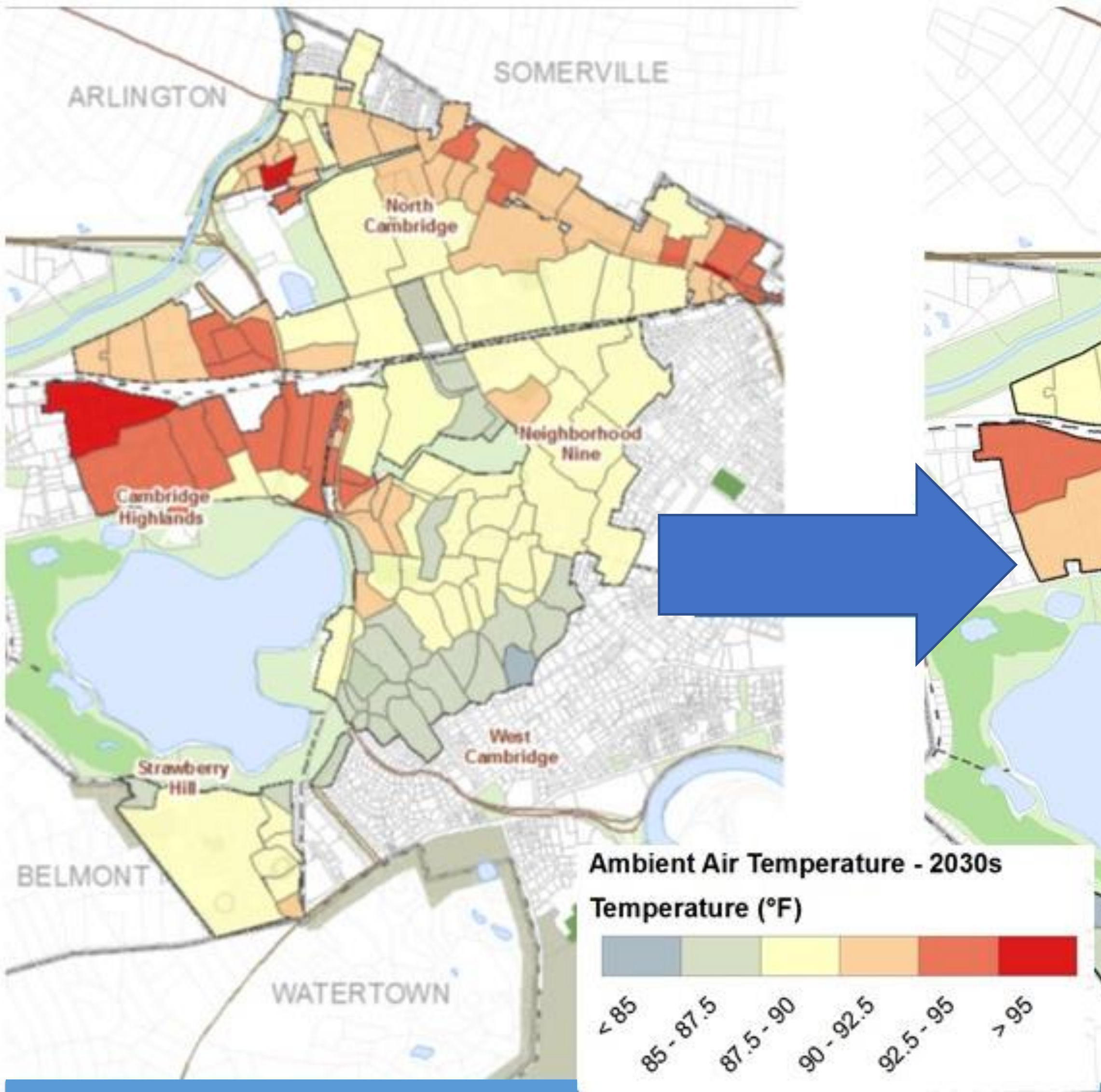
How do High-Performing Buildings Perform in a Winter Blackout?



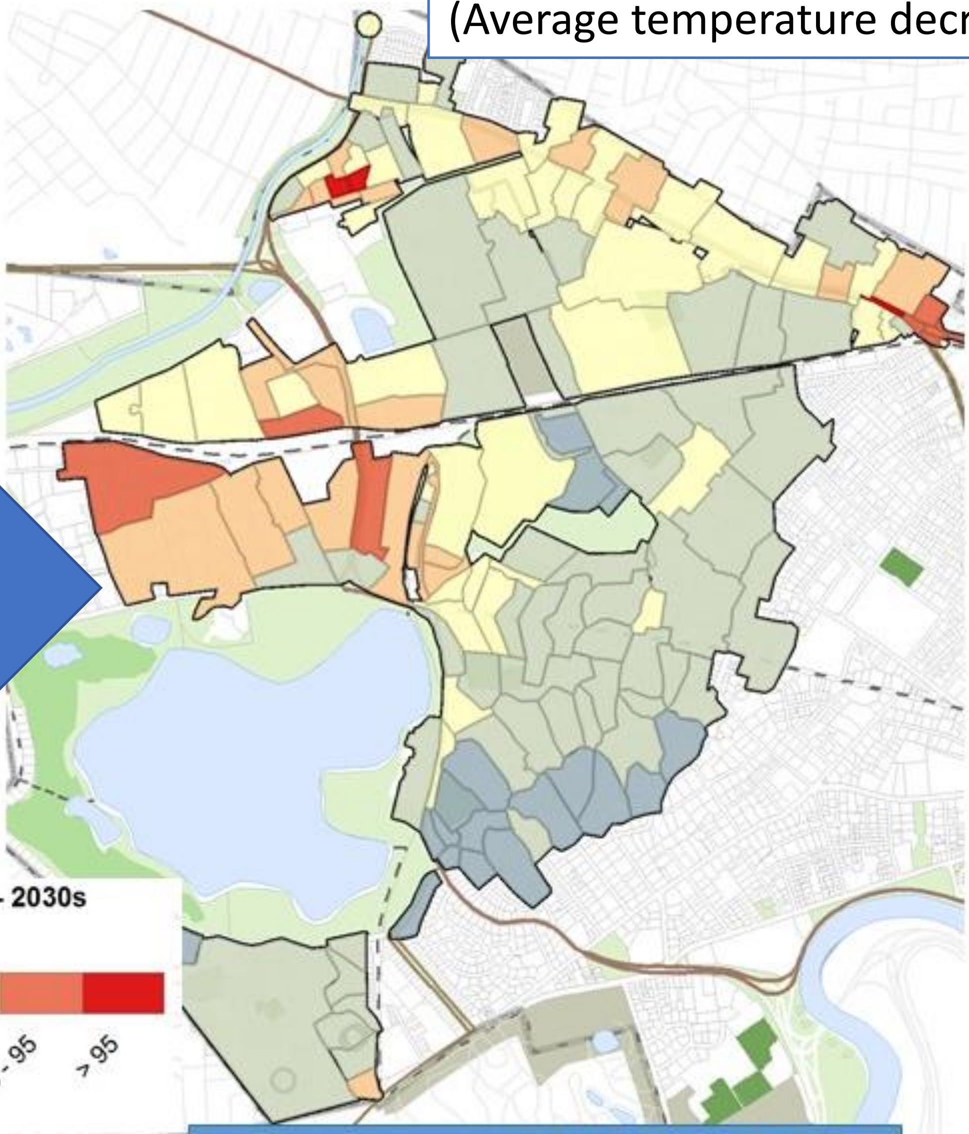
Impact of White Roofs on UHI

Impact of 50% of White Roofs on UHI

Max. temp reduction by 4.5°F
(Average temperature decrease 2.4°F)

