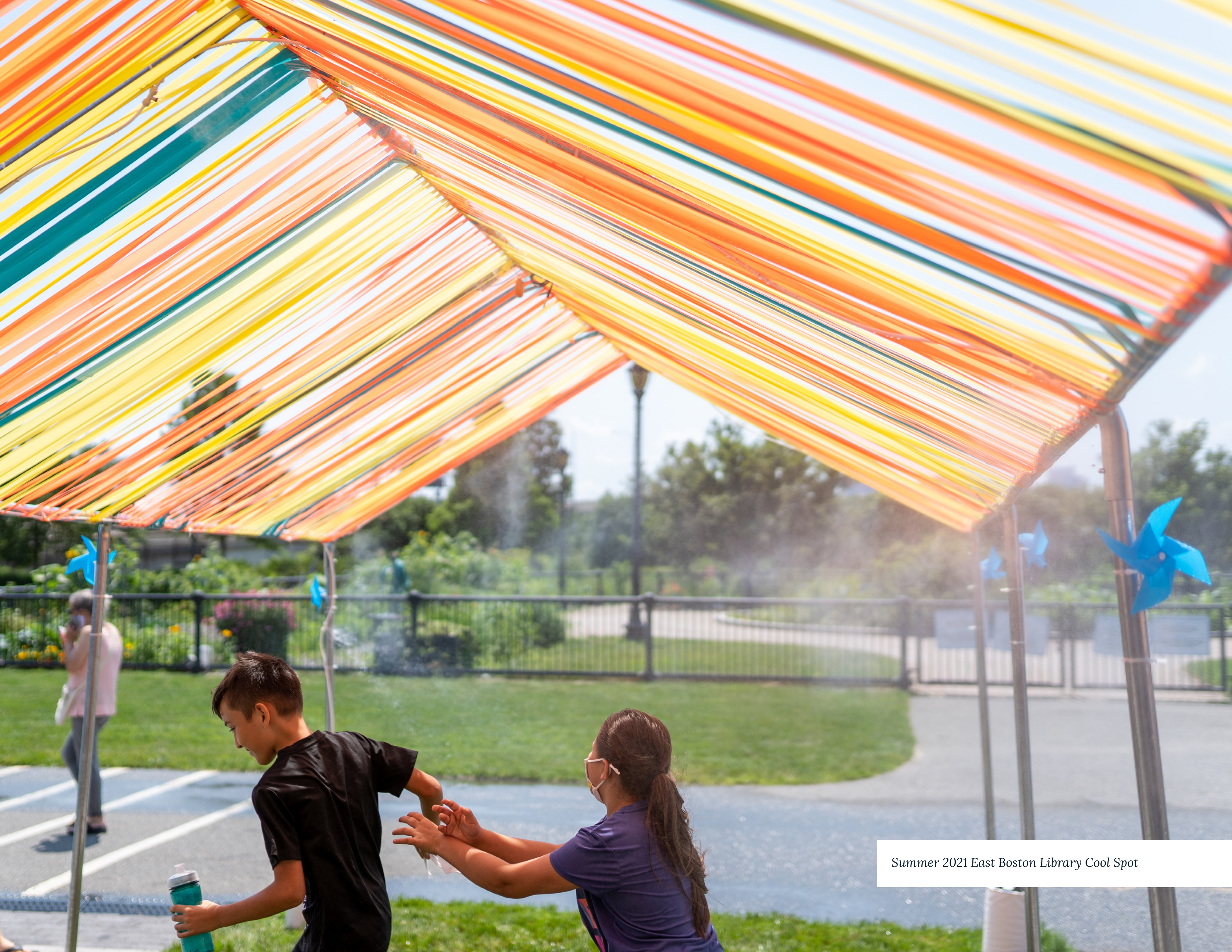
HEAT RESILIENCE SOLUTIONS FOR BOSTON

FINAL REPORT

April 2022

CITY *of* BOSTON



Summer 2021 East Boston Library Cool Spot

APRIL 22, 2022

Dear Neighbors,

As a coastal city, the effects of climate change are already a part of our everyday life. Here in Boston, we experience rising sea-levels, flooding from increasingly intense storms, and extreme heat. We're responding to these challenges with creative solutions that will protect our communities today and for generations to come.

Extreme heat is more than just an inconvenience or a discomfort—it negatively impacts our neighborhoods, our infrastructure, and our health. It means a loss of tree canopy, green space, and a degradation of air quality. It means more frequent power failures and transportation issues. It means more medical emergencies and heat related disease or illness. While extreme heat affects everyone, some of us are particularly vulnerable: our youngest and oldest residents and those with medical illnesses or disabilities are at elevated risk. Also at elevated risk are residents in historically underserved and redlined neighborhoods; often residents with low incomes or limited English skills. It is critical that we act now to keep Boston livable and keep our residents safe and cool.

Heat Resilience Solutions for Boston presents a roadmap for navigating extreme heat. By building on the legacy of previous resilience plans, including 2016's *Climate Ready Boston* report, we will be prepared to combat climate change. This study centers people and recognizes the challenges extreme heat poses to our quality of life. It focuses on environmental justice neighborhoods that disproportionately face extreme heat: Chinatown, Dorchester, East Boston, Mattapan, and Roxbury.

Our commitment to make Boston a Green New Deal city is a commitment to environmental justice. It's a commitment to transform Boston so that all residents can access healthy homes, fresh food, and clean air and water. By coming together and expanding our existing climate response, we can make our neighborhoods safer and more sustainable; we can strengthen our infrastructure, safeguard our public health, and improve our public spaces, all while preparing our workforce for a green future. With *Heat Resilience Solutions for Boston*, we're taking a critical step towards realizing this vision for all of our communities.

Sincerely,

Michelle Wu

Michelle Wu
Mayor of Boston

Mayor Michelle Wu

SASAKI

Klimaat

WSP

ALL ACES, INC

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CITY OF BOSTON

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唐人街公立图书馆
Chinatown Public Library
ASH
房租
Rent: $0
食物
免费
FREE FOOD
EXPERIENCE CHINATOWN
Lily Xie & Crystal Bi
"Dream Chinatown" by Lily Xie & Crystal Bi
inspired by BCNC youth's artwork

ACKNOWLEDGMENTS

The City of Boston wishes to acknowledge the many partners and community stakeholders who supported this project. Without their participation, the project would not have been possible.

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Uphams
Corner
Savin Hill
Four Corners/
Geneva
JAMAICA
PLAIN

01 INTRODUCTION AND PROCESS

INTRODUCTION

The effects of climate change are not new to Bostonians. Boston is already experiencing the effects of increasing storm intensity, rising seas, heavier downpours, and hotter summers. These effects are projected to grow over the coming decades. The City of Boston is committed to equitably protecting residents from the climate impacts that we are experiencing and that we are projecting in the future.

While the challenges of climate change are complex, Boston can take bold and creative action to prepare our residents, our neighborhoods, and our city as a whole for our changing climate, while advancing environmental justice and equity. *Heat Resilience Solutions for Boston* (the *Heat Plan*) presents the City's action plan to prepare for the near-term and long-term impacts of extreme heat in a changing climate. As a product of the Climate Ready Boston initiative, the City's ongoing program to prepare Boston for the effects of climate change, this plan provides an in-depth analysis of extreme summer temperatures during a recent heat wave and an all-of-government framework for strategies to reduce the risks of extreme heat. The plan helps accelerate Boston's progress toward increased climate resilience, charting our course for protecting residents from the effects of extreme heat.

While all of Boston experiences extreme heat, there are temperature hotspots throughout the city. Some residents and communities experience greater risk to the impacts of extreme heat due to environmental factors, the legacy of past investment decisions, health factors, and age. Residents and communities who may experience disproportionate risk include older adults, children, communities of color, people with lower English proficiency, people with lower incomes, people who are unhoused, and people with medical illnesses or disabilities.

The neighborhood focus areas in this study included Chinatown, Dorchester, East Boston, Mattapan, and Roxbury. By ensuring that heat resilience solutions developed in this plan are appropriate both for environmental justice communities in Boston who face elevated risks and the city as a whole, we can ensure that our heat resilience investments can also help us build a better, more resilient Boston with justice and equity at the center. Delivering on strategies that respond to the needs of our most overburdened residents will help us build toward a more climate-ready Boston. This plan creates a framework to take critical action to address the ways that we must adapt to the impacts of climate change while putting Boston on a path to become a Green New Deal city.

The project was funded by a Municipal Vulnerability Preparedness Action Grant through the Massachusetts Executive Office of Energy and Environmental Affairs. The project was also supported through additional funding from the Barr Foundation for the Climate Ready Boston program. This plan links existing efforts with new and planned initiatives that collectively will help prepare Boston for the immediate and future impacts of extreme heat.

WHAT DOES HEAT RESILIENCE MEAN IN BOSTON?

Heat resilience means preparing people, buildings, infrastructure, and the public realm to withstand extreme heat events. For Boston, this means ensuring that all residents and other stakeholders have the resources they need to stay cool and safe in hot summer months. It also means reducing temperatures in hotspots throughout the city to address the disproportionate impact of heat waves in Boston—and to ensure that indoor and outdoor spaces help preserve the health and comfort of residents in an equitable way. To build resilience to heat, Boston must address three factors of heat risk: *exposure* to extreme heat, the *adaptive capacity* to access cooling, and the *sensitivity* to changes in temperature due to underlying factors like health or age that may influence vulnerability to heat. This report presents a comprehensive framework of strategies to address these core factors of heat risk—and to prepare Boston for extreme heat, both today and under future climate conditions.

Extreme heat is the number one cause of weather-related deaths in the United States, more than tornadoes, hurricanes, flooding, and cold winter weather combined.[1] [2] In Boston, extreme heat is a growing concern with more hot days, longer heat waves, and higher summer temperatures due to climate change. How much temperatures continue to increase will depend on how quickly and by how much global greenhouse gas emissions can be reduced. Since 1960, Boston's average summer temperature has increased (see figure to the right). Additionally, between 2010 and 2020, Boston experienced more hot days than any decade in the previous 50 years. This trend is projected to continue. If emission trends continue as they are, it's predicted that there will be up to 25 to 42 days above 90°F, including up to 1 to 6 days above 100°F by the 2050s.[3][i] For communities who are already overburdened, increasing extreme heat risks can cause disproportionate impacts.

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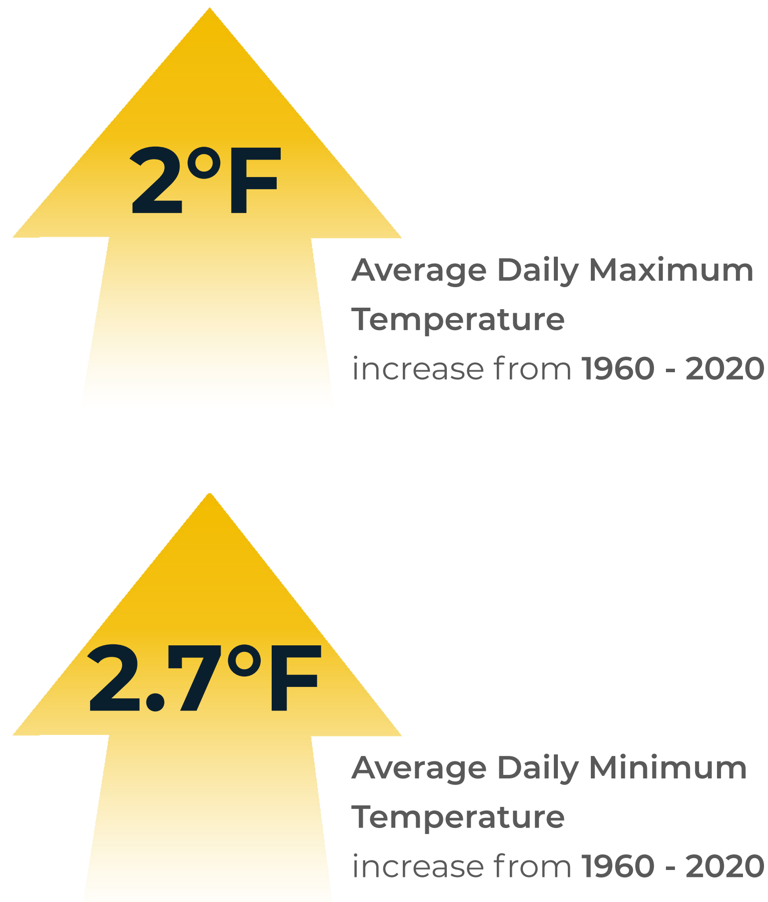
i These ranges present 17-83% confidence interval projections for RCP 8.5.

On average, summer days and nights are getting warmer.



Source: NOAA National Centers for Environmental Information; data pulled for 1960-2020 Logan International Airport weather station average maximum and minimum temperatures based on May to September data.

PROJECT PURPOSE

We can build a more just, equitable, and resilient Boston.

We are preparing Boston for extreme heat and its impacts, both today and in the coming decades. The *Heat Plan*, provides a citywide framework for heat resilience. Out work focuses on overburdened communities that will be most impacted by rising temperatures in Boston

This plan presents the City of Boston's vision for a comprehensive approach to address heat resilience. The *Heat Plan* provides an in-depth analysis of where temperatures are highest across the city during a heat wave—and the environmental factors that contribute to differences in those extreme heat conditions. The plan also presents community experiences of extreme heat impacts and offers a comprehensive framework of strategies to increase access to cooling, improve social resilience, and address conditions that contribute to hotter neighborhoods. This plan complements and builds upon emergency preparedness policies and procedures developed by the Boston Office of Emergency Management (OEM) and the Boston Public Health Commission (BPHC). It recommends longer-term planning for resilience to extreme heat alongside near-term actions that complement ongoing emergency preparedness efforts.

This plan presents new methodologies, updated future temperature projections, new extreme temperature models, heat risk and vulnerability profiles for five environmental justice focus areas, the City's heat resilience strategies, and next step actions to advance heat resilience across Boston. Inputs to the plan included existing plans and programs for climate resilience in Boston and the broader region, as well as detailed heat modeling and stakeholder and community discussions.

Summer 2021 Egleston Square Library Cool Spot

PLANNING PROCESS

THREE PHASE PROCESS

The project team developed the *Heat Plan* over a 14-month period in three phases that brought together community and stakeholder perspectives with heat modeling and analysis.

PHASE 1: ANALYSIS AND EXISTING INFORMATION REVIEW

The first phase included data gathering, review of previous and ongoing planning efforts, and developing a citywide heat analysis. This phase included two stages of extreme heat analysis: citywide and neighborhood-level patterns. The neighborhood-level analysis focused on Chinatown, Dorchester, East Boston, Mattapan, and Roxbury. The purpose of the neighborhood-level analysis was to evaluate how current day heat impacts vary across the city, identify temperature hot spots within environmental justice neighborhoods, and assess how racism, inequality, historic urban planning decisions, and other policies have influenced existing heat exposure and vulnerability. This phase also included the first community open house and the formation of the Community Advisory Board (CAB) to guide the planning process.

PHASE 2: HEAT RESILIENCE STRATEGIES

The second phase included drafting guiding principles for heat resilience based on community feedback from the first phase. The primary focus of the second phase was developing a series of draft strategies for heat resilience informed by findings from the citywide heat analysis and stakeholder and community perspectives. This phase explored considerations for heat resilience citywide and neighborhood-specific applications of strategies within the five neighborhood focus areas.

PHASE 3: IMPLEMENTATION ROADMAP AND FINAL REPORT

The final phase of the project focused on refining the strategies, developing a benefit-cost analysis (BCA) for cooling homes, schools, and streets; creating a neighborhood-scale heat simulation to model the effectiveness of the physical heat reduction strategies; and developing an implementation roadmap.

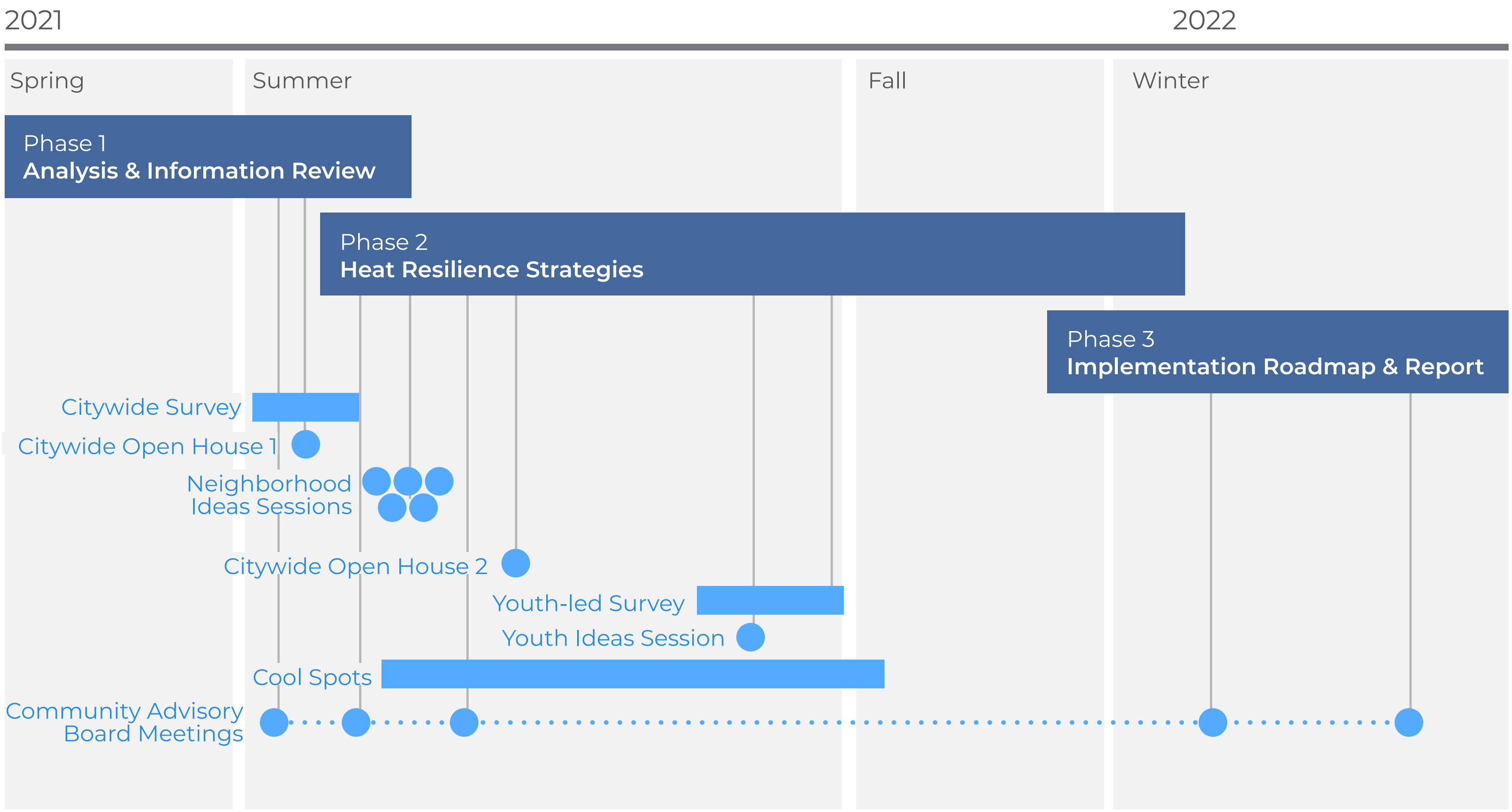
STAKEHOLDER ENGAGEMENT

The strategies in this document reflect significant input and support from Boston residents and other stakeholders. Participants in the process shared perspectives from their lived experience in Boston with heat and access to cooling. Community feedback directly shaped the heat resilience strategies included in this plan.

PLANNING IN THE CONTEXT OF COVID-19

Due to the COVID-19 pandemic, the project team designed engagement activities to comply with public health guidelines and to provide flexible methods and times for participation. Based on these objectives, the City's approach to community engagement included a range of ways for residents to engage. The project included virtual meetings to engage discussion and collaborative strategy development. These virtual sessions included two open houses, five neighborhood ideas sessions, and a forum specifically for youth. These sessions were recorded and made available on the project website to provide more opportunities for ongoing feedback in response to the same questions discussed in the live event. During virtual meetings, the City also shared information about existing local resources related to cooling and utilities and rental assistance.

Project Schedule



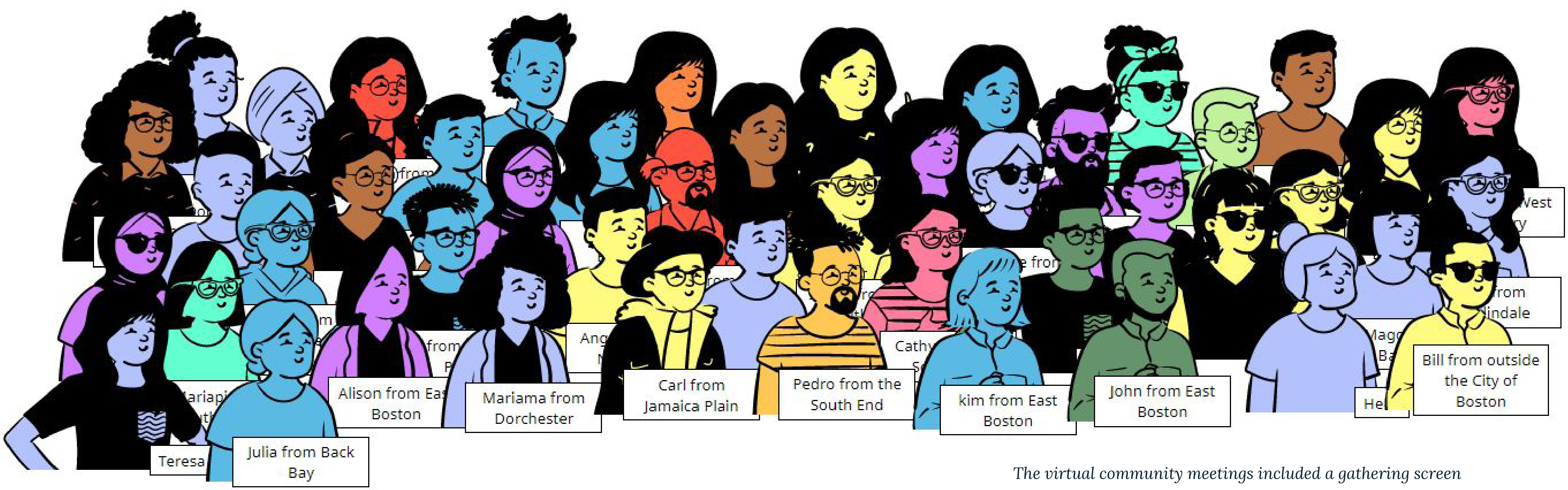
Other engagement activities included a citywide survey and a web-based comic builder with social media integration. Two engagement activities took place in-person: a youth-led survey solicited information from residents, and two Boston Public Library Cool Spot installations in East Boston and Egleston Square provided heat risk and resilience information to visitors over the course of summer 2021, which are described in more detail below.

STEERING COMMITTEE

The Steering Committee included representatives from City departments, agencies, and commissions. The Steering Committee convened five times virtually to define core goals and priorities, review and provide feedback on the resilience strategies, and provide guidance on implementation actions. This all-of-government committee acted as a technical sounding board to ensure feasibility and integration with ongoing and future policy, planning, and capital improvement initiatives.

COMMUNITY ADVISORY BOARD (CAB)

The Community Advisory Board (CAB) formed early in the planning process. The CAB included residents of Boston who provided a range of perspectives that highlighted cross-sectional considerations with heat resilience. Over the course of the plan, the CAB convened virtually five times. The CAB served as a key partner in shaping an inclusive community engagement process, ensuring that community priorities were reflected throughout the resilience strategies and goals, while also promoting the study to friends, neighbors, and colleagues.



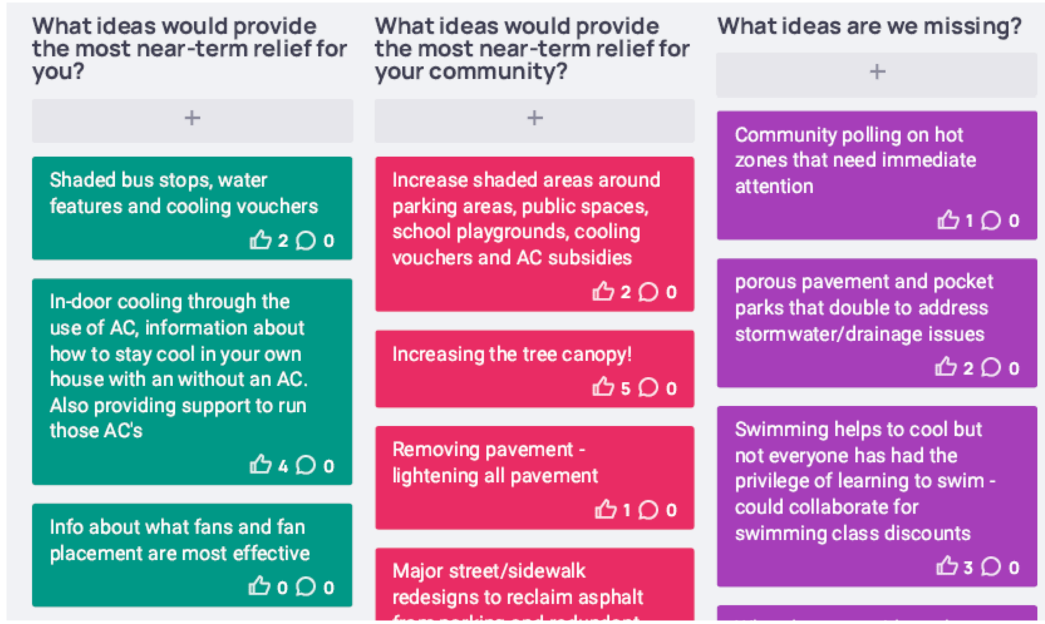
The virtual community meetings included a gathering screen

COMMUNITY OPEN HOUSES

The project team hosted two virtual community open houses to share the findings of the citywide heat analysis and gather community perspectives on extreme heat impacts and effective resilience strategies. These open houses focused on reaching a broad range of Boston residents and other stakeholders. The sessions also shared information about existing City resources and programs to access cooling, utility assistance, and tree planting. Translation was provided in Spanish, Mandarin, Cantonese, Vietnamese, and Haitian Creole. In total, more than 100 people participated across the two sessions.

HEAT RESILIENCE STORY COMIC BUILDER

The Heat Resilience Story Comic Builder is a web-based community engagement tool developed for the plan to cultivate empathy through storytelling. Using the Comic Builder, participants can build a personal avatar and design three scenes that reflect their heat experience. The Comic Builder was used live during the first community open house and was also made available on the project website. Heat stories were compiled into a virtual flip book for participants to read each other's stories and see the variety of heat experiences. In all, more than 40 stories were shared.



Virtual self-reflection time during the second open house

The Heat Stories Comic Builder Tool

CITYWIDE SURVEY

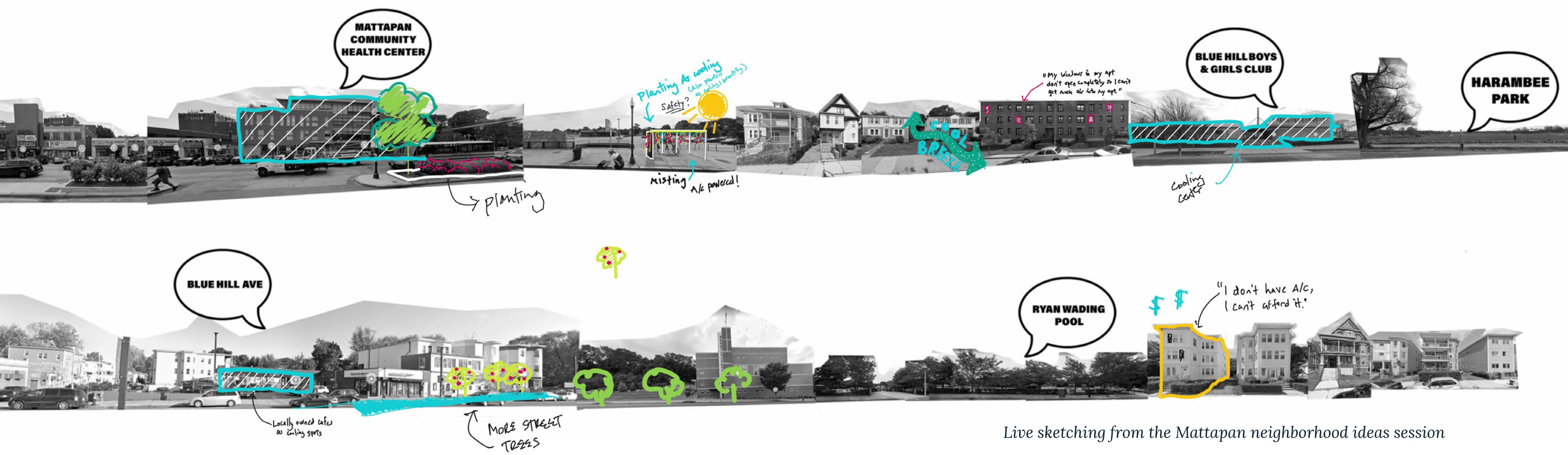
A survey gathered citywide perspectives about existing heat experiences, barriers to staying cool, and ideas for heat resilience. The survey included two sections: a written section and a map-based section to pinpoint where in Boston participants stay cool and where they feel hot. The project compared results from the mapping survey with the modeled results of the citywide heat analysis to understand how the model's findings compared to real-life experiences of survey respondents. In total, over 80 people participated in the survey.

YOUTH-LED SURVEY

Boston youth also spearheaded deployment of the citywide survey, gathering an additional 151 responses including 64 from Dorchester and 30 from Roxbury. The project aggregated results from this survey with responses from the citywide survey for analysis. In addition to gathering additional survey responses, the youth-led survey respondents included 19 young people, providing the project team with valuable information about how they experience heat in Boston. Youth conducted in-person survey collection using tablets at the No Books, No Ball basketball tournament series on Saturdays at Ramsay/Durbee Park located along the South End/Roxbury line, the Boston Prep Charter School Vaccination Clinic conducted by the Black Boston COVID-19 Coalition, and Downtown Crossing. They received training on pandemic safety, as well as masks, hand sanitizer, and gloves.

NEIGHBORHOOD IDEAS SESSIONS

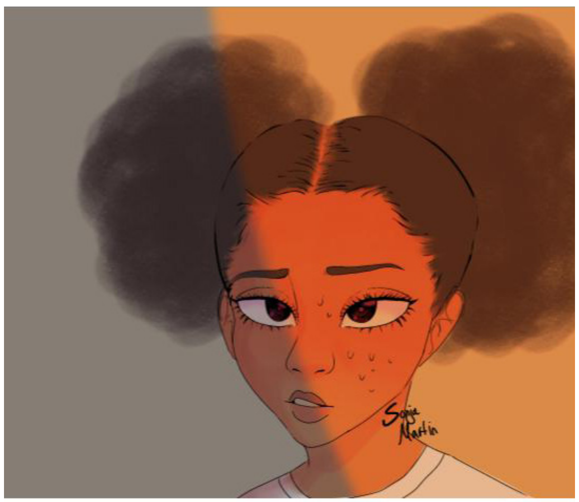
A series of five virtual neighborhood ideas sessions gathered localized ideas for heat resilience strategies. One ideas session took place for each of the five focus neighborhoods: Chinatown, Dorchester, East Boston, Mattapan, and Roxbury. Translation was available for each meeting, based on common languages in each neighborhood. The same content and feedback questions from the sessions were also available in an online survey format for stakeholders to share input and learn about neighborhood-specific heat findings. Overall, over 50 people participated in the sessions or shared their feedback through the ideas sessions.



Live sketching from the Mattapan neighborhood ideas session

YOUTH IDEAS SESSION

Another ideas session invited young people to share their experiences with heat and their ideas for staying cool. Featuring original art and poetry, the sessions highlighted the creativity of Boston's youth and helped the project team understand the nuances of how heat affects youth and some of the unique barriers they face in accessing cool spaces. This session had 14 youth participants.



Heat-related art by Sonja Martin capturing her youth experience, shared during the youth ideas session

Cool Spot at East Boston Public Library in summer 2021

> *"In Boston...most people don't have enough money to go and buy a cool drink,*
> *And most of us kids, especially Black ones, aren't allowed at the community pools, or ponds, or lakes,*
> *Because we cause problems and disturbances,*
> *Or really just because we look intimidating and too much like gangsters.*
> *If most people can't afford to buy a cool drink,*
> *They definitely can't afford to buy an AC or a fan,*
> *It's just too expensive to keep yourself cold,*
> *And there aren't a lot of options, and there aren't a lot of places to go to cool down."*
>
> *-Boston's heat problem, poetry by Joshua Alves, shared during the youth ideas session*

COOL SPOTS

In summer 2021, the project team partnered with the Boston Public Library (BPL) and the Mayor's Office of New Urban Mechanics (MONUM) to pilot two of the six outdoor WiFi Cool Spots at BPL branches across Boston. Cool Spots at the Egleston Branch in Roxbury and the East Boston Branch served as pop-up outdoor community spaces that provided 24-hour daily internet access. These sites expanded access to WiFi and provided safe, socially distanced outdoor gathering spaces during the COVID pandemic. The designs included a range of cooling features, including shaded seating and misting. Each Cool Spot contained a series of temperature sensors that provided real-time reporting of weather conditions at various points across the sites, allowing Cool Spot visitors to see how shade and vegetation influence air temperatures and how experiences can vary significantly even across a small area. The Cool Spots served as community resilience hubs where the City provided information about heat relief, including materials on how to access free fans and air conditioner units, utility assistance, and other support through City of Boston and partner programs such as food assistance and rental relief.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Uphams
Corner
Savin Hill
JAMAICA
PLAIN
Four Corners/
Geneva


Suffolk Downs
Orient Heights
Wood Island
EAST
WINTHROP
Castle Island

02 CONTEXT

CENTERING ENVIRONMENTAL JUSTICE AND EQUITY

CENTERING ENVIRONMENTAL JUSTICE AND EQUITY IN HEAT RESILIENCE

Climate change poses a greater threat to some Bostonians. Seniors and young children, people with limited English proficiency, and those with low incomes, medical illnesses, or disabilities are all at elevated risk.[1] Centering environmental justice and equity throughout planning processes can ensure that strategies and outcomes meet the needs of Bostonians who may be disproportionately affected by extreme heat impacts.

To accomplish this, it was critical that the project be informed by history and grounded in environmental justice and an equity-centered approach. The project team and Steering Committee participated in a facilitated training on systemic racism, racial equity, and historic development patterns in Boston to set a foundation for the planning process. The project team explored how Boston's history has informed existing conditions and discussed how unconscious biases can impact planning and implementation. The project team aimed to build a shared understanding of institutional culture and Boston's social and historical context to guide an intentional and effective process to produce effective resilience measures.

Systemic inequities and racism have left lasting impacts in Boston's hottest neighborhoods.

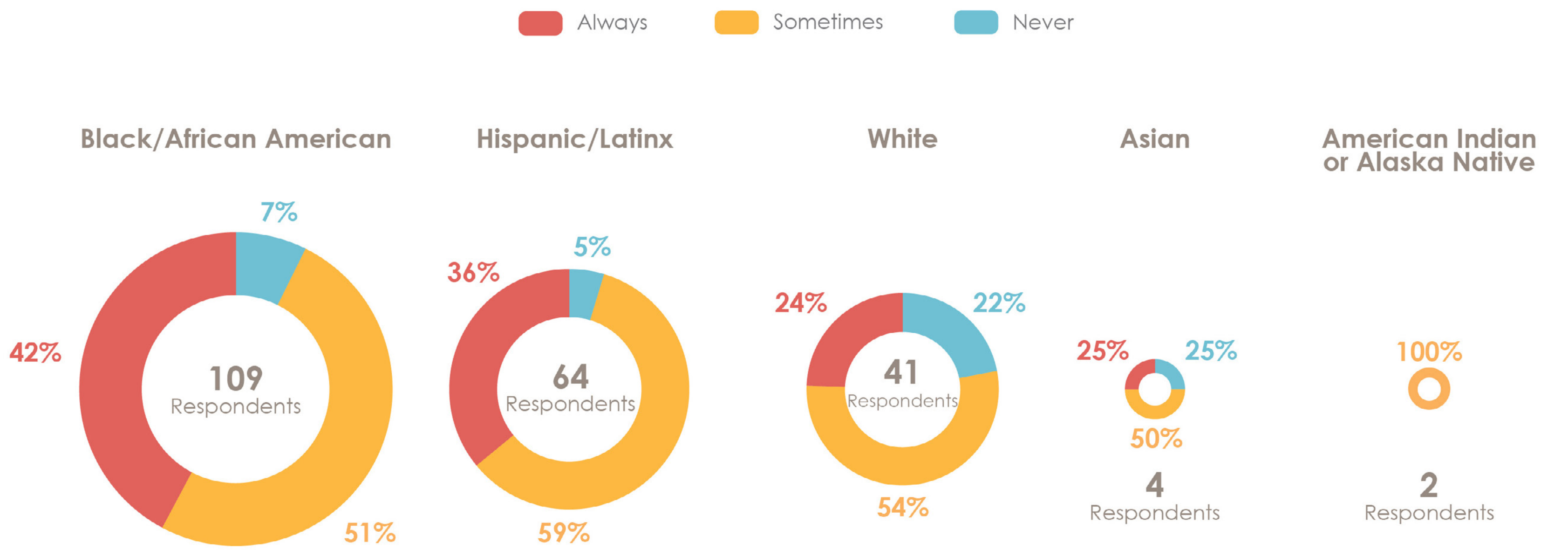
Elements of the built environment affect exposure to heat and the ability to access cooling, and can also contribute to greater sensitivity to heat risk. Trees and other nature-based cooling features, building materials, and the overall design of the built environment can affect both the local air temperature and the quality of the air. Factors including the distribution of trees, accessible green space, and the amount of hardscape across neighborhoods today are results of past planning decisions.

Thoughtful acknowledgement of how Boston's historical context has informed today's built environment and current experiences is critical to addressing the root causes of heat risk and vulnerability. Histories of racism and inequitable investment across neighborhoods in Boston have played a role in shaping the experiences of communities who experience disproportionate impacts of climate risk today. This includes environmental justice communities such as communities of color, lower-income communities, and immigrant communities, all of whom may also face compounding social, economic, and public health stressors. As a result, high summer temperatures can be more dangerous for environmental justice communities who live and work in temperature hot spots. In preparing residents and communities for extreme heat, Boston must do so in a way that addresses systemic inequities in exposure to heat, access to cooling, and sensitivity to heat risk.

A people-centered and equity-focused approach to heat resilience advances multi benefit strategies.

The *Heat Plan* helps advance a just and equitable plan to reduce extreme heat impacts. The plan identified five neighborhood focus areas to assess neighborhood-level extreme heat factors and impacts including Chinatown, Dorchester, East Boston, Mattapan, and Roxbury. These neighborhoods have some of the highest extreme temperatures across the city that overlap with where environmental justice populations live and work. By focusing the planning process and strategy development with environmental justice communities ,we can develop co-beneficial resilience strategies that will help us build a more equitable city.

When it is very hot outside, how often do you feel too hot at home?



The citywide online survey showed that the majority of respondents feel too hot in their home. However, the burden of heat exposure at home falls disproportionately on Black and Latinx communities. Of Black respondents, 42% always feel hot in their home (represented by the red segment in the graph), while the percentage of white respondents that always feel hot is just over half of that. While 5% of Latinx respondents never feel hot in their home (represented by blue in the graph above), the percentage of white respondents that never feel hot in their home is about four times higher.

Although the survey was not a statistically representative sample of the City of Boston, it still illustrates the disproportionate exposure of heat experienced by people of color in their own homes.

PLANNING CONTEXT

The Heat Plan identifies strategies to address the impacts of extreme heat events. The heat resilience strategies presented in the plan range from near-term actions to provide immediate cooling to long-term strategies to decrease localized ambient temperatures. The Heat Plan builds on and complements many recent and ongoing planning climate preparedness efforts. Collectively, the plans, policies, and programs detailed below have provided a foundation for building heat resilience in Boston.

PLANS, POLICIES, AND PROGRAMS

CLIMATE READY BOSTON

Climate Ready Boston is the City's initiative to prepare Boston for the near- and long-term impacts of climate change. The 2016 *Climate Ready Boston* report presented an assessment of Boston's vulnerabilities to climate impacts and proposed initiatives to build resilience across neighborhoods, infrastructure, buildings, and residents. Climate Ready Boston was a major step in integrating climate preparedness into all aspects of city planning, review, and regulation and included the following:

- Updated climate projections
- Comprehensive evaluation of current and potential future risks through a vulnerability assessment study
- Eight focus areas with spatially concentrated flood risk, including Charlestown, Charles River, Dorchester, Downtown, East Boston, Roxbury, South Boston, and South End
- Climate Resilience Initiatives including policy, planning, programmatic, and financial initiatives to address the identified risks

Since 2016, the City of Boston has conducted coastal resilience planning in neighborhoods along Boston's coastline. The City will continue long-term resilience and adaptation planning to address extreme urban heat through this study.

IMAGINE BOSTON 2030

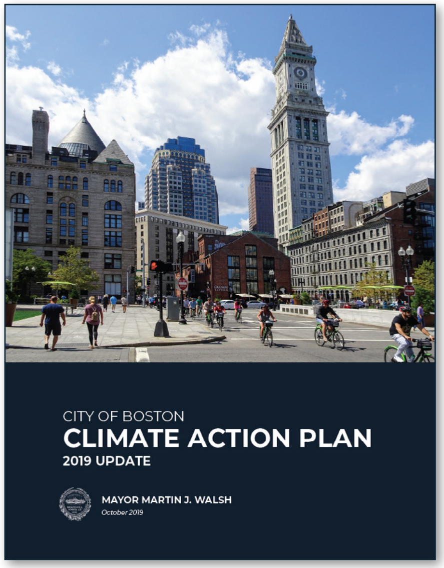
The City's first comprehensive plan in 50 years, *Imagine Boston 2030*, sets a long-term vision for the City and outlines goals towards economic growth, increased affordability and equity, and climate change preparedness for 2030. This plan highlights some cross-cutting challenges and opportunities related to climate change, as the City assesses future policy, zoning, and other requirements in response to Boston's changing needs. Strategies detailed in the report include steps towards improving environmental quality and resiliency of waterfront areas, enhancing energy efficiency and security, as well as preparing Boston's built infrastructure and its residents for the impacts of climate change.