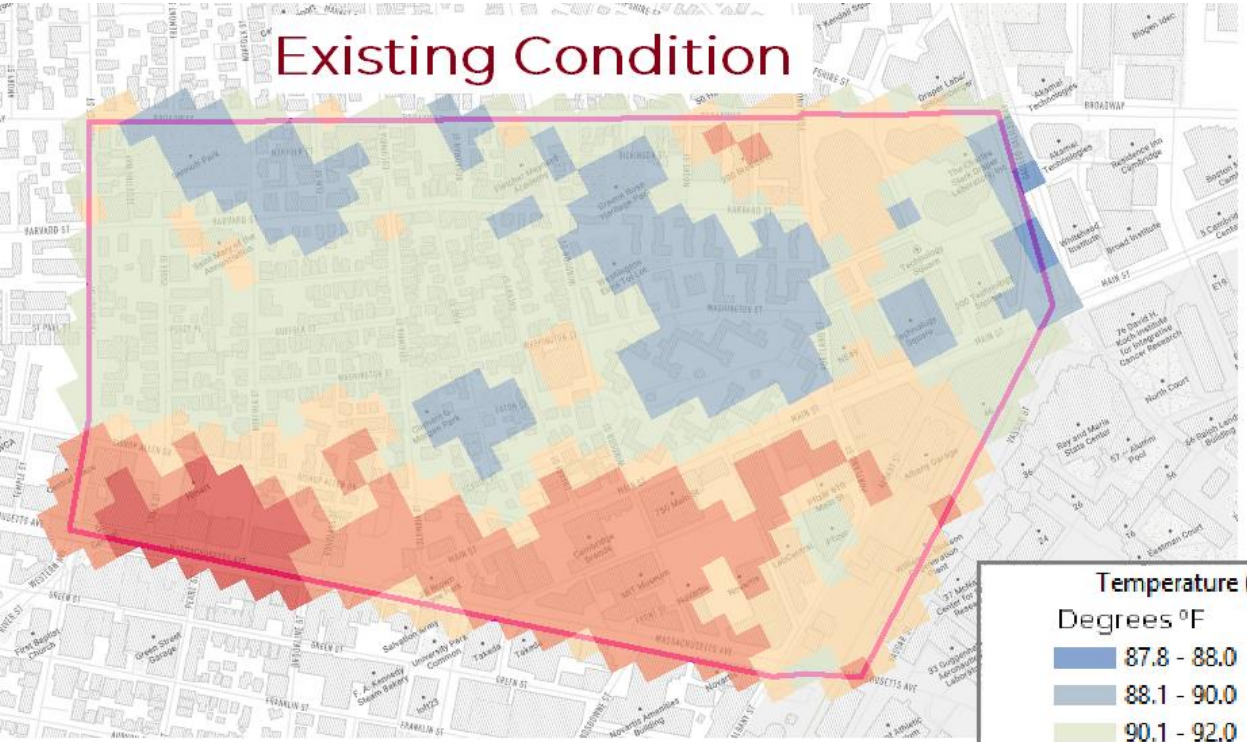


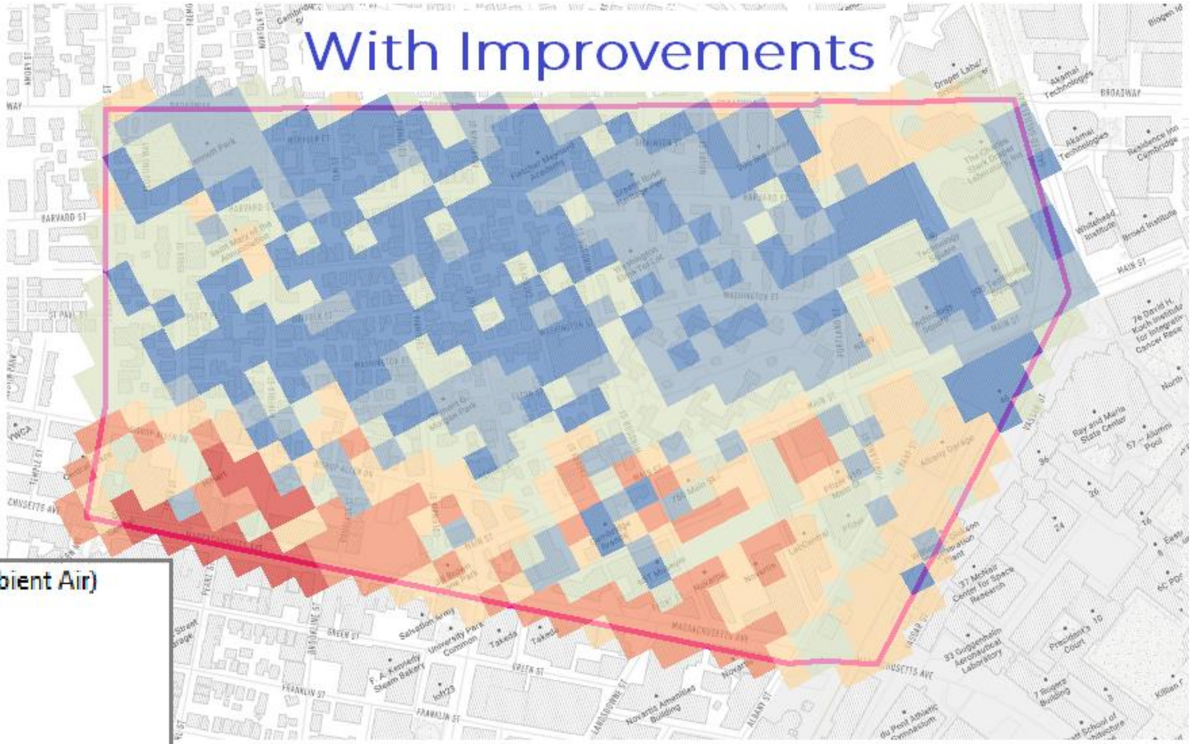
Temperature 90˚F



Temperature with 50% Cool Roofs

COOLING STRATEGIES: To what extent can localized high temperatures be reduced?





Temperature (2030 Ambient Air)
Degrees °F
- 87.8 - 88.0
- 88.1 - 90.0
- 90.1 - 92.0
- 92.1 - 94.0
- 94.1 - 96.0
- 96.1 - 100.0

Average Temperature = 92°F

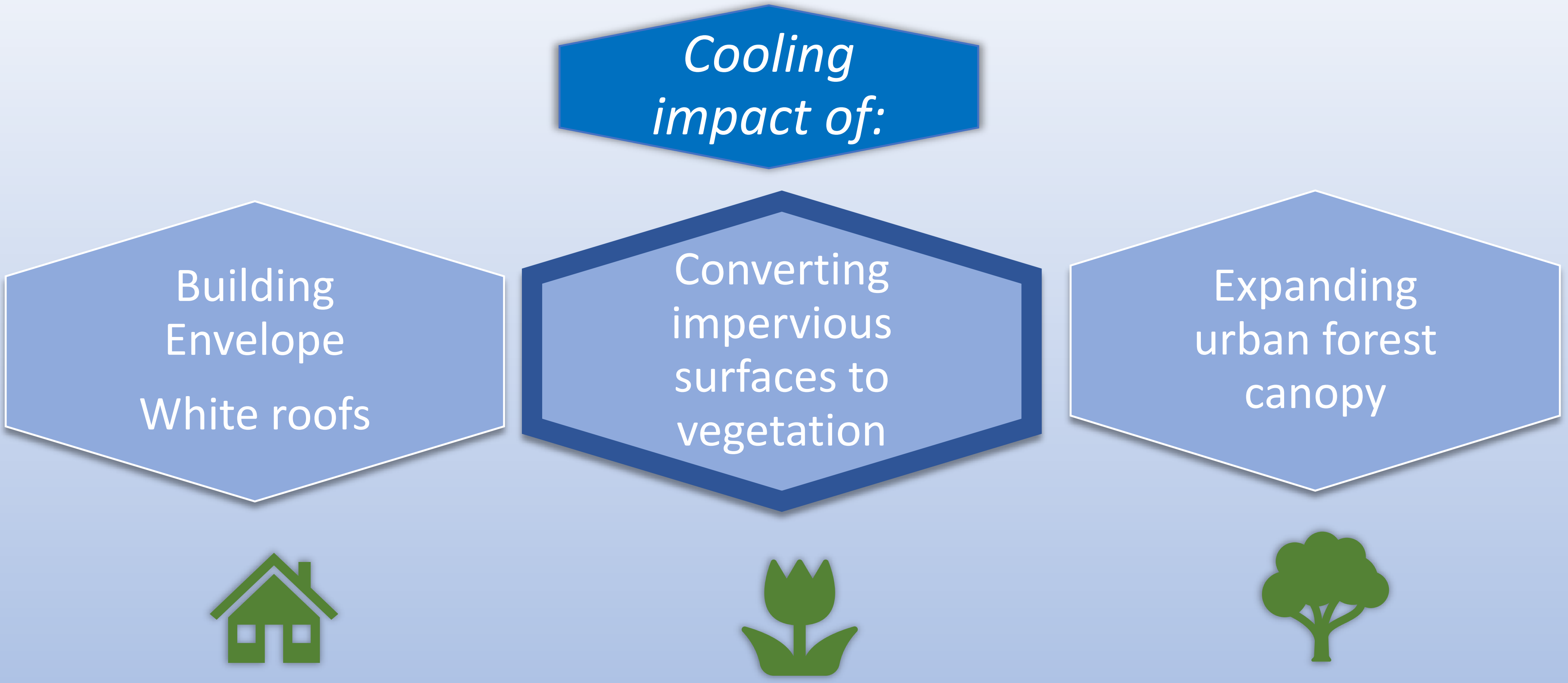
Percent of Port area > 92ºF : 44%

Average Temperature = 90°F

Percent of Port area > 92ºF : 29%

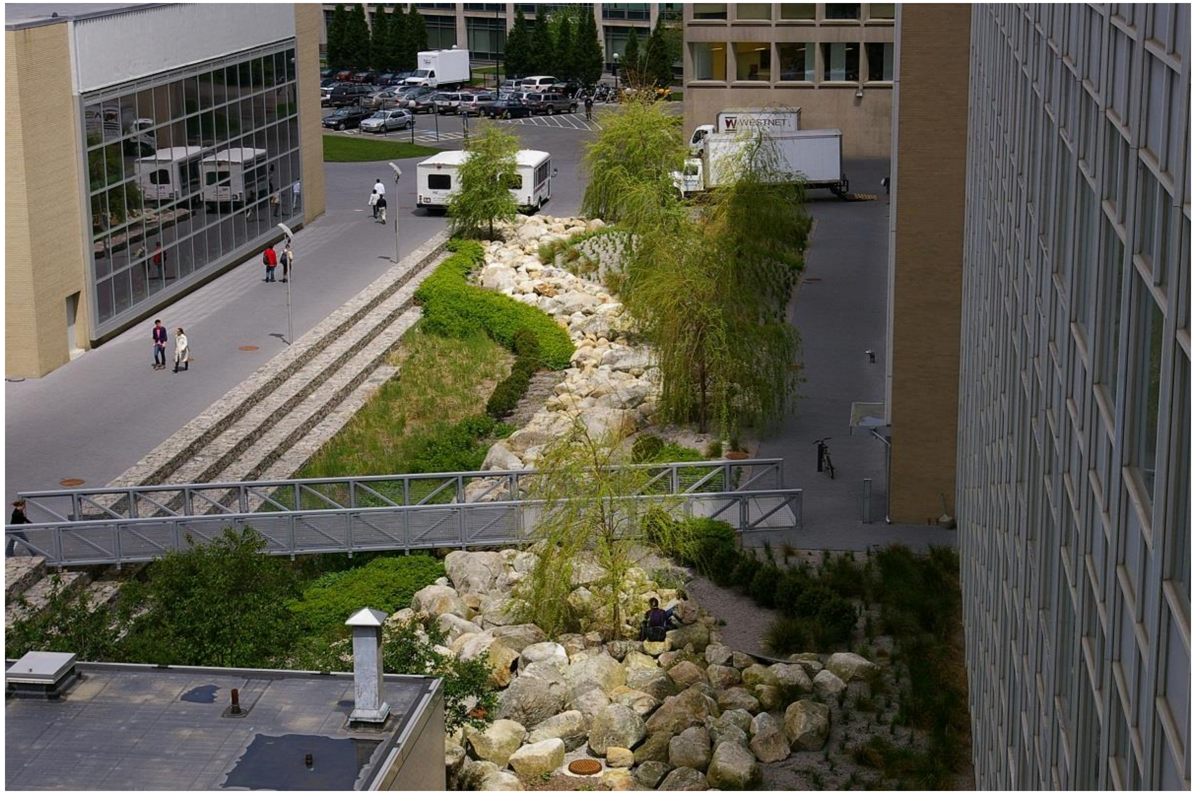
Draft Figure: Based on Ambient Air Temperature on a 90 Degree Day