2019 CLIMATE ACTION PLAN UPDATE

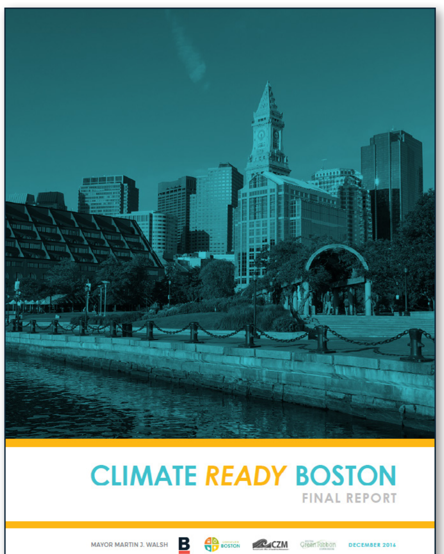
Future temperatures in Boston will depend on how much global greenhouse gas emissions are reduced. The 2019 *Climate Action Plan Update* is Boston's roadmap to reach citywide carbon neutrality goals. The plan includes action steps to achieve zero net energy and zero net carbon buildings through deep energy retrofits and electrification, emphasizing equity and stakeholder engagement. The 2019 update builds on the *Boston 2014 Climate Action Plan Update*.[2]

RESILIENT BOSTON

Released in 2017, *Resilient Boston* outlines strategies within four long-term vision areas crafted to build



2019 Boston Climate Action Plan



2016 Climate Ready Boston

the overall resilience of Boston, with particular consideration given to addressing its history of racism, segregation, and racial inequities. *Resilient Boston* was developed as part of the City's participation in the Rockefeller Foundation's 100 Resilient Cities initiative.

HEALTHY PLACES: PLANNING FOR HEAT, TREES, AND OPEN SPACE

The Healthy Places Initiative is a coordinated planning effort across several City plans: the *Heat Resilience Solutions for Boston*, the *Urban Forest Plan*, the *Parcel Priority Plan*, and the *Open Space and Recreation Plan*. Together, these plans expand the urban tree canopy, improve the parks system, and help Bostonians thrive in a changing climate.

The *Urban Forest Plan* (UFP) will help the City deliver a thriving, collaboratively sustained urban forest. The UFP builds on the 2014-2019 Boston Parks Urban Canopy Change assessment. The goal is to create a strategic plan that is based on science and defined by the needs and desires of the community, to ensure Boston's urban forest will be better managed both today and 20 years from now.

The *City of Boston Open Space and Recreation Plan* 2022-2028 will present the process, analysis, plan goals, and objectives for improving and protecting open space in Boston.

The *Parcel Priority Plan* is a long-term visioning plan to prioritize parcels of land to acquire and protect for public use.

GREATER BOSTON AREA RESEARCH GROUP (GBRAG)

In 2016, the City of Boston and the Green Ribbon Commission convened the Boston Research Advisory Group (BRAG), now named the Greater Boston Research Advisory Group (GBRAG), to better understand local climate change impacts and develop the Climate Projection Consensus. Both BRAG and GBRAG were funded and supported by the Barr Foundation. The Climate Projection Consensus summarized four factors of climate change, including extreme temperature, sea level rise, extreme precipitation, and coastal storms. These factors drive major climate hazards in Boston, including coastal and riverine flooding, stormwater flooding, and extreme heat.

GBRAG is completing an update to the first Climate Projection Consensus, which will provide updated projections of the climate hazards facing Boston. The temperature projections included in this report include the updated projections produced by GBRAG.

CLIMATE RESILIENT DESIGN STANDARDS AND GUIDELINES FOR PROTECTION OF PUBLIC RIGHTS-OF-WAY

In 2018, the City of Boston completed design standards for engineers and designers to use when designing flood-resilient infrastructure. These guidelines include design adjustments for extreme heat and were created to address concerns related to health and safety impacts, thermal expansion, material degradation from excessive heat, pavement softening, and impacts on electrical or mechanical systems.[3] The design guidelines also call for the consideration of low maintenance plants that reduce urban heat when designing flood protection infrastructure.

DEVELOPMENT REVIEW

Large new development projects (over 50,000 square feet), small projects (over 20,000 square feet), planned development areas, and institutional master plans are subject to development review by the Mayor's Office of Planning/Boston Planning and Development Agency (BPDA). Two specific zoning articles relate to development characteristics that can influence heat conditions on and around development sites. Article 80 review includes evaluation of a proposed project's impact on the public realm and the environment. Both of these areas can result in impacts that contribute to increased localized temperatures. Article 37 includes a checklist review of a proposed development's green building qualities.

PUBLIC HEALTH AND EMERGENCY MANAGEMENT

Several existing plans specifically address the City's operational approach to extreme heat events. Extreme Temperature Annexes, developed by BPHC and OEM, outline operational procedures for deploying information, services, and assistance during periods of extreme heat emergencies.

In 2021, the update of the City's Natural Hazard Mitigation Plan (NHMP) was completed through OEM and adopted by the City Council. The Federal Emergency Management Agency (FEMA) requires the City to update its Natural Hazard Mitigation Plan every five years to remain eligible for funding used to put in place the strategies identified in the plan. The NHMP provides a comprehensive plan to reduce or eliminate current vulnerability and damages associated with climate-related hazards in addition to a range of other natural disaster types. Together, the NHMP and Climate Ready Boston are coordinated to ensure Boston is prepared for and can recover from natural disasters.

ONGOING NEIGHBORHOOD DEVELOPMENT PLANS

Near-term implementation and the long-term success of heat resilience strategies following the plan will depend on coordination with ongoing neighborhood development plans, especially in the *Heat Plan's* focus neighborhoods. This plan aims to be an asset for further coordination with the following development plans:

» PLAN: East Boston
» PLAN: Newmarket
» PLAN: Mattapan
» PLAN: Downtown
» PLAN: Charlestown

COASTAL RESILIENCE PLANNING

In addition to the impacts of extreme heat, Boston also faces increasing risk of flooding resulting from sea-level rise and coastal storms. As a coastal city, identifying flood projection solutions for Boston's shoreline has been a major priority. Since the release of the 2016 *Climate Ready Boston* report, the City has completed neighborhood-level coastal resilience planning along Boston's coastal neighborhoods. These studies include East Boston and Charlestown Phase I in 2017, South Boston in 2018, and North End/Downtown and Dorchester in 2020. The primary goal of these neighborhood coastal resilience plans was to take a closer look at the localized impacts and specific strategies that could be undertaken to mitigate coastal flood risk.

In fall 2020, the City of Boston's Environment Department, through Climate Ready Boston, launched Coastal Resilience Solutions for East Boston and Charlestown (Phase II) to assess sections of each neighborhood that were not assessed during the 2017 Phase I study. The study evaluates coastal flood risk in the neighborhoods and identifies flood protection strategies that effectively reduce this flood risk, while creating additional benefits for the community and improving overall quality of life. After the completion of Phase II, the City will have developed coastal resilience solutions for all of Boston's coastal neighborhoods.

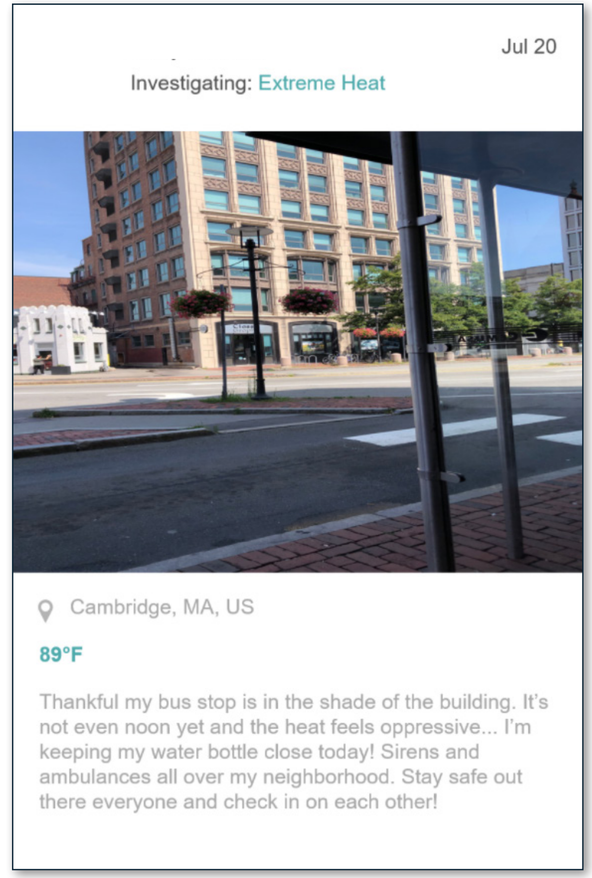
REGIONAL CONTEXT OF RESILIENCE AND HEAT PREPAREDNESS

The *Heat Plan* coordinated with three ongoing regional heat vulnerability analysis and preparedness planning efforts in Greater Boston:

- Wicked Hot Mystic through the Museum of Science, the Mystic River Watershed Association (MyRWA), and the City of Cambridge
- C-HEAT through Boston University (BU), GreenRoots, and the City of Chelsea
- Regional heat preparedness planning through the Metropolitan Area Planning Council (MAPC)

The project team convened with these teams to share data, collaborate on community outreach materials, and coordinate project tasks. This collaboration helped to ensure the *Heat Plan* builds on and complements previous and parallel efforts.

A key difference of the *Heat Plan* is that the analysis included air temperature modeling, whereas other projects included temperature maps developed from satellite data or from temperature sensors. During the modeling process, the project team compared the model outputs to other independent data sources, including MAPC's land surface temperature derived from satellite data. The existing data sets provided helpful comparison points to review patterns that emerged from the *Heat Plan*'s citywide heat analysis.



Wicked Hot Boston's Citizen Science Platform: Wicked Hot Boston studied extreme heat through community-based participatory science. Source: Museum of Science


EVERETT
SOMERVILLE
3
28
CHARLESTOWN
CAMBRIDGE
WATERTOWN
East Boston Memorial Park
Maverick
DOWNTOWN
ALLSTON/ BRIGHTON
90
20
Packards Corner
CHINATOWN
90
Tufts Med
Brighton
FENWAY/ KENMORE
SOUTH END
NEWTON
Mass Ave
SOUTH BOSTON
Brigham Circle
Ruggles
BROOKLINE
Roxbury Crossing
Nubian Sq
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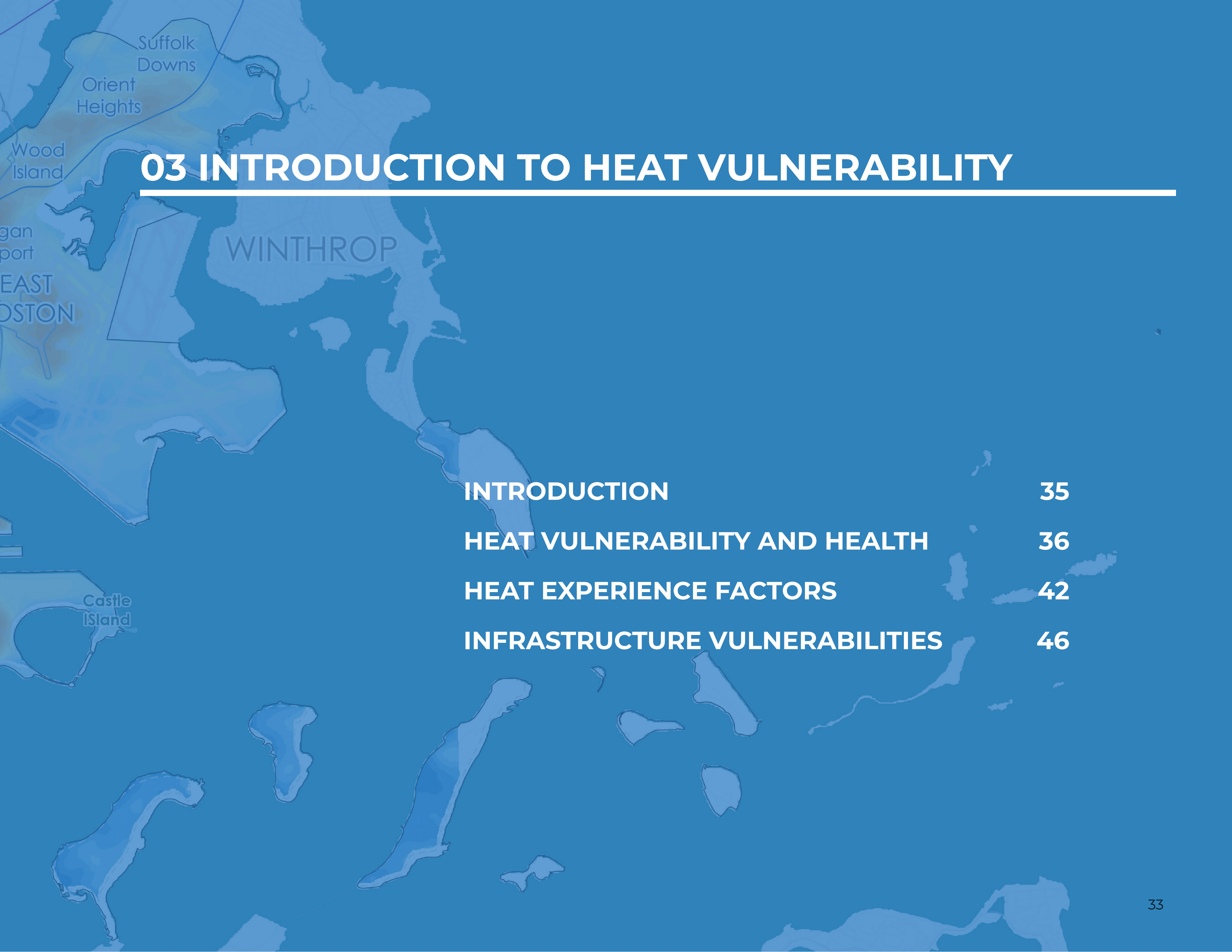
JAMAICA PLAIN
Four Corners/ Geneva



03 INTRODUCTION TO HEAT VULNERABILITY


xfinity

INTRODUCTION

This chapter introduces concepts related to heat vulnerability, and discusses the relationship between high heat and public health. Additionally, this chapter dives into the multiple factors that affect residents' heat experiences. Lastly, this chapter briefly touches on how high heat also affects the infrastructure in the city. To help with understanding heat vulnerability, risk, and resilience, below is a list of common heat resilience terms that will show up throughout in the Heat Plan.

COMMON HEAT RESILIENCE TERMS

Air Temperature: Air temperature can be influenced by humidity, wind flow, building form, surfaces (ground, walls, roofs), and the surrounding atmosphere.

Land Surface Temperature: The temperature of surfaces is influenced by a variety of factors including land cover, reflectivity, location, time of day and year, cloud cover, wind flow, and shadows.

Perceived Temperature: What the surrounding temperature feels like to the human body. It takes into account humidity, temperature, solar, and wind exposure.

Universal Thermal Climate Index: Measurement used for perceived thermal comfort. Boston's average summer perceived temperature is 73°F. Summer daytimes are generally warm to hot with moderate to high heat stress.

Relative Humidity: The percentage of water vapor in the atmosphere that can be retained in the atmosphere without condensation.

Extreme Heat: A prolonged period of very hot weather, which may include high humidity.[1]

Urban Heat Island: Urban areas that experience higher temperatures than outlying areas (buildings and roads absorb the sun's heat more than forests or water bodies).

Heat Wave: Three or more consecutive days above 90°F.

Heat Alert: In Boston, this is issued when there is a heat wave.

Heat Advisory: In Boston, this is declared when there is a heat wave, which is a period of three or more consecutive days above 90°F heat index.[2]

Heat Emergency: In Boston, this is declared when there is a period of two or more consecutive days above 95°F heat index, and the overnight temperature does not fall below 75°F.

Vulnerability: The disproportionate susceptibility of some social groups to the impacts of hazards, including death, injury, or disruption of livelihood.

Heat Vulnerability: How likely someone is to experience heat-related health problems.

Heat Exposure: The amount of heat people, the environment, systems, or other elements experience or are subject to. Exposure considers both heat intensity as well as duration.

Heat Sensitivity: The degree to which people, the environment, systems or other elements are affected by exposure to heat.

Adaptive Capacity: The ability to adjust to climate change, to moderate potential damages, to take advantage of opportunities, or to cope with consequences.

Heat Stress: When a person is exposed to extreme heat or in a hot environment, they are at risk of heat stress. Continued heat stress can increase the risk of heat related illness and injuries.

Heat Related Illness: Illness caused by high temperatures and humidity, which can include symptoms like muscle spasms, headaches, and dizziness. The most common heat-related illnesses include heat rash, heat cramps, heat exhaustion, and heat stroke.

Heat Exhaustion: Blood flow to vital organs decreases.

Heat Stroke: Body systems begin to stop functioning due to heat.[3]

HEAT VULNERABILITY AND HEALTH

The risks associated with extreme heat disproportionately affect some people and communities more than others. There are three main factors that affect heat vulnerability: exposure, sensitivity, and adaptive capacity.

HEAT EXPOSURE

Some people experience greater exposure to extreme heat than others. People with elevated heat exposure include those with jobs, living situations, or hobbies in outdoor or indoor environments without adequate shade to block direct sunlight or ventilation to circulate cool air flow. Examples of people with elevated heat exposure include people experiencing homelessness, residents in temperature hotspots, outdoor workers, and athletes.

Greater heat exposure can also be a result of the surrounding built environment. While all of Boston experiences extreme heat, there are localized temperature hot spots across the city where the risks of extreme heat are greater. For example, areas adjacent to dark, paved surfaces without canopy cover experience higher temperatures as a result of direct sunlight that is absorbed by the surface. Frequent and prolonged exposure to heat and extreme heat can cause dehydration and heat-related illness, including heat cramps, heat exhaustion, and heat stroke.[4]

EXAMPLES OF PEOPLE WITH ELEVATED HEAT EXPOSURE

- People experiencing homelessness
- Residents of hot neighborhoods
- Outdoor workers
- Athletes

From a worker health perspective, we definitely need to provide more support for outdoor workers and policies requiring more shade and water breaks for heat waves.
-open house participant

HEAT SENSITIVITY

In addition to heat exposure, heat vulnerability is also affected by how sensitive one may be to extreme heat. People with elevated heat sensitivity include those with chronic health conditions (especially respiratory conditions), children, and older adults. People with chronic health conditions can be more vulnerable to heat as they may be less likely to sense changes in temperature or may be taking medications that can make the effects of heat worse. Children and youth often rely on others to keep them cool and hydrated when it is hot outside, and may not understand the signs of heat-related illness before they become more severe. Older adults do not adjust as well as younger people to sudden temperature changes and are more likely to have chronic medical conditions that change their body response to heat.[5]

EXAMPLES OF PEOPLE WITH GREATER HEAT SENSITIVITY:

» People with chronic health conditions (e.g., asthma, diabetes)
» Children and youth
» Older adults

ADAPTIVE CAPACITY

A person's ability to adapt to extreme heat by taking measures to cool themselves also affects their heat vulnerability. The ability to access cooling resources is a critical factor of adaptive capacity. Low adaptive capacity can result from barriers to opportunities and resources that help cope with heat stress. People with lower adaptive capacity may be unable to make their immediate surroundings cooler or more comfortable, to relocate to a cooler place, or to receive help from others nearby.

EXAMPLES OF PEOPLE WITH LOWER ADAPTIVE CAPACITY:

» Individuals who live alone or do not have close social contacts to reach out to for support
» Homebound individuals or people with limited mobility
» Individuals without air conditioning or who need to limit its use due to utilities affordability
» Individuals lacking access to transportation
» Individuals facing language barriers

BOSTON'S RISK FROM EXTREME HEAT IMPACTS THE ENTIRE CITY POPULATION

As a coastal city, Boston is preparing for the impacts of multiple climate hazards including sea-level rise, coastal storms, extreme precipitation, and extreme heat.

Significant planning has already been completed for Boston's coastal neighborhoods. This plan brings a similar focus to heat resilience. Both flooding and extreme temperature hazards pose increasing challenges for Boston's residents, businesses, and infrastructure, but vary in important ways.

Extreme heat affects all of Boston today.

While some neighborhoods and residents experience greater extreme heat risks, all of Boston is hotter than surrounding suburban and rural areas and is at risk during heat waves.

Extreme heat impacts cause significant health risks.

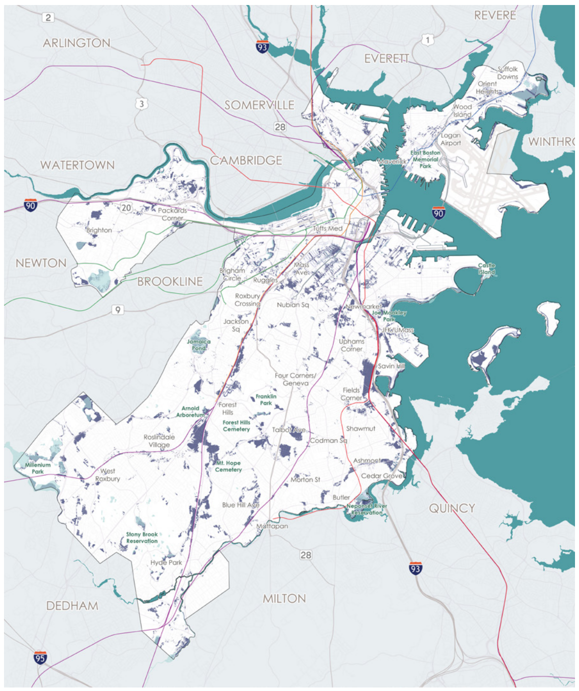
In Boston, the health impacts associated with extreme heat risk are a critical concern. Hot weather can cause heat exhaustion and heat stroke. It can also exacerbate symptoms of underlying health conditions including asthma, diabetes, and other respiratory and cardiovascular conditions. Extreme heat days can increase air pollutants like smog that can further aggravate respiratory symptoms and asthma.

Even though heat-related illnesses are largely preventable,[6] warning symptoms can go undetected or untreated. Many Bostonians lack access to the basic resources—air conditioning, water, rest, and shade—needed to keep their bodies at a healthy temperature during their daily home, work, school, and transportation routines. Two national studies on deaths attributed to heat impacts have estimated about 50 to 100 heat-attributable deaths for an average Boston summer.[7] As Boston gets hotter, taking additional actions to equitably protect the health and safety of residents through investments in heat resilience is critical.

Extreme heat is already a daily stressor for many Bostonians during hot weather.

Heat is already a chronic stressor for daily life for many Bostonians across the city. Imagine a Bostonian without home air conditioning who commutes to work on foot or by bus, or perhaps works outside. If bus stops lack shade, the wait for a bus could be even less comfortable. This person will experience cumulative heat exposure while outdoors and while commuting—and will have little relief at home and overnight. The *Heat Plan* considers a continuum of experiences to plan for heat resilience needs. Recognizing how extreme heat can affect various aspects of daily routines, the *Heat Plan* identifies heat resilience interventions and investments focused on a broad range of daily activities to protect the health and safety of residents and workers.

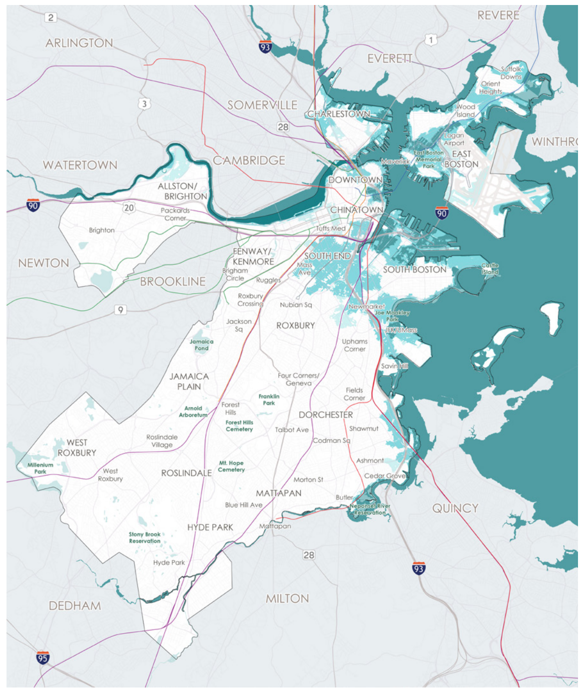
Green infrastructure to reduce stormwater flooding could also reduce temperatures.



STORMWATER FLOODING
36” SLR - 2070S OR LATER

- *Near-term (2030s-2050s)*
- *Medium-term (2050s-2070s)*
- *Long-term (2070s onwards)*

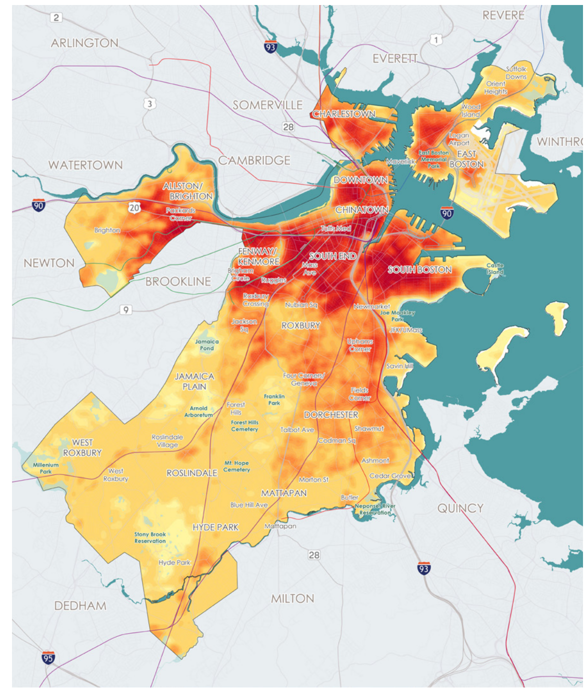
Coastal flooding risk will increase over the coming decades. Synergies with heat resilience are possible with waterfront strategies that reduce flood risk.



FLOOD PROGRESSION MAP
36” SLR - 2070S OR LATER

- *Average Monthly High Tide*
- *10% Annual Chance Storm*
- *1% Annual Chance Storm*

Extreme heat already affects all of Boston. Some areas experience longer, hotter high-heat conditions.



HEAT EVENT HOURS
MODELING BASED ON JULY 2019 DATA

Less than 25 hrs — *More than 37 hrs*

INCREASES IN HEAT RISK AND PUBLIC HEALTH IMPACTS

If greenhouse gas emissions continue at the current rate, it is likely that Boston will have up to about 60 days over 90°F each year by the 2070s—and up to about 80 days over 90°F each year by the 2080s.

Future temperatures in Boston will depend on how much we are able to cut our greenhouse gas emissions. If emissions trends continue at the current rate (RCP 8.5), climate projections estimate that the number of very hot days (over 90°F) will most likely (17th to 83rd percentile) increase from 10 days in the 2000s[8] to 33 to 62 days by 2070. Under a reduced emissions scenario (RCP 4.5), the number of very hot days (over 90°F) is projected to most likely be 22 to 43 days by 2070.[9] Even if emissions are reduced, Bostonians will face increasing heat risk.

Today, the impact of extreme heat on health is evident when looking at daily Boston EMS clinical incidents.[i] Daily heat-related[ii] EMS incidents data from 2012 to 2021 show there was an overall rise in incidents during the summer months (June to August) compared to the rest of the year.[10] In 2021, June saw the second highest number of incidents (92 incidents), indicating that the two heat waves in June, one of which was a heat emergency, played a role in the spike of heat-related illnesses. During a five-day heat wave in June 2021 where temperatures exceeded 90°F, the total of heat-related EMS incidents was 48, with a peak of 14 incidents on a single day when temperatures hit 95°F. In the five days after the heat wave, the average maximum temperature was 82°F, and only two incidents occurred. This data might be missing incidents not directly classified as heat or heat exhaustion, meaning that incidents indirectly related to heat might not be accounted for in these numbers.

Boston EMS responds to an average of 347 clinical incidents per day. During heat emergencies it is common to see a 20% or more increase in call volume, at times exceeding 100 additional clinical incidents in a single day.[11] An overall rise in incidents during heat waves and emergencies is clear, but the full extent might not be apparent. Police and fire dispatch calls also increased during extreme heat, suggesting there are indirect effects of heat on people's behavior and health.[12]

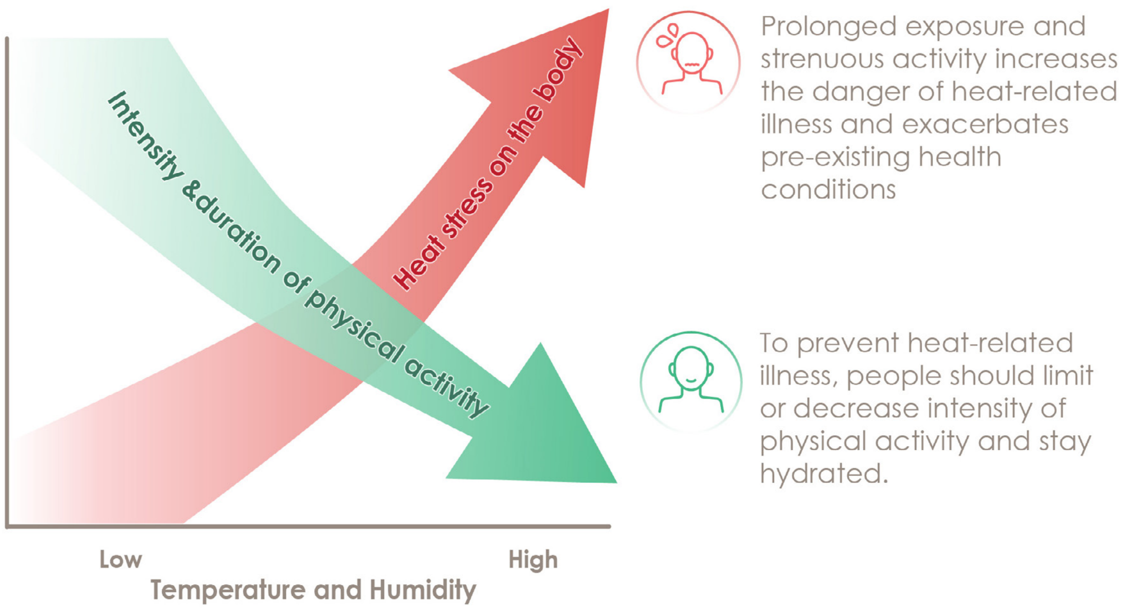
"Extreme heat can cause negative health impacts, including direct loss of life, increases in respiratory and cardiovascular diseases, and challenges to mental health." -2016 Climate Ready Boston

It is not just about days over 90°F. If greenhouse gas emissions continue at the current rate, it's likely that Boston will have up to 140 days over 80°F—and up to 14 days over 100°F— by the 2070s.

i A Boston EMS clinical incident is typically generated by someone calling 911 for a medical emergency resulting in the dispatch of an ambulance.
ii These counts include patient encounters with either a type code of "Heat" or a clinical impression related to heat, such as "Heat exhaustion." However, the data may be missing some counts that don't have these classifications (indirect heat-related incidents).

HEAT, PHYSICAL ACTIVITY, AND HEAT STRESS

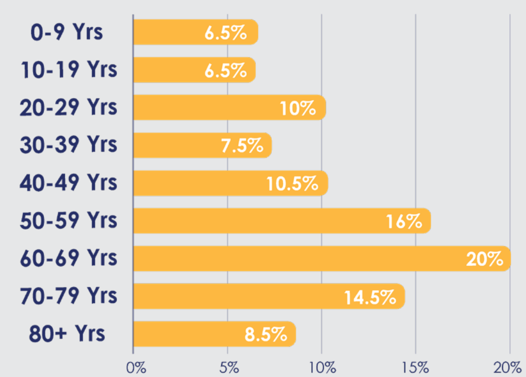
When temperature and relative humidity increase, the likelihood of heat disorders with prolonged exposure or strenuous activity increases, and can cause major health and safety concerns.[17] The increased heat stress on the body exacerbates preexisting health conditions. To prevent this, people should limit or decrease their intensity of physical activity and stay hydrated.



ASTHMA AND HEAT

In Massachusetts, 10.2% of adults and 12.9% of children, about one out of eleven people, live with asthma.[13] Research shows that extreme heat can worsen asthma, and even increase hospitalization rates and total costs.[14 15] A 2010 study led by Boston EMS, BPHC, and the Centers for Disease Control and Prevention (CDC) found that hospitalization rates for asthma was highest in Black and Hispanic populations in children under five, and those living in large multi-family affordable communities were exposed to more risk factors.[16] More recently, data from Boston EMS (2018-2020), show that asthma EMS incidents are more prevalent for adults aged 60 to 69 years old. The disproportionate burden of both asthma and heat can create a compounding effect on at-risk populations. As a result, heat is more dangerous, and heat resilience strategies need to prioritize providing cooling to these communities.

PERCENT OF TOTAL ASTHMA INCIDENTS BY AGE GROUP FROM 2018-2020



Data Source: Boston EMS, 2018 - 2020 Asthma Incidents

HEAT EXPERIENCE FACTORS

Heat experiences are a result of multiple factors. Air temperature, humidity, and wind influence individual experiences with extreme heat risk. There are also compounding factors in addition to weather conditions, which affect heat experiences.

PERSONAL HEALTH AND COOLING ACCESS

Chronic health conditions and age can increase vulnerability to heat risk.

Similarly, physical and financial access to cooling can also affect heat exposure. This includes affordability of home air conditioning or the ability to relocate to other air conditioned spaces.

PHYSICAL ENVIRONMENT (BUILT AND NATURAL)

Trees and parks help cool off neighborhoods, while denser neighborhoods and large amounts of pavement make them heat up more and stay hot longer.

A neighborhood's characteristics and surroundings influence its air temperature. Factors that make a neighborhood hotter include the following:

- Denser buildings, especially if buildings are typically brick or have dark roofs
- Large amounts of pavement, especially if it is unshaded
- Fewer trees or green spaces
- A location that is not within a few blocks of the waterfront or a large park

AIR FLOW

The dynamic nature of air shapes how individuals and neighborhoods experience heat.

How well air can move influences how much hot air builds up in a given location and how much cool air can displace it to provide relief. Green spaces and coastal breezes are sources of cooling air flow that can bring cooler air to surrounding blocks. Cooling effects can spread more effectively with space between buildings and infrastructure for air to flow. Franklin Park effectively provides a large-scale natural cooling source that helps the adjacent area stay 5 to 7°F cooler than areas a few more blocks inland.[i] In contrast, without air flow, there is little room for the hot air to escape. These areas tend to remain hotter overnight.

HISTORY AND STRUCTURAL INEQUITY

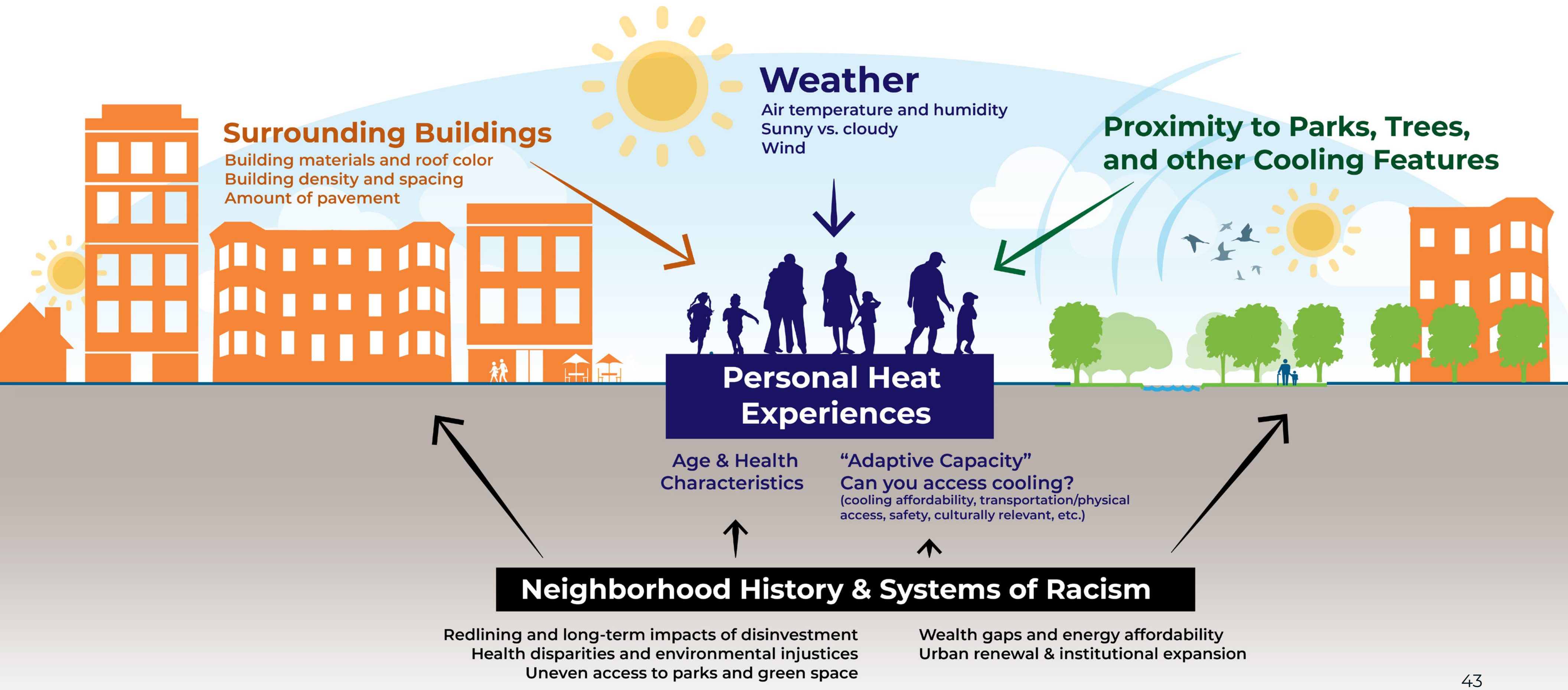
Environmental injustices and systemic racism are drivers of differences in heat experiences for both places and people.

Disparities in access to cooling and the distribution of extreme temperatures across the city have been influenced by histories of underinvestment and disinvestment that have shaped everyday life in Boston. Areas home to communities of color and immigrant communities are more likely to be temperature hotspots. These areas may also be in greater proximity to land uses that exacerbate air pollution burdens, which can exacerbate chronic health conditions, like asthma.

i Citywide Heat Analysis. See Chapter 4 Extreme Heat Risk in Boston for more information.

Heat experiences are more than just the weather.

Buildings and proximity to green and open spaces also play a role. Influencing these factors is neighborhood history and systems of racism, which places disproportionate burdens of Boston's heat on communities of color, immigrants, low-income residents, and unhoused communities.



REDLINING

The City continues to strive toward a just and resilient climate future, while adapting and responding to the changing context we live in. As we plan for future climate change, we must look back and understand how Boston's historical context has impacted current day conditions to inform our future decision making.

Between 1935 to 1940, federal officials developed and used a grading system for the Home Owners' Loan Corporation (HOLC) in cities across the nation. This system used color-coded maps to rank city neighborhoods based on perceived riskiness of providing loans for mortgages. This ranking system was highly correlated with the racial composition of neighborhoods. Communities of color, immigrant communities, and lower-income areas were typically given low grades. The lowest grading was outlined in red and labeled hazardous, meaning they were considered high-risk for mortgage lenders.[18] This practice made it difficult for people in redlined areas to qualify for mortgage loans, reducing opportunities for wealth-building associated with homeownership. The practice was formally abolished in 1968 with the enactment of the Fair Housing Act, however, many public and private investments had already been patterned based on these maps.

Discriminatory housing practices continues to impact neighborhoods today. A 2020 study that looked at more than 100 cities across the United States found that redlined neighborhoods are on average 5°F hotter in summer than areas that weren't redlined.[19] These neighborhoods, which are predominantly lower-income neighborhoods,[20] also have fewer trees and parks, and more dark pavement. These factors increase heat in the built environment.

In Boston, the neighborhoods of Roxbury, Dorchester, East Boston, and Chinatown include redlined areas. Mattapan was given a grade of "declining." In Chapter 4, the *Heat Plan* presents an analysis of the HOLC map and current day extreme temperatures to explore how the use of historical housing and real estate practices have shaped the burdens placed upon environmental justice communities in Boston today.

OTHER EXAMPLES

Examples of past planning actions that have lasting effects on health and heat vulnerability today include the following:

- Interstate construction through Chinatown elevated air pollution for residents while making access to downtown jobs easier for suburban commuters.
- The loss of East Boston's Wood Island Park for Logan International Airport's expansion in the 1960s removed an important and beloved park. Today, the surrounding area is one of the hottest in East Boston.
- The presence of bus and truck traffic in and near Lower Roxbury and Nubian Square leads to greater exposure to air pollution, and these areas have higher rates of asthma among neighborhood residents. Research studies have found a link between air pollution exposure and asthma.[21]

We know communities that contribute the least to climate pollution bear the greatest impacts of climate change. As we prepare our communities for the impacts of extreme heat, we must place people first. This means designing and implementing targeted policies and programs with and for disadvantaged and overburdened communities, lower-income neighborhoods, people with limited English proficiency, and other drivers for the disproportionate impacts of climate change.


300 Meet to Fight Artery Route Planned by Volpe
ROBERT HANRON
Daily Boston Globe (1928-1960); Oct 23, 1953;
ProQuest Historical Newspapers Boston Globe (1872 - 1979)
pg. 1

300 Meet to Fight Artery Route Planned by Volpe

By ROBERT B. HANRON

Chinese merchants and garment industry leaders and workers last night joined forces to kill the state plan to route the Boston Central Artery through their district.

More than 300 representatives of these groups convened at a hastily-called meeting in the Chinese Merchants Association Building at Hudson st. and Harrison av. to map strategy for a fight-to-the-finish battle to save their homes, businesses and jobs.