Cooling from Green Roofs + White Roofs: 1.7 °F
Cooling From New Tree Canopy: 0.3 ° F



Resiliency Planning Objectives for Heat

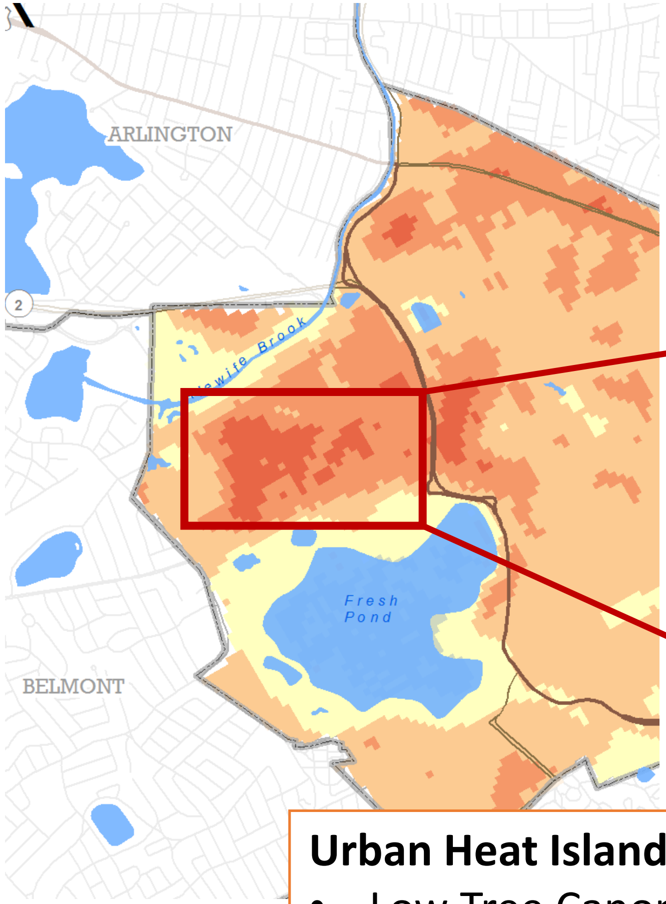
Reducing Impervious Areas Through Green Infrastructure Reduces Temperatures



Infiltration under Longfellow Park

Rain Garden at Stata Center, MIT

Impervious Areas – Increase Temperatures

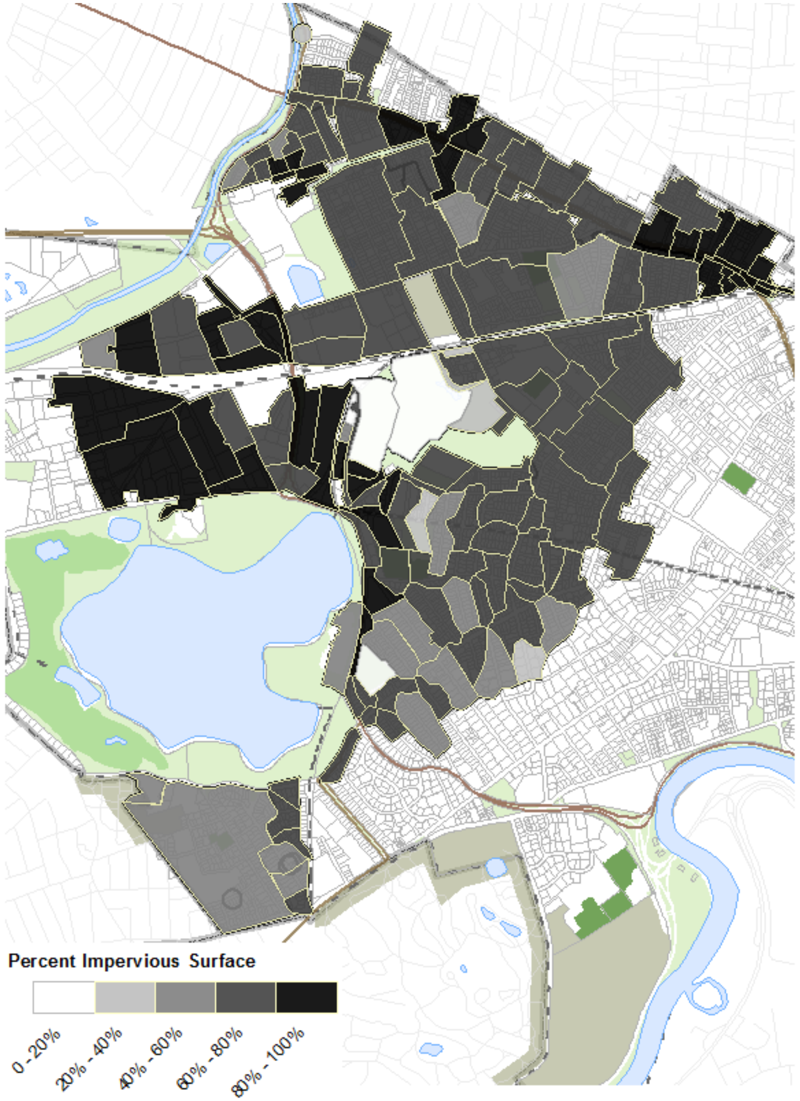


Urban Heat Island:

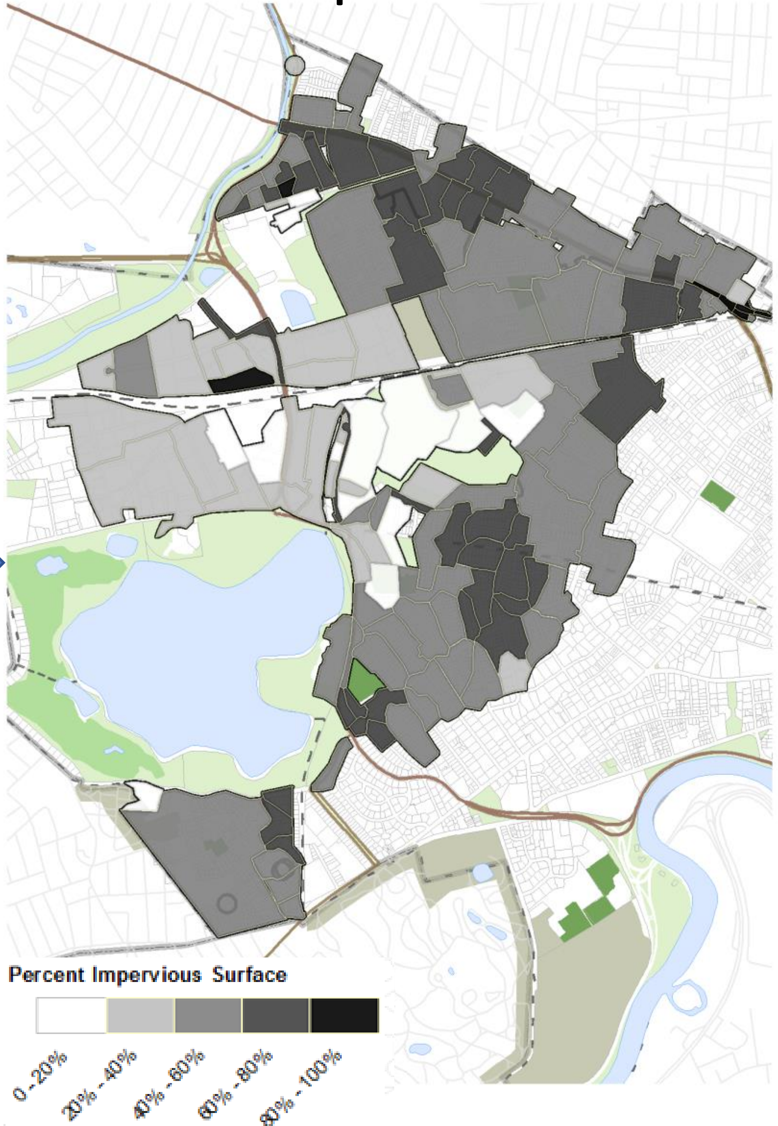
- Low Tree Canopy %
- High % Impervious Surface
- Large Square footage of roofs
- Dark roofing surfaces (Low SRI)

Test Case – Maximum Extent Practicable

Green Infrastructure Effectively Reduces Impervious Area



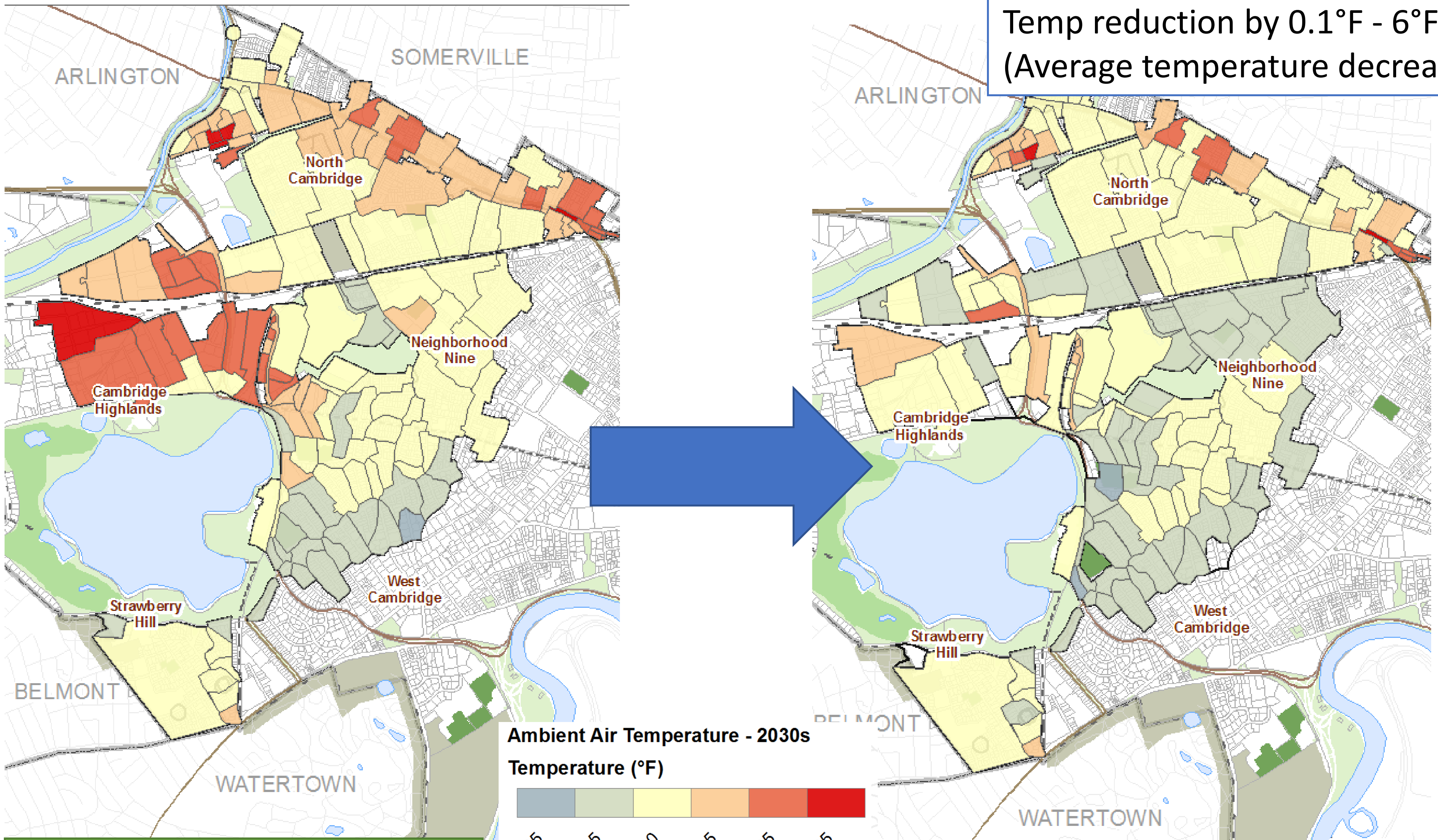
Existing Impervious Surface by Catchment



Proposed Impervious Surface with Green Infrastructure at MEP

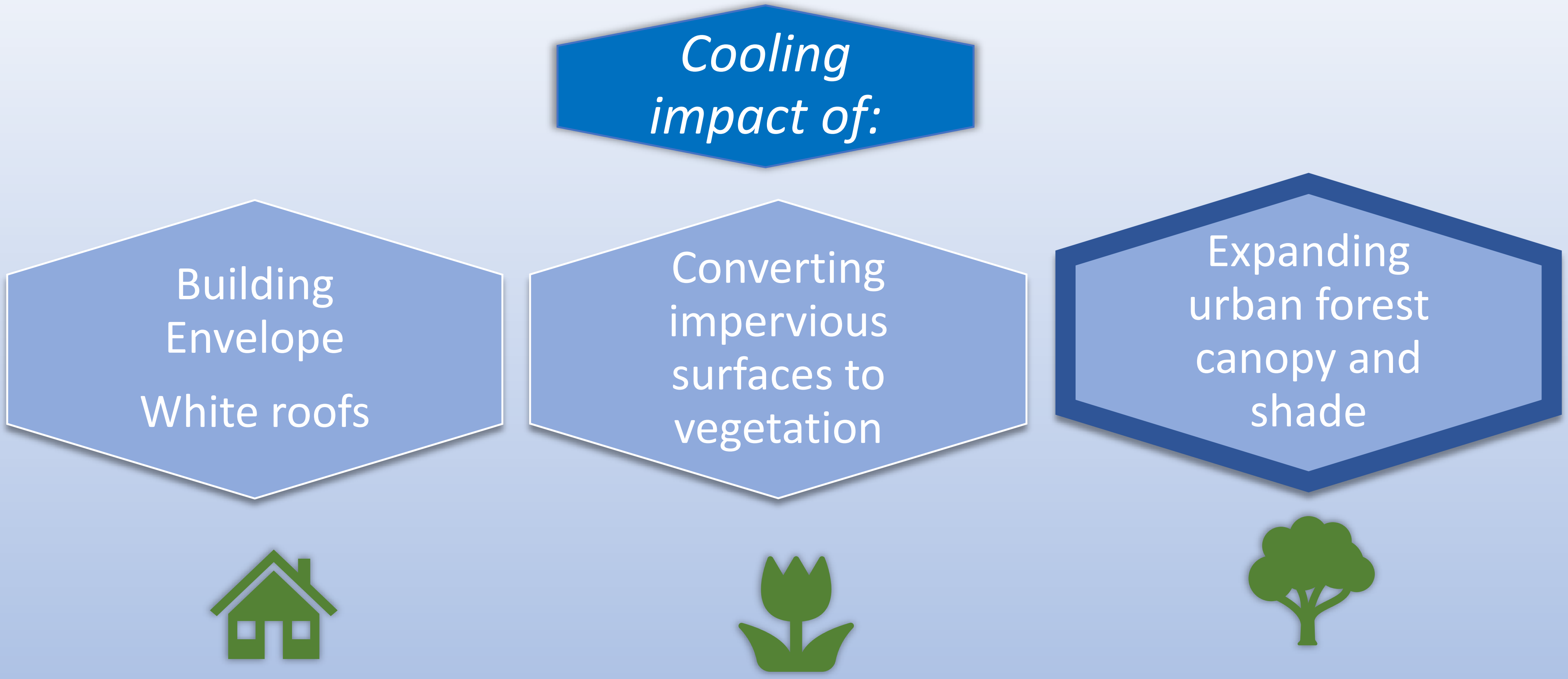
Green Infrastructure Reduces Temperatures

Temp reduction by 0.1°F - 6°F
(Average temperature decrease 1.7°F)



Temperature 90˚F

Temperature with Green BMPs at MEP



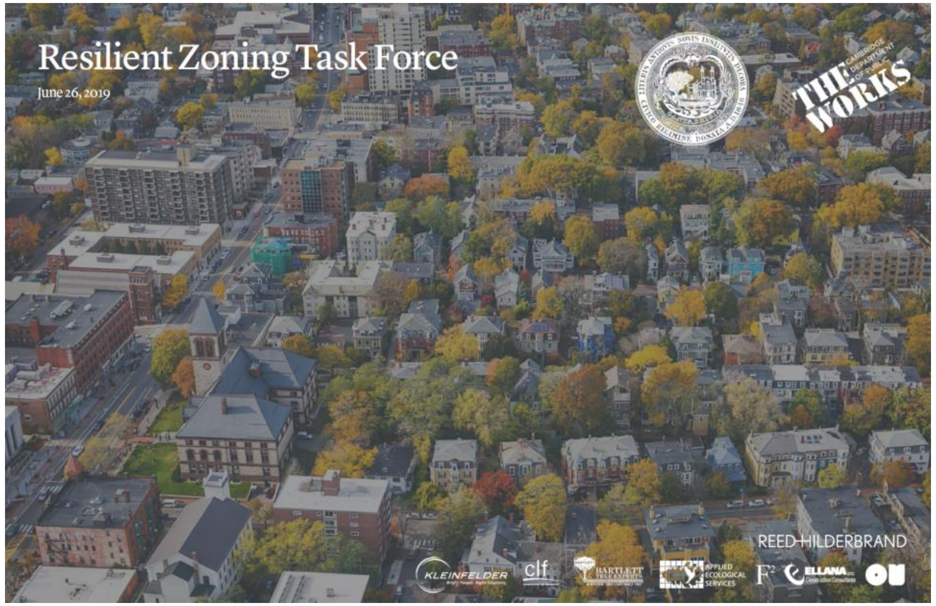
Resiliency Planning Objectives for Heat

Urban Forest Master Plan

In 2009 citywide canopy cover	30%
In 2018 citywide canopy cover	26%

Where is our existing canopy cover located?