PROTEST Page 37

Boston Globe 1953; Source: Boston Chinatown Atlas

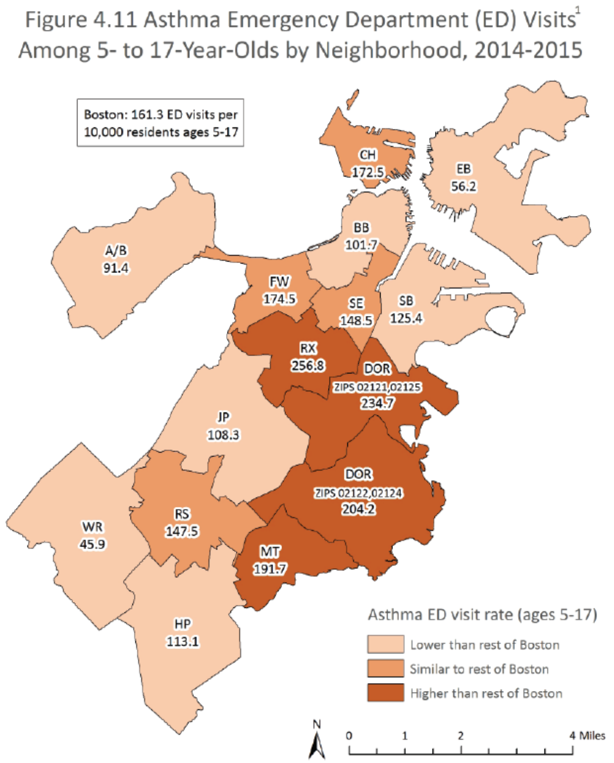
Wood Island Park in East Boston (1925).
Source: Boston Pictorial Archive

"In 1898, the Wood Island Park in East Boston opened. Designed by the famous landscape architect, Frederick Law Olmsted, the park included ball fields, tennis courts, a gymnasium, bathhouses, picnicking areas and lots of green space. On hot days, people entered the park in search of cool sea breezes beneath the huge 200-year-old elms, maples, and oak trees. Children enjoyed rolling down the hills, and swimming in the beaches. And on the weekends, families came to the park first thing in the morning; securing a spot to spend the day. In the late '60s, the park was razed to make way for airport expansion."

-East Boston Museum

"The inequitable exposure of communities of color to transportation pollution reflects decades of decisions in Massachusetts about transportation, housing, and land use. Decisions about where to place highways, where to invest in public transportation, and where to build housing have all contributed to a transportation system that concentrates emissions on communities of color."

-Union of Concerned Scientists



Asthma rates are highest in Roxbory.
Source: Health of Boston Report 2016-2017 (BPHC)

INFRASTRUCTURE VULNERABILITIES

TRANSPORTATION INFRASTRUCTURE

Extreme heat also impacts built infrastructure that residents, workers, and visitors rely on to move about the city.

Roads and Rights of Way

Concrete is susceptible to buckling under extreme temperatures due to thermal expansion.

Subway and Trolley

Additionally, heat causes steel rail tracks to expand, which stresses the ties, ballasts, and rail anchors, resulting in a heat kink that requires repairs to avoid derailments.[23] To account for these impacts, speed restrictions are implemented when temperatures reach 90°F, which can impact commute times in the summer.[24] Extreme heat also causes power lines to droop, requiring service adjustments that cause passenger delays. Further delays can result from equipment failure and reduced lifespan of necessary systems. For example, higher temperatures inside encased traffic lights and signal controls can result in equipment failure.

Heat kink along the Orange Line rail tracks
Source: MBTA

Roads buckling in extreme heat
Source: Mackenzie Huber, The Argus Leader Via AP

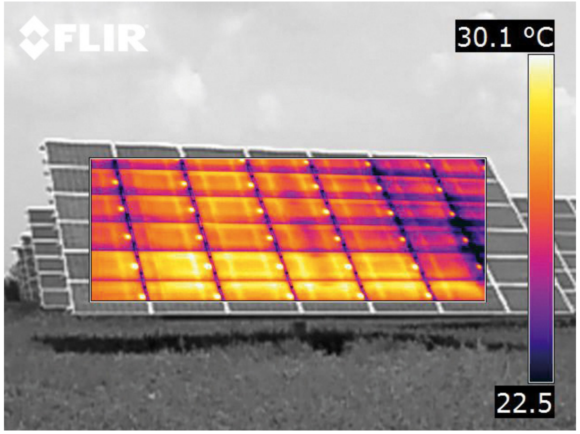
IMPACT ON TRANSPORTATION INFRASTRUCTURE

- Buckled roads
- Track repairs for railways
- Speed restrictions on railways
- Drooping power lines
- Power outages affecting transit operations

ENERGY INFRASTRUCTURE

Energy infrastructure and the potential for heat-related power outages is also a risk that impacts heat experiences. Extreme heat can lead to increased peak summertime energy consumption, reduced transmission capacity, and decreased efficiency of solar panels.

For every 1.8°F increase above 77°F, the efficiency of solar panels is reduced by 0.1 to 0.5%.[25] Temperatures of solar panels in Boston can reach 149°F.[26] Depending on the manufacturer, utility-scale photovoltaics may experience summertime capacity reductions of 0.7 to 1.7% per one degree Celsius reduction.[27] Additionally, transmission capacity may be reduced by 1.9 to 5.8% under a business-as-usual emissions scenario, relative to 1990-2010.[28] On top of that, electricity consumption during the summer months may reach three times the average consumption rate in 1960-2000. This is due to additional cooling loads from the predicted increased number of heat waves without improving building envelope and energy efficiency.[29] The combination of these risks increases the likelihood of heat-related power outages, which can affect people's adaptive capacity, or ability to cool off using air conditioning and fans. High voltage lines are particularly vulnerable, as they are not able to dissipate heat effectively due to their thickness.



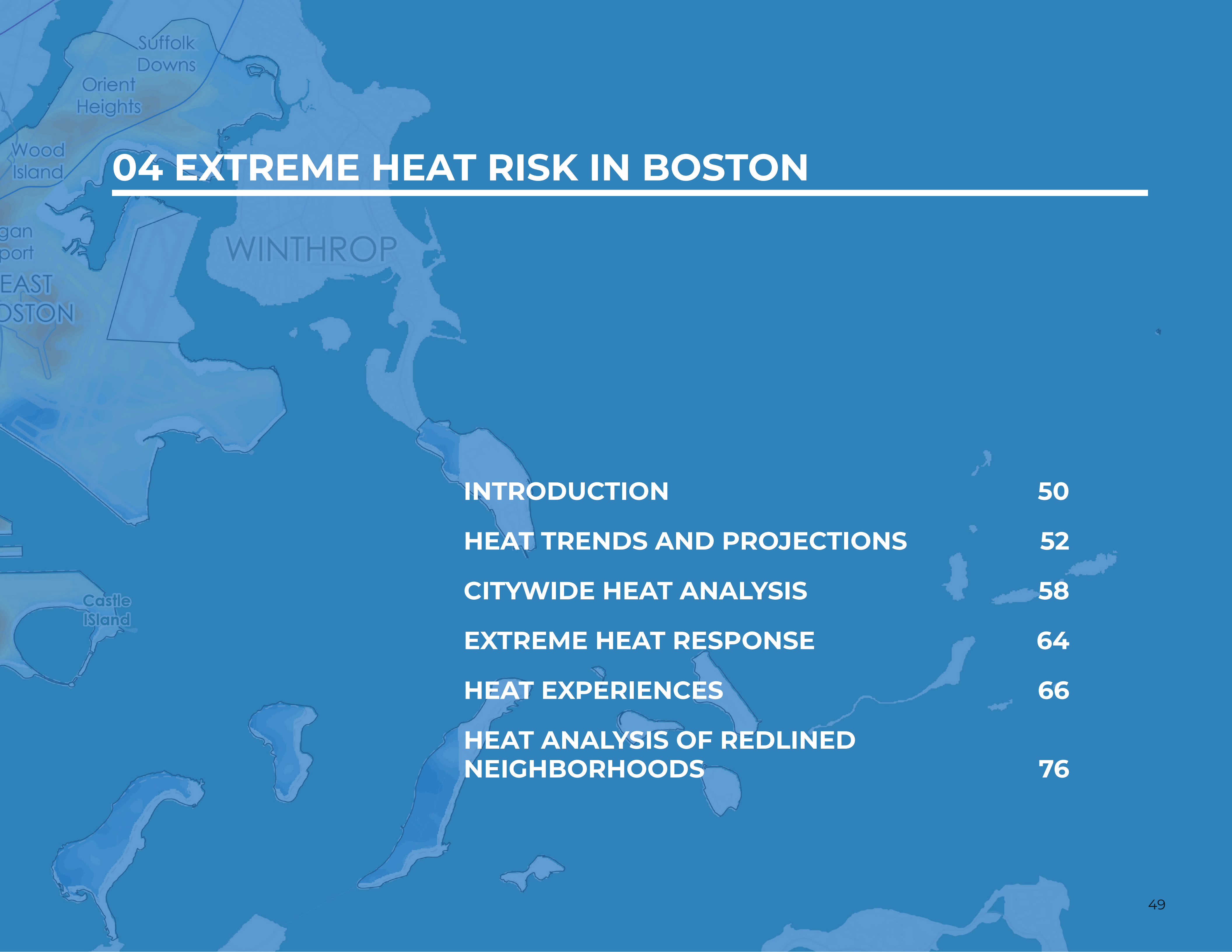
Hot solar panels
Source: FLIR Media

High voltage power lines power lines sagging in the heat

IMPACT ON ENERGY INFRASTRUCTURE

- Decreased efficiency of solar panels
- Reduced transmission capacity
- Increased peak summertime loads
- Heat-related power outages
- High voltage power lines


EVERETT
SOMERVILLE
CHARLESTOWN
3
28
WATERTOWN
CAMBRIDGE
East Boston Memorial Park
Maverick
DOWNTOWN
ALLSTON/ BRIGHTON
90
20
Packards Corner
CHINATOWN
90
Brighton
Tufts Med
FENWAY/ KENMORE
SOUTH END
NEWTON
Mass Ave
SOUTH BOSTON
Brigham Circle
BROOKLINE
Ruggles
Roxbury Crossing
Nubian Sq
Newmarket
9
Joe Moakley Park
Jackson Sq
ROXBURY
JFK/UMass
Jamaica Pond
Uphams Corner
Savin Hill
JAMAICA PLAIN
Four Corners/ Geneva



04 EXTREME HEAT RISK IN BOSTON

INTRODUCTION

The Heat Plan conducted an analysis of extreme temperatures across Boston to understand where the greatest heat impacts are, how different communities and populations are impacted, and what factors contribute to varying heat experiences in Boston.

This section details updated projections for extreme heat days, a citywide spatial analysis of air temperature, and community perspectives shared throughout the project's engagement process.


COME LEARN GROW
BOSTON PARKS & RECREATION
FACE PAINTING

HEAT TRENDS AND PROJECTIONS

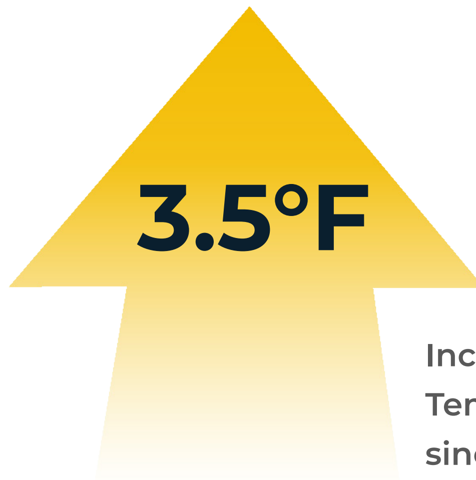
HISTORIC HEAT TRENDS

In Massachusetts, due to climate change, temperatures have increased by 3.5°F since the beginning of the 20th century.[1] In the last decade (2010–2020), Boston experienced more hot days than any decade in the previous 50 years. The total number of days at or above 90°F was 161 days in the past decade—31 days above the average by decade in the past 60 years (130 days). These daytime temperatures were accompanied by an increase in the number of warmer nights, with a total of 10 nights at or above 78°F—6 more nights compared to the 60-year decade average (4 days).[2][i]

In the last decade, hot days were also hotter. Average high and low daily temperatures were higher (1.2°F and 1.6°F, respectively) than the 60-year decade average (75.6°F and 59.5°F, respectively). When comparing the average high and low daily temperatures in the 1960s to the 2010s, temperatures increased by 2.0°F and 2.7°F, respectively.[3]

Historically, days above 90°F have mostly occurred between May and September. Between 1960 and 2020, Boston experienced the most number of hot days (over 90°F) and hot nights (over 78°F) in July.[4]

Warming Temperatures

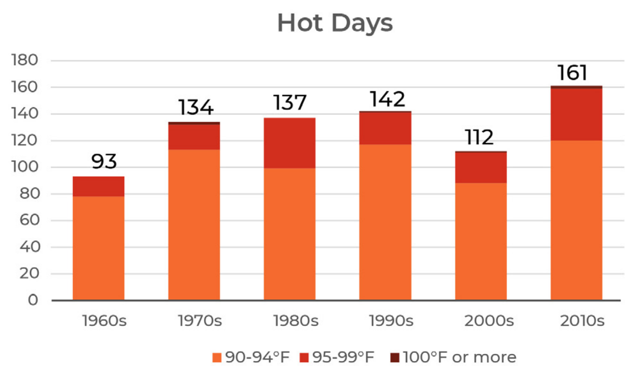


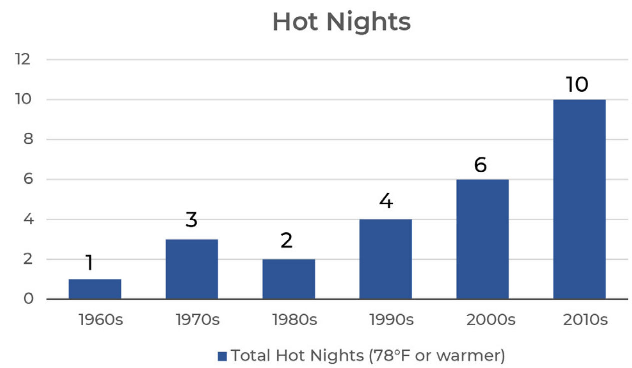
Increase in Massachusetts Temperature since 1900

The number of hot days and hot nights is expected to increase in both low and high carbon emissions scenarios through the end of the century.

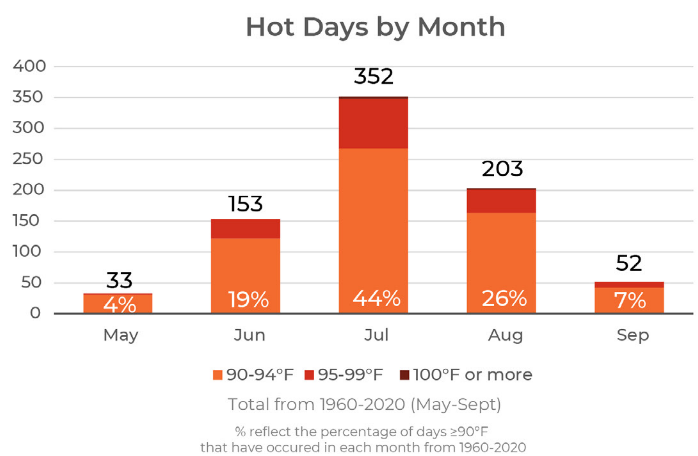
i 60-year decade average is based on 1960 to 2020; average maximum and minimum temperatures based upon May to September data.

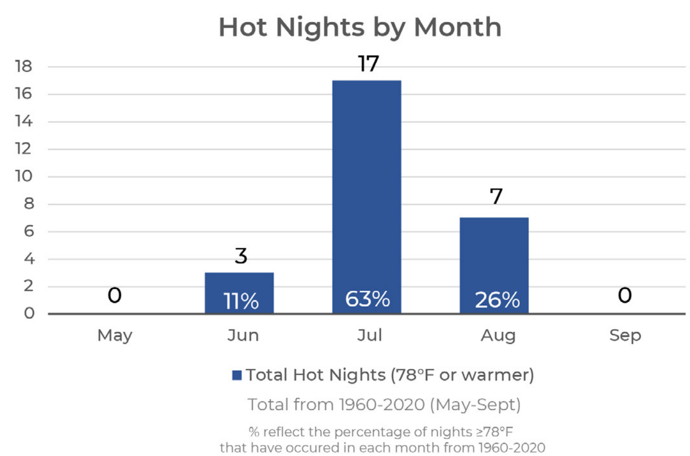
In the last decade, Boston experienced more hot days and nights than any decade in the previous 50 years.





Historically, days above 90°F have mainly occurred between May and September.





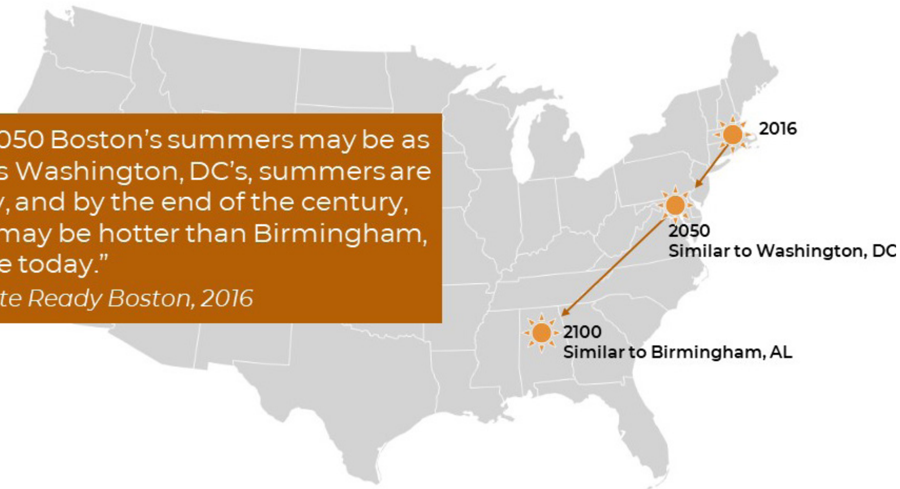
Source: NOAA National Centers for Environmental Information; data pulled for 1960-2020 Logan International Airport weather station average maximum and minimum temperatures based on May to September data

FUTURE PROJECTIONS

The Number of Very Hot Days will Increase

How much Boston's temperatures continue to increase will depend on how quickly and by how much global greenhouse gas emissions can be reduced. Even a small increase in average temperatures will lead to more frequent very hot days and nights, along with longer and hotter heat waves.[5]

> "By 2050 Boston's summers may be as hot as Washington, DC's, summers are today, and by the end of the century, they may be hotter than Birmingham, AL are today."
> *Climate Ready Boston, 2016*



PROJECTIONS FOR THE BUSINESS-AS-USUAL EMISSIONS SCENARIO

Historically, Boston summers included 10 days over 90°F (observed baseline for the 1986-2015 period from the LOCA dataset).[i] By the 2070s, the number of days over 90°F could increase six to seven-fold.[6, ii] In a scenario where emissions trends continue at the current rate (RCP 8.5), climate projections estimate that the number of very hot days (over 90°F) will most likely (17th to 83rd percentile)[iii] increase from a range of 17 to 26 days by the 2030s, to 25 to 42 days by the 2050s, and 33 to 62 days by the 2070s. In an extreme case, the number of very hot days (over 90°F) could reach up to 87 days by the 2080s.

PROJECTIONS FOR THE REDUCED EMISSIONS SCENARIO

If aggressive action is taken to reduce emissions (RCP 4.5), the number of very hot days (over 90°F) by the 2070s will be about half (20 to 38 days) what we might see in the previous high emissions scenario. Even with reduced emissions, Bostonians will face increasing chronic heat risk as the number of days over 80°F will increase. Although Boston's extreme heat response is based on 90°F and 95°F thresholds, 80°F may be uncomfortable for some community members, especially those with greater heat vulnerability. The number of days over 80°F, currently about 62 per year, will most likely increase from 73 to 91 days in the 2030s to 84 to 107 days by the 2070s. In an extreme case, the number of days over 80°F could reach up to 140 days by the 2070s. This means that the duration of summer weather will become longer and the future summer season will likely extend beyond the typical 92-day summer from June to August.

INCREASED HEAT EMERGENCY DECLARATIONS

As heat risk increases, the number of heat emergency declarations in Boston may also increase with more days above the 95°F threshold. Historically, Boston experienced only 1.5 days over 95°F, annually. By the 2030s, Boston will most likely experience 4 to 8 days over 95°F (RCP 8.5), annually. This is projected to increase to 11 to 32 days by the 2070s. Historically, days over 100°F have not been common (0.1 days over 100°F). However, by the 2070s, Boston is likely to reach up to 14 days over 100°F in a year. In an extreme case, the number of days over 100°F in a year could reach up to 20 by the 2070s.

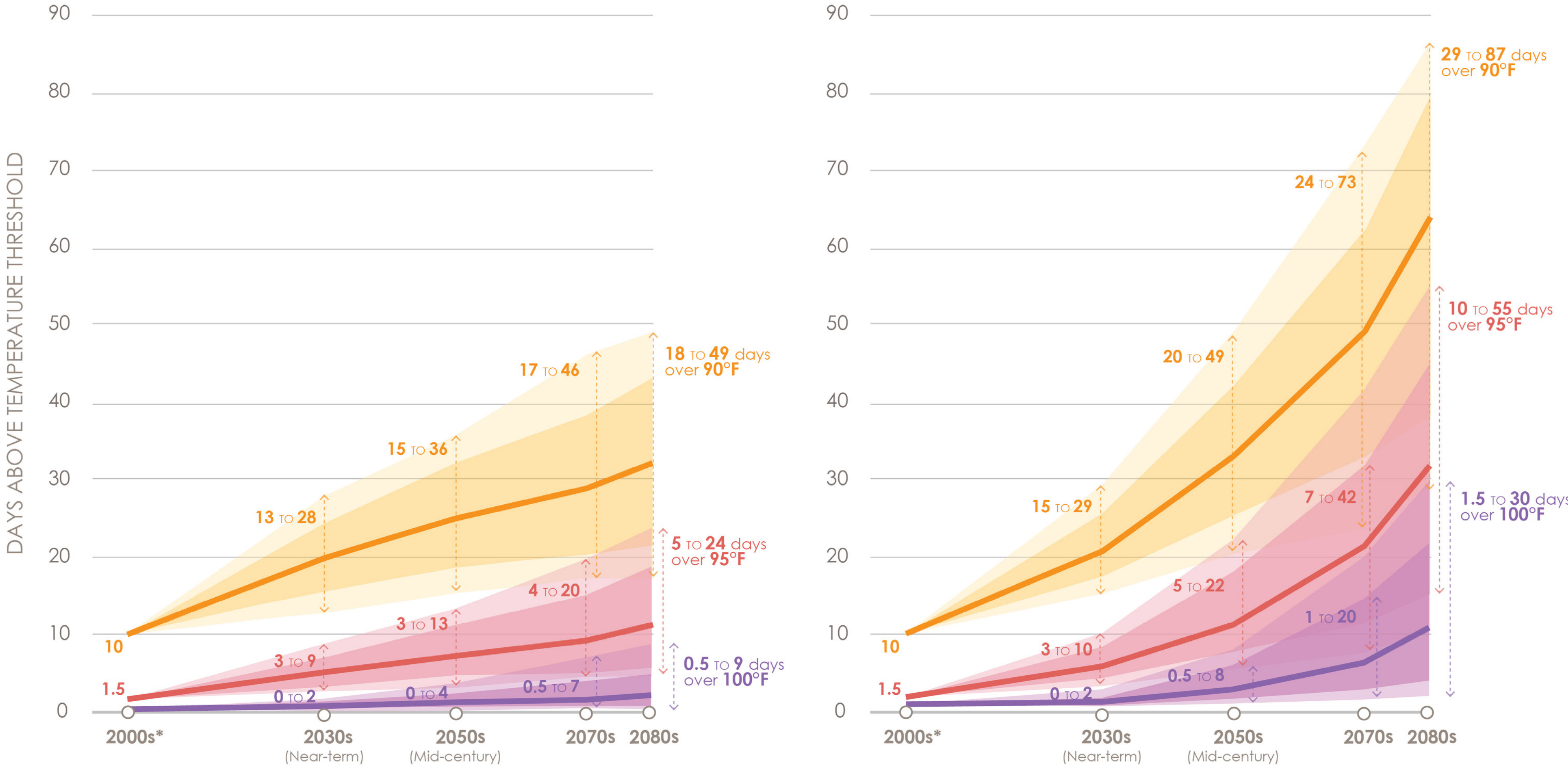
In 2021, Boston experienced 24 days above 90°F and four heat waves.[7] With temperatures increasing even in the reduced emissions scenario, preparing for the impacts of extreme heat in Boston is urgent today.

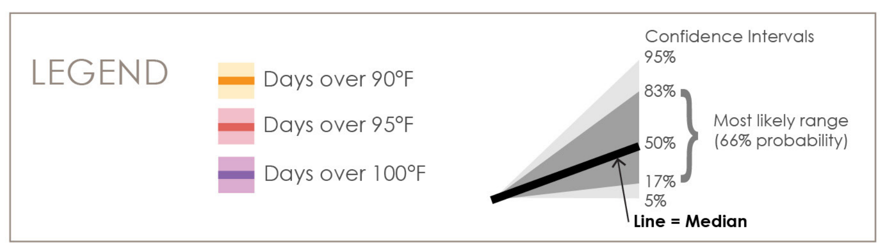
---

i The historic baseline varies depending on the period used.
ii This uses the GBRAG, Local Constructed Analogs (LOCA) dataset. The baseline used in 2016 *Climate Ready Boston* is 11 days over 90°F.
iii The most likely range reflects 17-83% confidence intervals from the GBRAG, LOCA dataset.

THE NUMBER OF VERY HOT DAYS WILL INCREASE, EVEN IF WE REDUCE CARBON EMISSIONS.

REDUCED EMISSIONS (RCP 4.5) / BUSINESS-AS-USUAL EMISSIONS (RCP 8.5)

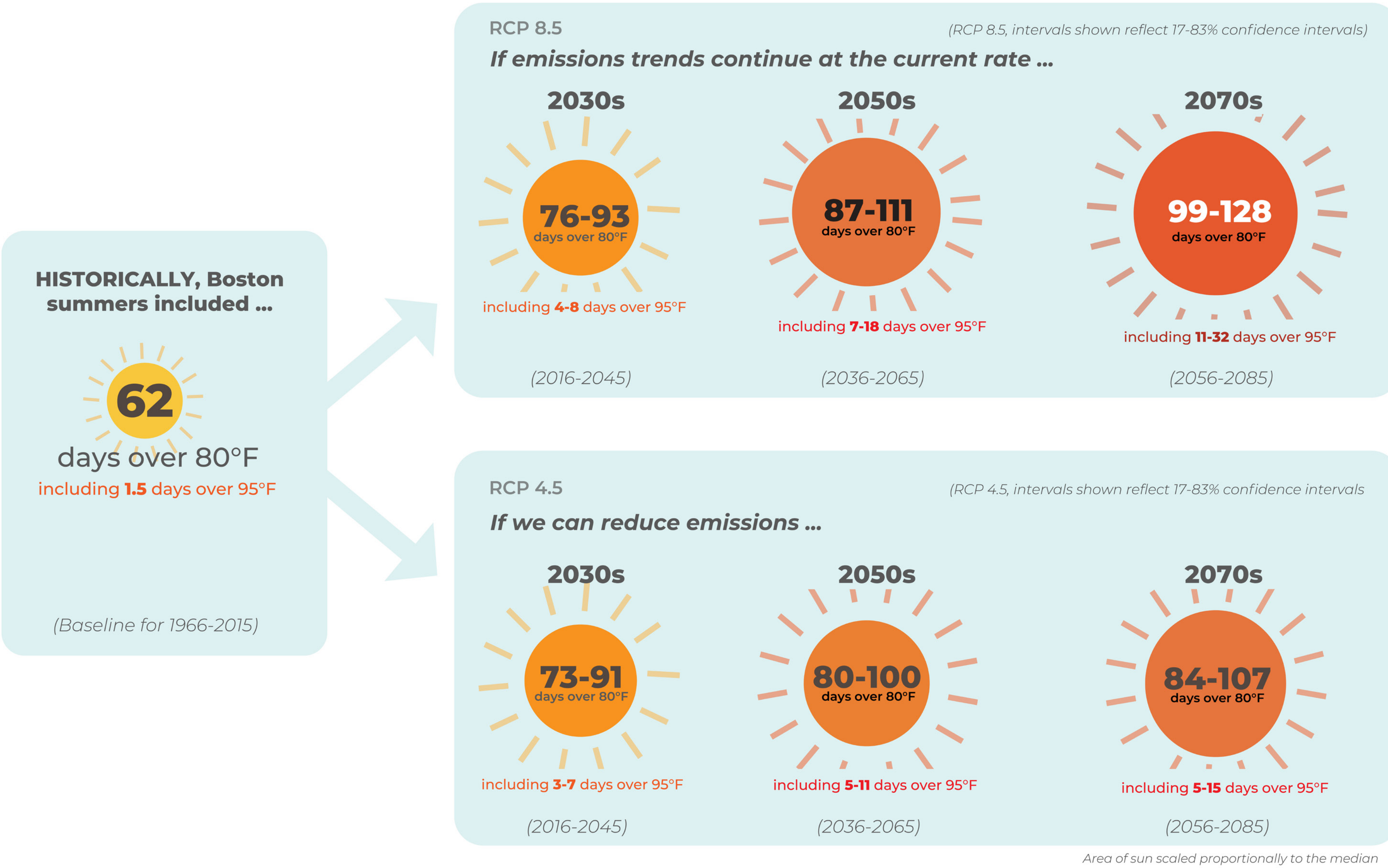




* Baseline represents historical average from 1966-2015.
Confidence intervals shown represents total possible range (5-95%)
Data source: GBRAG LOCA 2021

Source: GBRAG 2021, LOCA dataset. Baseline for 2000s (30 year period: 1966 - 2015).

BY THE 2070S, THE CURRENT JUNE TO AUGUST SUMMER SEASON WILL MOST LIKELY BE ABOVE 80°F EVERY DAY.



Source: GBRAG, LOCA dataset. Baseline for 2000s (30 year period: 1966 - 2015).

AN INCREASE IN DAYS ABOVE 90°F MEANS LONGER AND MORE FREQUENT HEAT WAVES.

HISTORICALLY, Boston summers included ...

10
days over 90°F
including **0.1** days over 100°F

(Baseline for 1966-2015)

RCP 8.5 *(RCP 8.5, intervals shown reflect 17-83% confidence intervals)*

If emissions trends continue at the current rate ...

2030s
17-26 days over 90°F
including **0.5-1.5** days over 100°F
(2016-2045)

2050s
25-42 days over 90°F
including **1-6** days over 100°F
(2036-2065)

2070s
33-62 days over 90°F
including **2-14** days over 100°F
(2056-2085)

RCP 4.5 *(RCP 4.5, intervals shown reflect 17-83% confidence intervals*

If we can reduce emissions ...

2030s
16-24 days over 90°F
including **0.5-1** days over 100°F
(2016-2045)

2050s
19-32 days over 90°F
including **0.5-2** days over 100°F
(2036-2065)

2070s
20-38 days over 90°F
including **0.5-4** days over 100°F
(2056-2085)

Area of sun scaled proportionally to the median

CITYWIDE HEAT ANALYSIS

A weeklong analysis period during July 18 to 24, 2019, was selected to produce modeled air temperature maps for the plan.

This week coincided with a very intense heat wave with peak temperatures of approximately 96.8°F on July 21 and 22 (measured at Logan International Airport). The air temperature maps produced for the *Heat Plan* include daytime temperature, nighttime temperature, heat event duration, and urban heat island index. A detailed technical memo on the data used and modeling methodology can be found in Appendix 1.

NEW HEAT MODELS AND DATA SETS ALLOW US TO BETTER UNDERSTAND:

Air Temperature: Localized daytime and nighttime air temperatures across the city.

Urban Heat Island Index: How urban characteristics like building massing, density, trees, and parks contribute to heat exposure.

Heat Duration: Where high heat conditions are longer and more intense.

URBAN HEAT ISLANDS AND MEASURING HEAT

The urban heat island effect in this analysis is measured as the near-surface air temperature difference between a specific urban location and rural location that is located further away from urban centers. The rural location provides a baseline temperature to compare against temperatures in the urban location. This metric is known as the Urban Heat Island Index (UHII). The UHII highlights areas that remain hot for longer, representing both the intensity and duration of localized heat within the city. The design and the built environment within cities impact how hot or cool a city, neighborhood, or a street feels. Heat experiences tend to be hotter within cities compared to more suburban or rural areas due to the urban heat island effect.

Dark, paved, and impervious surfaces, such as asphalt roads and buildings with black roofs, contribute to the urban heat island effect. These surfaces absorb more heat than vegetated or light colored surfaces, and they release this heat back into the surrounding environment. Areas with less trees, grass, and other vegetation tend to feel hotter when there is little shade or evapotranspiration to help reduce high air temperatures. Tall buildings and dense development also impact heat within a city. Building form and orientation can change how ventilating wind flows through corridors, how readily radiated heat can disperse, and how much sun or shade hits the surface.

This analysis also calculated heat event duration, which is the number of hours within the analysis week where heat conditions exceed daytime temperatures at or above 95°F and nighttime temperatures above 75°F. This metric is useful to identify neighborhoods that stay the hottest for the longest period during high-heat conditions.

The results from the citywide heat analysis were mapped at the city-scale to identify the hottest areas in Boston. The analysis then compared these areas to where community members feel the hottest according to a map-based online survey conducted as part of the *Heat Plan*'s engagement process. This data is available on the Climate Ready Boston Map Explorer website.[i]

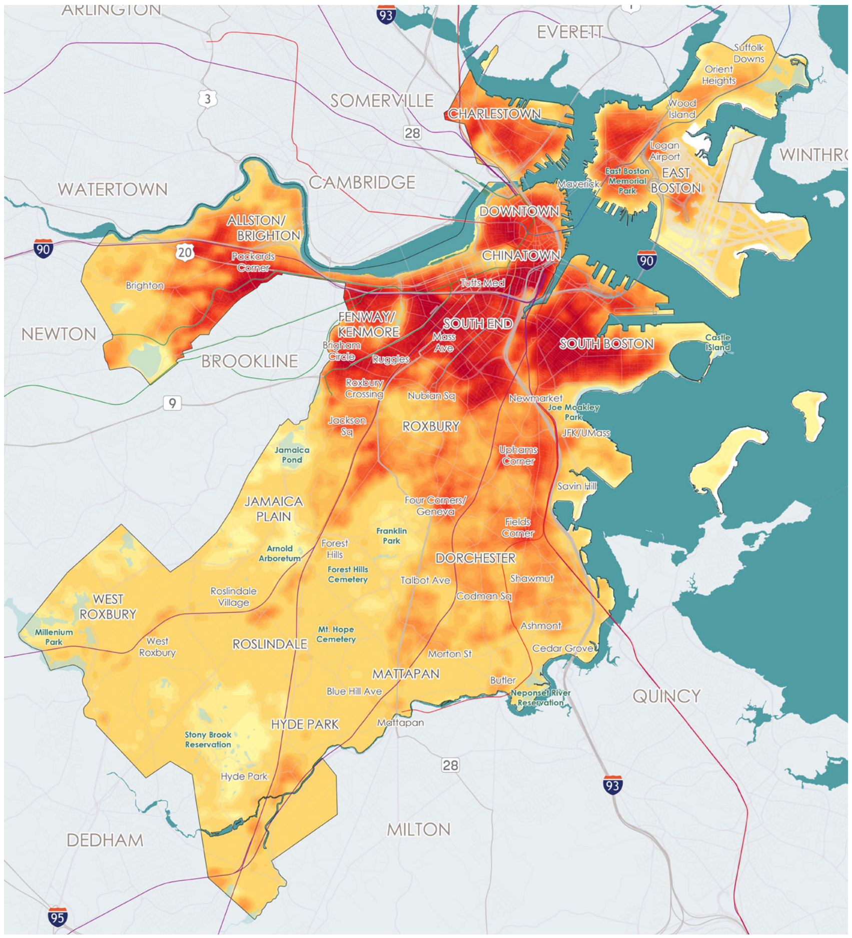
i The Climate Ready Boston Map Explorer can be found here: https://www.boston.gov/departments/environment/climate-ready-boston-map-explorer

HOW TO READ THE CITYWIDE HEAT ANALYSIS MAPS

How data is represented in a map can influence how it is interpreted. Below are two maps illustrating the same heat event hours dataset from the citywide heat analysis. The map on the left uses a yellow to red color scale to communicate that extreme heat already affects all of Boston, while the map on the right uses a blue to red color scale to highlight areas that are hottest in the city. The maps on the following pages use the blue to red color scale to help identify and emphasize the hottest hotspots in the city. While reading through this chapter, it's important to remember that although some neighborhoods experience greater extreme heat risks, all of Boston is hot and at risk during heat waves.

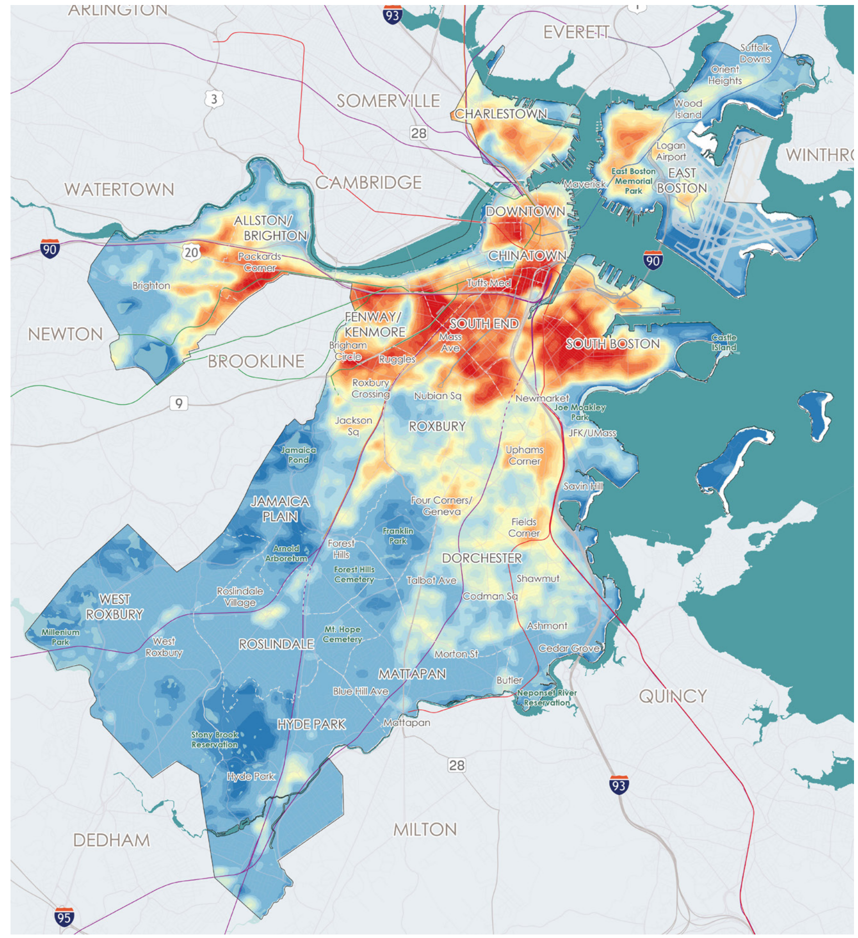
All areas of blue on the maps are still part of the urban heat island of Boston and are hotter than the surrounding suburban and rural areas.

Extreme heat already affects all of Boston.



HEAT EVENT HOURS: *Less than 25 hrs* *More than 37 hrs*

Some places are hot for longer.



HEAT EVENT HOURS: *Less than 25 hrs* *More than 37 hrs*

DAYTIME AIR TEMPERATURE

Boston is very hot during the day...

On high-heat days, all parts of Boston experience high air temperatures. Even the coolest places in Boston—like Franklin Park or Stony Brook Reservation—still experience temperatures that are above 95°F for extended periods. The daytime air temperature map shows that most of the city, except for large open spaces like Franklin Park, can reach over 100°F during a heat wave. Daytime air temperatures are generally high in areas that have high solar exposure due to impervious surfaces, limited vegetation, or limited wind ventilation. For example, areas like downtown Boston—where there is limited vegetation, tall buildings, and a lot of paved surfaces—can reach temperatures around 105°F.

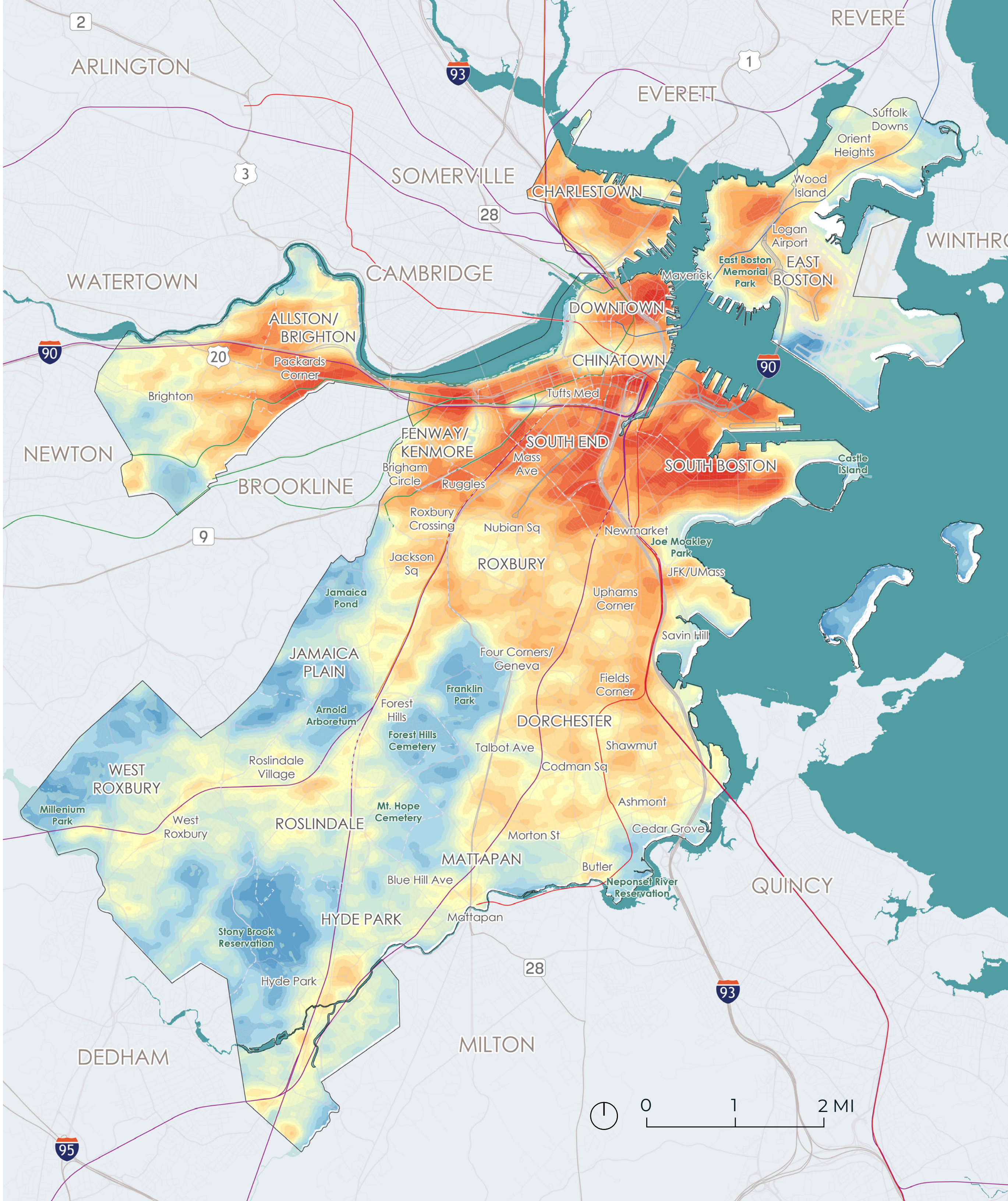
3PM:
AIR TEMPERATURE

More than 107°F

City median: 99.5°F

Less than 92°F

The citywide daytime median air temperature was 99.5°F during the heat wave.