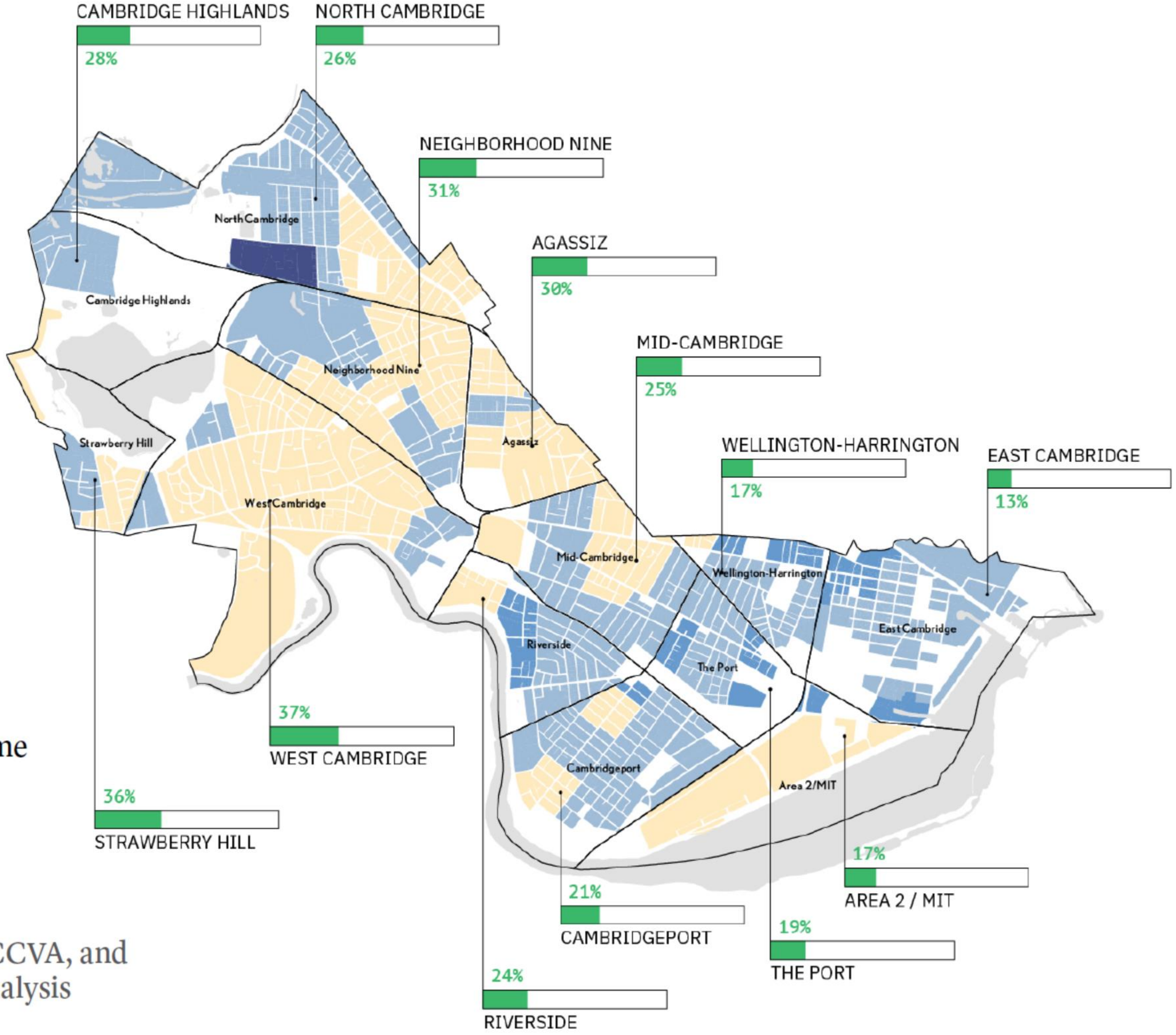
Residential	39%
Public Right-of-way	22%
Open Space	22%
Institutional	8%
Commercial	4%
Industrial	2%
Public	2%



More trees

CANOPY INEQUITY

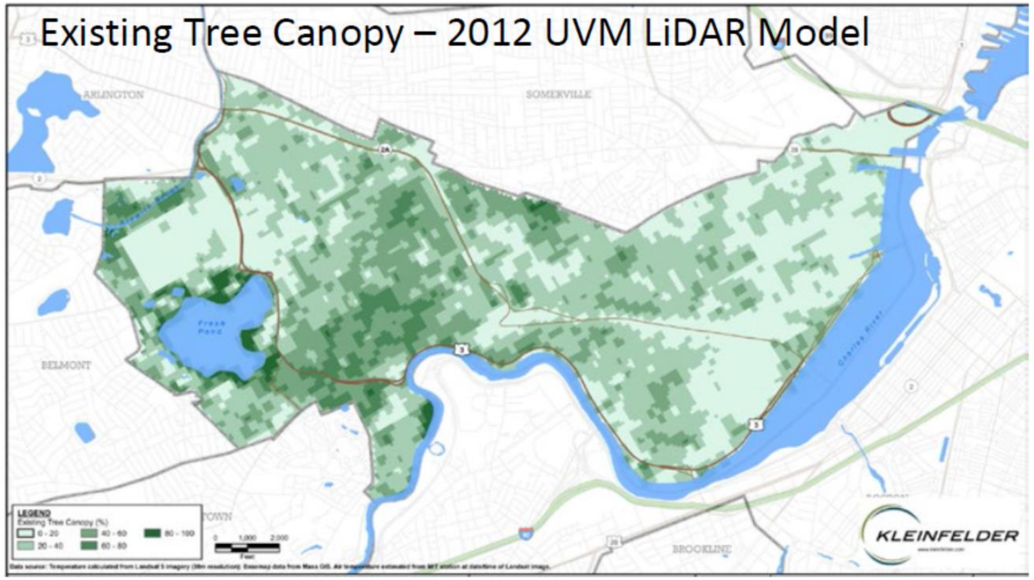
Many vulnerable populations have lower canopy coverage



- None
- Minority
- Minority and Low Income
- Minority, Low Income and English Isolation

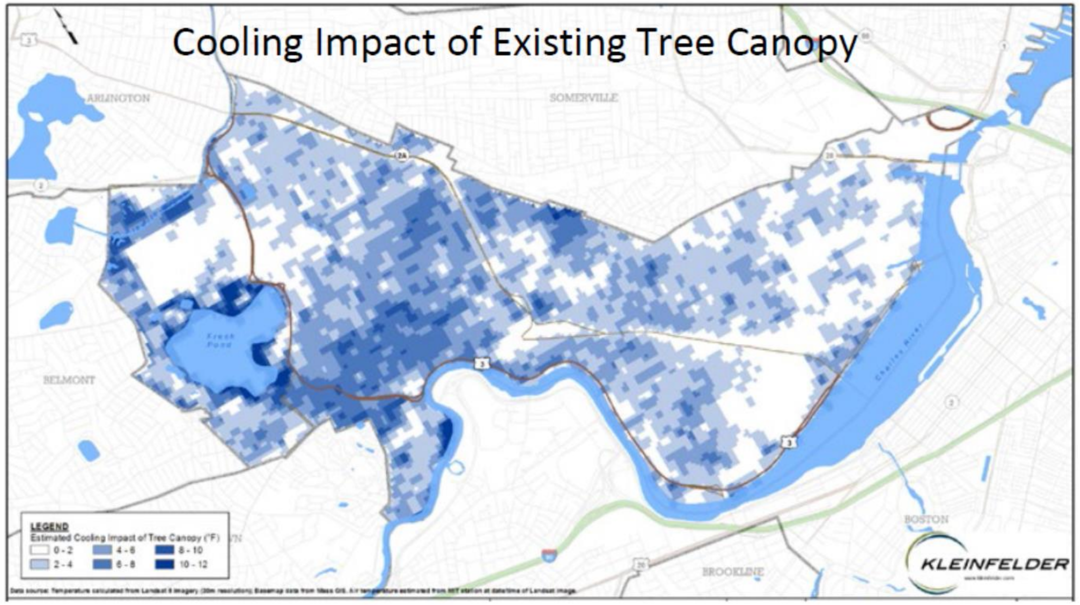
Source: 2010 US Census Data, CCVA, and CUFMP 2018 canopy analysis

Estimating Cooling Impact of Existing Urban Forest Canopy



Cell Resolution: 30 meters x 30 meters (100' ft x 100' ft)
Canopy data from 2009

Calculated Cooling Impact:
+1% tree canopy increase relates to 0.12 °F of cooling



CCPR assumed linear relationship; Ziter (2019) indicates cooling from tree canopy is non-linear (45% key threshold)

Source: Appendix D Urban Heat Island Protocol for Mapping Temperature Projections, Kleinfelder for the City of Cambridge, November 2015

How do trees impact temperatures?

(90 degree day)

A.

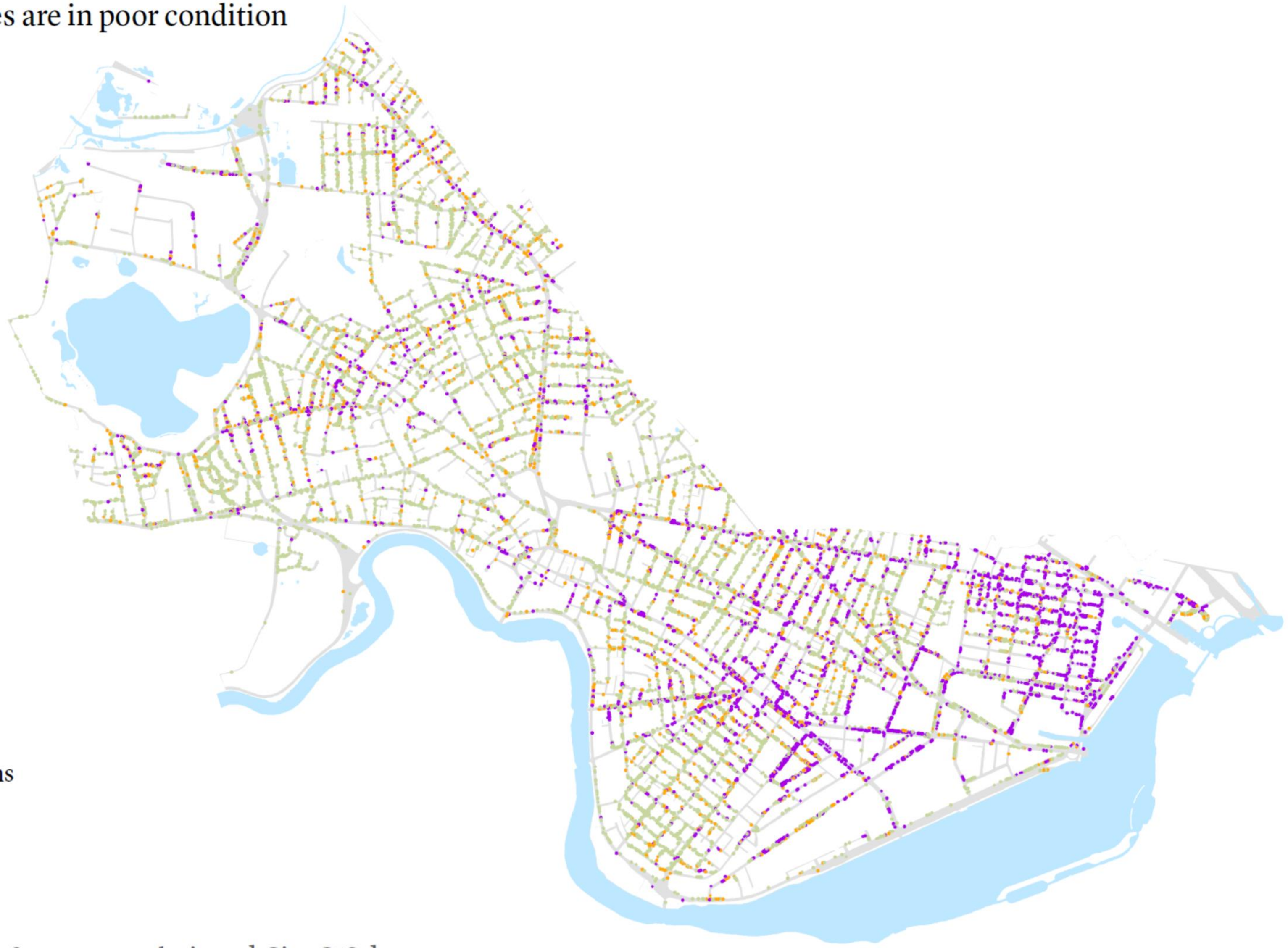
B.