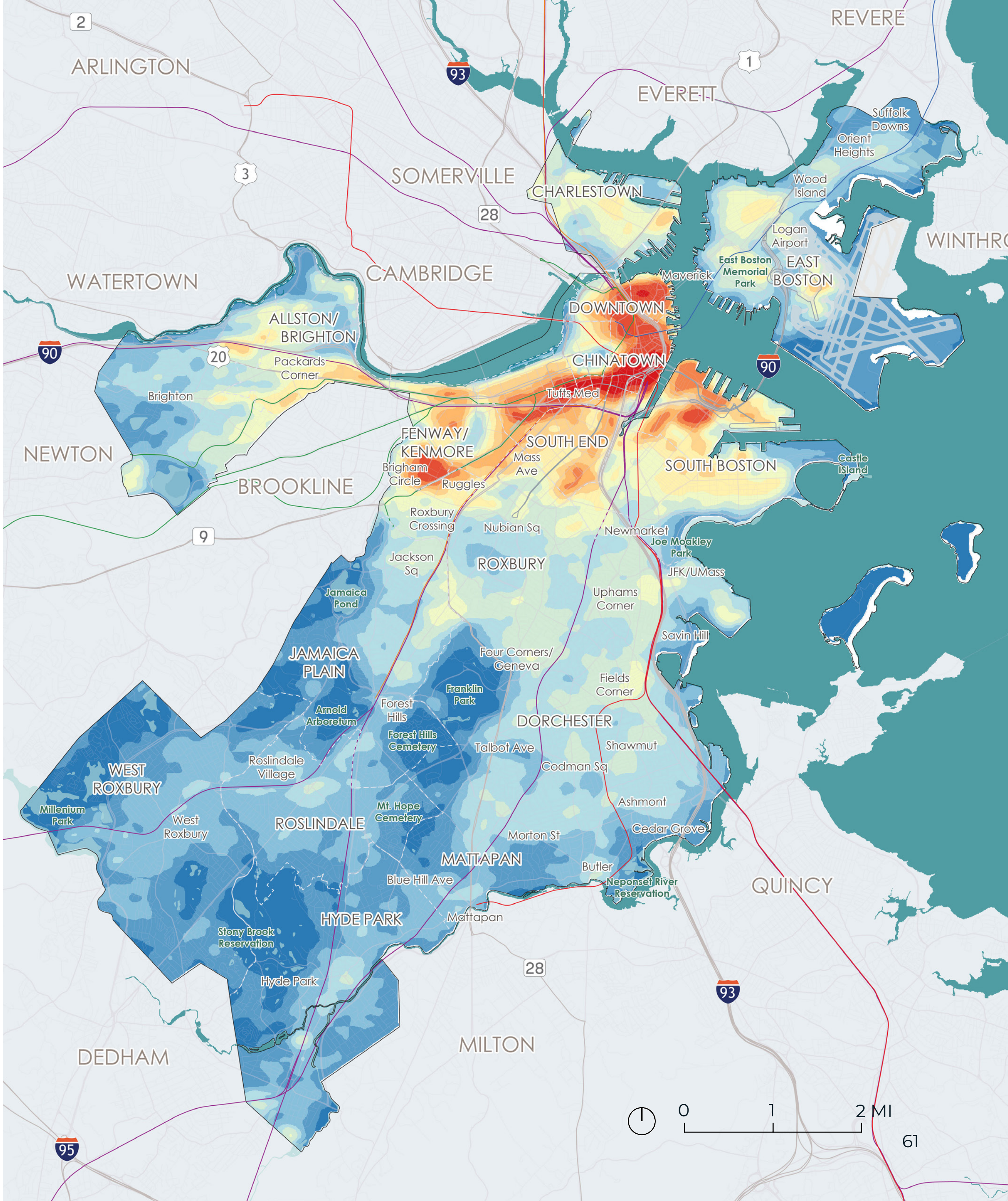


NIGHTTIME AIR TEMPERATURE

...And is also hot at night

The nighttime temperature map shows that the densest part of the city isn't just hottest during the day, but is also hottest at night. This means heat relief at home is needed to address the health impacts of high nighttime temperatures, especially for residents with higher risks. High nighttime temperatures generally follow densely built urban centers that trap heat within the urban canopy. The limited ventilation, sky view, and high thermal storage of these areas tend to retain and slowly release stored heat. For example, downtown Boston can reach temperatures above 90°F at night.

The citywide nighttime median air temperature was 81.9°F during the heat wave.

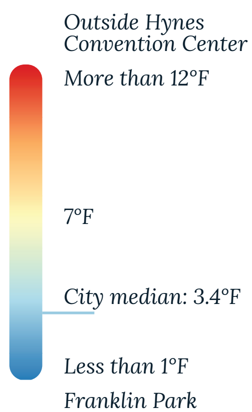


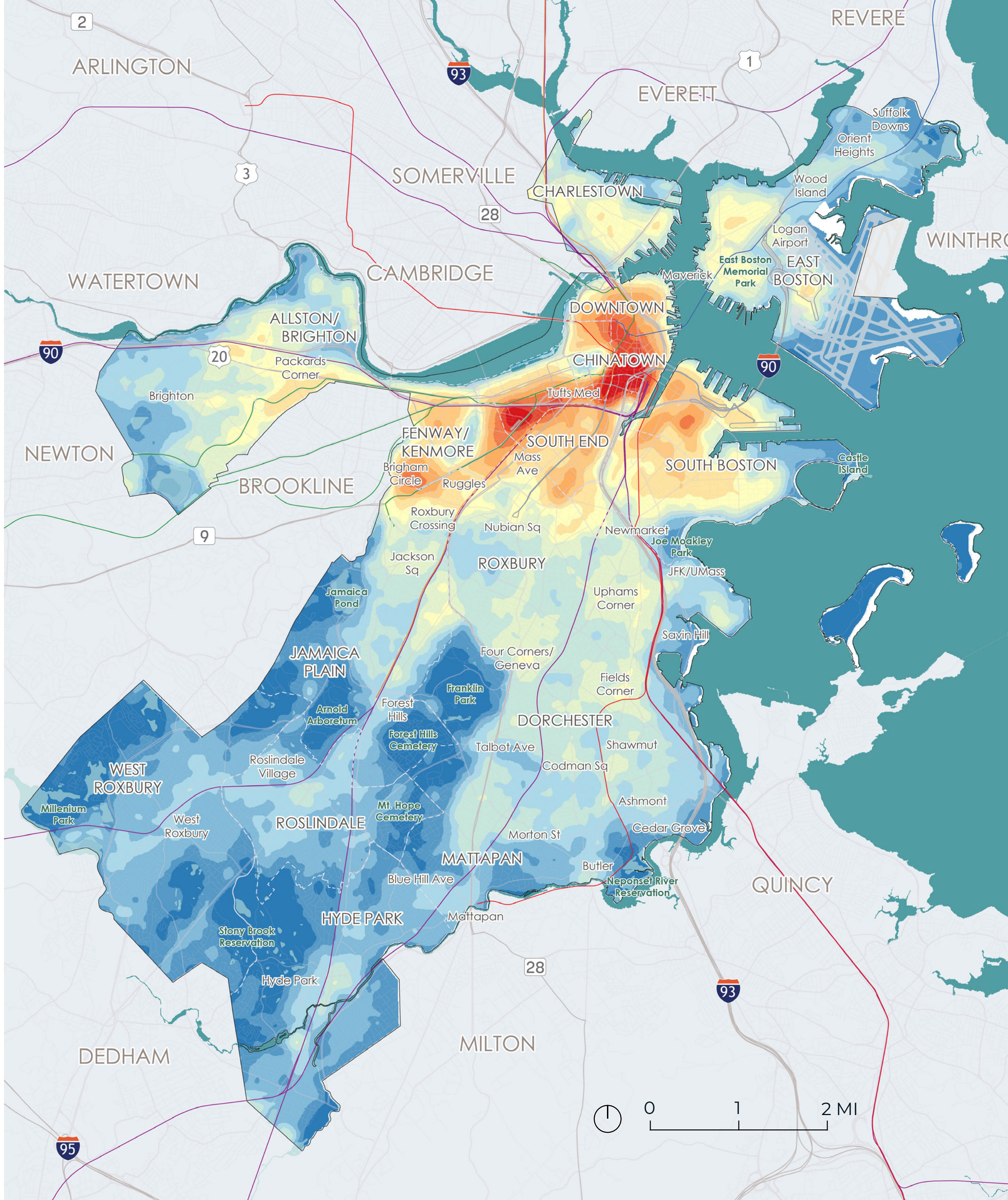
URBAN HEAT ISLAND INDEX

Coolest and hottest points in Boston

The UHII is represented in this map as an average daily temperature difference above the rural ambient temperature, or number of degrees (°F) above the coolest points in Boston. Several areas in Boston are consistent with the rural ambient temperature and are considered the coolest points in Boston, including Franklin Park, Stony Brook Reservation, and areas of West Roxbury and Jamaica Plain. Areas that are at least 10°F hotter than the coolest points include places like outside Hynes Convention Center where there are wide roads and little vegetation. The UHII map illustrates a similar spatial pattern to the nighttime temperature map. Areas experiencing the most intense and longest heat are Chinatown, Downtown Boston, the South End, South Boston, and Back Bay. Allston, Brighton, Charlestown, East Boston, and parts of Dorchester and Roxbury also experience hotter and longer heat events compared to the city median (3.4°F).

UHII: °F ABOVE COOLEST POINT IN BOSTON





HEAT DURATION

Some places are hot for long periods of time.

Understanding which areas experience extreme heat for the longest period of time helps identify where to prioritize long-term heat mitigation strategies. Heat duration is represented as the number of hours within the analysis week where air temperatures maintained a high-heat condition, exceeding 95°F during the day and staying above 75°F at night.

Some places experience disproportionately greater heat risk, with higher temperatures and extended heat wave conditions.

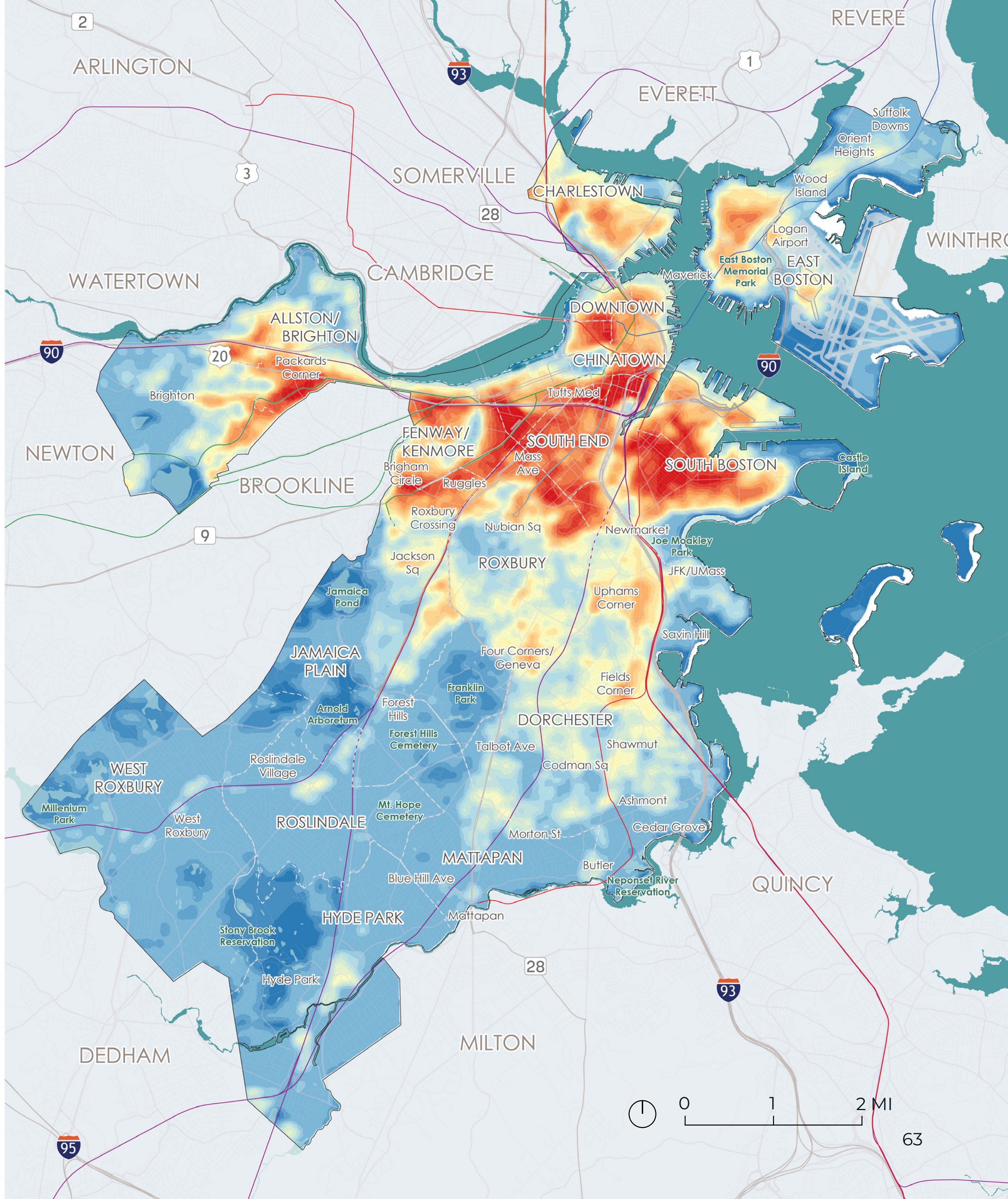
These neighborhoods enter high-heat conditions sooner, reach higher air temperatures, and remain in heat wave conditions longer. In this citywide heat analysis, Chinatown remained in a high-heat condition for 37 hours, with afternoon air temperatures climbing to 104 to 107°F and nighttime temperatures in much of the neighborhood remaining over 90°F. In contrast, West Roxbury's western area remained in high-heat conditions for 25 hours, with afternoon temperatures around 95°F and nighttime temperatures around 80°F. Other hotspots that are most distinct in the heat duration map include Uphams Corner, Four Corners, Fields Corner, and Jackson Square (more than 30 hours).

HEAT EVENT HOURS:

More than 37 hrs

30 hrs

Less than 25 hrs



EXTREME HEAT RESPONSE

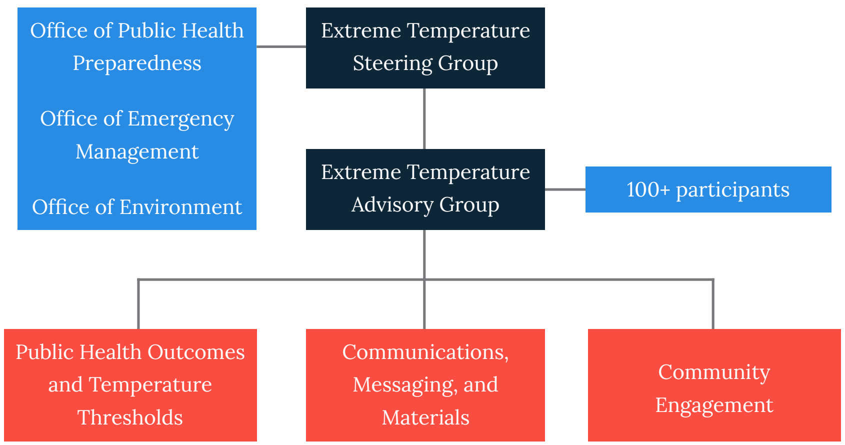
In Boston, a heat advisory is issued if there is a heat wave—a period of three or more consecutive days above 90°F. A heat emergency is declared if there is a period of two or more consecutive days above 95°F, and the overnight temperature does not fall below 75°F.[i]

From an operational perspective, the BPHC Extreme Temperatures Response Plan aims to reduce heat-related health risks and outcomes for Boston residents, especially people most vulnerable to extreme heat impacts. The Extreme Temperatures Response Plan shifts management of extreme heat and cold events to the BPHC, including coordination of the respective City of Boston departments to communicate and engage with communities to enhance preparedness to extreme temperatures.

When a heat emergency is declared, public facilities like designated Boston Centers for Youth and Families (BCYF) community centers are activated to serve as cooling centers within Boston neighborhoods. Typically, BCYF centers require registration, but during a heat emergency, facilities are open to all residents. Additionally, if residents are signed up for AlertBoston, the City's emergency alert system, they will receive emergency alerts by phone, email, or text. Residents are also often directed to non-emergency City services during heat waves by calling into the City's constituent services hotline, 311.

The City of Boston has also implemented short-term cooling strategies, such as the distribution of cooling appliances to older adult residents and residents with disabilities or chronic illness. A pilot program of the Healthy Places Initiative distributed 400 air-conditioning units to 123 lower-income and high risk residents (e.g., people with asthma and lower incomes, older adults with lower incomes) and 277 additional older adult and disabled residents of Boston Housing Authority (BHA) communities during summer 2021. An additional 700 box fans were also distributed in BHA facilities for older adult and disabled residents to support cooler, healthier homes.

Planning Structure of the Extreme Temperatures Steering Group



Source: Adapted from Collaborative Planning for Extreme Temperature Response in the City of Boston. Accessed March 2022. https://delvalle.bphc.org/mod/wiki/view.php?pageid=159

i These thresholds are relevant as of 2022. As average temperatures increase, these thresholds are subject to change in the future.

Fan distribution as part of the pilot Healthy Places Initiative in summer 2021

Hampton House Apartments in Roxbury

Eva White Apartments in the South End

Eva White Apartments in the South End

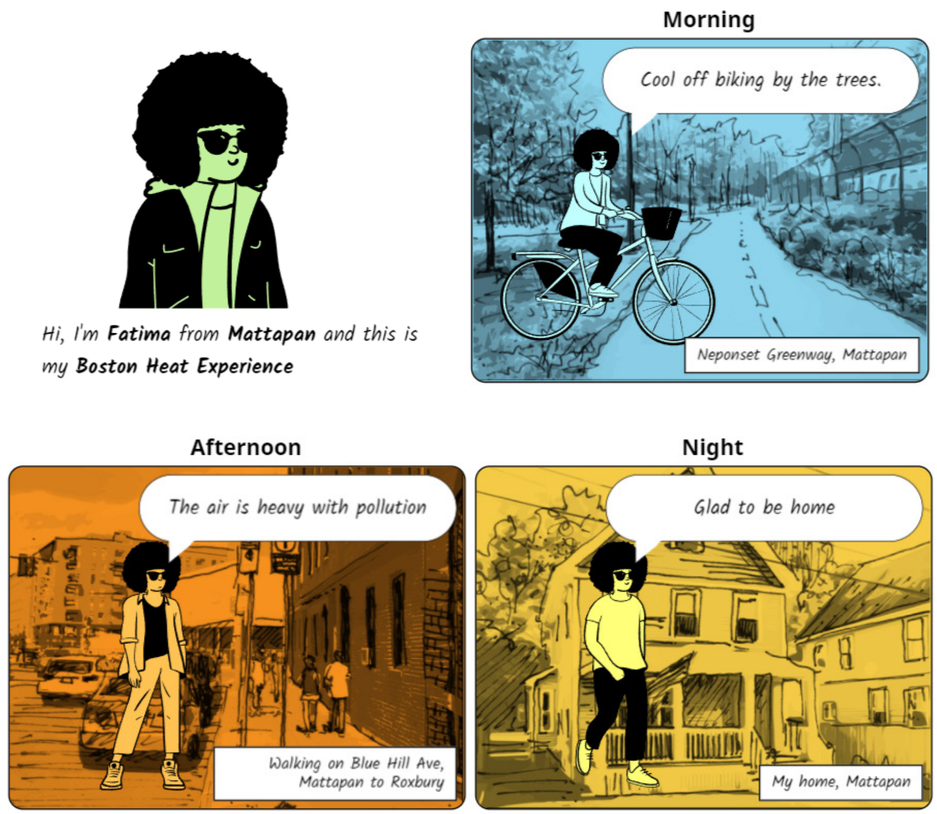
HEAT EXPERIENCES

Over 390 people participated in the heat resilience strategies process through online surveys, focus neighborhood idea sessions, a youth idea session, and open houses. In addition to engaging people from the five focus neighborhoods (Chinatown, East Boston, Dorchester, Roxbury, Mattapan), residents from nine other neighborhoods shared how they stay cool during the summer and how the built environment makes their neighborhood hotter.

WHERE IS IT HOTTEST IN BOSTON FOR RESIDENTS?

Part of the online survey included an interactive mapping portion that asked where people feel too hot inside and too hot outside, and which routes felt uncomfortably hot. Of the more than 80 people that responded to the survey form, 27 respondents mapped where they felt too hot. The majority of the 27 respondents live in Dorchester, while other respondents live in Charlestown, East Boston, Jamaica Plain, Mission Hill, Newton, Roslindale, and the South End.

HEAT RESILIENCE STORY COMIC BUILDER



The project developed an online comic builder to facilitate and empower community participants to share their heat story experience in a creative way. Participants created a character and illustrated what they do to stay cool on hot summer days.

STAYING HOME WHEN IT'S HOT

Of respondents to the online survey, 97% think that high heat is an important issue during the summer, and 91% of people feel too hot in their home when it is very hot outside. Despite feeling hot at home, two-thirds of stakeholders, which includes the majority of people 34 to 64 years old and people over 65 years old, stay home on a very hot day to limit physical activity, with 60% always using air conditioning. Those who never or sometimes use air conditioning at home mainly limit their use (or do not have access) because of unaffordable utility bills or electrical and insulation issues in older buildings.

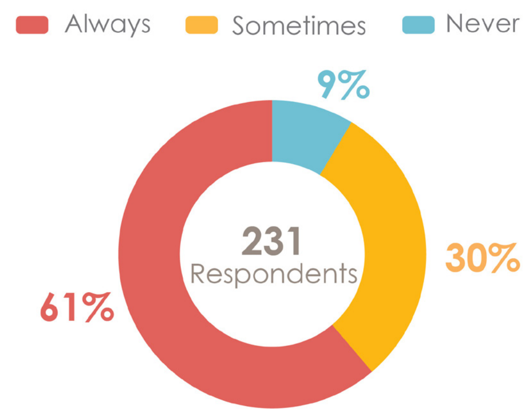
Other ways residents stay cool on a hot summer day include turning on the air conditioner at home, using fans, drinking water, and taking cold showers.

The majority of respondents always use an air conditioner at home. However, for those who sometimes or never use air conditioning at home, it is mainly because the utility bill is not affordable.

When not at home, people go to an outdoor public place, such as a pool or park, or a privately-owned place, like the mall or home of a friend.

If you feel too hot in the summer, what do you do to stay cool?

When it is very hot outside, how often do you use air conditioning in your home?



> *I stay home most of the time and underneath my fan all day. I have asthma and it's not safe for me to be out in the summer when it's hot.*
> *-youth participant*

PUBLIC COOLING LOCATIONS

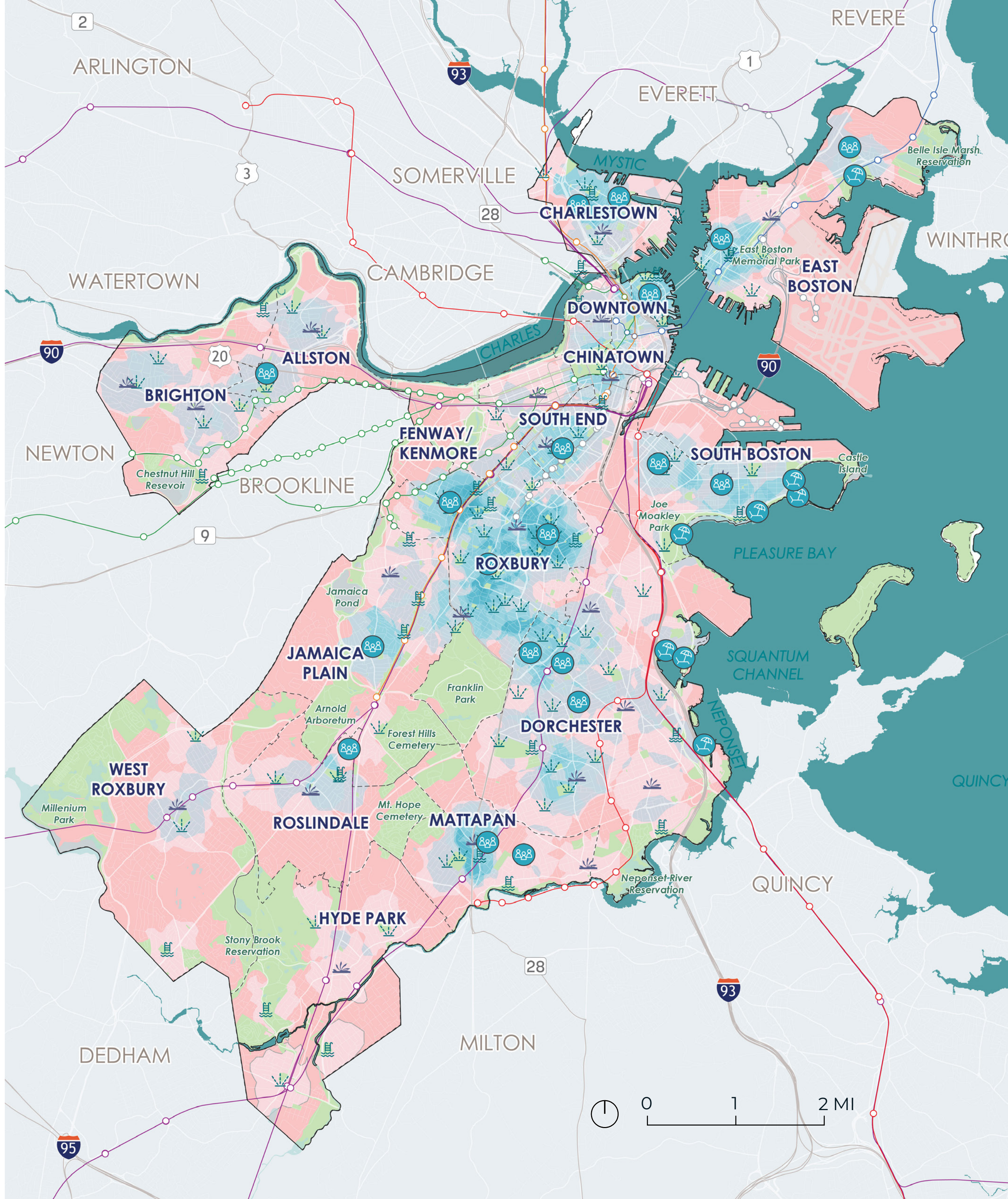
Gaps in the existing cooling network

Many parts of the city have public places to cool off within a 10-minute walk, but some areas within neighborhoods fall outside of this range. These areas are highlighted in red: East Boston and many neighborhoods in the southwest. These red gaps increase when cooling places aimed at young children, like tot sprays, are removed from consideration.

PUBLIC PLACES TO COOL OFF

- *Pools (BCYF and DCR)*
- *Tot Sprays*
- *Libraries*
- *Beaches*
- *Community Centers*[i]
- *No Cooling Centers*
- *More Cooling Centers Within 10-minute Walk*

i BCYF Summer 2020 Cooling centers were used for this map.



OFFICIAL COOLING CENTER GAPS

Places more than a 10-minute walk from an official cooling centers

Many of the places not within a 10-minute walk of a public cooling center[i] are near large open spaces, such as around Stony Brook Reservation and Jamaica Pond. However, some areas still experience over 37 hours of extreme heat without access to a cooling center. Some of these places include parts of Dorchester near I-93 and Fenway/Kenmore.

Survey respondents shared that additional public cooling locations and cooling centers are needed for adults, especially seniors who are more vulnerable to extreme heat.

HEAT EVENT HOURS:

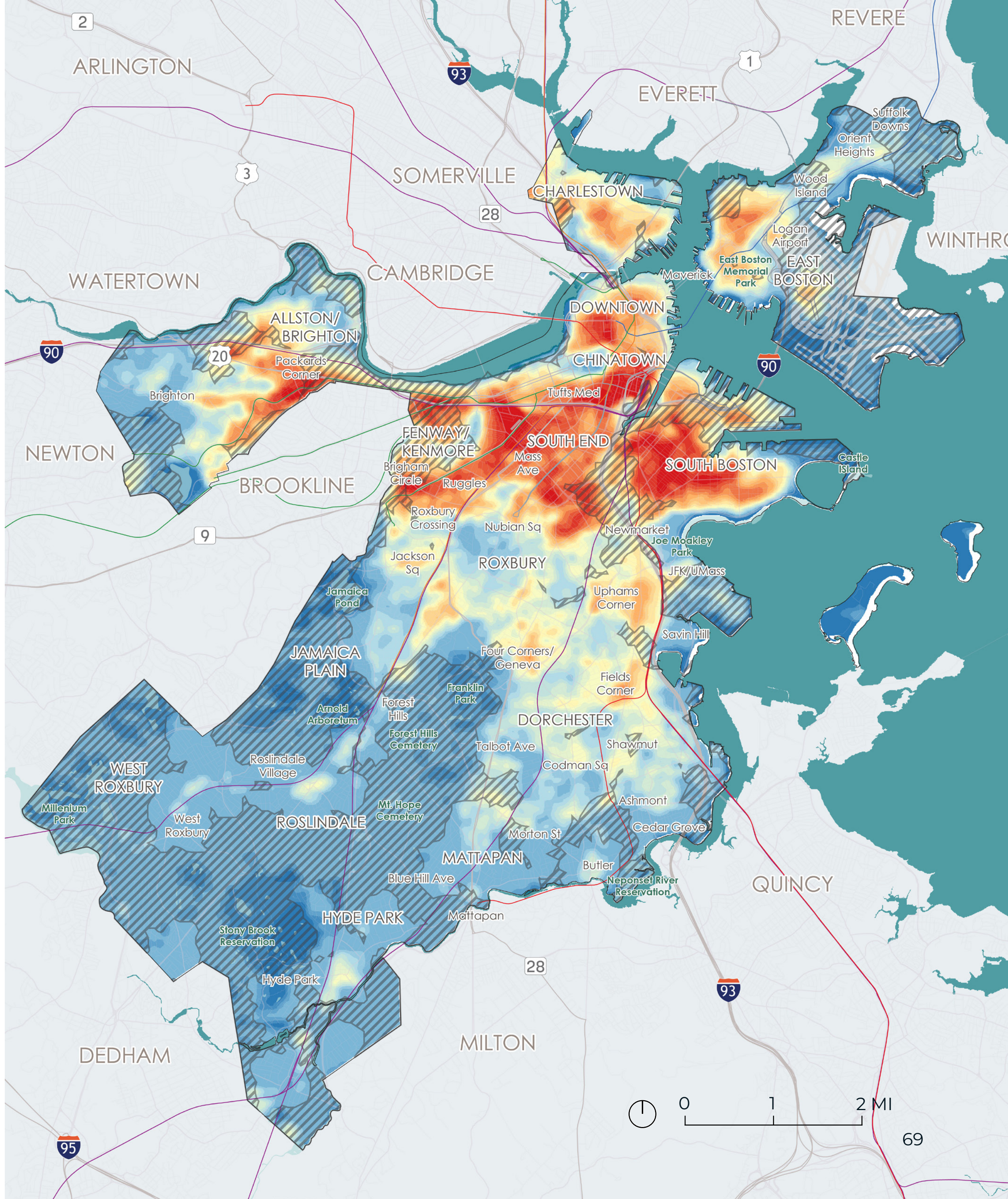
More than 37 hrs

30 hrs

Less than 25 hrs

Cool-off Gaps

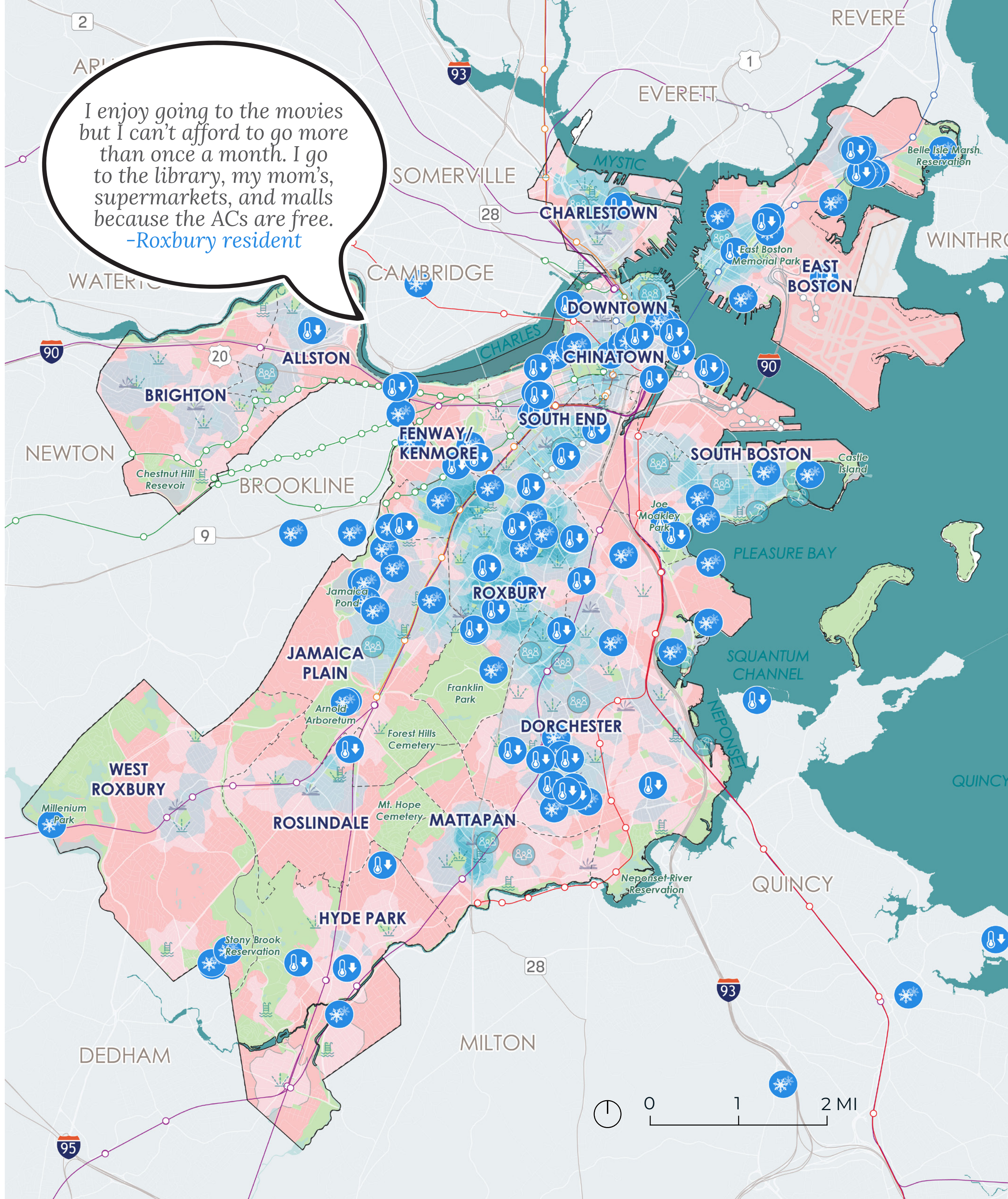
i BCYF Summer 2020 Cooling centers were used for this map.



SURVEY RESULTS: COOL DESTINATIONS

Affordable, accessible, and welcoming to all

Based on survey responses, popular options when it is hot outside include going to an outdoor public place, an indoor public place, or an indoor privately-owned place. Respondents preferred to stay cool at a friend, relative, or neighbor's home with a pool or air-conditioning. Other locations with water features like tot sprays or fountains are especially popular with people under 34 years old, while swimming pools are mostly visited by people 34 to 64 years old. Respondents shared a desire for additional public water features that serve people of all ages. In addition to outdoor places, respondents shared that air conditioned places, like movie theaters and malls, are critical community spaces on a hot day. Public indoor spaces, including cooling centers, community centers, and libraries, are also places residents use on a hot day. Respondents shared that improvements to registration, opening hours, and programming could increase their use. Respondents also shared that cool indoor public places should create a welcoming and safe environment for all, especially people of color and youth.



COOLING CENTERS

No Cooling Centers

More Cooling Centers Within 10-minute Walk[i]

WHERE DO YOU...

Go to cool off inside

Go to cool off outside

i BCYF Summer 2020 Cooling centers were used for this map.

SURVEY RESULTS: STREETS AND CORRIDORS

Survey respondents shared their priority for safe pedestrian and bicycle uses on City streets. Some routes are too hot to walk, run, or wheel on a hot day. Additionally, corridors with large vehicles or exhaust from heavy traffic also contribute to hotter streets with greater pollution that can affect health and safety. Respondents shared that wide streets and those with larger areas of impervious surfaces are also creating corridors that are sometimes uncomfortably hot.

From the word cloud, the top four reasons for why respondents felt their neighborhood was hotter than other places in Boston are the following:

1. *Very few trees*
2. *Lots of pavement, concrete, and asphalt*
3. *Lack of green space*
4. *Lack of AC or affordability of AC and utility bills*

What makes your neighborhood hotter than other places you experience in Boston?

SURVEY RESULTS: WHERE DO YOU FEEL HOT OUTSIDE?

Comments on the online mapping survey allowed people to give context for why a specific location is hot.

Much of South Huntington lacks street trees and is so wide that few trees shade the opposite side.

1

The wide streets and high traffic through Egleston Square make it uncomfortable to walk around, though the two small parks along this route are great for gathering.

2

This stretch of Warren Street is unpleasant for walking or waiting for the bus. Very little shade, lots of big vehicles.

3

HEAT EVENT HOURS:

More than 37 hrs

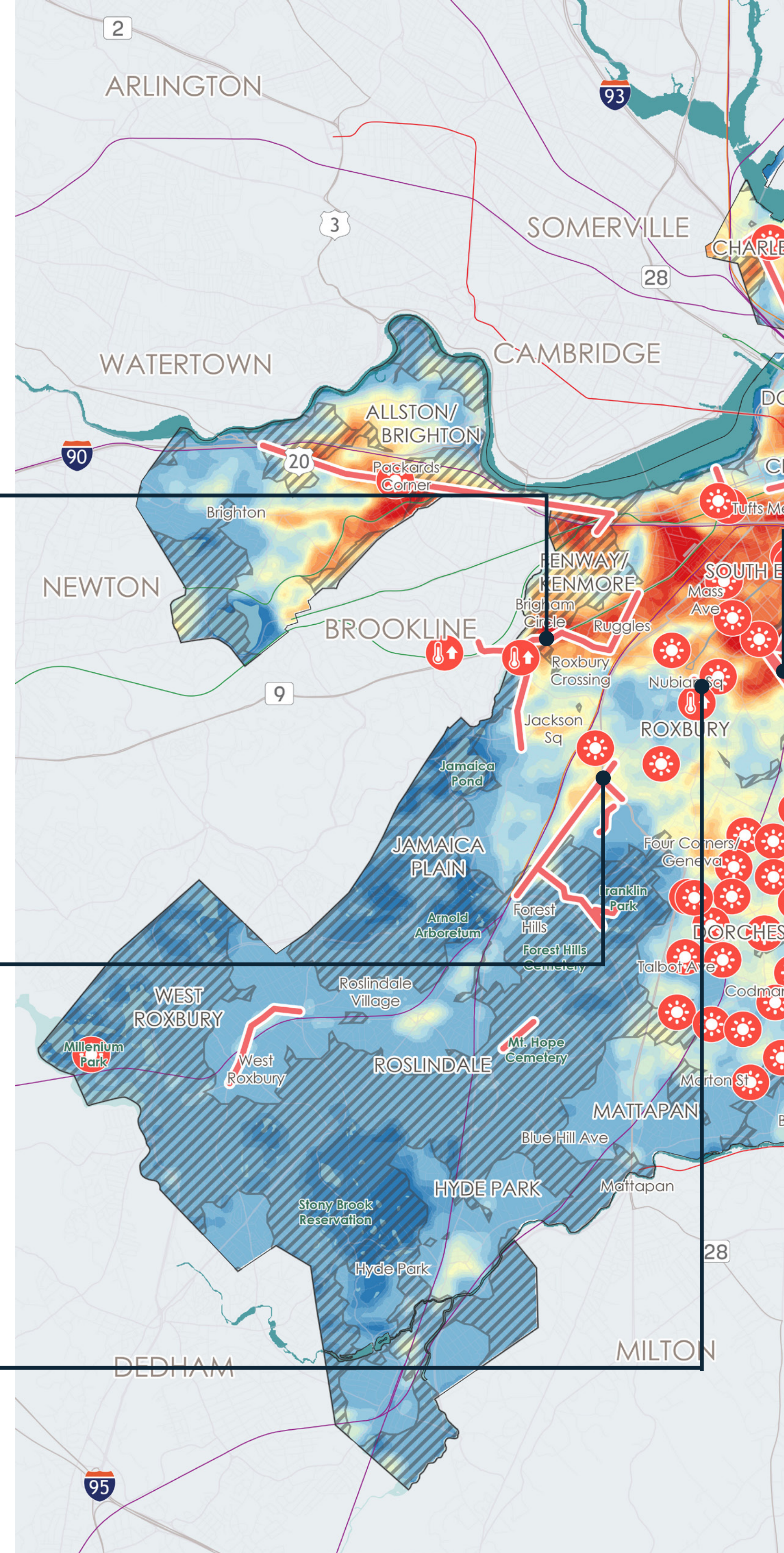
30 hrs

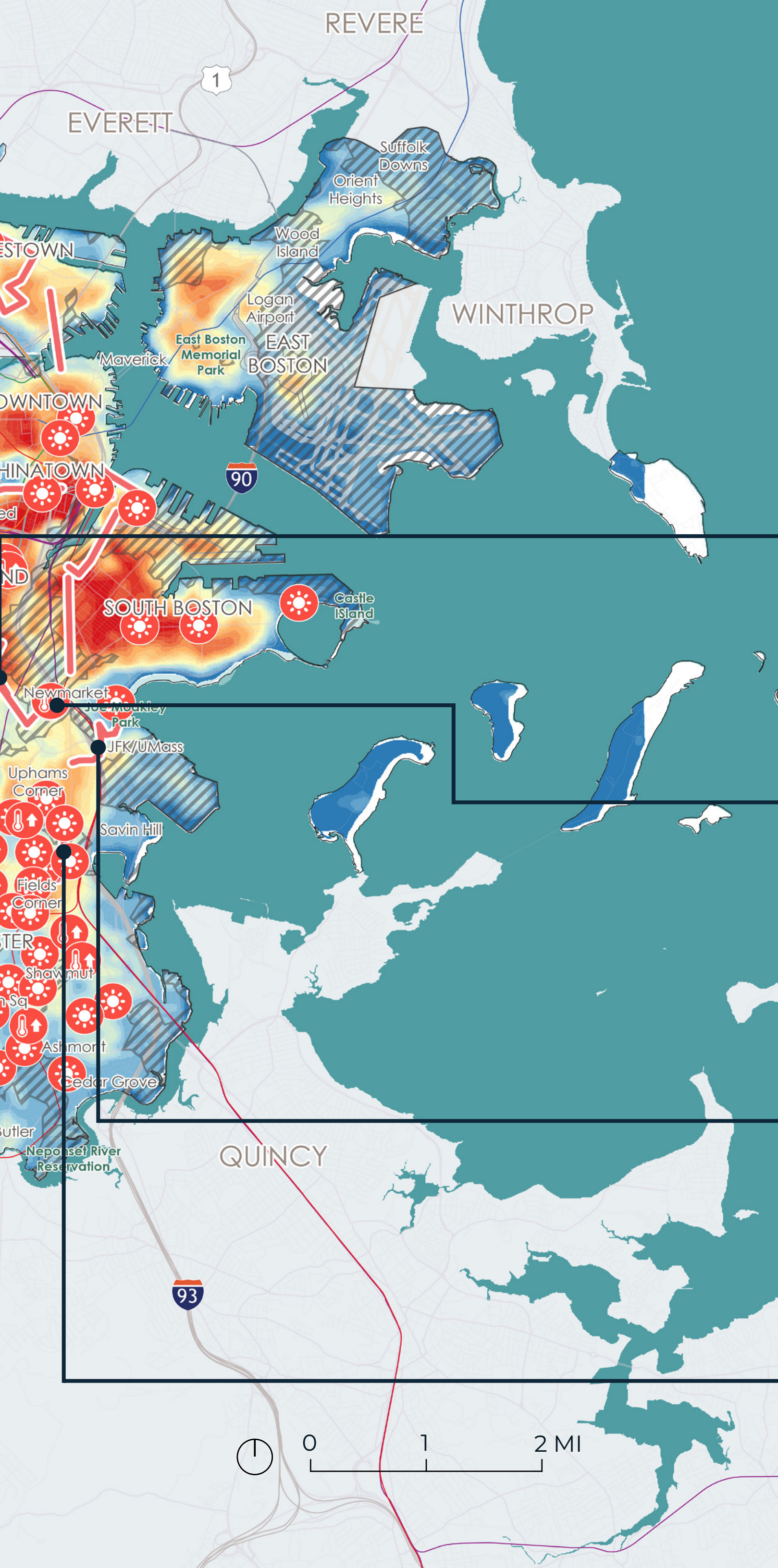
Less than 25 hrs

Cool-off Gaps

WHERE DO YOU...