C.

Building Setbacks Affect Street Trees

CONDITION OF STREET TREES

24% of street trees are in poor condition



Tree Health Conditions

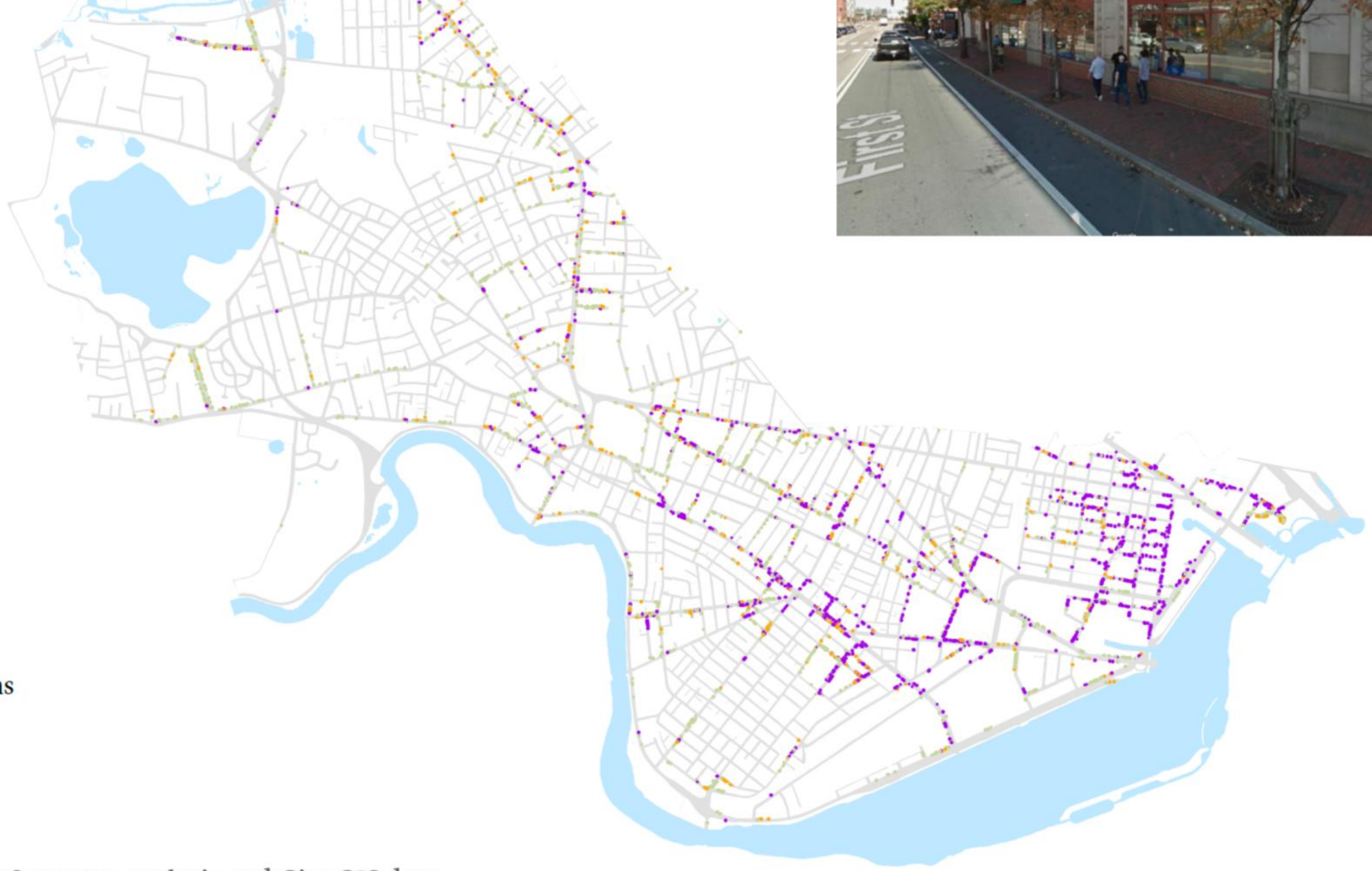
- Fair
- Good
- Poor

Source: CUFMP 2018 canopy analysis and City GIS data.

Building Setbacks Affect Street Trees
No front yard setbacks

CONDITION OF STREET TREES

39% of trees in sidewalks greater than 8' are in poor condition.
Frequently these areas have no front yard setbacks



Tree Health Conditions

- Fair
- Good
- Poor

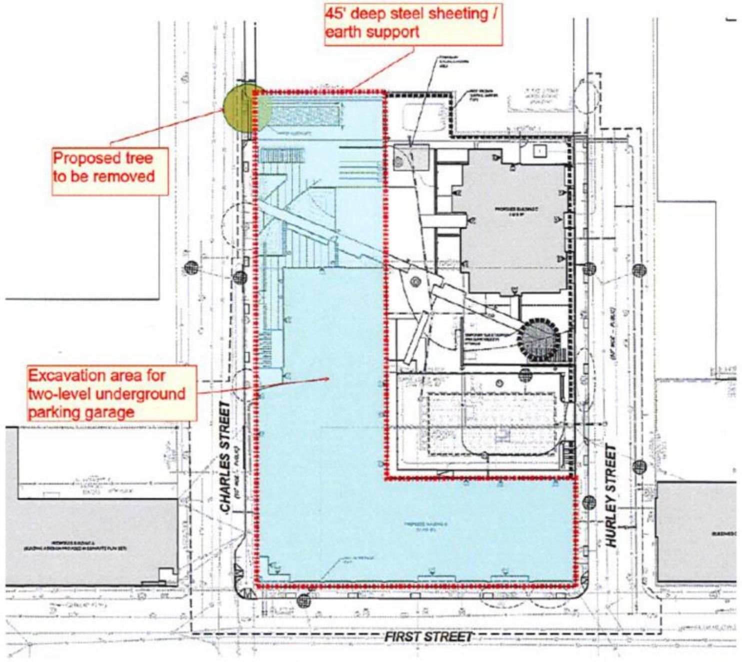
Source: CUFMP 2018 canopy analysis and City GIS data.

Building Setbacks Affect Street Trees

R.O.W. CANOPY

Zero lot line construction negatively impacts large street trees

Large Zelkova was removed because proposed construction on a Charles St lot required severe pruning of canopy and cutting of major structural roots that had grown into the property.