- *Feel too hot inside*
- *Feel too hot outside*
- *Uncomfortably hot routes*





4 This route is all concrete, not a single tree. Many of our residents in Boston who are battling homelessness also hang out here, and look sunburned during the summer. There is no shade and riding a bike is very hot.

5 Many people come here because it has free and accessible parking, shopping, and places to eat. There is, however, no place to cool down for free. NO green areas. No trees.

6 It is so hard to get here by public transit and then it is too hot. Too much hard surface.

7 It's so much hotter, dustier, and uncomfortable to walk or bike this stretch of Dorchester Ave. than the section preceding or just after.

COMMUNITY'S PRIORITIES

Bostonians shared that their highest priorities for heat resilience include increasing shade and trees, reducing dark surfaces and pavements, increasing comfort in dense developed areas, addressing the impacts of pollution on health and wellbeing, and increasing the accessibility and affordability of places to cool off.

Many Bostonians rely on green spaces and the urban tree canopy to help stay cooler in hot weather. Residents shared that maintaining the existing tree canopy and increasing shaded seating in public spaces are critical priorities.

Additionally, many Bostonians stay at home during a heat wave, even when they are feeling hot. Residents shared that investments to purchase or upgrade air conditioners and fans, install shades and blinds, and pay for electric bills to run appliances are key priorities.

Many neighborhoods in Boston are more dense and developed areas, with more pavement and dark surfaces that absorb heat and increase air temperatures. Residents shared that developing buildings, streets, and the public realm in a way that helped cool the city was a priority.

Some roads in Boston have a large amount of traffic, both car and freight vehicles, which causes harmful air pollution that particularly affects residents living with medical illnesses. Residents shared that approaches to transportation and transit in the City that minimized air pollution, while supporting cooler streets, was a priority.

Across all issue areas, residents shared a priority for all strategies and actions of the City to acknowledge and educate residents on the drivers of disproportionate exposure to heat. They identified their vision of a City that places heat resilience within a series of interconnected opportunities around housing, affordability, development, food and health access, closing wealth gaps, and racial and environmental justice.

Hearing these priorities, the *Heat Plan* aims to center environmental justice and equity in creating an all-of-government plan to mitigate the risks and effects of extreme heat. With temperatures and extreme heat projected to increase in the future, this plan focuses on a wide range of strategies that deliver on seven categories of benefits to comprehensively address current and future heat risk for all Bostonians: heat reduction, heat relief, increased adaptive capacity, improved public health, economic opportunity, environmental benefits, and environmental justice and equity.

Taken together, these seven priority benefits speak to a range of strategies in the *Heat Plan*, allowing the City of Boston to implement high-priority strategies that focus on people, communities, neighborhoods, infrastructure systems, and the City as a whole. From long-term reductions in heat exposure to near-term relief from heat waves and a more inclusive green economy, the benefits of heat resilience investments are broad and will help put Boston on a path to becoming a Green New Deal city.

What cooling interventions would you like to see in your neighborhood?

Safe AND ACTUALLY FUN spaces outside the house. A lot of spaces are just like, go here and hang out, but there's nothing to do there. Why don't we make the places that youth want to hang out (shops, coffee places, etc.) de facto cooling spaces and support businesses to draw more people in during hot times.
-yYouth ideas session participant

Ideas that focus on systemic issues, evaluating the root cause of excessive heat .
-oOpen house participant

I'd love to see more tree planting initiatives in neighborhoods with less trees. Historically and presently, these are predominantly neighborhoods with a greater concentration of Black and Latinx families. Much research has documented the significance of trees and green spaces to help reduce violence and increase wellness (specifically respiratory health).
-Roslindale resident

I think that older apartments and homes need better cooling resources. I have an elderly grandmother that can't afford AC. She stays with me when it gets too hot.
-Dorchester resident

It does get extremely hot in Boston. I feel there's not enough cooling for the elderly and people with medical conditions who are also affected.
-Dorchester resident

Students can't learn when it's hot, teachers are at risk. Need to modernize school buildings and develop strategies to address heat.
-Open house participant

HEAT ANALYSIS OF REDLINED NEIGHBORHOODS

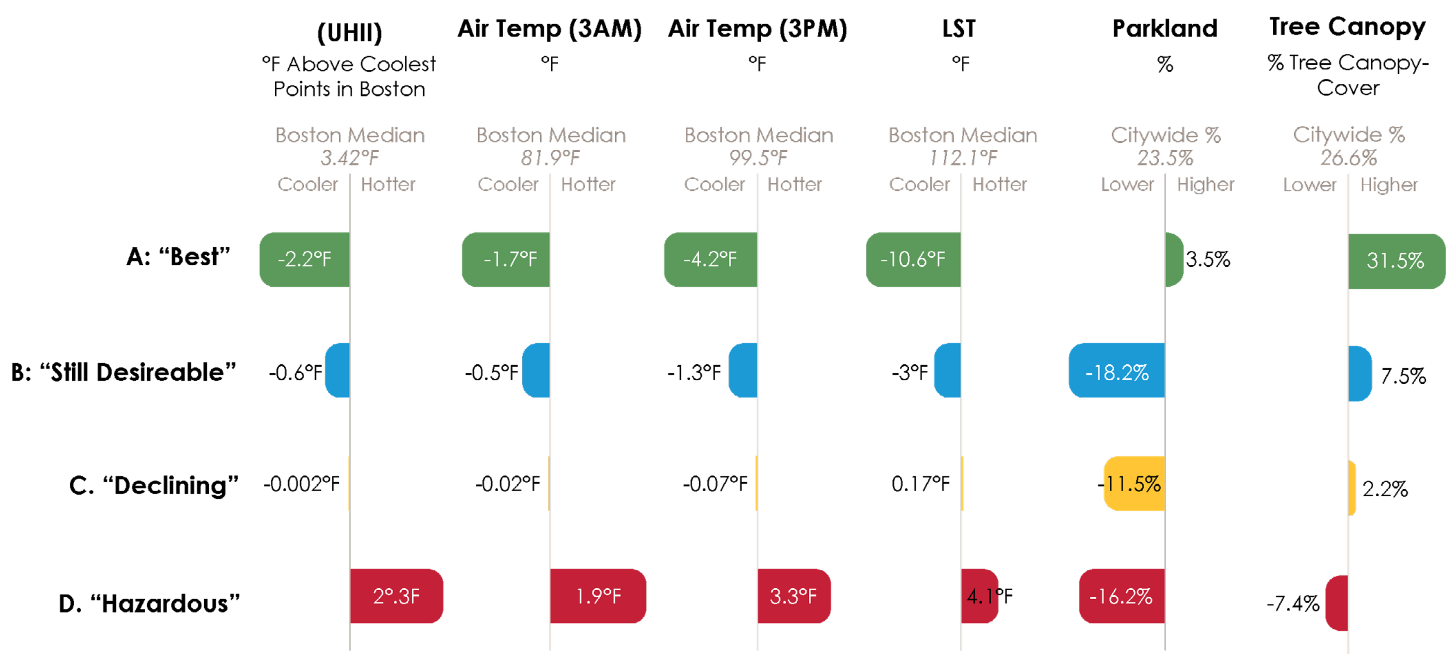
Redlined areas are 7.5°F hotter in the day, 3.6°F hotter at night, and have 20% less parkland and 40% less tree canopy than areas designated as A: Best.

REDLINED AREAS ARE HOTTER FOR LONGER

Understanding and acknowledging the historical context of disinvestment and subsequent effects on the built environment in Boston is critical to planning for heat vulnerability and resilience (see Chapter 3 for context on redlining). The plan compared the HOLC historical grading map with present day extreme temperatures and heat duration.

The analysis showed that heat event duration and air temperature overall was greater in areas that had been rated declining or hazardous compared to areas that were rated best or still desirable. Non-redlined areas are cooler when looking at UHII, nighttime air temperature, daytime air temperature, and land surface temperature, while redlined areas are hotter across these metrics. Additionally, non-redlined areas have less impervious surface and more tree canopy cover.

Redlined areas are hotter in all heat metrics than other categories



Beginning in the 1930's, many of Boston's neighborhoods were redlined by lenders. These areas experienced decades of underinvestment and today are significantly hotter places to live, work, and go to school.

HEAT EVENT HOURS:

More than 37 hrs

30 hrs

Less than 25 hrs

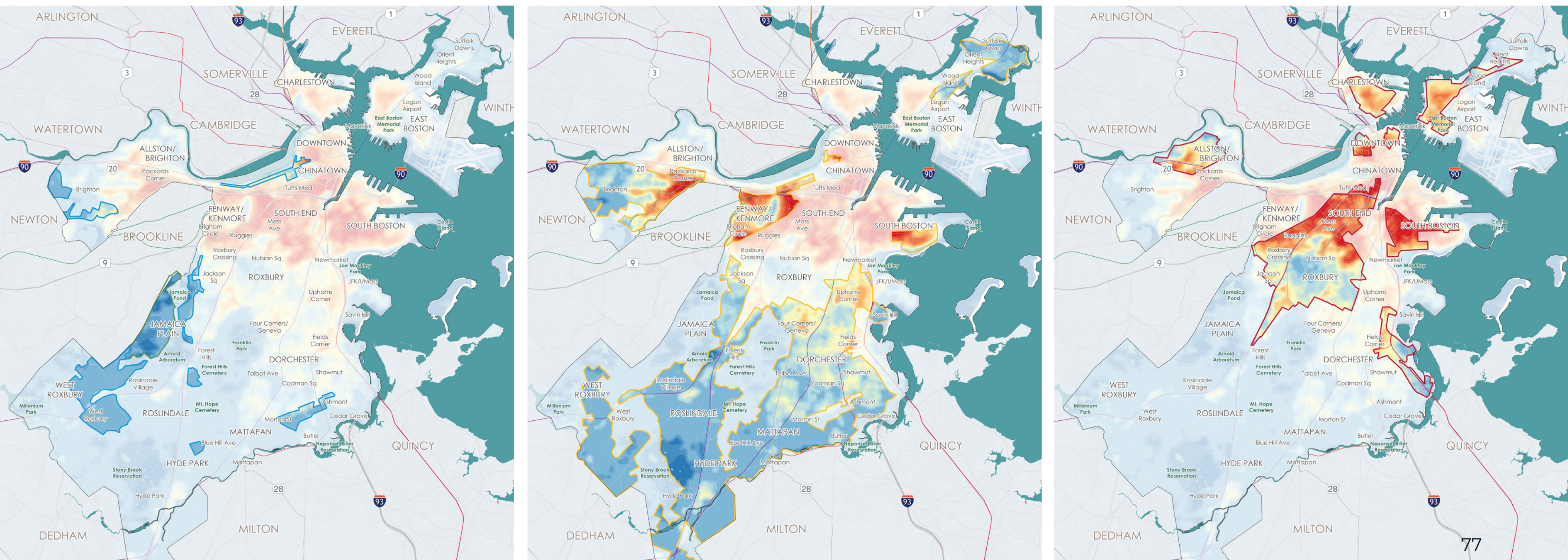
0 2 MI

Redlining boundaries are overlaid on the heat event hours dataset to visually explore how heat intensity and length during a heat wave varies between redlined and non-redlined neighobrhoods.

A: Best and B: Still Desirable

C: Declining

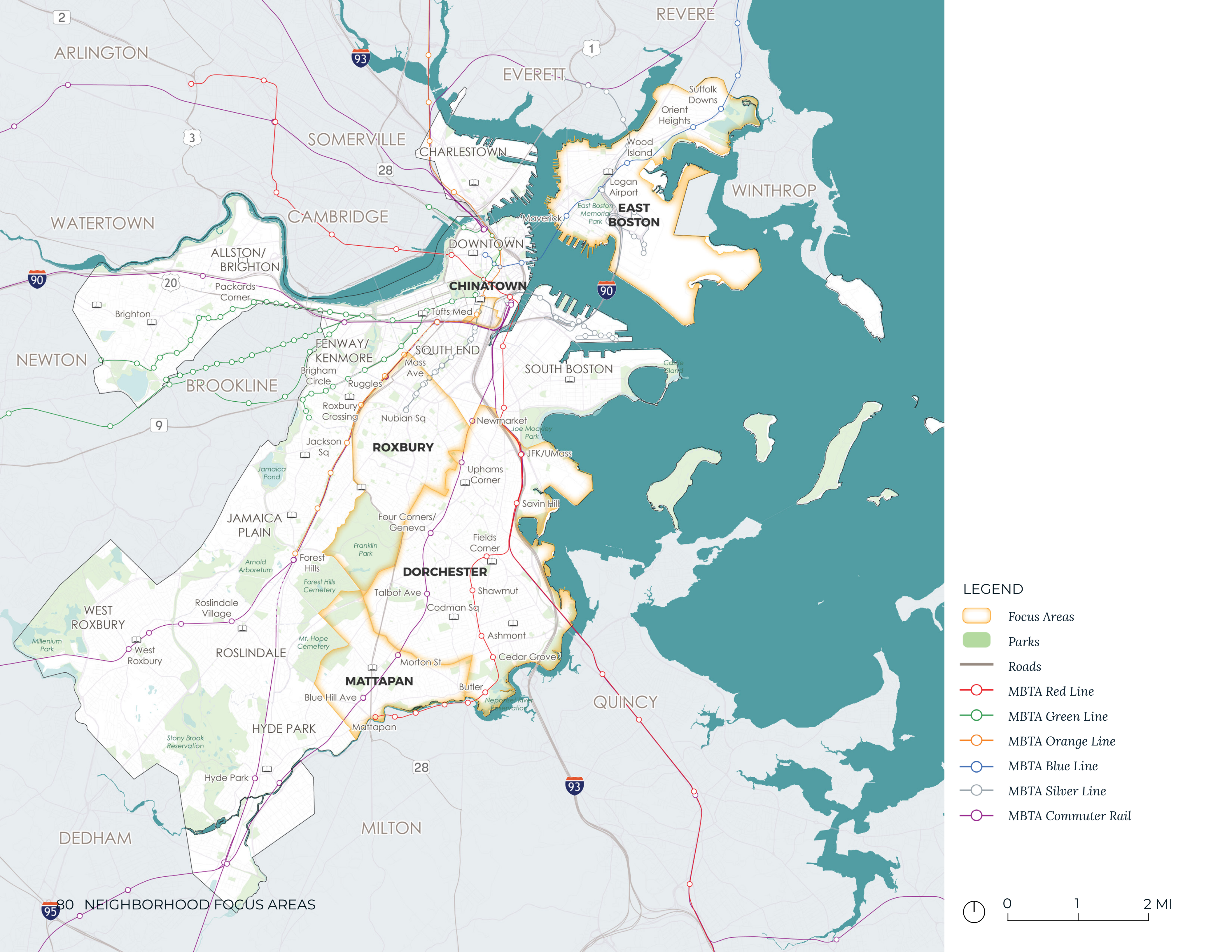
D: Hazardous



Data Source: Robert K. Nelson, LaDale Winling, Richard Marciano, Nathan Connolly, et al., "Mapping Inequality," American Panorama, ed. Robert K. Nelson and Edward L. Ayers


EVERETT
SOMERVILLE
3
28
CHARLESTOWN
WATERTOWN
CAMBRIDGE
Maverick
East Boston Memorial Park
DOWNTOWN
ALLSTON/ BRIGHTON
90
20
Packards Corner
CHINATOWN
90
Brighton
Tufts Med
FENWAY/ KENMORE
SOUTH END
NEWTON
Mass Ave
SOUTH BOSTON
Brigham Circle
Ruggles
BROOKLINE
Roxbury Crossing
Nubian Sq
Newmarket
Joe Moakley Park
9
Jackson Sq
ROXBURY
JFK/UMass
Jamaica Pond
Uphams Corner
Savin Hill
JAMAICA PLAIN
Four Corners/ Geneva

05 FOCUS NEIGHBORHOODS



 NEIGHBORHOOD FOCUS AREAS

INTRODUCTION

The planning process and strategy development for the Heat Plan included additional detailed study of solutions within five of the hottest environmental justice neighborhoods in Boston: Chinatown, Dorchester, East Boston, Mattapan, and Roxbury.

The intention of the *Heat Plan* is to define an equity-centered framework to reduce the risks and effects of extreme heat. While the whole city is hot, some communities and individuals can experience greater extreme heat exposure and risk, including communities of color, immigrant communities, communities where English is spoken as a second language, older adults, individuals with chronic health conditions, and youth.

The *Heat Plan* contains a wide range of strategies that are applicable to every neighborhood of the City of Boston. Additionally, the *Heat Plan* looks to ensure the needs of overburdened neighborhoods and vulnerable residents are met and prioritized through these strategies. The five neighborhoods on which the *Heat Plan* focused in greater detail include Chinatown, Dorchester, East Boston, Mattapan, and Roxbury. Heat and social vulnerability data from the 2016 *Climate Ready Boston* Vulnerability Assessment were used to identify critical hot spots across Boston that also coincide with environmental justice communities with minority, low- to no-income, and English-isolation characteristics.

TA series of five listening sessions took place virtually to understand lived heat experiences in each focus area and identify strategies that residents expressed as critical needs in their communities. To reduce barriers to participation, these sessions used a combination of virtual chat, interpretation, breakout groups, surveys, and sketching. Translation was available for each meeting, based on common languages in each neighborhood.

The following neighborhood sections dive into each neighborhood's heat story, lived experiences, vulnerabilities, and opportunities.

EACH NEIGHBORHOOD HAS A UNIQUE HEAT STORY

CHINATOWN

Extreme heat day and night

Due to denser buildings (many brick and with dark roofs) and limited trees and green space, Chinatown heats up significantly during the day. At night, that heat is released into a dense neighborhood with limited air flow, keeping temperatures hotter throughout the night. The area around the Chinatown Gate experiences especially elevated temperatures.

DORCHESTER

Pockets of heat

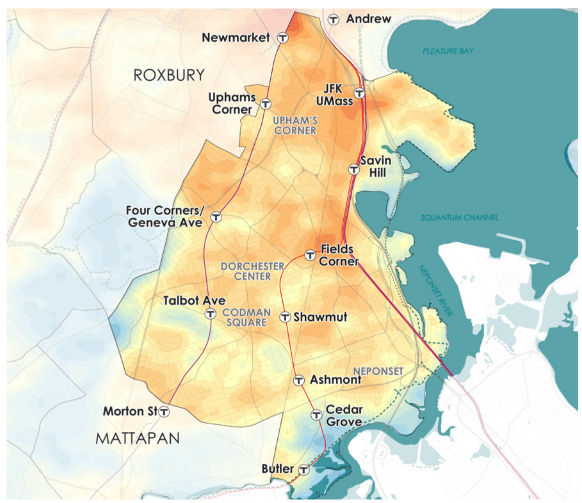
As a large neighborhood, Dorchester has some areas that are hotter (Fields Corner, JFK/UMass MBTA station, and Newmarket and South Bay areas) and some areas that are cooler (around parks or adjacent to the waterfront). Contributing factors to hotter areas are unshaded pavement, parking lots, and dark roofs.

EAST BOSTON

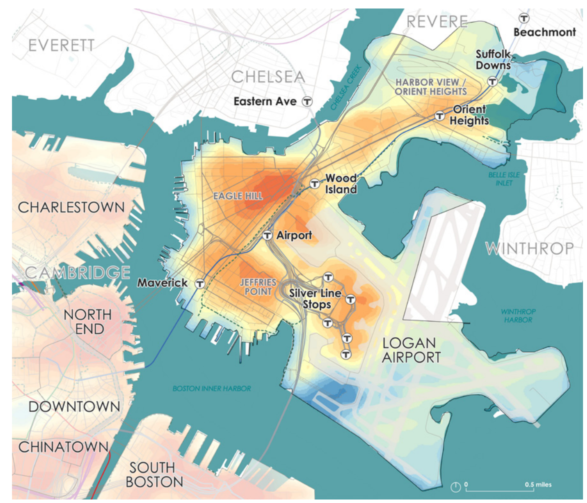
Cool waterfronts and hot inland neighborhoods

Although waterfront areas benefit from the cooling influence from Boston Harbor as well as waterfront green spaces like Piers Park and Belle Isle Marsh, the inland neighborhood areas experience much hotter temperatures, due to building density and less green space and tree canopy. Significant neighborhood temperature hot spots include the area around the Logan Rental Car Center and the Day Square and northwest Eagle Hill areas.

Chinatown Daytime Air Temperatures



Dorchester Daytime Air Temperatures



East Boston Daytime Air Temperatures

ROXBURY

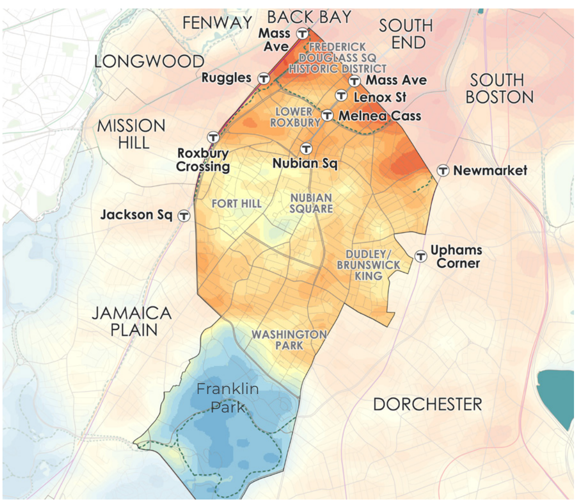
Cooler Franklin Park area but hotter elsewhere

Franklin Park provides a cooling effect on nearby blocks, but other areas in the neighborhood experience hotter air temperatures. The Frederick Douglass Historic District, Boston Medical Center, and areas near Newmarket are all especially hot due to a combination of brick buildings, dark roofs, limited green space, unshaded pavement, and dense massing.

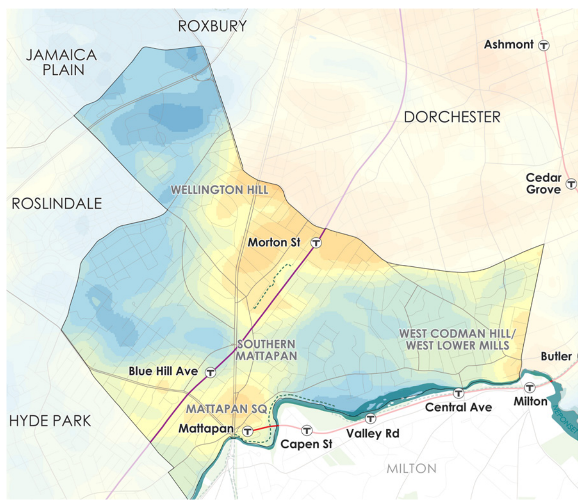
MATTAPAN

Proximity to green spaces supports nighttime cooling

Mattapan benefits from cooling effects from nearby green spaces, the Neponset River, and tree canopy in some areas of the neighborhood. However, areas around Milton Station, Mattapan Station, and Lower Mills are all hotter, due to patterns of dark roofs and large unshaded parking and pavement. Many wide streets with limited trees further contribute to elevated air temperatures.

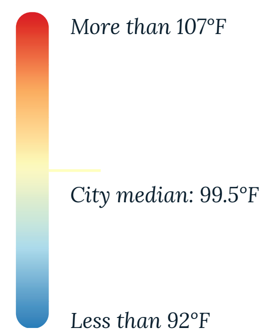


Roxbury Daytime Air Temperatures



Mattapan Daytime Air Temperatures

DAYTIME (3PM) AIR TEMPERATURE



CHINATOWN


CHINATOWN GATE
KNEELAND STREET
CHINATOWN NEIGHBORHOOD CENTER
INTERSTATE


TYLER STREET
TUFTS MEDICAL CENTER


AUNTIE KAY & UNCLE FRANK CHIN PARK

NEIGHBORHOOD CONTEXT

Chinatown experiences some of the hottest daytime and nighttime temperatures in Boston, and its heat story is shaped by its physical characteristics and neighborhood history.

Chinatown is a thriving neighborhood in the heart of Boston that has been home to many immigrant communities throughout its history. Today, Chinatown residents represent many nationalities: Chinese, Taiwanese, Vietnamese, Filipino, Thai, Japanese, and more.[1] Chinatown is a hub for many Asian and other immigrant communities in the Boston region. The neighborhood provides a sense of home that centers culture and identity from China as well as other Asian countries, providing access to culturally relevant goods and supportive services.[2]

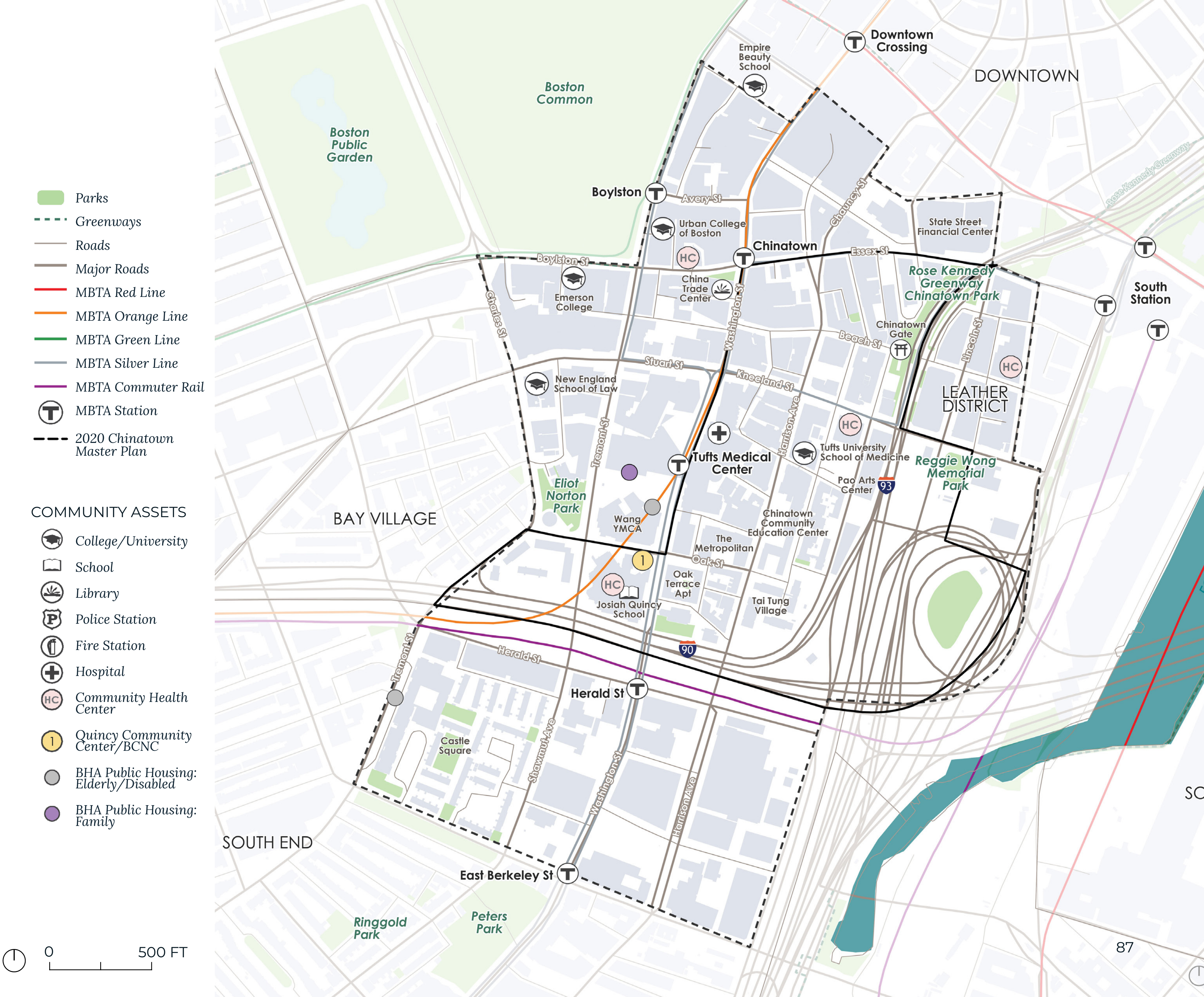
Chinatown has a history of resident advocacy and community-led planning. Residents and community organizations have come together when urban renewal, interstate expansion, and other projects have affected the neighborhood. Every 10 years since 1990, the community has spearheaded its own neighborhood plan. Over the past several decades, Chinatown organizations and residents have spearheaded and advocated for the development, renovation, and preservation of affordable housing.

The neighborhood's history has shaped its urban fabric and heat experiences over time. Prejudice, discrimination, and racism against Chinese and other Asian immigrants, including the Chinese Exclusion Act of 1882, the Immigration Act of 1924, and other national efforts, affected Asian immigrants to the United States. This history informed both the creation of enclaves like Boston's Chinatown to support new and longtime residents, and the lack of inclusion in public planning decisions that affected the neighborhood. The neighborhood was a hub of industry and transportation, including the elevated (El) railway and the widening of Harrison Avenue. These uses increased air pollution in the neighborhood.[3] From the 1930s to 1960s, many parts of the neighborhood were classified as "D: Hazardous" on HOLC maps.[4] The construction of Interstates 93 and 90 through Chinatown displaced residents and businesses.[5]

The cumulative effects of these events over time have resulted in a neighborhood that has fewer trees and parks, wider roads, more vehicular traffic, and increased air pollution. Residents have raised air pollution as a significant concern.[6] Chinatown is in the top 95th to 100th percentile for diesel particulate matter, 70th to 80th percentile for air toxics cancer risk, 80th to 90th percentile for respiratory hazard index, and 99th percentile for traffic proximity and volume, compared to all block groups in the United States.[7] As a result of the neighborhood's environment, it experiences hotter temperatures and residents have a greater risk of developing respiratory conditions that increase residents' sensitivity to extreme temperatures.

RECENT AND ONGOING PLANNING EFFORTS

- PLAN: Downtown (Mayor's Office of Planning/BPDA)
- Chinatown Master Plan 2020 (Chinatown and MAPC)
- Parcel R-1 Chinatown Disposition Planning (Mayor's Office of Planning/BPDA)

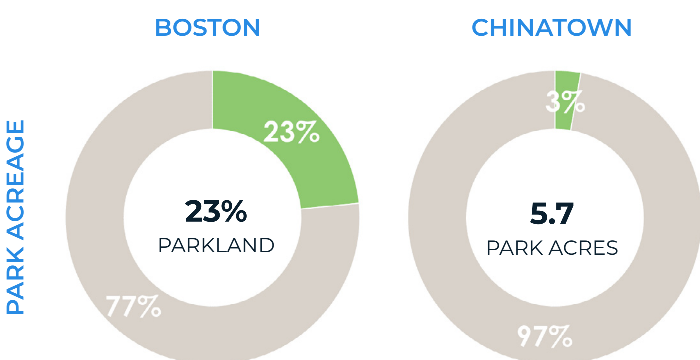

Parks
Greenways
Roads
Major Roads
MBTA Red Line
MBTA Orange Line
MBTA Green Line
MBTA Silver Line
MBTA Commuter Rail
MBTA Station
2020 Chinatown Master Plan
COMMUNITY ASSETS
College/University
School
Library
Police Station
Fire Station
Hospital
Community Health Center
Quincy Community Center/BCNC
BHA Public Housing: Elderly/Disabled
BHA Public Housing: Family
0
500 FT
Downtown Crossing
DOWNTOWN
Empire Beauty School
Boston Common
Boston Public Garden
Boylston
Avery St
Urban College of Boston
Chinatown
Chauncy St
Essex St
State Street Financial Center
Rose Kennedy Greenway
Rose Kennedy Greenway Chinatown Park
South Station
Boylston St
Emerson College
China Trade Center
Washington St
Charles St
Chinatown Gate
Beach St
Lincoln St
Stuart St
Kneeland St
New England School of Law
LEATHER DISTRICT
Harrison Ave
Tremont St
Tufts Medical Center
Tufts University School of Medicine
Reggie Wong Memorial Park
Pao Arts Center
93
Eliot Norton Park
BAY VILLAGE
Wang YMCA
Chinatown Community Education Center
The Metropolitan
Oak St
Oak Terrace Apt
Josiah Quincy School
Tai Tung Village
90
Herald St
Herald St
Castle Square
Shawmut Ave
Washington St
Harrison Ave
SOUTH END
East Berkeley St
Ringgold Park
Peters Park

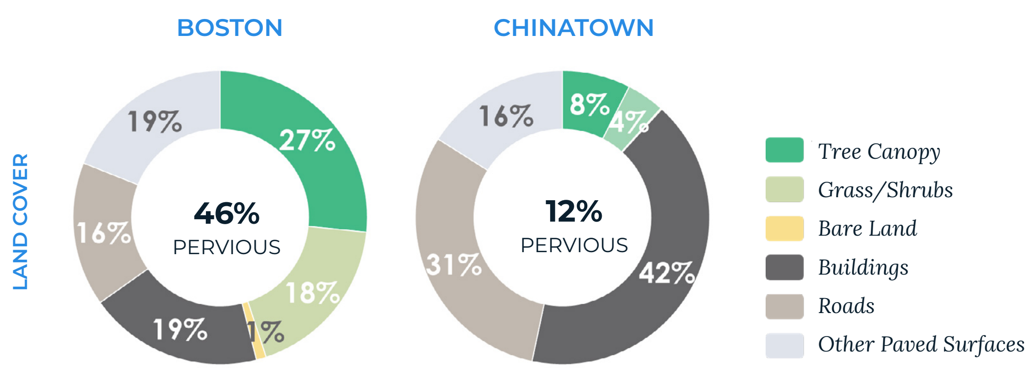
HEAT ANALYSIS

Hot Days, Hot Nights: Chinatown is the hottest of the five neighborhood focus areas during the day and night. The citywide heat analysis showed Chinatown's daytime and nighttime median temperature at 105.5°F and 87.9°F, respectively. Chinatown's daytime and nighttime temperatures were measured at 6°F hotter than the city's median (daytime is 99.5°F and nighttime is 81.9°F). For comparison, Franklin Park, one of the coolest places in Boston in the heat analysis, measured daytime temperatures around 90°F with nighttime lows in the low 80s. The hottest part of the neighborhood is around Chinatown Gate, where daytime temperatures measured 106°F, and nighttime temperatures measured 91°F. Many parts of the neighborhood were measured above 90°F at night. With such extreme overnight temperatures, mitigation of heat exposure in homes is particularly important in Chinatown. High nighttime temperatures are especially harmful to health because they do not allow residents to cool down from daytime heat.[8]

Chinatown's hotter microclimate is a result of multiple factors, including less green space, wide streets with limited street trees, building characteristics, and density. In comparison to many other parts of the city, there are fewer trees and less green space in Chinatown. Trees and parks have cooling effects on their surroundings due to shading and evaporative cooling, which reduce air and surface temperatures. Chinatown has the highest percentage of impervious surfaces at 88%, compared to 54% citywide. Of the land cover, 8% is tree canopy, and 3% of the neighborhood is dedicated to parks (compared to 27% tree canopy and 23% park space citywide). Major arteries like Kneeland Street, Harrison Avenue, and Surface Road have fewer street trees, so the pavement gets hotter during the day. The neighborhood's brick buildings and many dark roofs further absorb heat, contributing to hot indoor and outdoor settings.

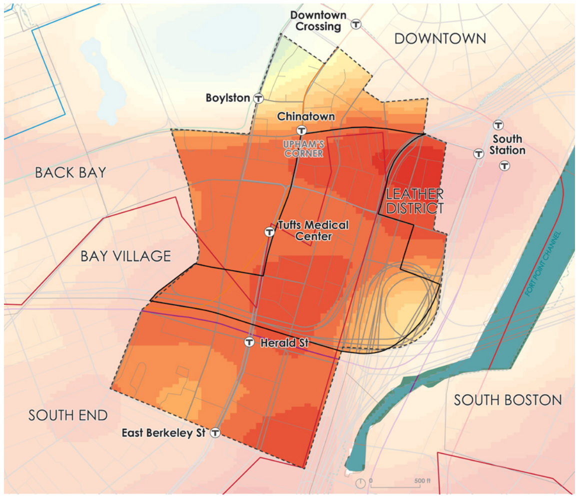
Dense development also factors into extreme heat conditions. Air that heats up in the daytime sun can remain restricted in the neighborhood overnight, which prevents cool night air from displacing hot daytime air. However, space between buildings can allow surface-level winds to blow out hot air.





Data Source: Tree Canopy Assessment 2019, BPRD

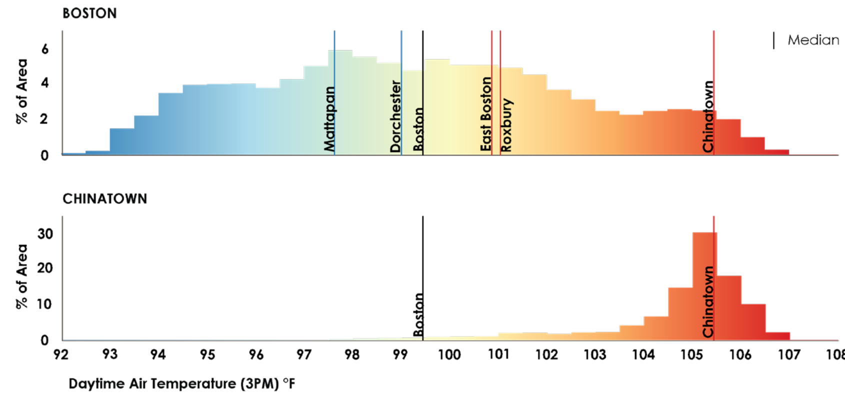
DAYTIME AIR TEMPERATURES



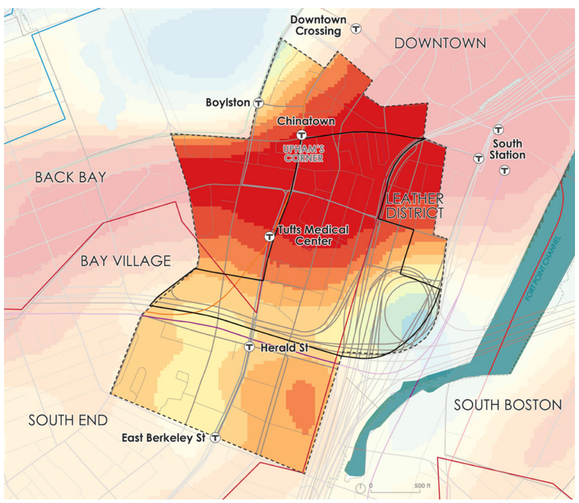
Daytime Air Temperature (3 p.m.): *Air temperatures reflect an average day during a heat wave week in July 2019*

3PM:
AIR TEMPERATURE

More than 107°F
Median: 105.5°F
City median: 99.5°F
Less than 92°F



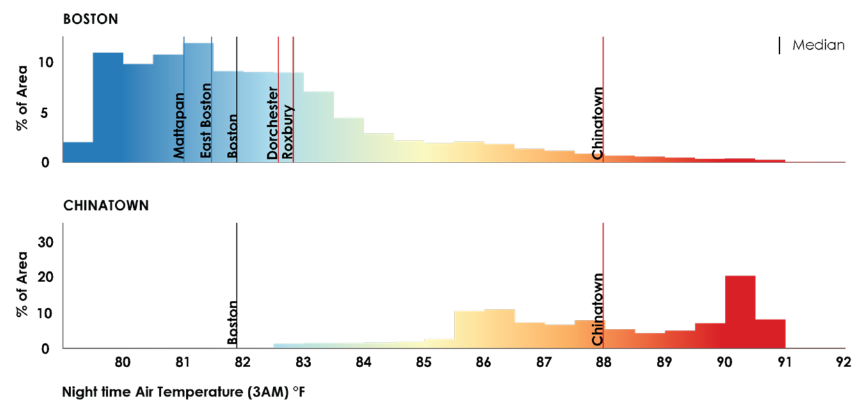
NIGHTTIME AIR TEMPERATURES



Nighttime Air Temperature (3 a.m.): *Air temperatures reflect an average night during a heat wave week in July 2019*

3AM:
AIR TEMPERATURE

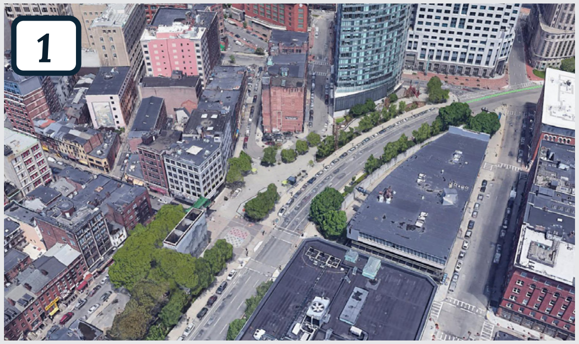
More than 90°F
Median: 87.9°F
City median: 81.9°F
Less than 92°F



0 1,000 FT

SAMPLE OF HEAT FINDINGS

These three areas illustrate examples of how Chinatown's land use affects daytime and nighttime temperatures, based on the citywide heat analysis.