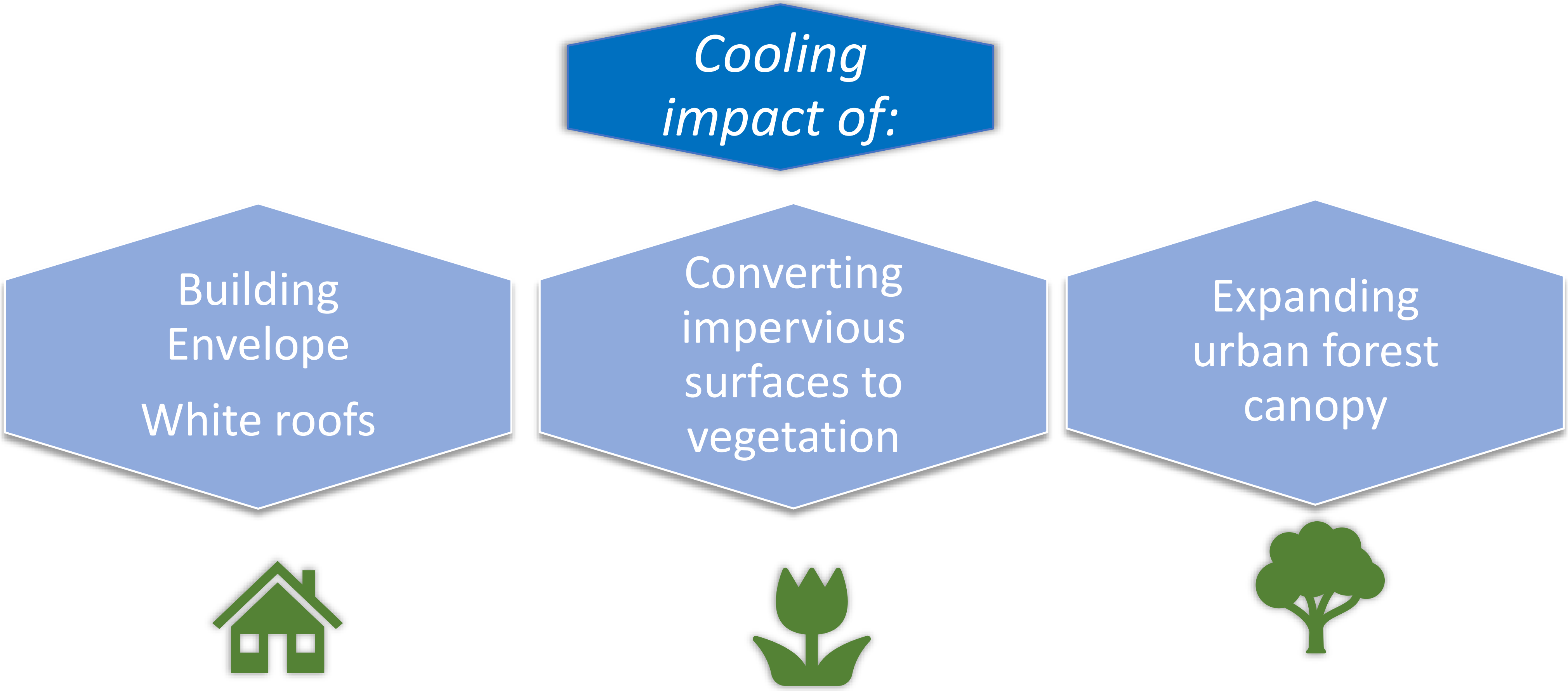
Location of Sheet Piling and Excavation

29 Charles St. Existing Zelkova

Additional Air Spading Photos

REED HILDERBRAND RESILIENT ZONING TASK FORCE JUNE MEETING | JUNE 26, 2019 17

Shade in addition to trees



Resiliency Planning Objectives for Heat

Summary of Findings

- **Efficient building envelopes** keep inside temperatures in a safe range during power outages.

- **White roofs yielded a 2.4°F cooling benefit** with a 50% level of implementation across existing buildings (area weighted average)

- White roofs are more effective in cooling, but do not have the additional benefits of **water quality improvement and flood reduction** for smaller storms.

- **Green Infrastructure and Reducing Impervious Areas reduce ambient temperature by 0.1°F - 6°F**, with an average temperature decrease of 1.7°F (area-weighted average across all catchments).

- **A 1% tree canopy increase relates to 0.12 °F of cooling.**

Peformance Standards: Examples

- Green Factor: Seattle
- Green Area Ratio: Washington DC
- LEED Resilience Pilot Credit for Passive Thermal Resilience
- Solar Reflectance Index

Prescriptive Standards: Examples

- Minimum landscape requirements
- Maximum impervious cover
- Passive House building envelope
- Community space sheltering requirement
- Back up power/energy storage
- Cool roof requirement

Discussion Framework

Heat Projections

How will urban heat islands affect temperatures and other conditions experienced by the Cambridge community?

Heat Impacts

What heat impacts should this group focus on? What heat impacts are of most concern?

Land Use and Development Strategies

What strategies might property owners employ to mitigate heat impacts, and what are the relevant benefits and costs of these strategies?

Summary of Task Force Discussion

Strategies

- Nonvegetative shading
- Thermal mass reduction
- Green Factor-like rating system
- Parking and impervious surface reduction
- Data collection to support modeling of heat impacts

Implementation

- Priority areas v. citywide actions
- Equity and access
- Compatibility and conflict with other City priorities

Principles and Objectives

Principles to Guide Zoning Strategies

What are the qualities that good climate resilience zoning strategies should have?

Principles to Guide Zoning Strategies

1. Focus on people, communities, and equity
2. Account for differentiation and choice
3. Balance strategies to address new construction and existing development
4. Use performance-based standards as well as prescriptive standards
5. Allow flexibility in changing circumstances
6. Support actions with co-benefits
7. Seek effectiveness
8. Make decisions based on best available data and science

Principles to Guide Zoning Strategies

1. **Focus on people, communities, and equity**
2. Account for differentiation and choice
3. Balance strategies to address new construction and existing development
4. Use performance-based standards as well as prescriptive standards
5. Allow flexibility in changing circumstances
6. Support actions with co-benefits
7. Seek effectiveness
8. Make decisions based on best available data and science

Principles to Guide Zoning Strategies

1. Focus on people, communities, and equity
2. **Account for differentiation and choice**
3. Balance strategies to address new construction and existing development
4. Use performance-based standards as well as prescriptive standards
5. Allow flexibility in changing circumstances
6. Support actions with co-benefits
7. Seek effectiveness
8. Make decisions based on best available data and science

Principles to Guide Zoning Strategies

1. Focus on people, communities, and equity
2. Account for differentiation and choice
3. **Balance strategies to address new construction and existing development**
4. Use performance-based standards as well as prescriptive standards
5. Allow flexibility in changing circumstances
6. Support actions with co-benefits
7. Seek effectiveness
8. Make decisions based on best available data and science

Principles to Guide Zoning Strategies

1. Focus on people, communities, and equity
2. Account for differentiation and choice
3. Balance strategies to address new construction and existing development
4. **Use performance-based standards as well as prescriptive standards**
5. Allow flexibility in changing circumstances
6. Support actions with co-benefits
7. Seek effectiveness
8. Make decisions based on best available data and science

Principles to Guide Zoning Strategies

1. Focus on people, communities, and equity
2. Account for differentiation and choice
3. Balance strategies to address new construction and existing development
4. Use performance-based standards as well as prescriptive standards
5. **Allow flexibility in changing circumstances**
6. Support actions with co-benefits
7. Seek effectiveness
8. Make decisions based on best available data and science

Principles to Guide Zoning Strategies

1. Focus on people, communities, and equity
2. Account for differentiation and choice
3. Balance strategies to address new construction and existing development
4. Use performance-based standards as well as prescriptive standards
5. Allow flexibility in changing circumstances
6. **Support actions with co-benefits**
7. Seek effectiveness
8. Make decisions based on best available data and science

Principles to Guide Zoning Strategies

1. Focus on people, communities, and equity
2. Account for differentiation and choice
3. Balance strategies to address new construction and existing development
4. Use performance-based standards as well as prescriptive standards
5. Allow flexibility in changing circumstances
6. Support actions with co-benefits
7. **Seek effectiveness**
8. Make decisions based on best available data and science

Principles to Guide Zoning Strategies

1. Focus on people, communities, and equity
2. Account for differentiation and choice
3. Balance strategies to address new construction and existing development
4. Use performance-based standards as well as prescriptive standards
5. Allow flexibility in changing circumstances
6. Support actions with co-benefits
7. Seek effectiveness
8. **Make decisions based on best available data and science**

Land Use and Development Objectives

What are the actual outcomes that the zoning recommendations will aim to achieve?

Land Use and Development Objectives

1. **Protect flood-sensitive uses by elevating or dry-floodproofing**
2. **Design buildings to withstand or recover from projected flooding**

Land Use and Development Objectives

3. Use green infrastructure in addition to gray infrastructure to manage stormwater on-site
4. Preserve existing vegetation
5. Create new vegetated areas and design so that plantings can thrive over time
6. Limit amount of paved area, increase permeable area
7. Provide shade with trees or structural shading where trees are infeasible, especially over paved areas

Land Use and Development Objectives

8. Use solar-reflective surface materials for roofs, buildings, and paved surfaces to the extent possible
9. Incorporate "passive resilience" features
10. Provide spaces for sheltering and services during extreme events
11. Create emergency plans with protocols to implement during an extreme weather event, where practical

Land Use and Development Objectives

12. Achieve the above results across larger areas (e.g., protective berms, elevated infrastructure, larger-scale green infrastructure, pooled open space, neighborhood preparedness plans)

13. Promote objectives with other environmental benefits, such as reducing energy demand, greenhouse gas emissions, and auto trip generation

Principles

1. people, communities, equity
2. differentiation and choice
3. new construction & existing development
4. performance-based & prescriptive standards
5. flexibility in changing circumstances
6. actions with co-benefits
7. effectiveness
8. best available data and science

Objectives

1. elevate & floodproof
2. design to recover
3. green infrastructure
4. preserve vegetation
5. create vegetation
6. limit paved areas
7. provide shading
8. use reflective surfaces
9. promote passive resilience
10. shelter in emergencies
11. create emergency plans
12. implement area-wide strategies
13. produce co-benefits

Questions?