1. LARGE FOOTPRINT BUILDINGS WITH DARK ROOFS

The dense area around Beech Street and the Chinatown Gate includes many buildings that are brick or have dark roofs, which absorb heat in the day. At night, the dense building form leaves less space for nighttime winds, so the stored heat cannot easily dissipate. Nearby interstates, like I-93, also absorb heat during the day. With limited green spaces and tree canopy, this area benefits less from shade and evapotranspiration that would help mitigate rising air temperatures.

2. LARGE RESIDENTIAL CAMPUSES

The heat analysis showed that residential campuses like the Castle Court Apartments can reach 104°F during the day, only a few degrees less than the northern areas of Chinatown. Although typologies like these may have significant amounts of pavement, there may also be a higher percentage of tree canopy that can help provide shade and cool the air. For some campuses with lower building density, heat absorbed during the day can escape more easily at night.

3. LARGE SURFACE ROADS

During the day, the portions of large surface roads like I-93 and I-90 and related on-ramps that lie on the southeastern edge of Chinatown can reach air temperatures of over 100°F. However, because of the open space and lack of building density, this area cools down more at night. The green space in the middle of the interstate loop contributes to cooling and is the coolest place in the neighborhood at night, measuring 83°F in the heat analysis.

AREAS EXPERIENCING LONGER HIGH-HEAT EVENTS

- College/University
- School
- Library
- Pools
- Hospital
- HC Community Health Center
- 1 Quincy Community Center/BCNC
- BHA Public Housing: Elderly/Disabled
- BHA Public Housing: Family

Heat Event Duration is the sum of all the hours during the analysis week (a heat wave week in July 2019) that the local modeled heat index is above 95°F, for days that the nighttime temperature does not drop below 75°F.

HEAT EVENT HOURS

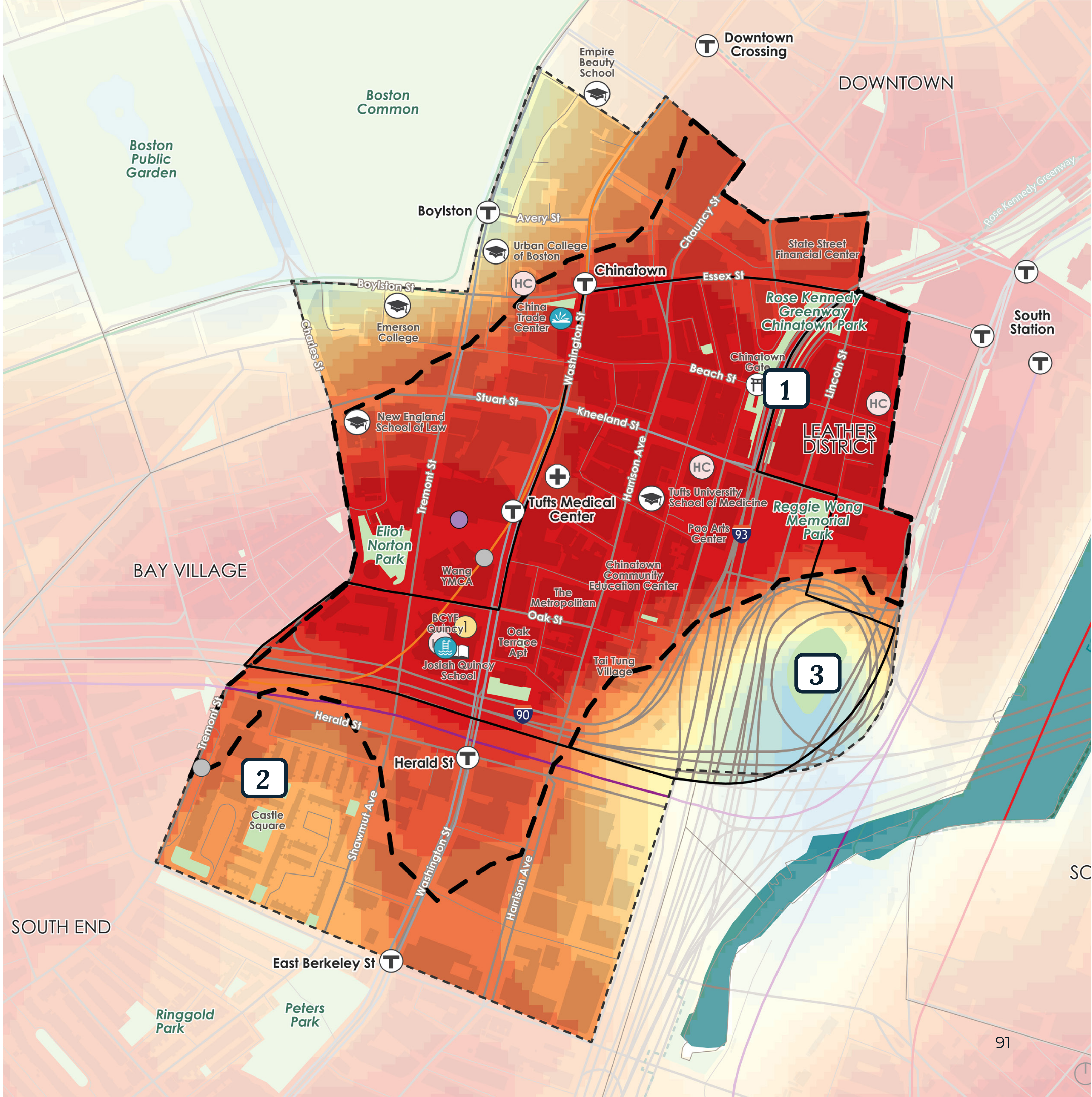
More than 37hrs

30 hrs

Less than 25 hrs

Longest Heat Event (More than 35 hrs)

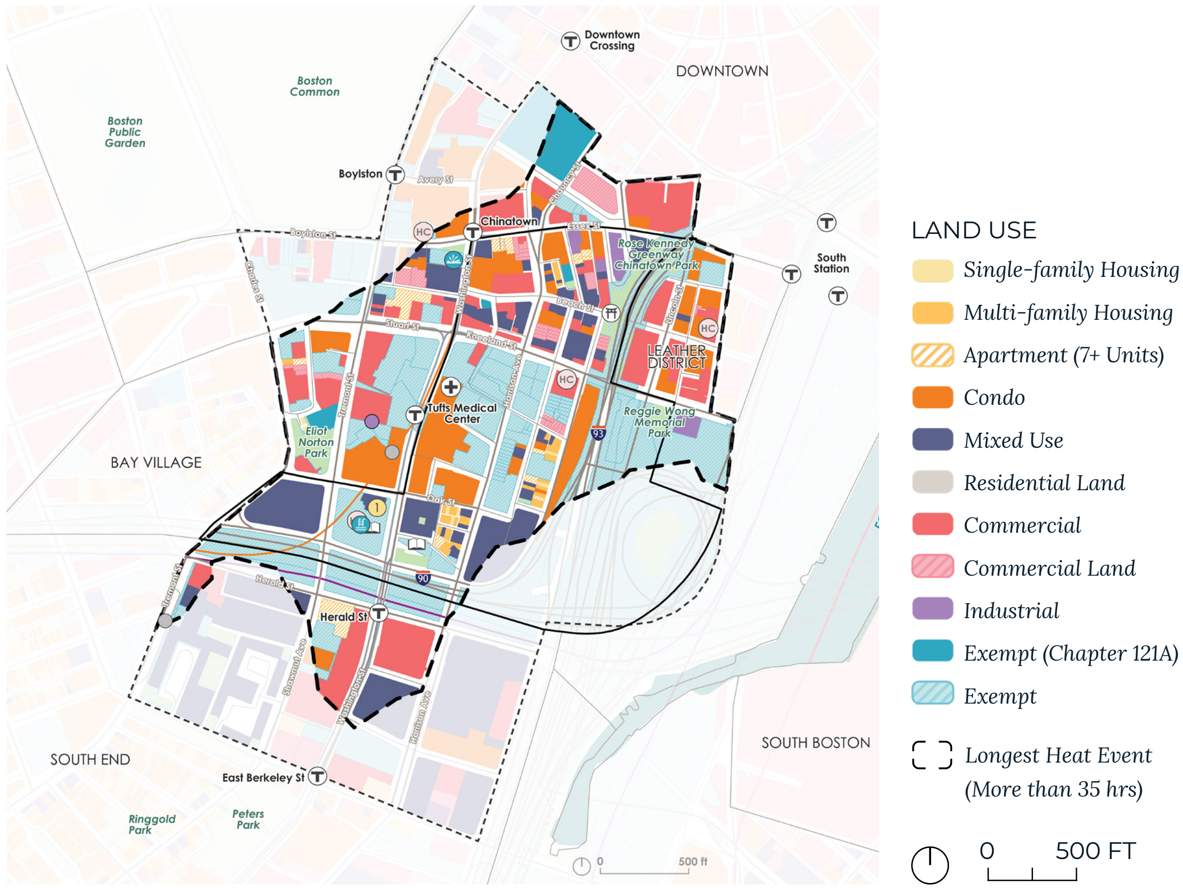
0 500 FT



LAND USE AND PEOPLE

The area of Chinatown that experiences the most intense and longest heat event duration includes areas north of Kneeland Street where there are condos and mixed-use type housing. However, temperature differences across Chinatown are relatively small compared to other neighborhoods. Even the cooler parts of the neighborhood during the day and night are still hotter than many other parts of Boston. The areas near Essex and Beach Streets to Tremont Street and around Tai Tung Village and Josiah Quincy School have higher population density. These areas also have temperatures that are at or above the neighborhood median temperature in the day (105.5°F). Contributing factors include building density, building materials, and lack of vegetation.

As described in Chapter 3, hot weather can create disproportionate health risks for some people, especially those who are younger or older, who have preexisting health conditions, or who are exposed to heat for longer periods of time. In Chinatown, young children (under 5 years) make up 2.5% of neighborhood residents (compared to 5% citywide), and older adults (over 65 years) make up 15% of neighborhood residents (compared to 12% citywide).[9] Of Chinatown residents, 21% are low-income (compared to 16% citywide), and 84% of housing units are renter-occupied (compared to 64% citywide).[10] Low-income residents and renters may face barriers to home retrofits or affording cooling options.



Data Source: Analyze Boston

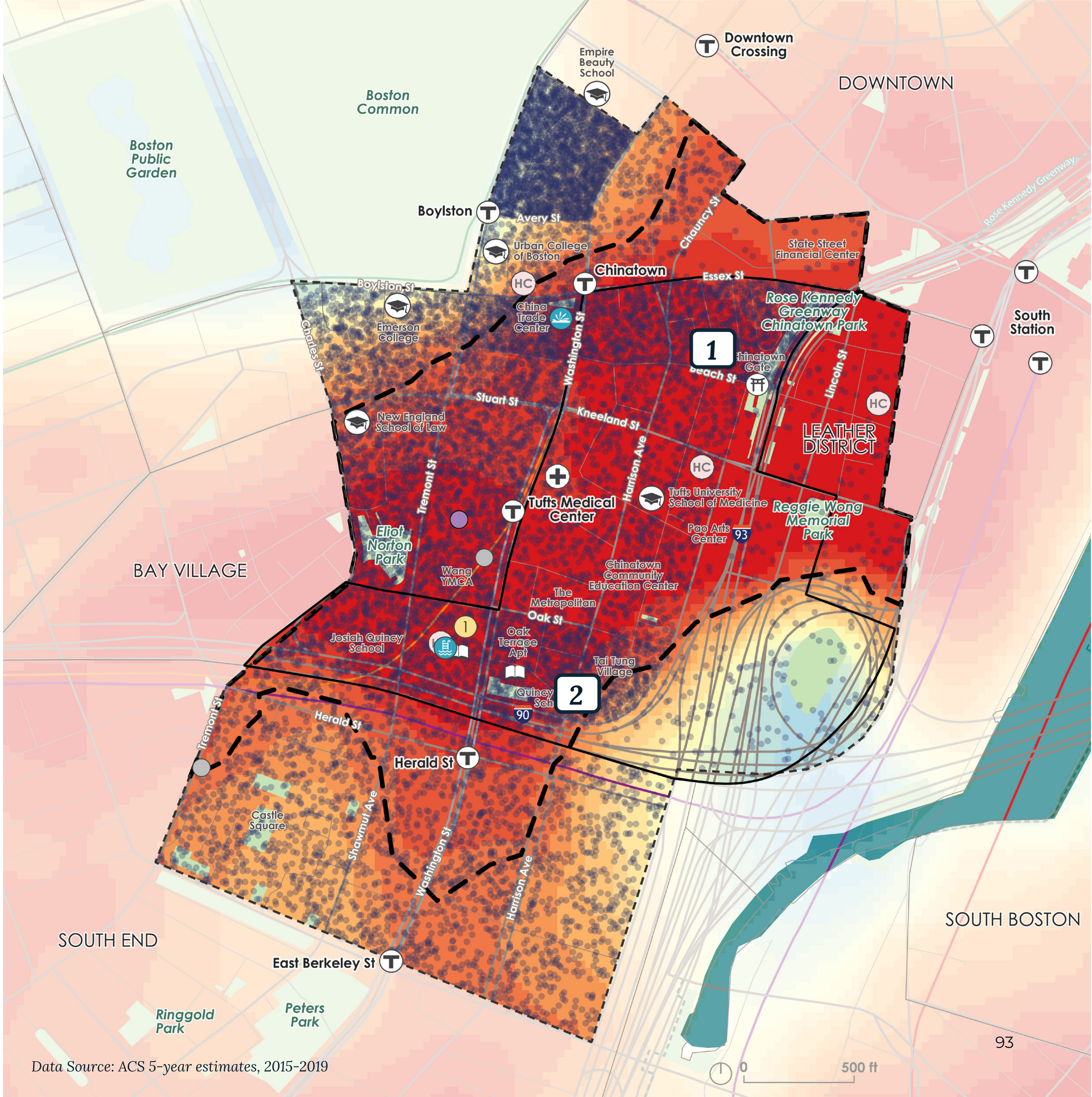
POPULATION DENSITY AND HIGH-HEAT EVENT DURATION

College/University
School
Library
Pools
Hospital
Community Health Center
Quincy Community Center/BCNC
BHA Public Housing: Elderly/Disabled
BHA Public Housing: Family

1 DOT = 1 PERSON

HEAT EVENT HOURS
More than 37hrs
30 hrs
Less than 25 hrs
Longest Heat Event (More than 35 hrs)

0 500 FT



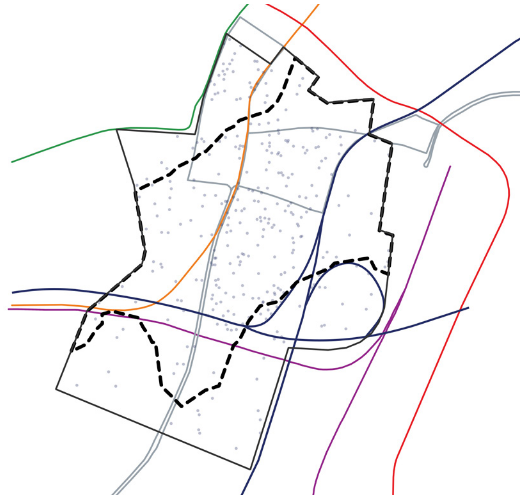
Data Source: ACS 5-year estimates, 2015-2019

RESIDENT DEMOGRAPHICS AND HEAT DURATION

These maps compare the density of Chinatown residents to areas with the longest duration event in the heat analysis. Chinatown's residents are predominantly Asian and white (composing 43% and 42% of the neighborhood, respectively).[11] However, Asian residents comprise the majority of those who live in areas that experience longer and more intense heat. These same areas have a higher density of low-income and renter-occupied housing.

YOUNG CHILDREN (<5 YRS)

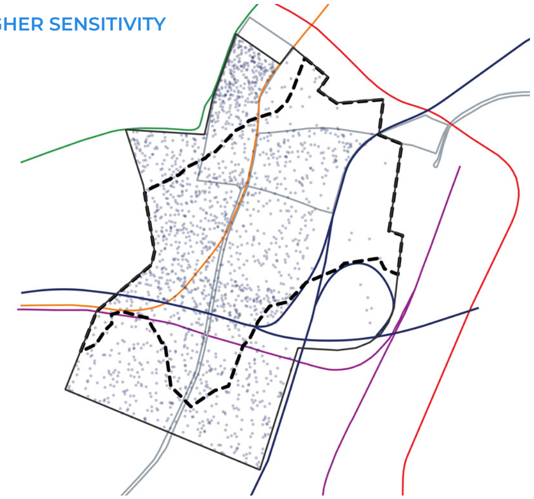
HIGHER SENSITIVITY



OLDER ADULTS (>65 YRS)

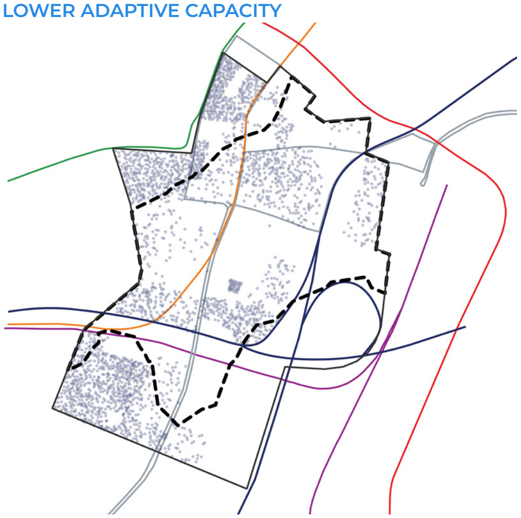
LOWER ADAPTIVE CAPACITY

HIGHER SENSITIVITY



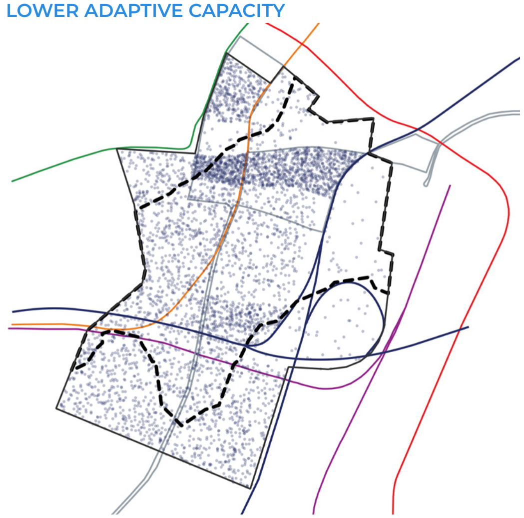
LOW-INCOME RESIDENTS

LOWER ADAPTIVE CAPACITY

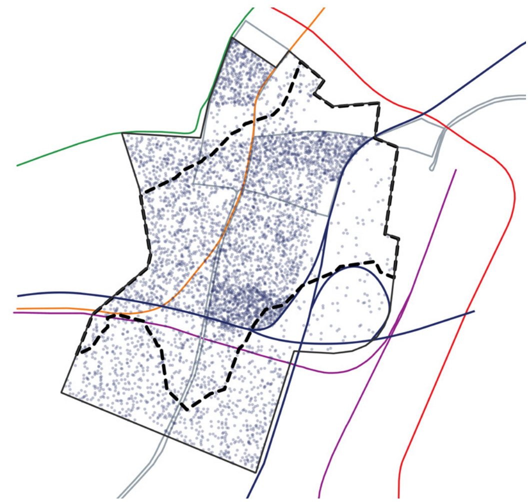


RENTER-OCCUPIED HOUSING

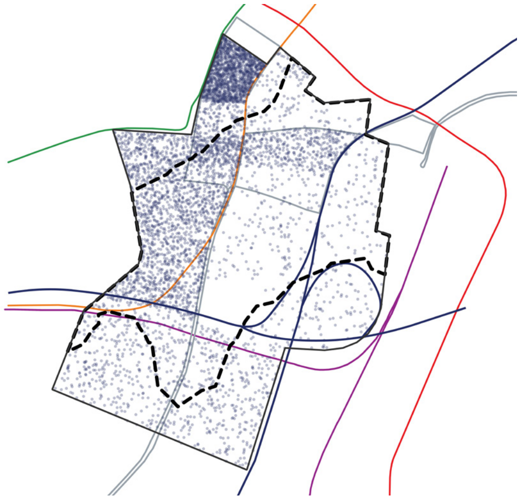
LOWER ADAPTIVE CAPACITY



ASIAN



WHITE



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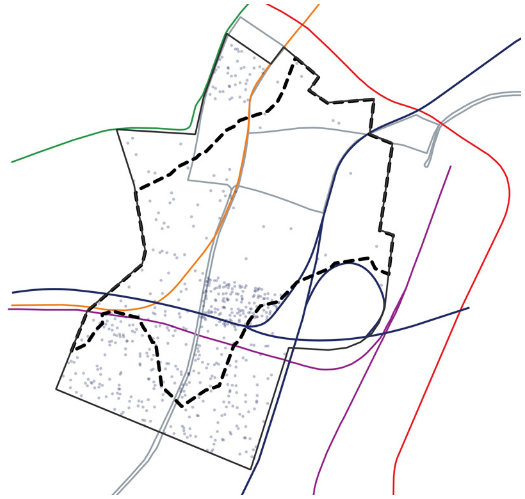
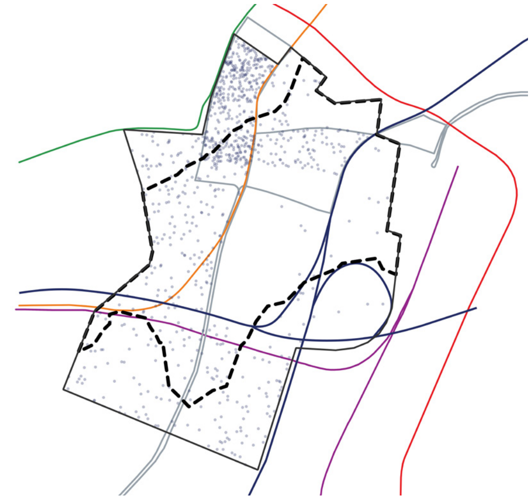
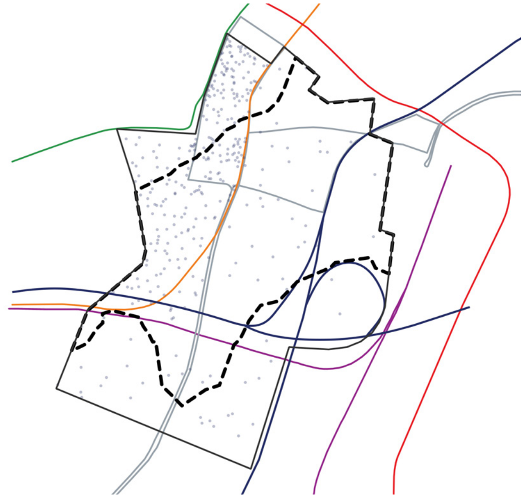


LATINX



AMERICAN INDIAN/
ALASKA NATIVE

2 OR MORE RACES

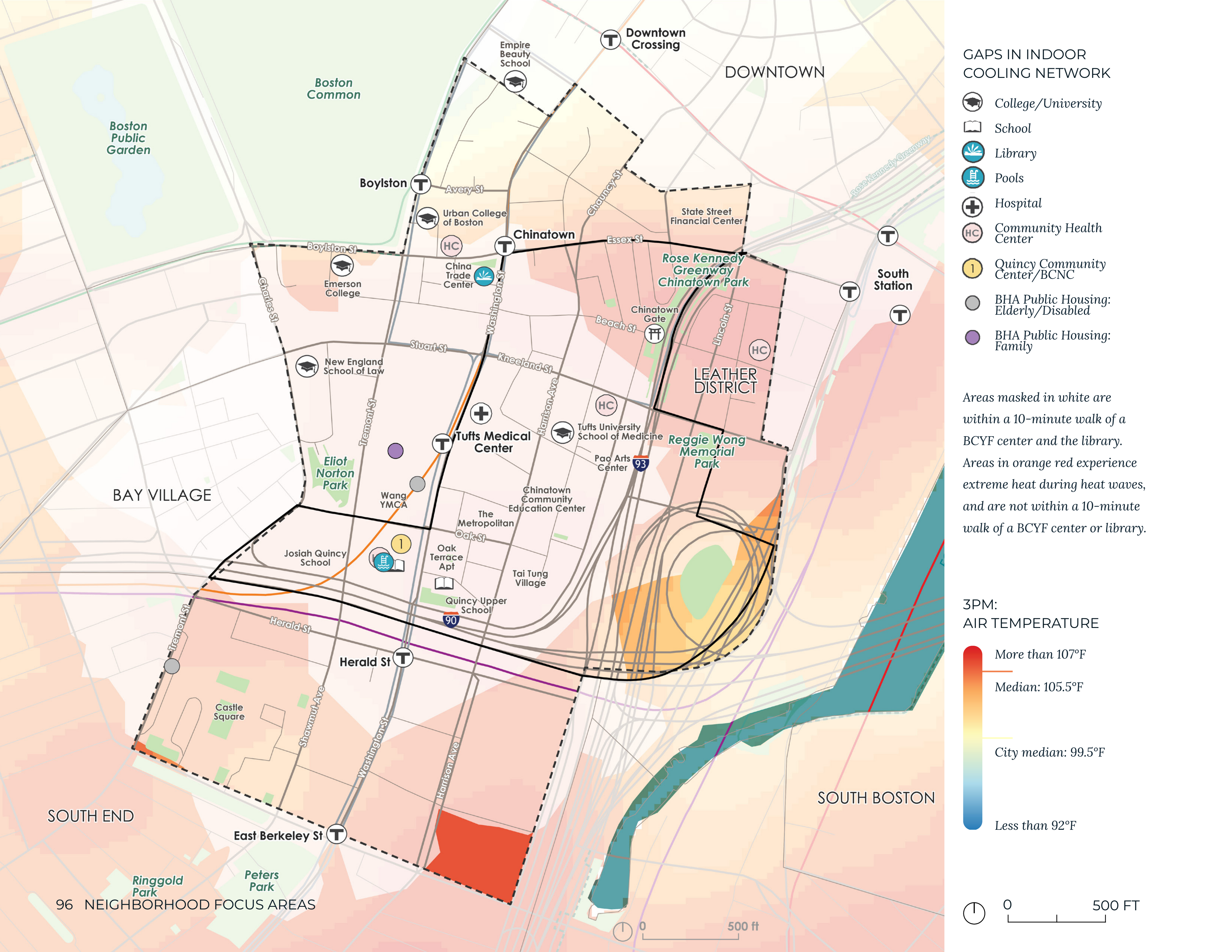


ANOTHER RACE

Data Source: ACS 5-year estimates, 2015-2019

Longest Heat Event (More than 35 hrs)

1 DOT = 1 PERSON


GAPS IN INDOOR COOLING NETWORK
College/University
School
Library
Pools
Hospital
Community Health Center
Quincy Community Center/BCNC
BHA Public Housing: Elderly/Disabled
BHA Public Housing: Family
Areas masked in white are within a 10-minute walk of a BCYF center and the library. Areas in orange red experience extreme heat during heat waves, and are not within a 10-minute walk of a BCYF center or library.
3PM: AIR TEMPERATURE
More than 107°F
Median: 105.5°F
City median: 99.5°F
Less than 92°F
0
500 FT
Downtown Crossing
DOWNTOWN
Empire Beauty School
Boston Common
Boston Public Garden
Boylston
Avery St
Urban College of Boston
Chinatown
Chauncy St
State Street Financial Center
Essex St
Boylston St
Emerson College
China Trade Center
Rose Kennedy Greenway Chinatown Park
Rose Kennedy Greenway
South Station
Charles St
Washington St
Chinatown Gate
Beach St
Lincoln St
Stuart St
Kneeland St
New England School of Law
LEATHER DISTRICT
Harrison Ave
Tufts Medical Center
Tufts University School of Medicine
Reggie Wong Memorial Park
Tremont St
Pao Arts Center
93
Eliot Norton Park
Wang YMCA
Chinatown Community Education Center
BAY VILLAGE
The Metropolitan
Oak St
Josiah Quincy School
Oak Terrace Apt
Tai Tung Village
Quincy Upper School
90
Herald St
Castle Square
Shawmut Ave
SOUTH BOSTON
SOUTH END
East Berkeley St
Ringgold Park
Peters Park
0
500 ft

COMMUNITY HEAT EXPERIENCES AND COOLING IDEAS

HEAT EXPERIENCES

Chinatown residents discussed their heat experiences and cooling ideas during the Neighborhood Ideas Workshop and through responses to the citywide survey. Areas of concern mentioned by participants included the effect of increasing density on air temperatures, air pollution from vehicles and trucks, dark surfaces, heat from electronic billboards, and hot homes. Participants were particularly concerned by the severity and duration of heat in their neighborhood. They appreciated that this process highlighted the challenges they faced and encouraged near-term action to improve conditions.

COOLING IDEAS

Chinatown residents suggested strategies that create a cooler environment, add more green space, and improve indoor cooling options. Participants shared the following ideas to increase access to cooling in Chinatown:

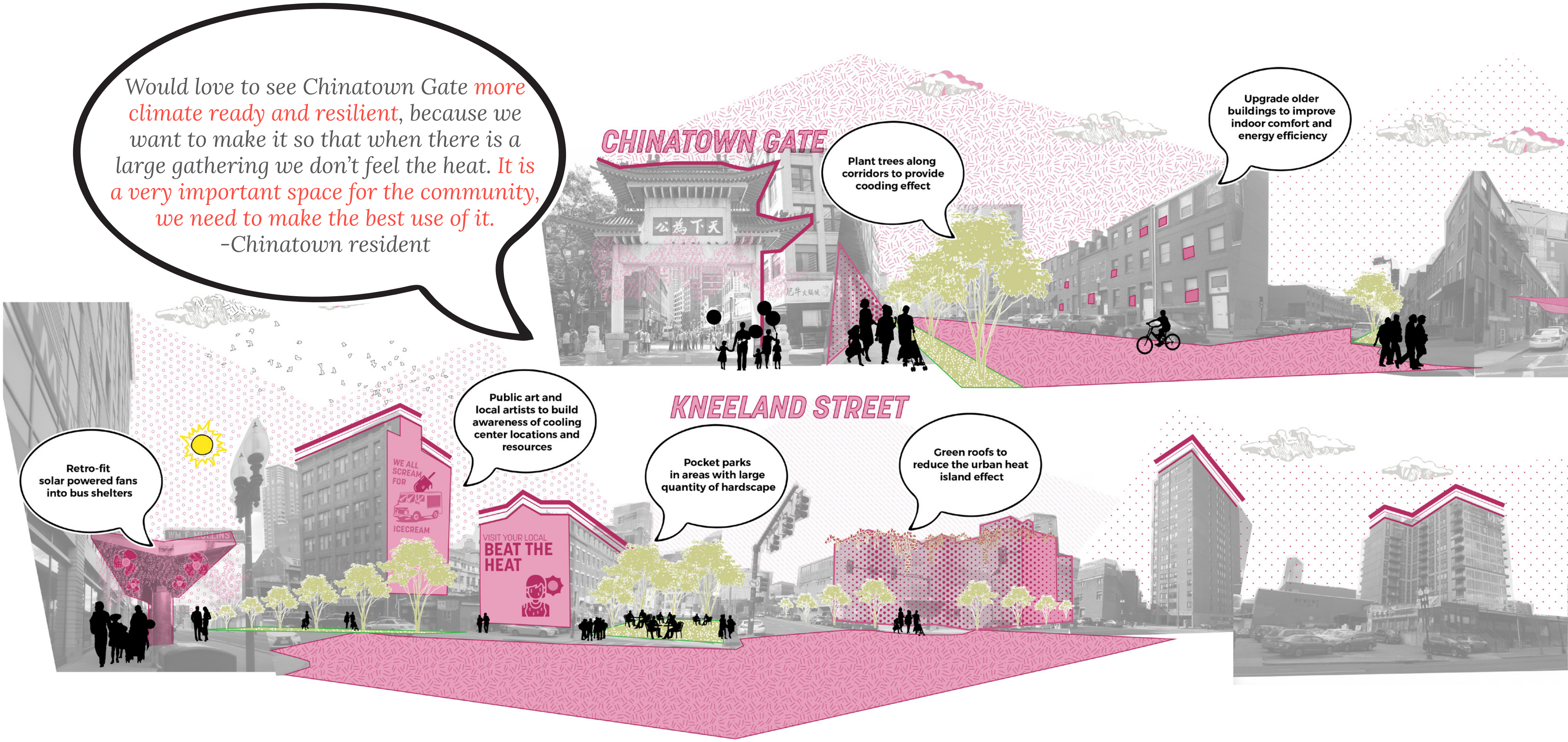
- Zoning and development review:
  Opportunities to improve zoning and development review to reduce adverse impacts of new development on the neighborhood's microclimate, which could include opportunities to improve airflow through the neighborhood to mitigate temperatures
- Cool surfaces:
  Opportunities for cooler, light-colored materials, including pavement, as well as vertical greening on walls
- Increased shade:
  Opportunities for more shade through both tree planting and other shade structures, which could provide cooling more immediately than the time it would take new trees to grow large enough to provide significant shade
- New cool outdoor gathering spaces:
  Opportunities to add more green space through pavement conversion, including shade, water features, and trees, and opportunities for active cooling with water such as spray pads, running water bodies, and misting, which could be complemented with more options for public indoor cooling spaces
- Cool Homes:
  Opportunities to retrofit existing buildings for improved energy efficiency and interior cooling, including incorporating passive cooling strategies

125 Lincoln proposed development will further increase height + density + number of cars in Chinatown, exacerbating the existing issues

Electronic billboards should be banned from Chinatown because they also emit a lot of heat and energy

Hottest place in Chinatown: the corner of Beach Street and Harrison Ave

OPPORTUNITIES FOR A COOLER CHINATOWN




Turn dark roofs into cool roofs
HUDSON STREET
Provide canopy and mist systems on narrow streets
Promote locally owned businesses as cooling locations through heat escape vouchers
TYLER STREET
TUFTS MEDICAL CENTER
Pop-up cooling relief activities for youth
INTERSTATE 90
More opportunities for water play and public art
AUNTIE KAY & UNCLE FRANK CHIN PARK
STAY COOL
Paint roadways with reflective paints to reduce the urban heat island effect

HEAT RESILIENCE OPPORTUNITIES

This section describes key needs for heat reduction or increasing access to cooling resources and opportunities to integrate resilience, based on neighborhood-level heat analysis and community feedback.

While all the strategies may be relevant to each neighborhood, each section lists specific heat resilience strategies that respond to the particular needs that have been identified. More details on the strategies listed below can be found in Chapter 6: Citywide Heat Resilience Strategies.

SHADED, VEGETATED, COOL WALKS TO LOCAL DESTINATIONS AND MAIN STREETS

Participants shared that the lack of vegetation, shade, and other cooling strategies along the streets of Chinatown can make walking to nearby local destinations uncomfortable. A higher percentage of Chinatown residents walk to work in Chinatown (49%) compared to Boston as a whole (15%),[12] suggesting that cooler streets are a particularly high need in Chinatown. Priority locations for cooling improvements could include wider streets where surface temperatures are higher and pedestrian traffic is high, such as Kneeland Street, Washington Street, Harrison Avenue, and Beach Street.

Narrow streets in areas with a higher density of residents, such as Beach Street to Essex Street, and Tyler Street to Tai Tung Village, are extremely hot. More shade and green gathering spaces could help reduce temperatures. Chinatown residents that participated in the planning process highlighted Beach Street as a corridor that receives a lot of foot traffic from the Chinatown Gate to Harrison Avenue. Participants suggested this area could be a potential location for adding shading features, especially on the street's northern side that receives more sunlight.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 6.1: ENHANCED COOLING IN POCKET GREEN SPACES AND STREET-TO-GREEN CONVERSIONS

STRATEGY 7.1: COOL COMMUTES

STRATEGY 7.3: COOL MAIN STREETS

COMMERCIAL BUILDINGS WITH COOL ROOFTOPS AND ENERGY EFFICIENT STRATEGIES

Many surfaces—roofs and ground-level—along main streets and mixed-use areas are dark, contributing to heat exposure. Participants in this planning process expressed that financial incentives could encourage building owners to invest in energy efficiency or other cooling improvements. Working with local community organizations to provide guidance and other resources to building owners can increase adoption of cooling strategies.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 5.2: COOL ROOFS PROGRAM

COOL, SHADED PAVEMENT AND SURFACE PARKING

A number of surface parking lots and wide roads with no vegetation contribute to the amount of hot, non-vegetated surfaces in Chinatown. The heat absorbed by these dark surfaces is not easily dispersed at night, making the neighborhood hot in the day and night. Opportunities include the use of light-colored paint for surfaces or installing shade structures to reflect sunlight.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 7.3: COOL MAIN STREETS

STRATEGY 9.3: HEAT RESILIENCE BEST PRACTICE GUIDELINES

COOL HOMES

Many of the buildings in Chinatown have dark flat roofs and are made out of brick, which absorbs more heat than other materials. Opportunities exist for information sharing about existing resources and programs with building owners and renters, and identifying other opportunities for cool homes and access to affordable energy.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 5.1: HOME COOLING RESOURCES DISTRIBUTION

STRATEGY 5.3: HOME ENERGY RETROFITS

STRATEGY 5.4: AFFORDABLE HOUSING RESOURCES AND RETROFITS

MORE SHADED GATHERING SPACES WITH NATURAL PLAY SPACE

Urban parks like Uncle Frank and Auntie Kay Chin Park (Chin Park) have light tree and bamboo cover; however, the land cover there is predominantly hardscape. The heat analysis measured the park's temperature at about 6°F hotter than the Boston Common. Chin Park is located near the Chinatown Gate where many residents gather daily and for events. Hot urban parks like Chin Park that serve as important community gathering areas are opportunities to prioritize cooling strategies.

Residents shared that there is a need throughout Chinatown for additional outdoor gathering spaces and parks, with vegetation, trees, shade, and cooling. As described above, the analysis shows Chinatown has less green space, parks, and tree canopy than Boston as a whole. Opportunities could include adding greenery and shade to existing pocket parks that are largely hardscape, such as at Harrison and Essex, and then identifying other suitable locations for new cool, gathering spaces.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 2.1: POP-UP HEAT RELIEF

STRATEGY 6.1: ENHANCED COOLING IN POCKET PARKS AND STREET-TO-PARK CONVERSIONS

STRATEGY 6.4: PLANNING FOR FUTURE PARKS

COOL SCHOOLS

Many schools in Boston have dark roofs and hardscape outdoor spaces. During capital improvements, these schools have opportunities to integrate cool roofs, trees, shade, and vegetation that can help reduce temperatures. In Chinatown, for example, the Josiah Quincy Elementary School has tiered roofs with some hardscape play surfaces. Schools like Josiash Quincy offer opportunities to consider cooling strategies like green spaces, shade structures, cool pavement, and cool roofs.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 5.5: COOL SCHOOLS

INDOOR COOLING NETWORK

One concern voiced by Chinatown residents during the planning process was that a lack of larger, free, indoor cool places. Chinatown has one BCYF center (BCYF Quincy) and a temporary library in the China Trade Center. BCYF Quincy was not a designated city cooling center in 2021. The limited choices and space can create gaps in accessing indoor cooling options. Indoor cooling options, including options for evening respite, are especially important given the neighborhood's hot microclimate throughout the day and night. Expansions to the indoor cooling network can include a mix of public and community cooling options, such as enhancing or expanding City-run cooling centers or working with community organizations to identify additional options.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 2.2: ENHANCED AND EXPANDED CITY-RUN COOLING CENTERS

STRATEGY 2.3: CITYWIDE COOLING NETWORK

RESILIENT DESIGN FOR NEW DEVELOPMENT

Like many Boston neighborhoods, Chinatown has been experiencing increasing development pressures in many parts of the neighborhood. Chapter 6 of this document includes three strategies related to development review, zoning, and heat resilience design guidelines. Development review could provide opportunities to consider how building massing affects the local microclimate and airflow. Continuing to support and expand affordable housing options is a priority throughout the City.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 8.1: UPDATED CLIMATE RESILIENCY CHECKLIST

STRATEGY 8.2: HEAT RESILIENCE BEST PRACTICE GUIDELINES

STRATEGY 8.3: ZONING REVISIONS TO SUPPORT COOLER NEIGHBORHOODS

DORCHESTER


TRIPLE DECKERS


DOHERTY-GIBSON PLAYGROUND

NEIGHBORHOOD CONTEXT

Dorchester's neighborhoods, squares, and corridors have diverse heat experiences, including pockets of high heat.

With more than 126,000 residents and over six square miles, Dorchester is the largest neighborhood in Boston.[13] It is often described as a neighborhood of smaller neighborhoods, each with their own distinct characters. Commercial districts like Upham's Corner, Fields Corner, and Codman Square are knit together by residential neighborhoods characterized by the triple-decker buildings for which the neighborhood and city is known.

One of the most diverse neighborhoods, 34% of residents are foreign-born.[14] Dorchester is home to Caribbean, Cape Verdean, Irish, Polish, and Vietnamese communities. Public transportation and highway access has significantly shaped development patterns in Dorchester. In the 1950s, the Old Colony Line railway was replaced by the Southeast Expressway.[15] During this period, these investments displaced the residents of the adjacent areas and reduced transit access for Dorchester residents. Redlining and blockbusting activities contributed to population decline, and Dorchester's population shrank from 162,000 people in 1950 to 101,000 people in 1980.[16] Residents raised their voices to secure recent investments in the Fairmount Indigo Rail Line and associated Station Area planning efforts that aim to reconnect Dorchester with Downtown Boston and guide sustainable development to support current residents and business owners.[17]

Dorchester is also dealing with escalating flood risk.. Up to 20% of the land area in Dorchester has a 1% annual risk of flooding in a future where Boston experiences 36 inches of sea level rise.[18] Coastal and riverine flood risks affect residential, commercial, and industrial land, including community assets like libraries, schools, and other facilities that can be places where people seek help or shelter during heat and other climate-related emergencies.[19]

Housing costs have increased rapidly, with median housing costs increasing 38% between 2010 and 2015.[20] Over that same period, median household income only rose 3%.[21] Local community groups have created a narrative around displacement that weaves together the economic displacement that they are currently experiencing with the future possibility of climate displacement and are trying to identify strategies that address both challenges.

RECENT AND ONGOING PLANNING EFFORTS

- PLAN: Newmarket, the 21st Century Economy Initiative
- Dorchester Avenue Project
- Upham's Corner Implementation
- Fairmount Indigo Planning Initiative
- PLAN: Glover's Corner, Dorchester
- Columbia Point Master Plan

Parks
Greenways
Roads
Major Roads
MBTA Red Line
MBTA Commuter Rail
MBTA Station

COMMUNITY ASSETS

School
Libraries
Police Station
Fire Station
Hospital
Community Health Center
1 Grove Hall Senior Center
2 Holland Community Center
3 Marshall Community Center
4 Perkins Community Center
5 Leahy/Holloran Community Center
BHA Public Housing: Elderly/Disabled
BHA Public Housing: Family

Dorchester is rich with community and regional amenities and landmarks. It is home to several distinct neighborhoods, each with their own character, and UMass Boston, the JFK Library, and the Edward M. Kennedy Institute.

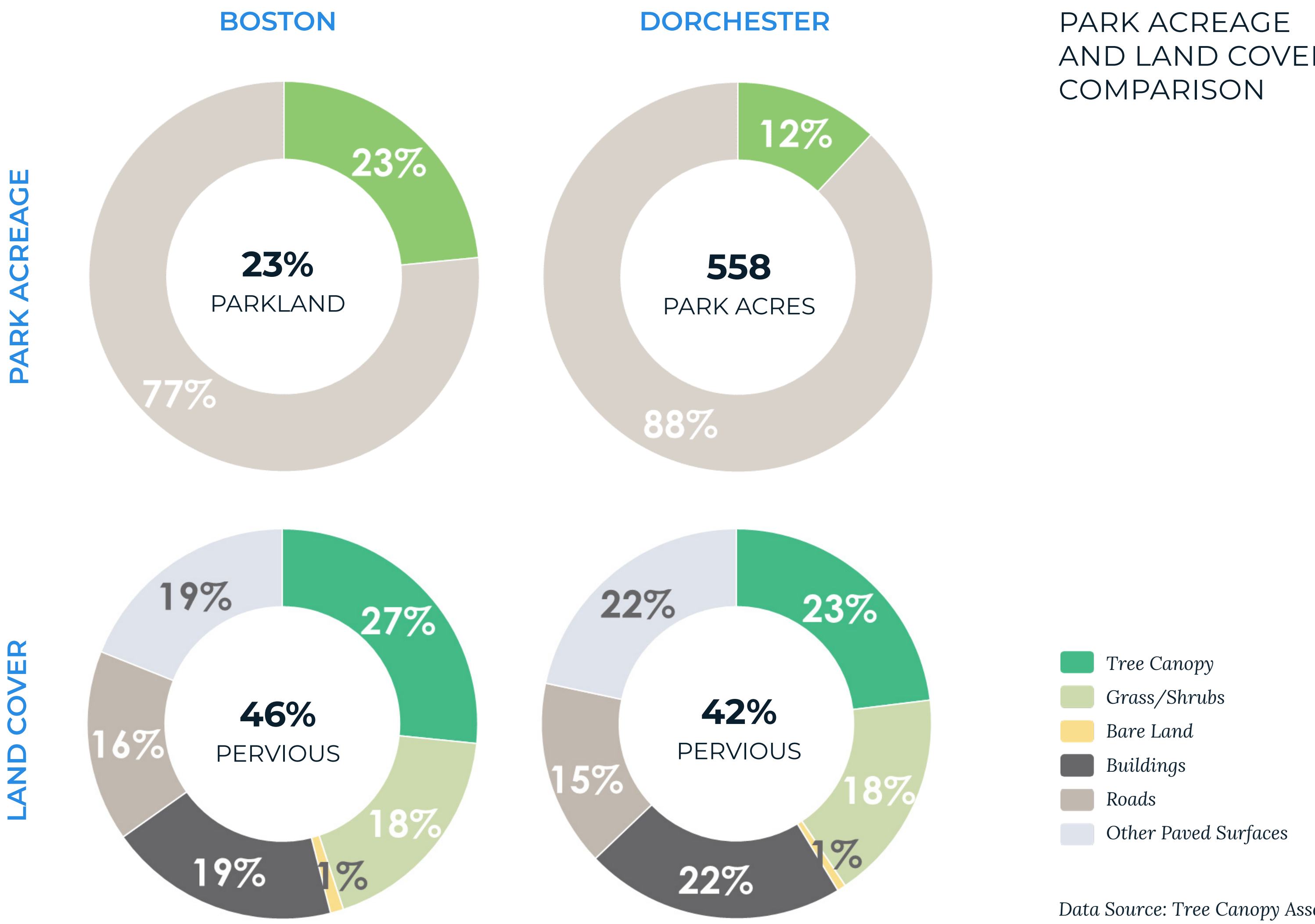
0 0.5 MI

HEAT ANALYSIS

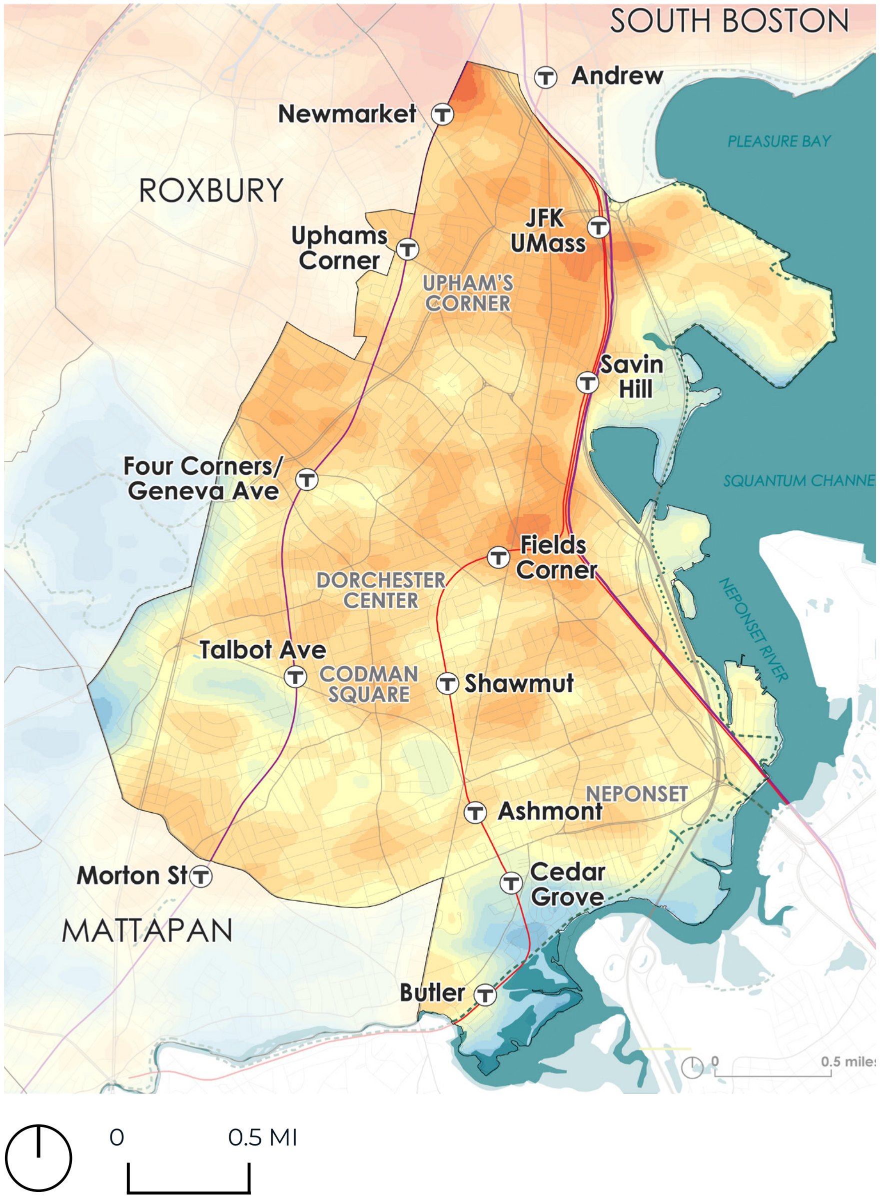
Areas of Dorchester experience temperatures that exceed Boston's median temperatures. Dorchester's daytime and nighttime median temperatures measured 100.9°F and 82.6°F, respectively, in the heat analysis. These temperatures are about 1°F hotter than the city's median (99.5°F and 81.9°F, respectively). However, some parts of the neighborhood, including residential areas and commercial centers, experience much hotter days and nights. For example, areas around Newmarket and South Bay Center showed the highest daytime and nighttime temperatures in the neighborhood: 105°F in the day, cooling to 84°F overnight.

Dorchester's hotter microclimates are a result of several factors, including less green space, building characteristics, and impermeable surfaces. The areas with a relative lack of green space and trees have less natural air cooling than many other parts of Dorchester and Boston. In addition, large commercial buildings with many dark roofs further absorb heat, contributing to hot indoor and outdoor air temperatures. Impervious surfaces make up 58% of Dorchester's land area. The locations of pervious surfaces and tree canopy coverage closely align with the cooler areas in the neighborhood. Areas with more impervious surface, especially unshaded pavement and large parking lots, align with the hotter areas of the neighborhood, like Newmarket and South Bay Center. Major infrastructure, such as I-93, several arterial roads, and rail lines, also contribute to heat in Dorchester.

PARK ACREAGE AND LAND COVER COMPARISON



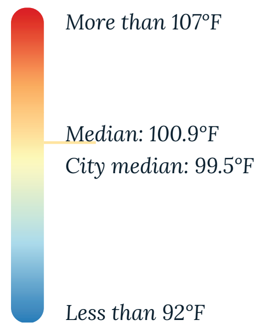
Data Source: Tree Canopy Assessment 2019, BPRD

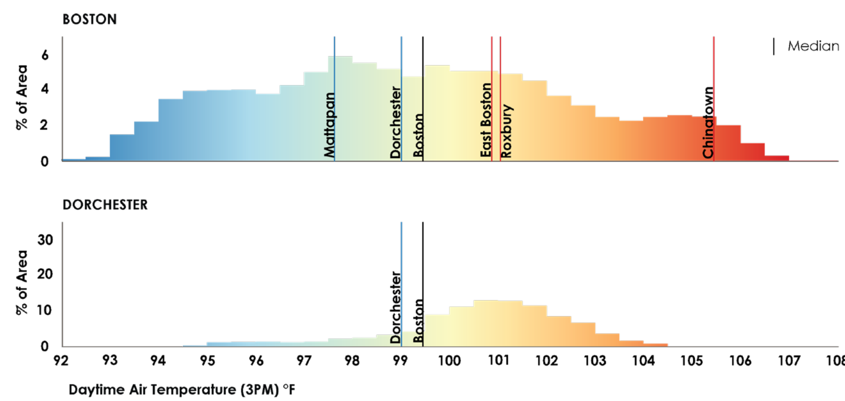


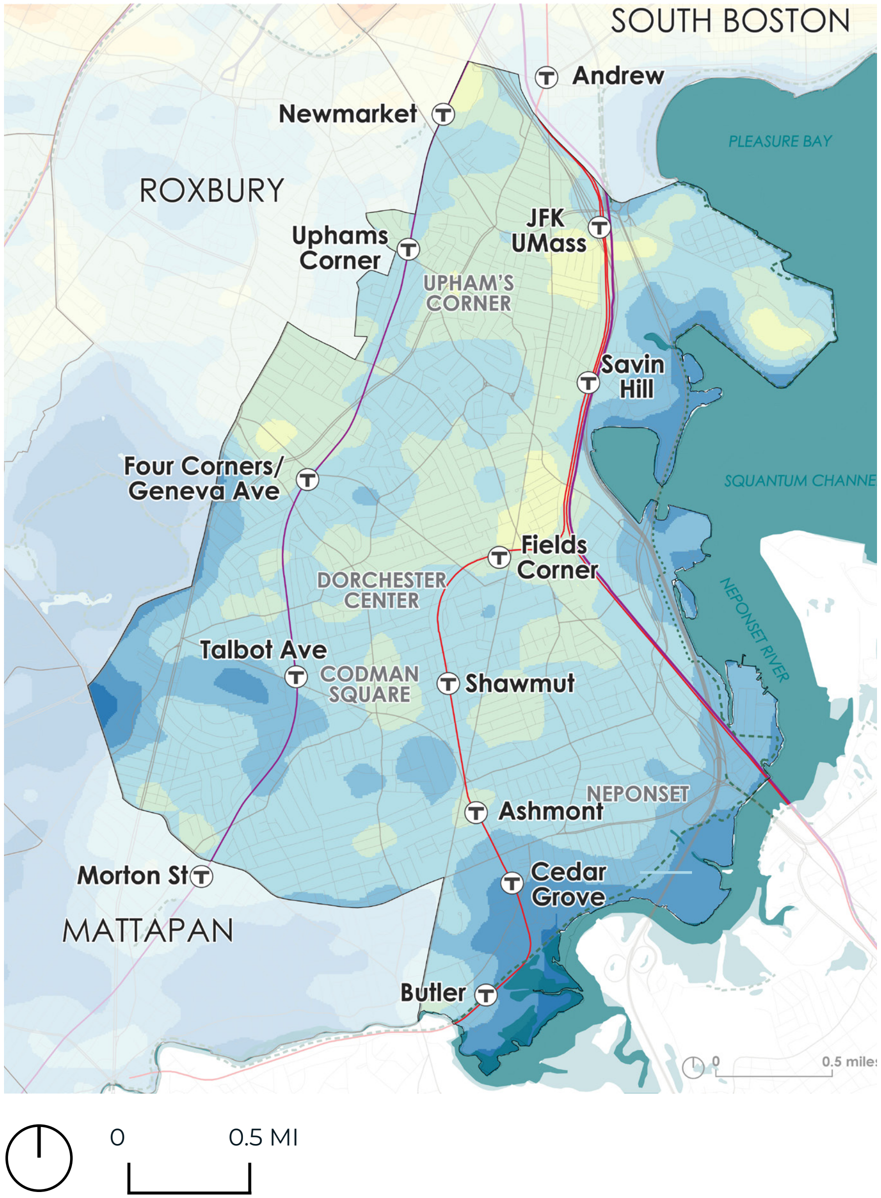
DAYTIME TEMPERATURES

Daytime Air Temperature (3 p.m.): Median neighborhood air temperature at 3 p.m. is about 1°F hotter than the Boston median.

3PM:
AIR TEMPERATURE



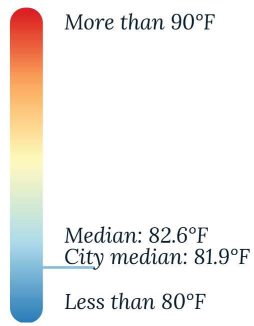


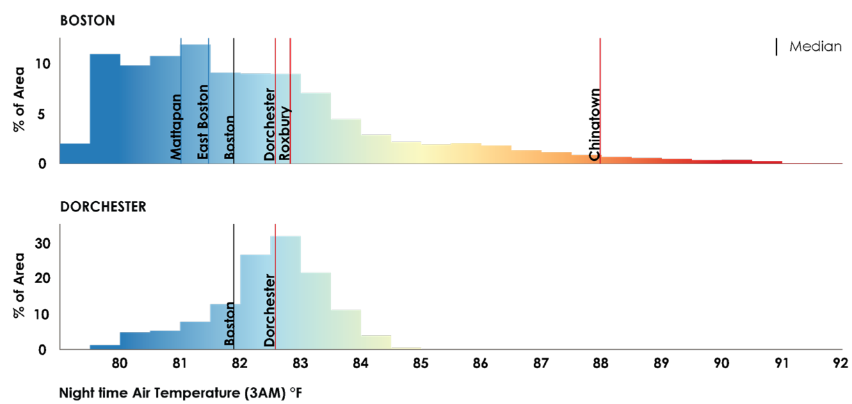


NIGHTTIME TEMPERATURES

Nighttime Air Temperature (3 a.m.): *Median neighborhood air temperature at 3 a.m. is less than 1°F hotter than the Boston median.*

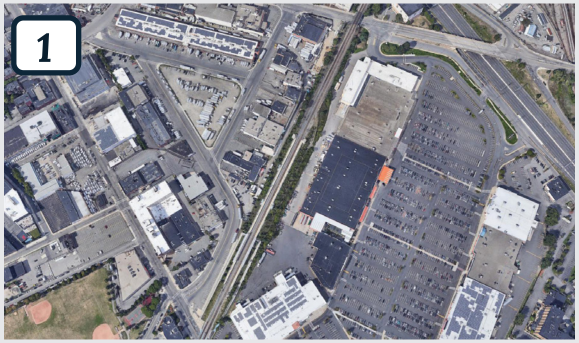
3AM:
AIR TEMPERATURE





SAMPLE OF HEAT FINDINGS

These three areas illustrate examples of how Dorchester's land use affects daytime and nighttime temperatures, based on the citywide heat analysis.

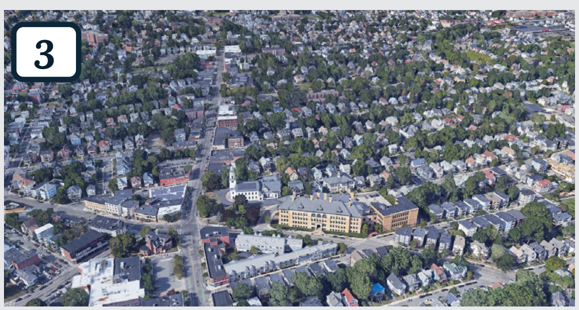


1. LARGE COMMERCIAL AND INDUSTRIAL BUILDINGS

Large commercial buildings with black roofs and black asphalt surfaces, like those found in Newmarket, heat up during the day, but the relatively low density building forms allow heat to radiate and dissipate at night. Nearby interstates, like I-93, also absorb a lot of heat during the day and contribute to heating the surrounding neighborhood. The limited green spaces and tree canopy in this area means that there is not as much shade and evapotranspiration to help mitigate rising air temperatures.

2. MIXED-USE COMMERCIAL DISTRICTS

Clusters of large mixed-use buildings with dark roofs, as found in Four Corners, absorb heat during the day. This and other similar zero-setback commercial areas can have limited tree canopy coverage shading sidewalks, so the asphalt streets heat up during the day and create hotter conditions for pedestrians. The density patterns and some vegetation help Four Corners cool off at night.



3. MULTI-WAY INTERSECTIONS

Multi-way intersections, as found in Codman Square and other neighborhood destinations, have a lot of pavement due to several major roadways and intersections. These areas often also have larger buildings with black roofs. Like in other kinds of mixed-use commercial districts, tree canopy coverage is mostly limited to backyards, leaving streets exposed to the sun during the day. The lower density and building heights help the area cool off at night.

AREAS EXPERIENCING LONGER HIGH-HEAT EVENTS

- School
- Hospital
- Community Health Center
- BHA Public Housing: Elderly/Disabled
- BHA Public Housing: Family
- Community Centers
- Pools (BCYF and DCR)
- Tot Sprays
- Beaches
- Libraries

Heat Event Duration is the sum of all the hours during the analysis week (a heat wave week in July 2019) that the local modeled heat index is above 95°F, for days that the nighttime temperature does not drop below 75°F.

HEAT EVENT HOURS

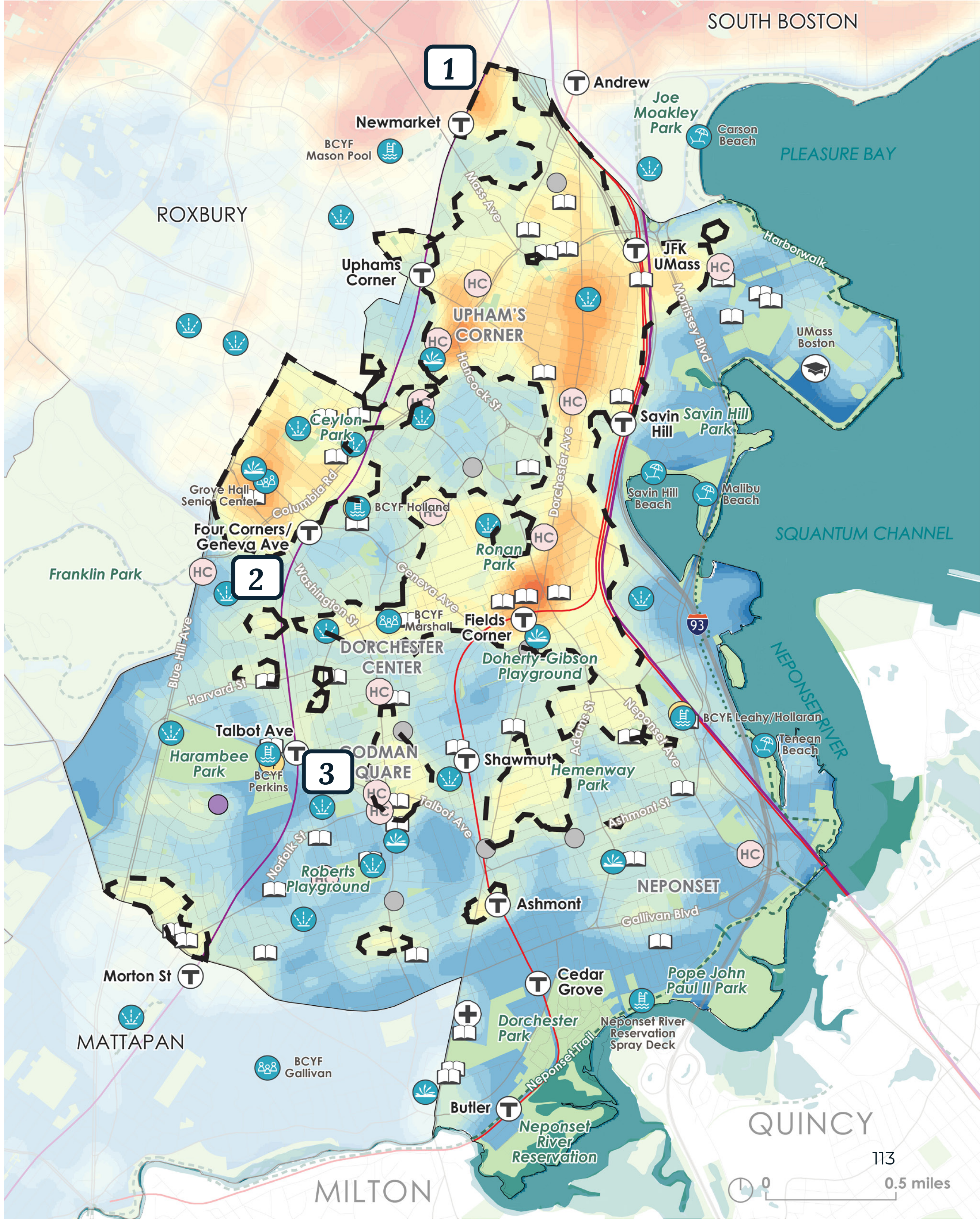
More than 37hrs

30 hrs

Less than 25 hrs

Longest Heat Event (More than 30 hrs)

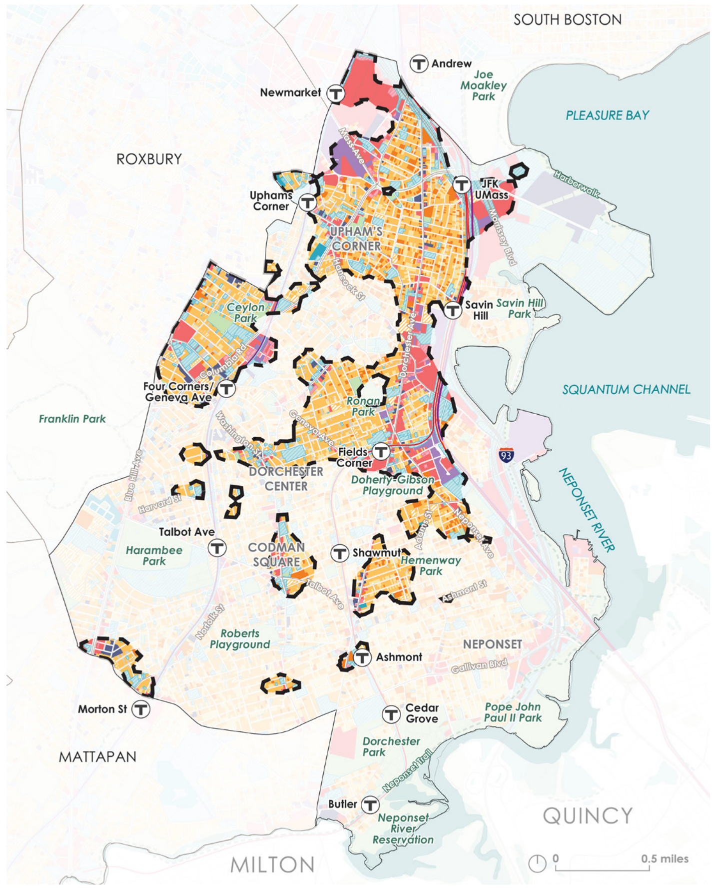
0 0.5 MI



LAND USE AND PEOPLE

Residential and commercial corridors (like Dorchester Avenue) are the most common land uses in the areas of Dorchester that experience the most intense and longest heat events. This means that extreme heat affects a range of residents, transit riders, business patrons, and workers. There is higher population density in areas with longer heat exposure at high intensity, such as Upham's Corner, Fields Corner, Four Corners, and Shawmut.

As described in Chapter 3, hot weather can create disproportionate health risks for some people, especially for those who are younger or older, who have preexisting health conditions, or who are exposed to heat for longer periods of time. In Dorchester, young children (under 5 years) make up 6% of neighborhood residents (compared to 5% citywide), and older adults (over 65 years) make up 12% of neighborhood residents (same as the citywide percentage).[24] Of Dorchester residents, 24% are low-income (compared to 16% citywide), and 64% of housing units are renter-occupied (same as the citywide percentage).[25] Low-income residents and renters may face barriers to home retrofits or affording cooling options.



Data Source: Analyze Boston

Land Use Map: The hottest and most intense areas of Dorchester are mainly residential, with main commercial corridors, like Dorchester Avenue

LAND USE

- *Single-family Housing*
- *Multi-family Housing*
- *Apartment (7+ Units)*
- *Condo*
- *Mixed Use*
- *Residential Land*
- *Commercial*
- *Commercial Land*
- *Industrial*
- *Exempt (Chapter 121A)*
- *Exempt*

Longest Heat Event (More than 30 hrs)

0 0.5 MI

POPULATION DENSITY AND HIGH-HEAT EVENT DURATION

Higher density in areas with longer heat exposure and intensity including Upham's Corner, Fields Corner, Four Corners, and Shawmut

1 DOT = 5 PEOPLE

HEAT EVENT HOURS

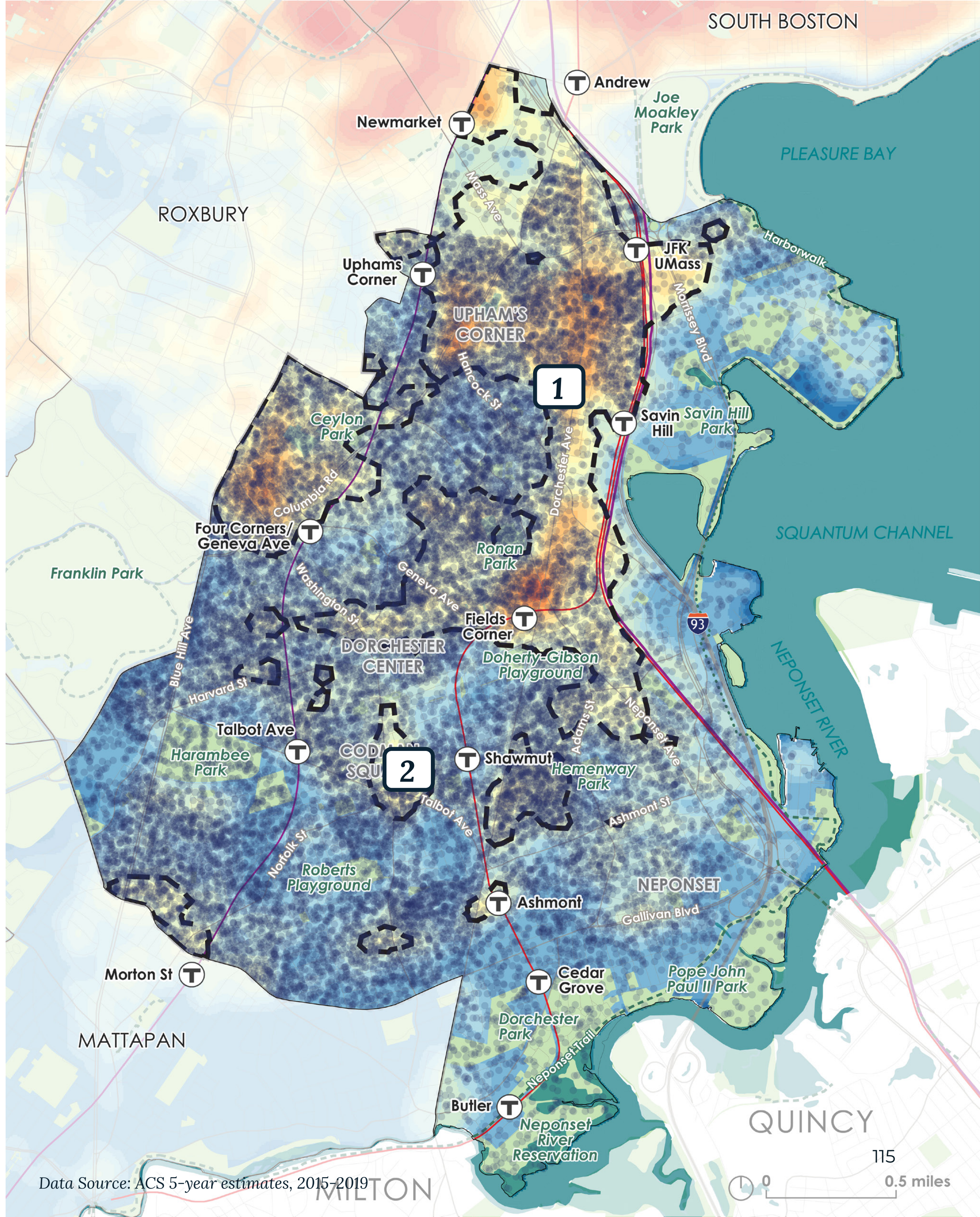
More than 37hrs

30 hrs

Less than 25 hrs

Longest Heat Event (More than 30 hrs)

0 0.5 MI



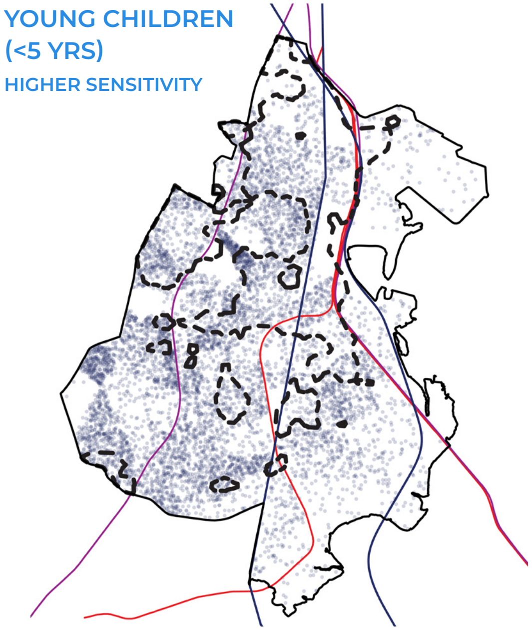
Data Source: ACS 5-year estimates, 2015-2019

RESIDENT DEMOGRAPHICS AND HEAT DURATION

The following maps compare the density of Dorchester residents to areas with the longest duration event in the heat analysis. Due to longer heat event duration and higher heat intensity, heat risk may be higher for residents in certain areas. For example, Fields Corner experiences long heat events (33 hours) 4 hours above the neighborhood median (29 hours), and is 6°F hotter than Franklin Park. Other areas that experience long heat event duration and high heat intensity include Four Corners (29 hours, 4.2°F), Upham's Corner (30 hours, 5.2°F), Newmarket (31 hours, 5.5°F), and along the Dorchester Avenue corridor (34 hours, 6°F).

YOUNG CHILDREN (<5 YRS)

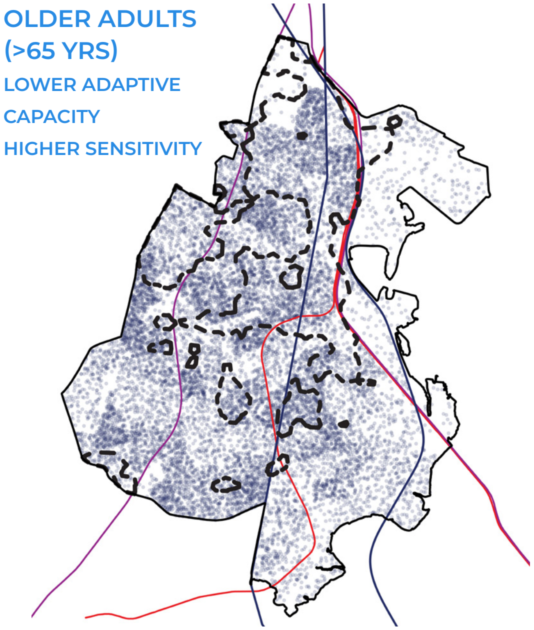
HIGHER SENSITIVITY



OLDER ADULTS (>65 YRS)

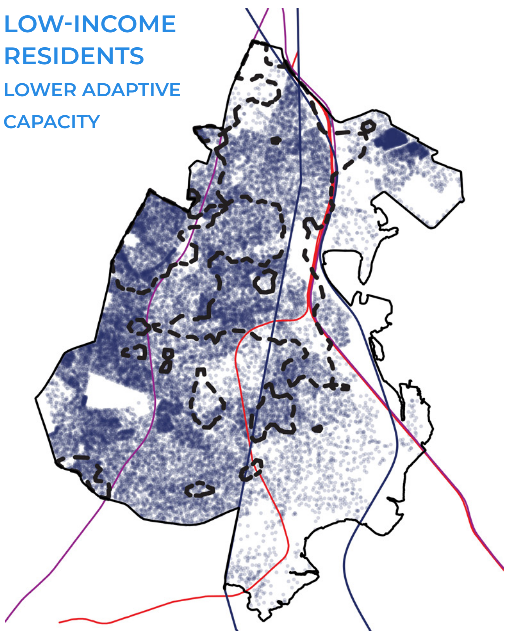
LOWER ADAPTIVE CAPACITY

HIGHER SENSITIVITY



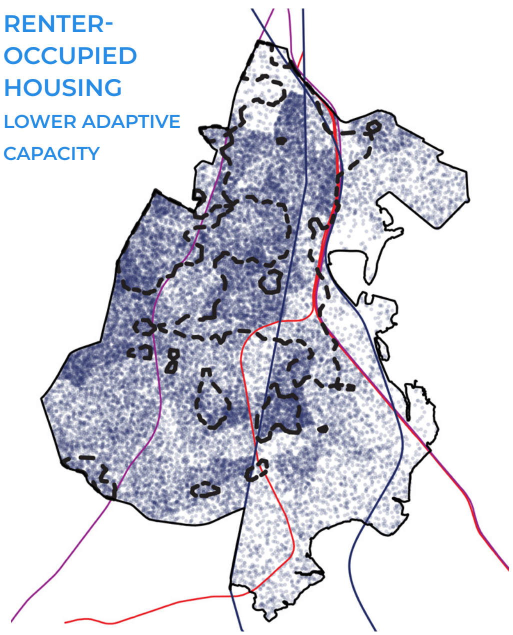
LOW-INCOME RESIDENTS

LOWER ADAPTIVE CAPACITY

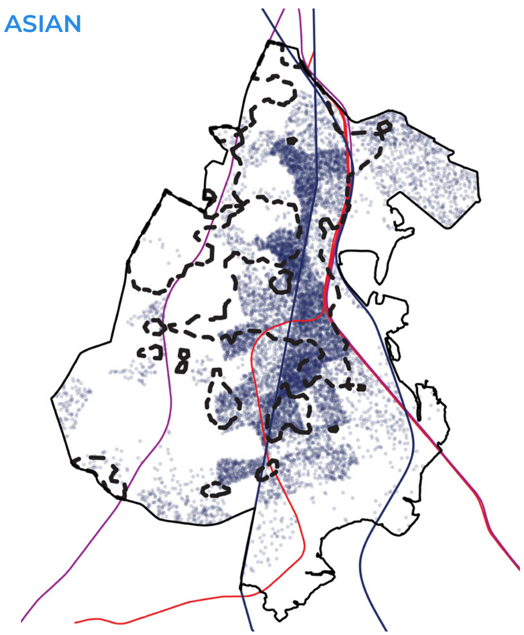


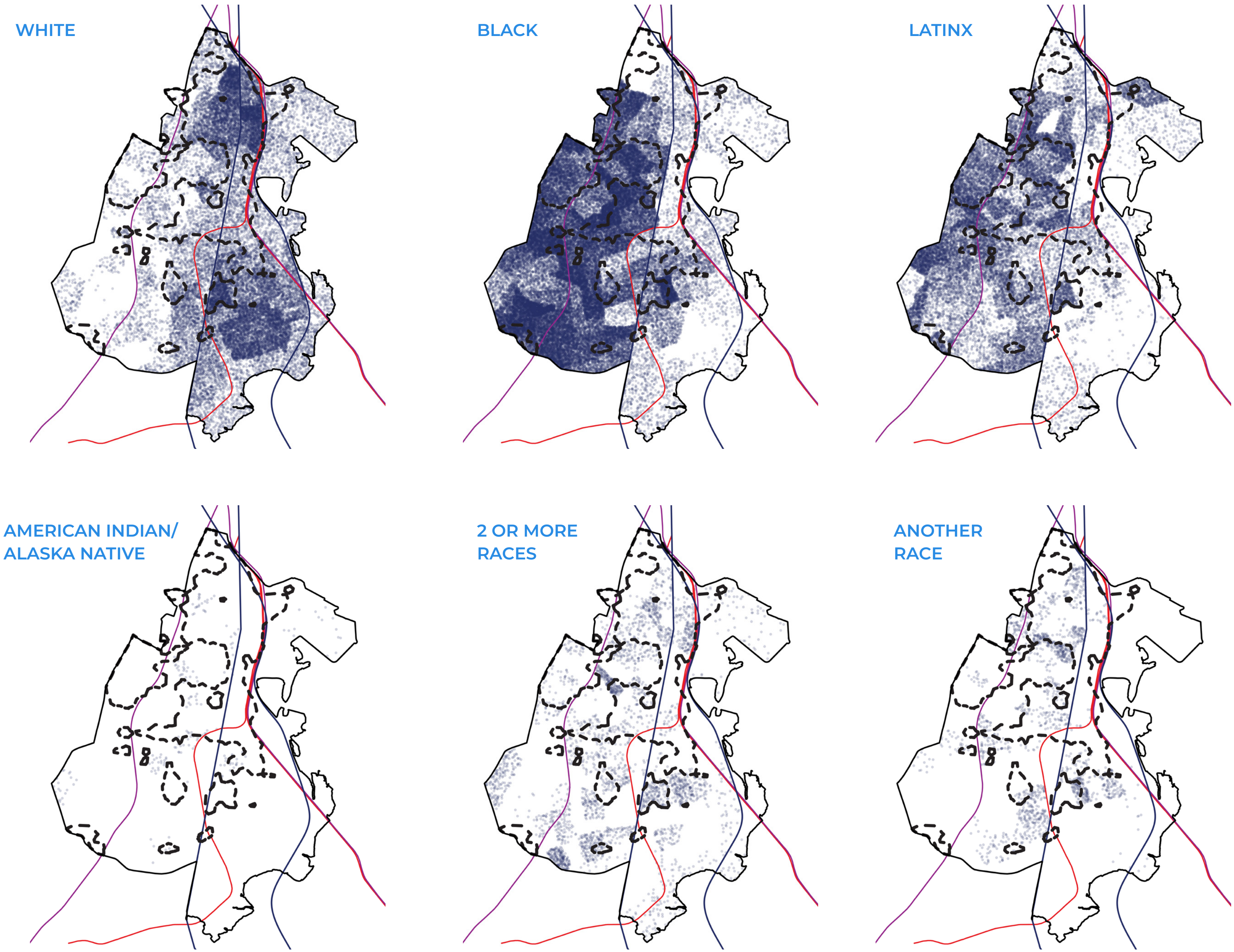
RENTER-OCCUPIED HOUSING

LOWER ADAPTIVE CAPACITY



ASIAN

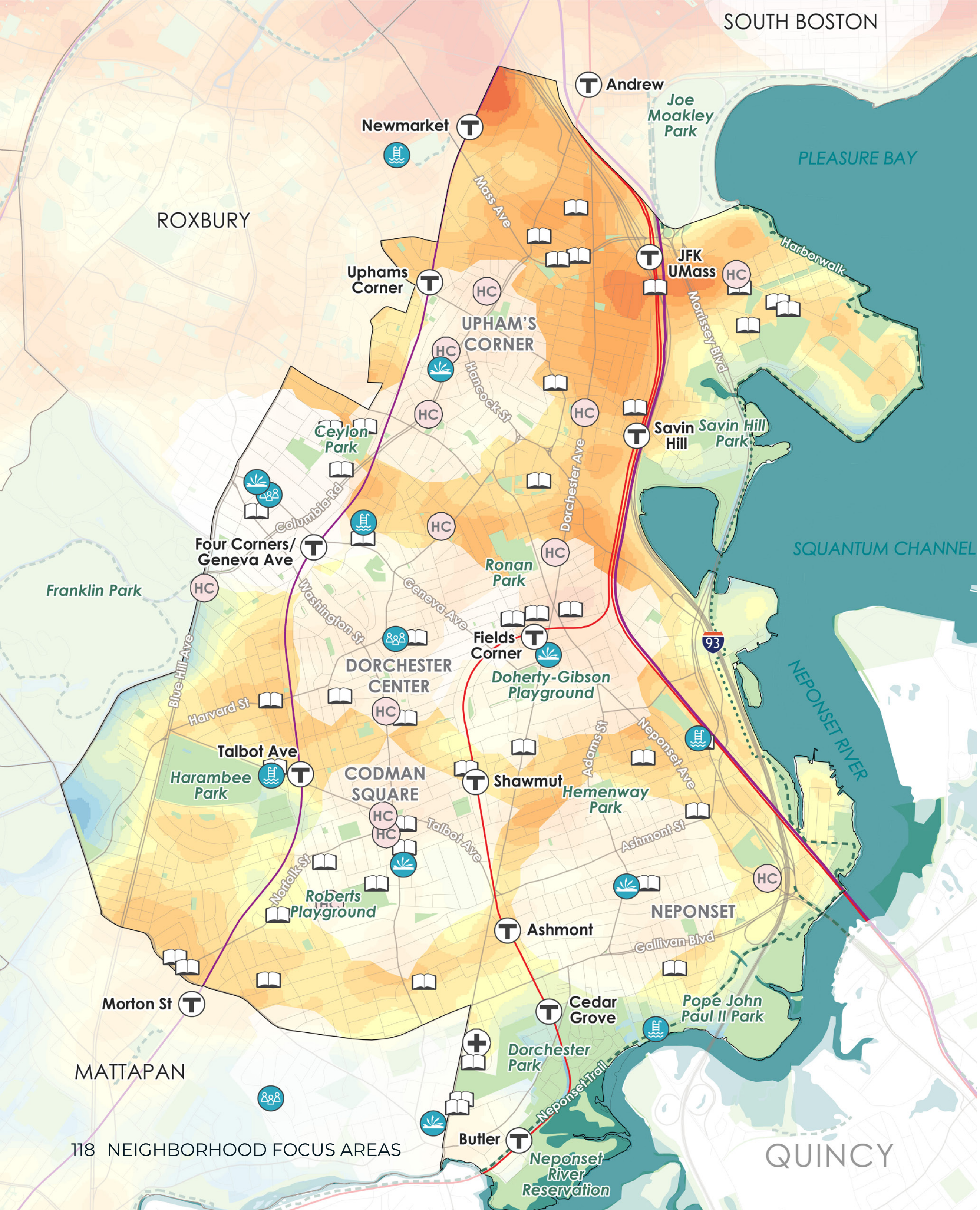




Data Source: ACS 5-year estimates, 2015-2019

Longest Heat Event (More than 30 hrs)

1 DOT = 1 PERSON



GAPS IN INDOOR COOLING NETWORK

- School
- Hospital
- Community Health Center
- BHA Public Housing: Elderly/Disabled
- BHA Public Housing: Family
- Indoor Cooling Center
- Pools (BCYF and DCR)
- Tot Sprays
- Beaches
- Libraries

Areas masked in white are within a 10-minute walk of indoor cooling centers and liraries. Areas in orange red experience extreme heat during heat waves, and are not within a 10-minute walk of an indoor cooling center or a library.[i]

3PM:
AIR TEMPERATURE

More than 107°F

Median: 100.9°F

City median: 99.5°F

Less than 92°F

i BCYF Summer 2020 Cooling centers were used for this map.