Zoning Considerations

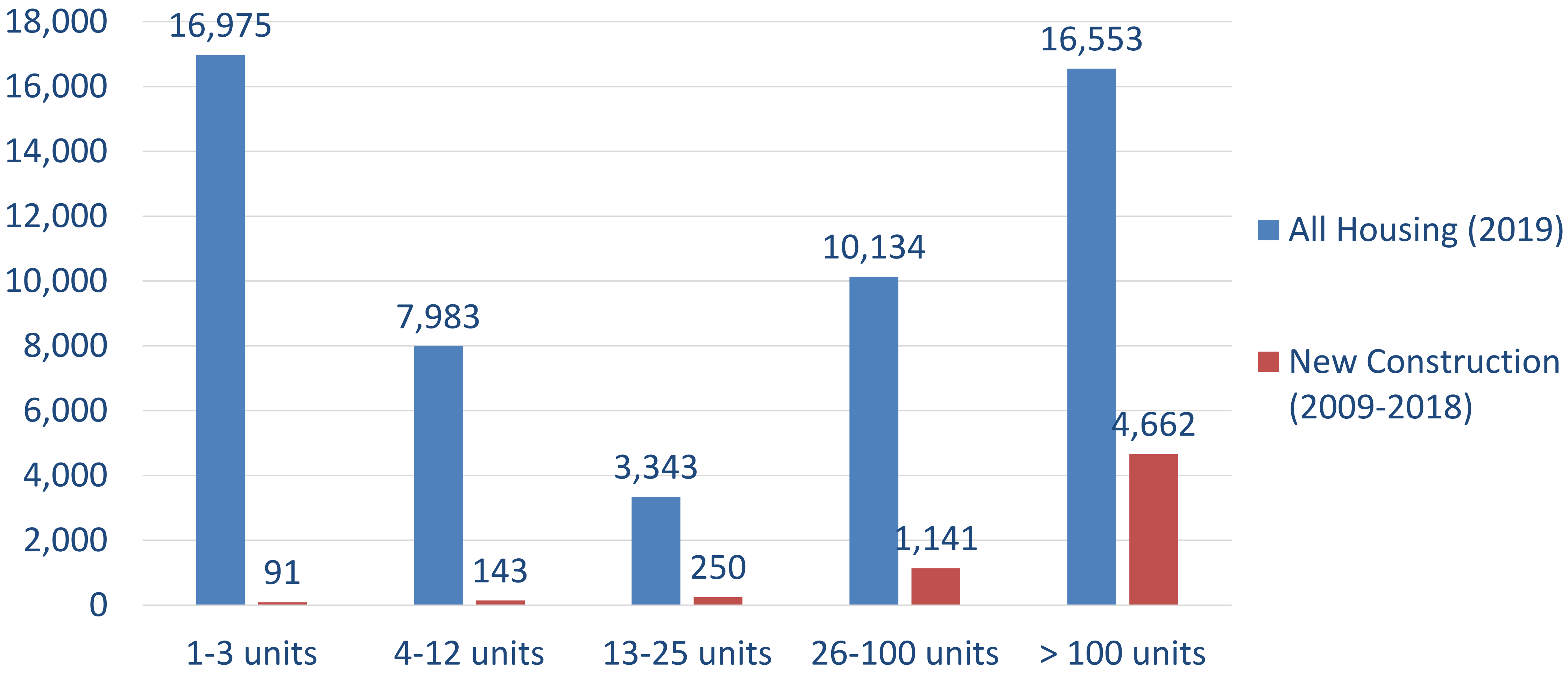
Zoning Doesn’t “Make” Anything

There is always an existing condition and a new condition. **Zoning protects existing conditions and regulates changes.**

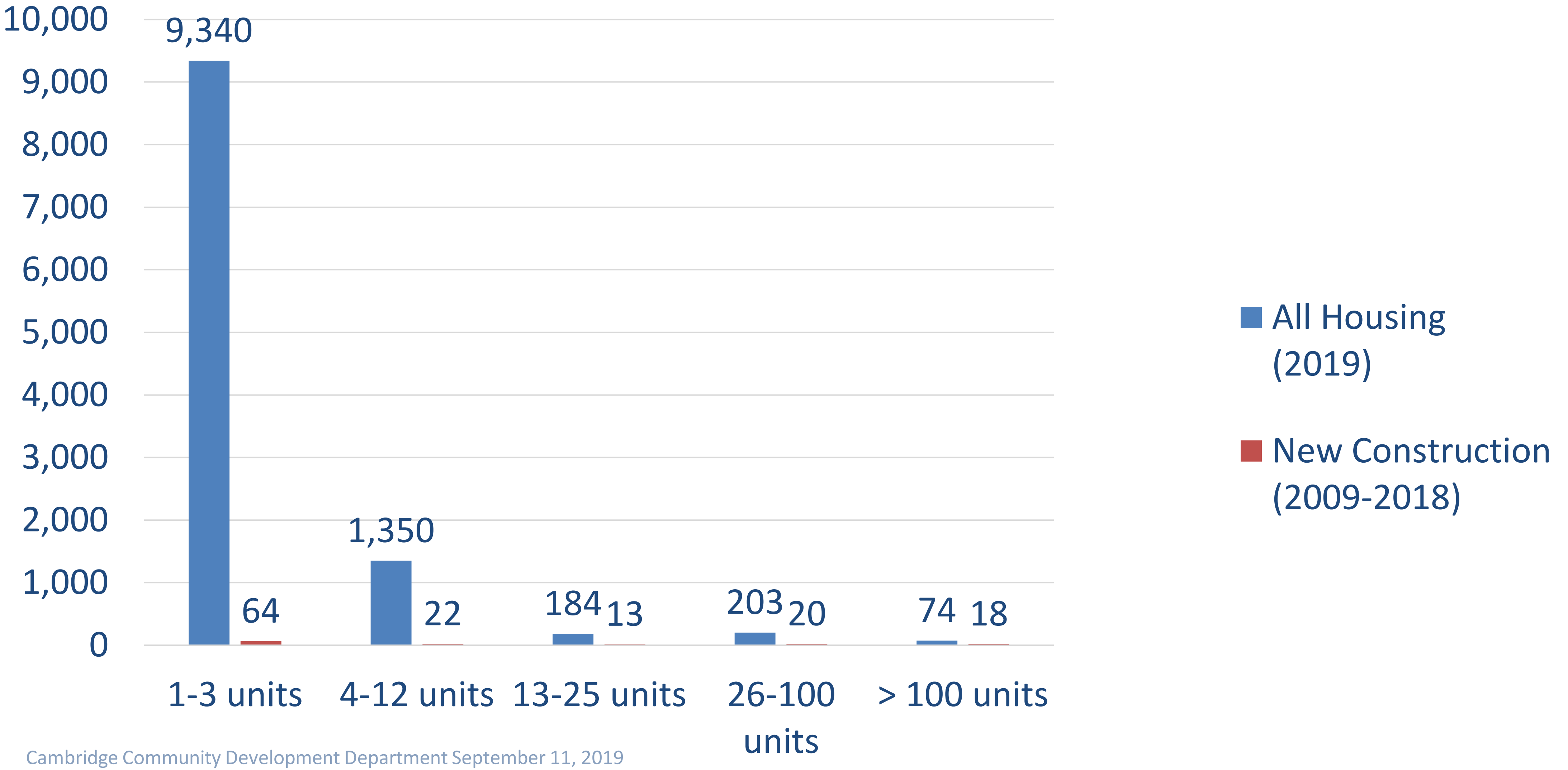
Property owners decide what changes to make. **Zoning (along with many factors beyond our control) affects the value of the proposed condition and the cost of making the change.**

Most often, change doesn’t happen. Sometimes the new condition is much more valuable than the existing and change will happen. If the cost of change is high, the existing condition is likely to remain.

Housing Units by Building Size



Housing Developments by Building Size



Zoning Does Some Things Better than Others

"Degree of Difficulty"	
Easier	Specific, quantifiable standards that are easy to measure and don't change
A bit tricky	Performance-based standards that are harder to measure but still measurable and related to physical design
Tough	Qualitative standards that require review, subjective interpretation and judgment
Very hard	Standards for ongoing activity or maintenance of characteristics that tend to change over time

Zoning Does Some Things Better than Others

Examples at Varying Scales, Locations	
All projects	Dimensional standards for height, setbacks, parking, &c. (Article 5.000 and Special Standards)
25,000 SF+	Green Building Requirements (Section 22.20)
Flood plain	Flood Plain Overlay District Standards (Section 20.70)
50,000 SF+ (& others)	Project Review procedures and Urban Design Objectives (Article 19.000)
Limited examples	Landscape maintenance, operational standards

Rule 1: Must Follow All Rules

Potential Overlap with Current Zoning Standards	
Open Space Requirements	Residential uses citywide have minimum private open space; neighborhood districts have minimum permeable open space (Section 5.22) Open space and permeability required for all uses in Alewife (Section 20.90) Public open space required in many major development areas (Articles 13, 14, 15)
Planting Requirements	Landscaping and trees required for surface parking lots (Section 6.48) Green area setbacks required in Alewife (Section 20.90) and some other areas Tree planting required in Parkway Overlay District (Section 20.60)
"Green Relief"	Exemptions/incentives for "functional" (planted) green roof area, exterior wall insulation, and sun-shading devices (Sections 22.30, 22.40, 22.50)
Environmental Standards	Green Building Requirements (Section 22.20) Flood Plain Overlay District Standards (Section 20.70) Urban Design Objectives re: environment, infrastructure (Sections 19.33, 19.34)

Rule 1: Must Follow All Rules

Potential Tension with Current Zoning Standards (and others)	
Basement Uses	Basement floor area not limited in single-family and two-family dwellings, waivable by special permit otherwise (Article 2.000) Special permit relief for basement apartments in some areas, with required flood impact review (Section 20.600)
Shading	Covered structures (e.g., porches, canopies) limited by floor area and setback requirements (Articles 2.000, 5.000)
Height	Height limits can disincentivize elevating uses (Article 5.000, special districts)
Parking and Pathways	Requirements for number of parking spaces, dimensions and width of drive aisles, access for bicycle parking all require paved surface (Article 6.000) Accessibility standards require paved surface (ADA, building code)
Urban Design	Urban Design Objectives re: conformance with established patterns, pedestrian and bicycle friendliness, historic preservation (Sections 19.31, 19.32, 19.35)

Questions for Discussion

- When should different strategies be used: prescriptive requirements, performance standards, review-based criteria, incentives?

- What in our current zoning could be adjusted to meet climate resilience objectives – height, GFA exemptions, parking?

- How should climate resilience objectives be balanced with others – housing, mobility, economic development, urban design, historic preservation?

Next Steps

Future Discussions

Date	Purpose
Meeting #9 – October 10	Discuss zoning recommendations
Meeting #10 – November 6	Review and revise zoning recommendations
Meeting #11 –November 21 (to be confirmed)	***Joint meeting with Health & Environment Committee*** recap work-to-date; present draft zoning recommendations
Meeting #12 – December 11	Finalize zoning recommendations

Thank You!