0 0.5 MI

COMMUNITY HEAT EXPERIENCES AND COOLING IDEAS

HEAT EXPERIENCES

Dorchester residents discussed their heat experiences and cooling ideas during the Neighborhood Ideas Workshop and through responses to the citywide survey. Areas of concern mentioned by participants included the cost of staying cool at home, the ability to access indoor cooling options outside of the home, the effects of new development on heat and green space, and the impacts of heat on outdoor workers, older adults, and people experiencing homelessness.

> *Dorchester is one of the more affordable neighborhoods in Boston, and it comes at a price because landlords do not install air units.*

> *Walking to parks is very hot, even if parks themselves are cooler.*

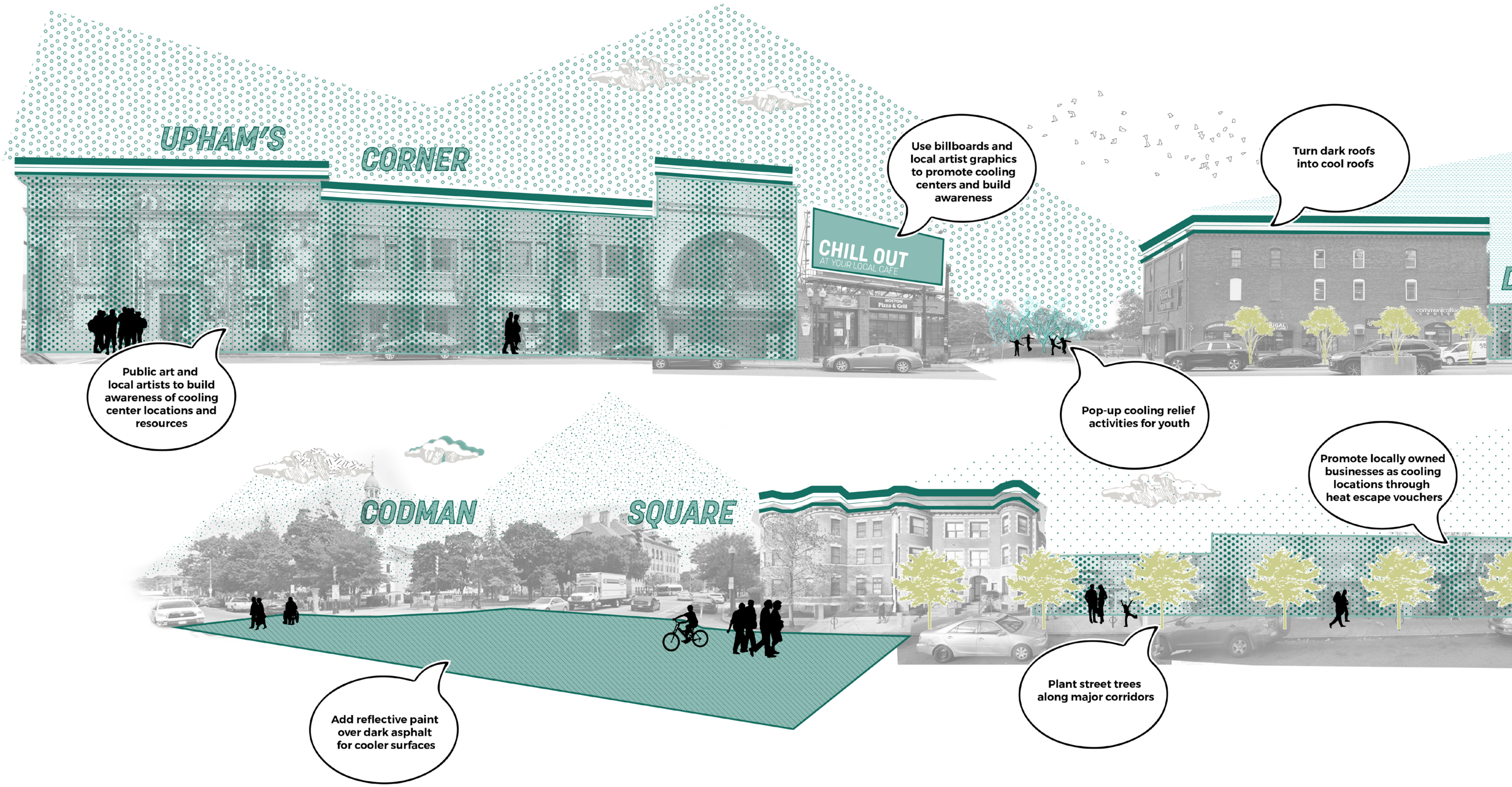
> *Health centers should be brought into the discussion as they serve significant numbers of local residents and have holistic views of health.*

COMMUNITY COOLING IDEAS

Dorchester residents suggested cooling strategies that expand access to cooling at home and in the neighborhood and increase cool outdoor spaces. Participants shared the following ideas to increase access to cooling in Dorchester:

- » Cool Accessible Parks:
  Additional shade elements and hydration stations in parks paired with digital wayfinding tools to help identify nearby open spaces
- » Public Cooling Centers:
  Opportunities to integrate public art and community engagement at Cool Spots and cooling centers
- » Affordable Ways to Stay Cool at Home:
  Opportunities to expand awareness about energy and utilities assistance programs to overcome challenges of staying cool at home and the cost of using air conditioning

OPPORTUNITIES FOR A COOLER DORCHESTER




DORCHESTER
CENTER
Create pocket parks in residential areas and complexes
Plant trees and vegetation to shade streets to promote cooler communities
FIELDS
Incorporate mist systems into public art
Create app to locate heat relief resources
Support indoor climate comfort for renters

HEAT RESILIENCE OPPORTUNITIES

This section describes key needs for heat reduction or increasing access to cooling resources and opportunities to integrate resilience, based on neighborhood-level heat analysis and community feedback.

While all the strategies may be relevant to each neighborhood, each section lists specific heat resilience strategies that respond to the particular needs that have been identified. More details on the strategies listed below can be found in Chapter 6: Citywide Heat Resilience Strategies.

COOL STREETS CONNECTING LOCAL DESTINATIONS AND MAIN STREETS

Major streets that link neighborhood destinations could be opportunities for more shade and cooling strategies, including shaded bus stops. Roads that had higher heat temperatures measured in the heat analysis include Dorchester Avenue, Columbia Road, Geneva Avenue, Neponset Avenue, Adams Street, Washington Street, Blue Hill Avenue, Bowdoin Street, and streets around Codman Square.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 7.1: COOL COMMUTES

STRATEGY 7.3: COOL MAIN STREETS

COMMERCIAL BUILDINGS WITH COOL ROOFTOPS AND COOL SOCIAL SPACES

Newmarket and South Bay Center in the northwest corner of Dorchester have expansive surface parking lots with limited vegetation, contributing to heat exposure in this area. Opportunities to mitigate heat include cool roofs, shaded bus stops, shaded parking lots, vegetation, and light surfaces.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 5.2: COOL ROOFS PROGRAM

RESILIENT DESIGN FOR NEW DEVELOPMENT

Like many Boston neighborhoods, Dorchester has been experiencing increasing development pressures in many parts of the neighborhood. Chapter 6 of this document includes three strategies related to development review, zoning, and heat resilience design guidelines. Development review could provide opportunities to consider how building massing affects the local microclimate. Continuing to support and expand affordable housing options is a priority throughout Boston

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 8.1: UPDATED CLIMATE RESILIENCY CHECKLIST

STRATEGY 8.2: HEAT RESILIENCE BEST PRACTICE GUIDELINES

STRATEGY 8.3: ZONING REVISIONS TO SUPPORT COOLER NEIGHBORHOODS

COOL HOMES

As development pressure in Boston continues to build, residents of Dorchester are experiencing rising rents and home prices as housing demand continues to outpace supply. Sharing resources about subsidized home energy retrofits with homeowners and landlords could support energy efficiency retrofits. These improvements can help reduce energy bills, as air conditioning does not need to be in use as frequently or for as long a time.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 5.1: HOME COOLING RESOURCES DISTRIBUTION

STRATEGY 5.3: HOME ENERGY RETROFITS

STRATEGY 5.4: AFFORDABLE HOUSING RESOURCES AND RETROFITS

MORE SHADED GATHERING SPACES WITH NATURAL PLAY SPACE

Although parks generally help cool their surroundings, some parks that have fewer trees or more hardscape surfaces can have less of a cooling effect. Ceylon Park, which includes an artificial turf field, measured approximately 101°F during the day in the heat analysis, 4°F higher than Harambee Park. Ronan Park measured approximately 102°F in the heat analysis. Upham's Corner, Four Corners, Fields Corner, and Codman Square were all hotter areas in the heat analysis. More vegetation, pocket parks, or shaded outdoor gathering spaces could be opportunities to provide relief from the heat in these areas.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 2.1: POP-UP HEAT RELIEF

STRATEGY 6.1: ENHANCED COOLING IN POCKET PARKS AND STREET-TO-PARK CONVERSIONS

STRATEGY 6.4: PLANNING FOR FUTURE PARKS

EAST BOSTON


LOGAN AIRPORT
CENTRAL SQUARE


EAST BOSTON WATERFRONT
EAST BOSTON MEMORIAL PARK

EAST BOSTON GREENWAY
BELLE ISLE MARSH

MAVERICK SQUARE

NEIGHBORHOOD CONTEXT

East Boston experiences a range of heat experiences, shaped by its geographic context, development pattern, and neighborhood history. Waterfront areas enjoy cooling coastal breezes, while inland neighborhoods, squares, and corridors are hotter.

Approximately 46,000 people live in East Boston today,[26] with over 50% of the population consisting of immigrants, the largest immigrant population of any neighborhood in Boston.[27] For much of the 1900s East Boston was dominated by Italian immigrants whose descendants still live in the neighborhood popularly known as Eastie. The majority of current residents who immigrated to East Boston came from Spanish-speaking countries, such as El Salvador, Columbia, Guatemala, and the Dominican Republic. More than half of East Boston's households speak Spanish at home.

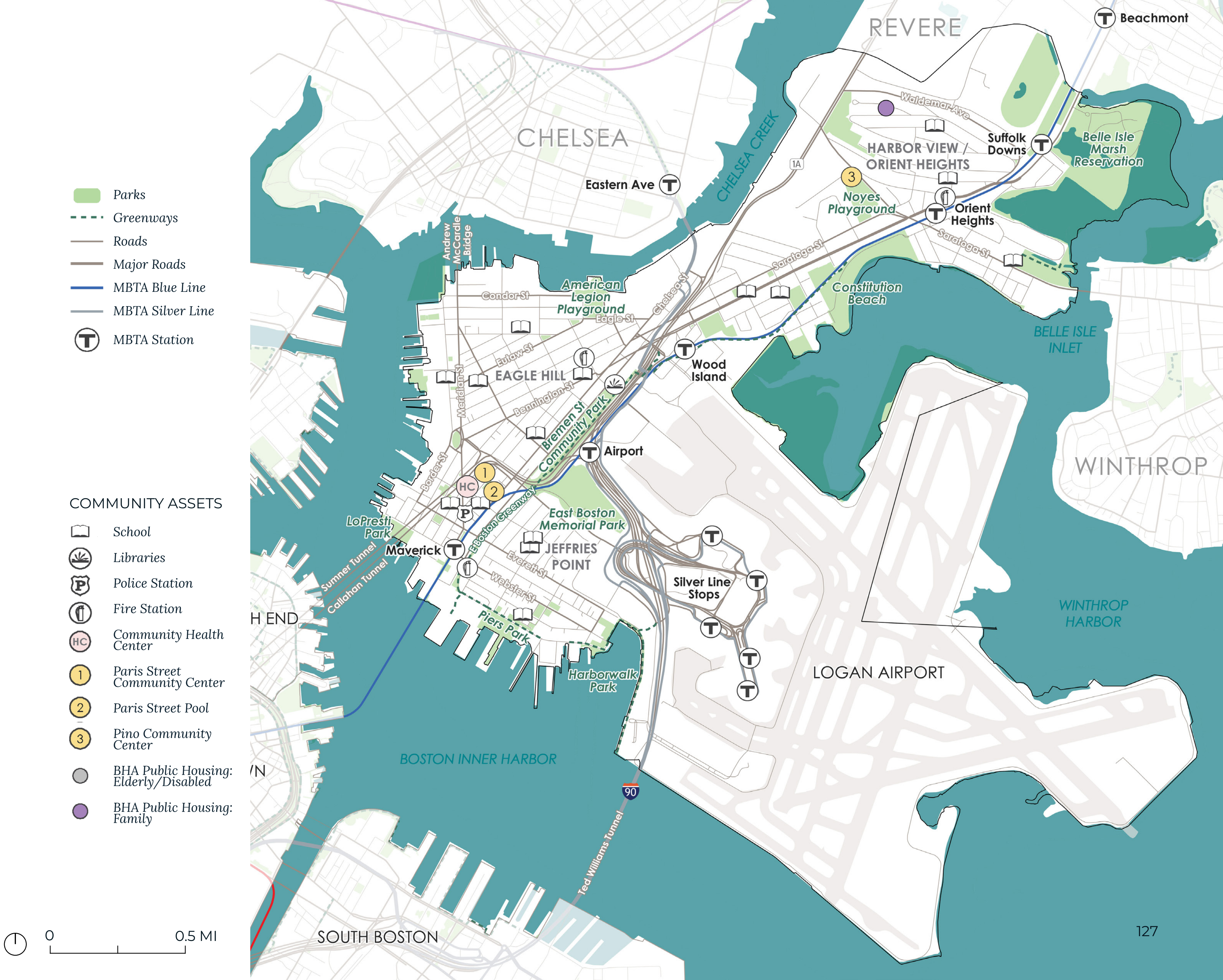
Formed by filling in land between five harbor islands, East Boston has dealt with the tension of development since its beginning. Most notably in 1923, the opening of what would become Logan Airport has shaped the evolution of East Boston. Wood Island Park—a beloved park designed by Frederick Law Olmsted—was removed in the 1960s due to airport expansion.[28] The cooling effects of a large urban park (more than 10ha) can reduce temperatures by 1.8°F to 3.6°F within a quarter of a mile from the park boundary.[29] The high concentration of transportation infrastructure contributes to neighborhood air pollution from airplanes, truck traffic, and regional transportation routes.

East Boston has seen significant new development over the past fifteen years, especially along the waterfront in Jeffries Point and the edges of Eagle Hill. East Boston is one of Boston's neighborhoods that is most vulnerable to coastal flooding and sea level rise. Of the neighborhood's land area today, 38% could be exposed to flooding in a 1% chance storm. A 1% chance storm is a more severe coastal storm, similar to the winter storms of 2018, that has a 1% chance of occurring each year, based on historical data. With rising seas, the flooding from 1% chance storms is projected to increase over time, with 58% of East Boston's land area exposed in a 1% annual chance storm in 2070.[30]

While residents of East Boston have always carried a disproportionate level of environmental burden for the region, they have responded with the kind of neighborhood organizing across racial and cultural lines that have made them a strong voice in the environmental justice movement.

RECENT AND ONGOING PLANNING EFFORTS

- PLAN: Downtown (Mayor's Office of Planning/BPDA)
- Coastal Resilience Solutions: East Boston, Phase 2

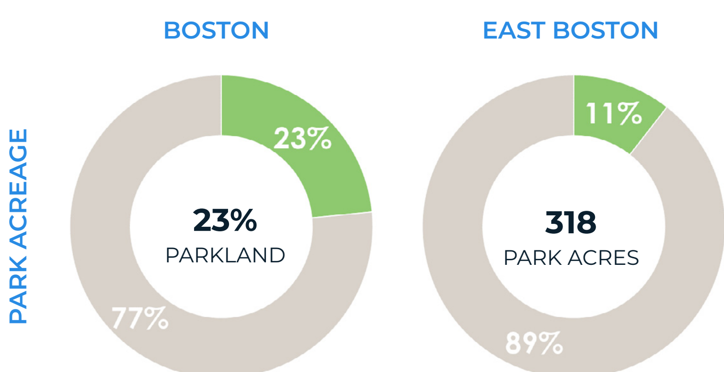

Parks
Greenways
Roads
Major Roads
MBTA Blue Line
MBTA Silver Line
MBTA Station
COMMUNITY ASSETS
School
Libraries
Police Station
Fire Station
Community Health Center
Paris Street Community Center
Paris Street Pool
Pino Community Center
BHA Public Housing: Elderly/Disabled
BHA Public Housing: Family
0
0.5 MI
REVERE
Beachmont
CHELSEA
CHELSEA CREEK
Eastern Ave
Waldemar Ave
Suffolk Downs
HARBOR VIEW / ORIENT HEIGHTS
Belle Isle Marsh Reservation
1A
Noyes Playground
Orient Heights
Saratoga St
Andrew McCardle Bridge
Condor St
American Legion Playground
Eagle St
Chelsea St
Constitution Beach
BELLE ISLE INLET
Eutaw St
EAGLE HILL
Meridian St
Bennington St
Wood Island
Bremen St Community Park
Airport
WINTHROP
Border St
HC
LoPresti Park
East Boston Greenway
East Boston Memorial Park
Maverick
JEFFRIES POINT
Sumner Tunnel
Callahan Tunnel
Everett St
Webster St
Silver Line Stops
H END
Piers Park
Harborwalk Park
WINTHROP HARBOR
LOGAN AIRPORT
BOSTON INNER HARBOR
90
Ted Williams Tunnel
SOUTH BOSTON

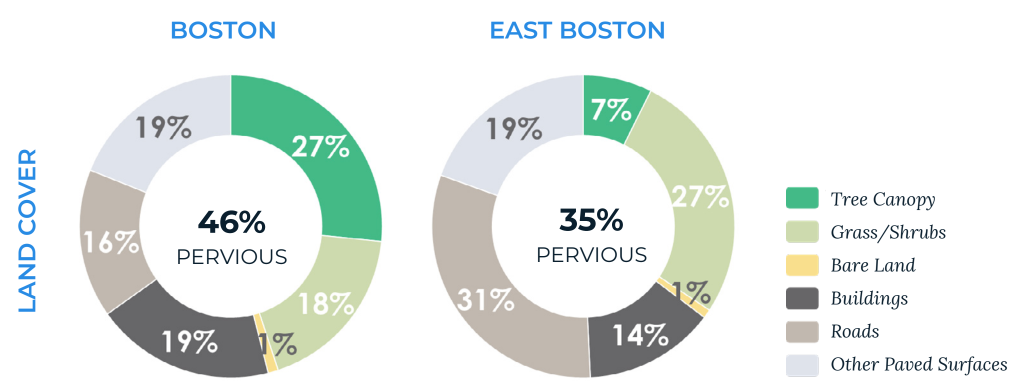
HEAT ANALYSIS

East Boston's heat story varies between coastal areas and inland areas.
In the heat analysis, East Boston's daytime (3 p.m.) and nighttime (3 a.m.) median temperature showed 101°F and 81.5°F, respectively, and temperatures vary significantly across the neighborhood. The temperature in East Boston's waterfront areas are generally below the neighborhood median temperature while inland areas experience temperatures that are higher than the neighborhood median. The heat analysis found the hottest part of the neighborhood to be the Eagle Hill and Day Square areas, where daytime temperatures measured at 105°F, and nighttime temperatures measured at 85°F. In waterfront areas, coastal breezes and the proximity to the waterfront moderate temperature increases. Piers Park measured 93°F at 3 p.m., 12°F cooler than Eagle Hill and Day Square areas. Belle Isle Marsh provides a similar cooling effect on nearby areas. Although areas along the coast cool down at night, many residential areas of the neighborhood are still above the city median (daytime is 99.5°F, nighttime is 81.9°F).

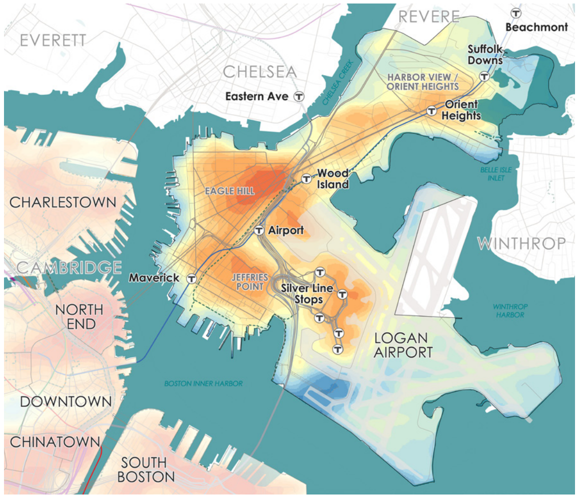
The cooling effects of coastal breezes bring cooler air into the neighborhood at night. East Boston's street grid supports the flow of air through the neighborhood. Streets like Bennington, Chelsea, and Saratoga have a generally southwest to northeast alignment. This direction lines up with prevailing wind patterns in Boston's summer. When wind blows from the coast, it can travel up these streets in a more unobstructed manner, bringing cooler air deeper into the neighborhood.

Contributing factors for East Boston's heat experiences include land cover, arterial roadways, and building density.
East Boston has a higher percentage of impervious surfaces than the city as a whole at 65%. Parklands comprise 11% of the neighborhood's land cover, which include Belle Isle Marsh, East Boston Memorial Park, Mary Ellen Welch Greenway, Piers Park, and Constitution Beach.





Data Source: Tree Canopy Assessment 2019, BPRD



DAYTIME AIR TEMPERATURES

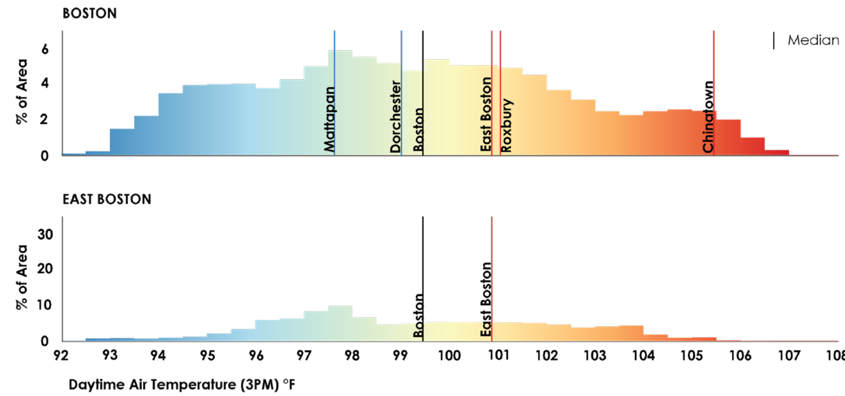
3PM:
AIR TEMPERATURE

More than 107°F

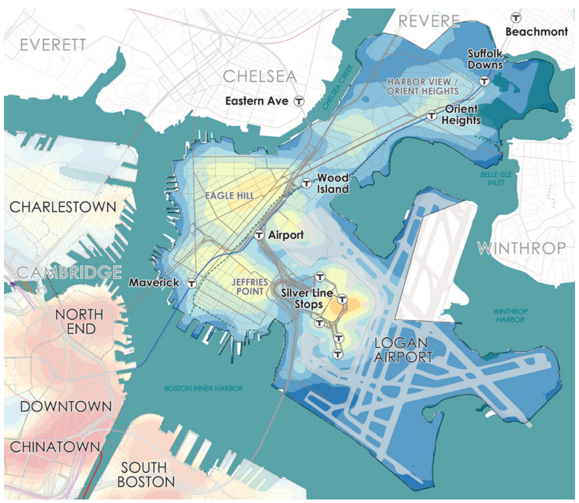
Median: 101°F

City median: 99.5°F

Less than 92°F



Daytime Air Temperature (3 p.m.): Median neighborhood air temperature at 3 p.m. is 1.5°F hotter than the Boston median.



NIGHTTIME AIR TEMPERATURES

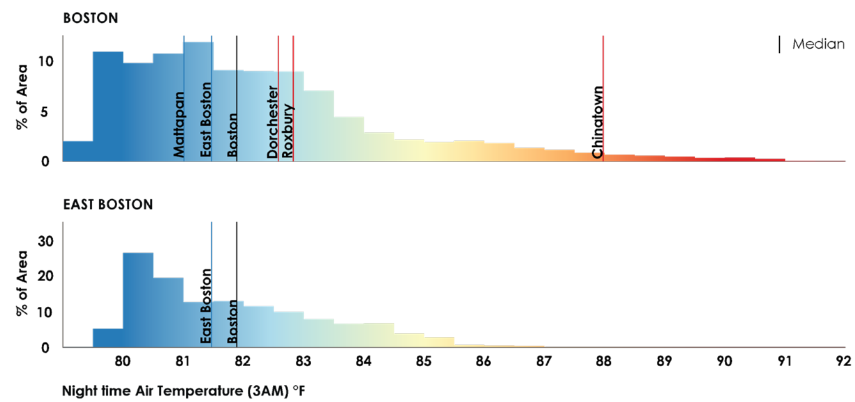
3AM:
AIR TEMPERATURE

More than 90°F

City median: 81.9°F

Median: 81.5°F

Less than 80°F



Nighttime Air Temperature (3 a.m.): Median neighborhood air temperature at 3 a.m. is less than 1°F cooler than the Boston median.

0 0.5 MI

SAMPLE OF HEAT FINDINGS

These three areas illustrate examples of how East Boston's land use affects daytime and nighttime temperatures, based on the citywide heat analysis.

1. ROADWAY INTERCHANGES

Areas with lots of roadway interchanges and infrastructure, like Orient Heights, experience high daytime temperatures. During the evenings, cool air comes into the neighborhood from the coastal areas, bringing temperatures down.

2. MULTIWAY INTERSECTIONS

Neighborhoods with multiway intersections, like eastern Eagle Hill neighborhood and Day Square, have roadways, higher density, less vegetation, and parking lots that contribute to high daytime temperatures. These areas are some of the hotter residential areas at night because they are further from the coast, too far for waterfront breezes to bring cooler air into the area.

3. LARGE SURFACE PARKING LOTS

The areas around the Rental Car Center and north Jeffries Point neighborhood have large parking areas, large building footprints, and few street trees, contributing to high daytime air temperatures. The area's closer proximity to the coastal edge helps it cool down a bit more at night than the Eagle Hill neighborhood, but it is still one of the neighborhood's hotter areas at night.

AREAS EXPERIENCING LONGER HIGH-HEAT EVENTS

- Schools
- Community Healthy Center
- Community Center
- Pools (BCYF and DCR)
- Tot Sprays
- Beaches
- Libraries

Heat Event Duration is the *sum of all the hours during the analysis week (a heat wave week in July 2019) that the local modeled heat index is above 95°F, for days that the nighttime temperature does not drop below 75°F.*

HEAT EVENT HOURS

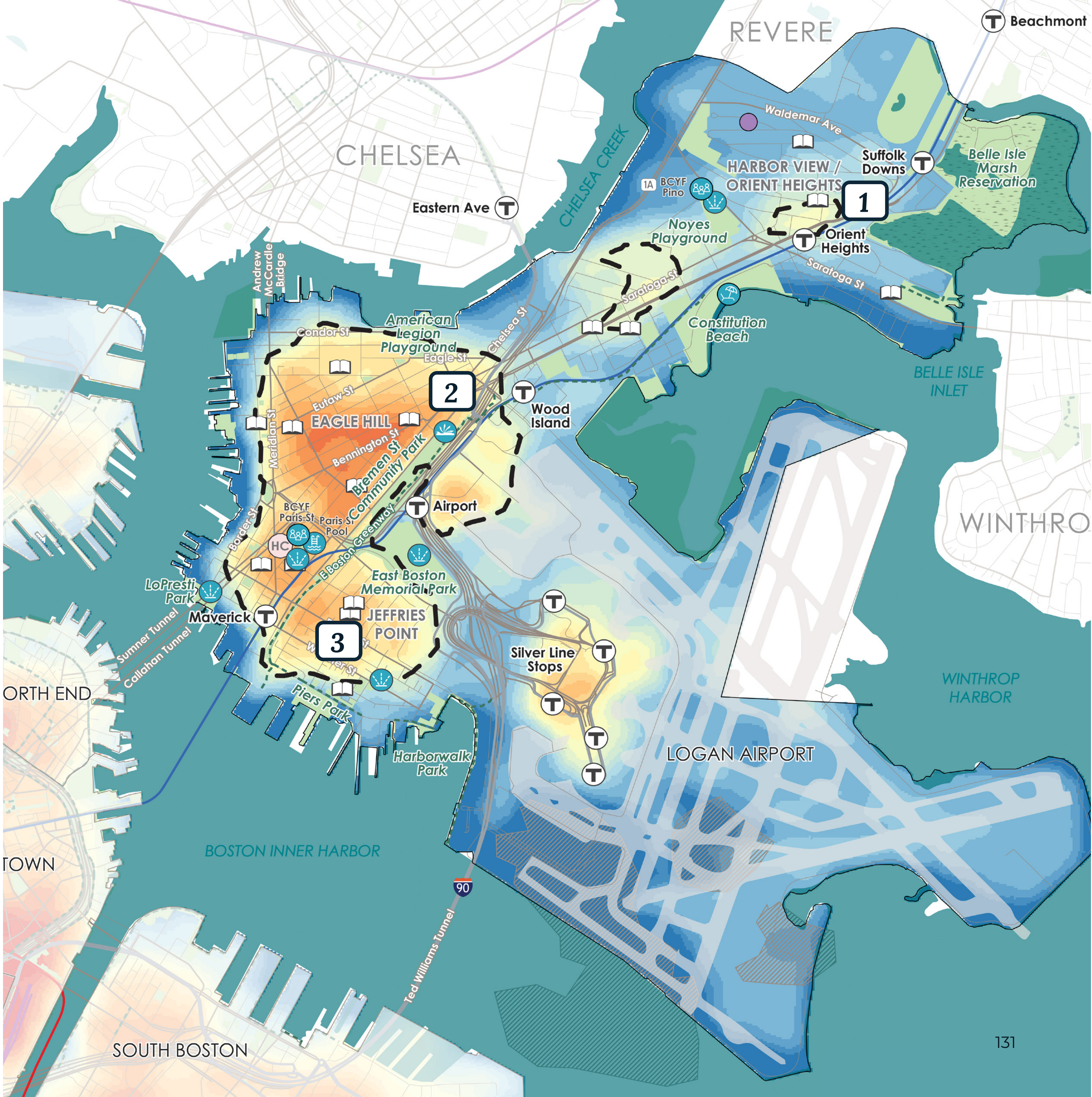
More than 37hrs

30 hrs

Less than 25 hrs

Longest Heat Event (More than 30 hrs)

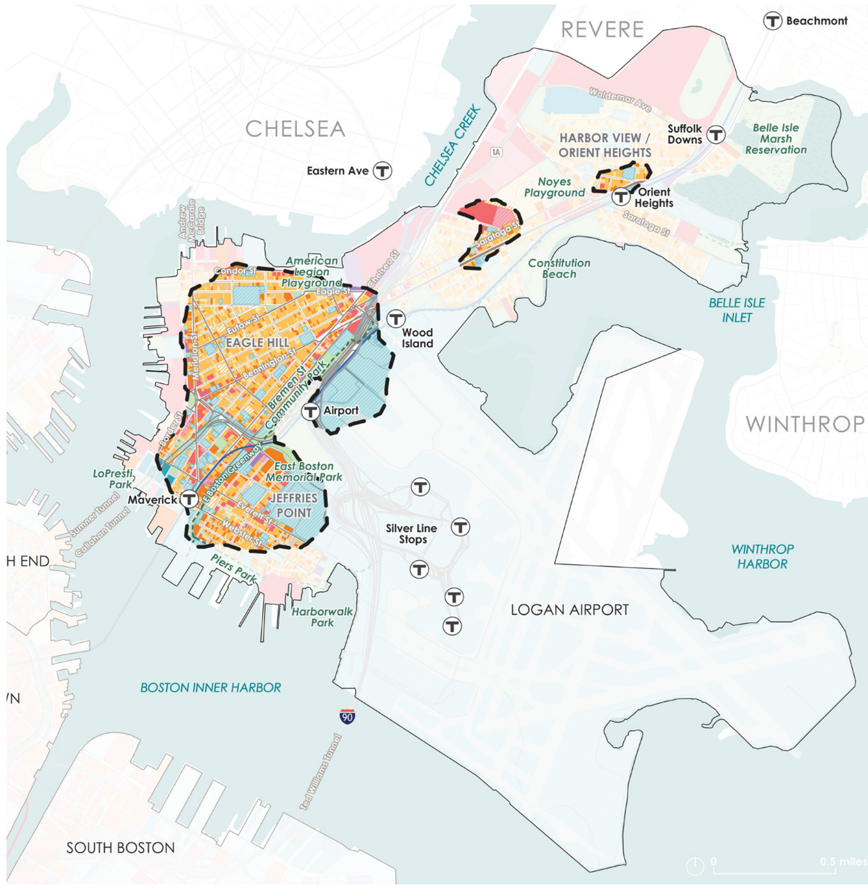
0 0.5 MI



LAND USE AND PEOPLE

Residential and commercial land uses are the most common land uses in the areas of East Boston that experience the most intense and longest heat events. This means that extreme temperatures in East Boston are affecting areas primarily home to homes and businesses, including residents, workers, and visitors to local shops.

As described in Chapter 3, hot weather can create disproportionate health risks for some people, especially for those who are younger or older, who have preexisting health conditions, or who are exposed to heat for longer periods of time. In East Boston, young children (under 5 years) make up 6% of neighborhood residents (compared to 5% citywide), and older adults (over 65 years) make up 9% of neighborhood residents (compared to 12% citywide).[33] Of East Boston's total population, 20% are low-income (compared to 16% citywide), and 81% of housing units are renter-occupied (compared to 64% citywide).[34] Low-income residents and renters may face barriers to home retrofits or affording cooling options.



Data Source: Analyze Boston

Land Use Map: The hottest and most intense areas of East Boston include a mixture of residential and commercial land use.

LAND USE

- *Single-Family Housing*
- *Multi-Family Housing*
- *Apartment (7+ Units)*
- *Condo*
- *Mixed Use*
- *Residential Land*
- *Commercial*
- *Commercial Land*
- *Industrial*
- *Exempt (Chapter 121A)*
- *Exempt*

Longest Heat Event (More than 30 hrs)

0 0.5 MI

POPULATION DENSITY AND HIGH-HEAT EVENT DURATION

- Schools
- Community Healthy Center
- Community Center
- Pools (BCYF and DCR)
- Tot Sprays
- Beaches
- Libraries

High population density in areas lacking cooling centers are facing long and intense heat events, such as the Eagle Hill area.

1 DOT = 5 PEOPLE

HEAT EVENT HOURS

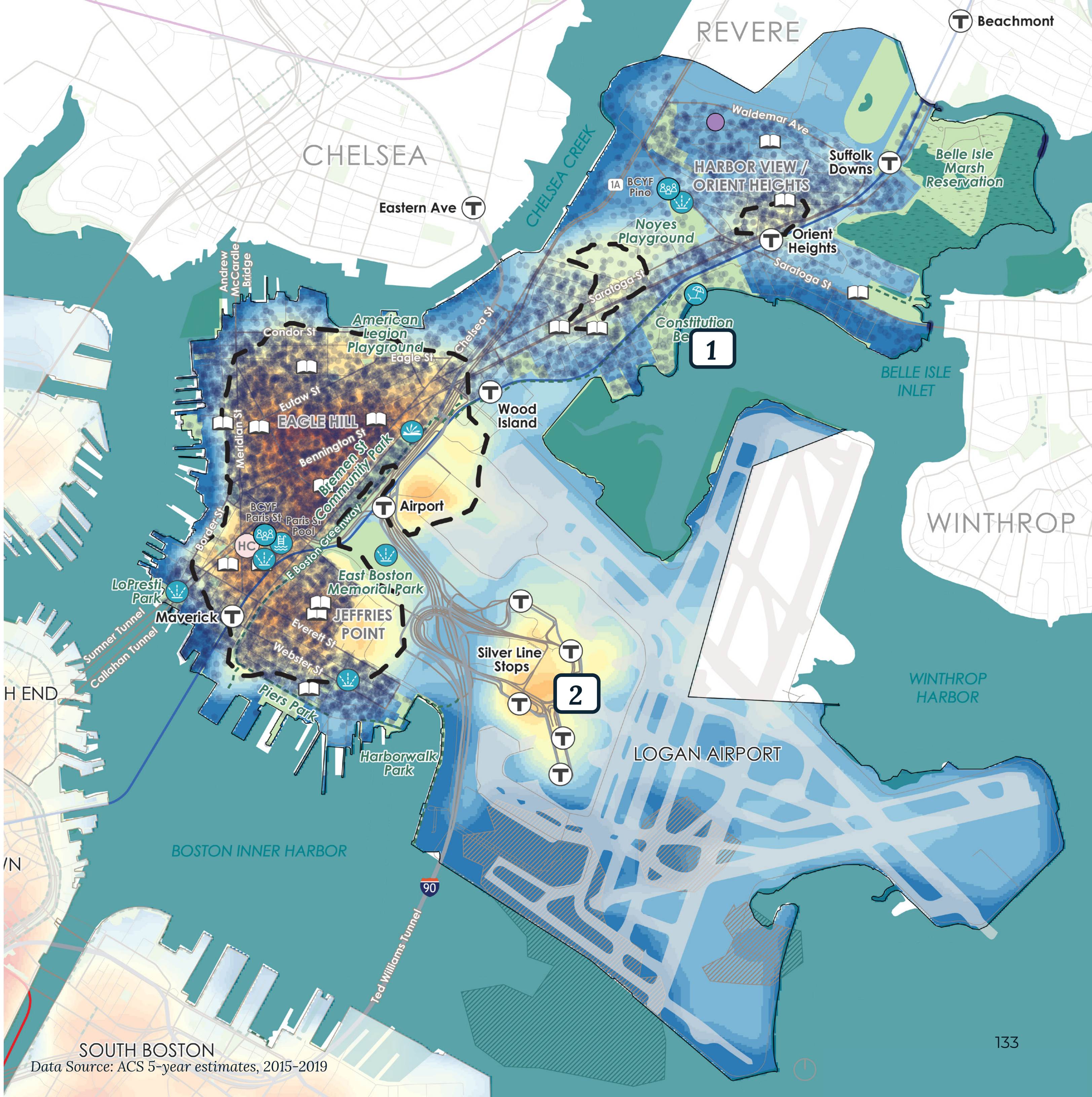
More than 37hrs

30 hrs

Less than 25 hrs

Longest Heat Event (More than 30 hrs)

0 0.5 MI



Data Source: ACS 5-year estimates, 2015-2019

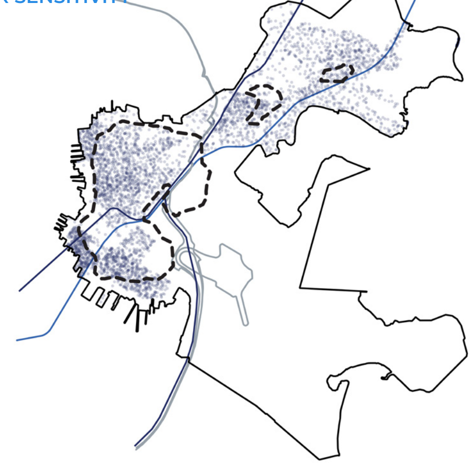
RESIDENT DEMOGRAPHICS AND HEAT DURATION

These maps compare the density of East Boston residents to areas with the longest duration event in the heat analysis. Renter-occupied housing is concentrated in Eagle Hill and Jeffries Point. Lower-income households are also located in Eagle Hill. Due to longer heat events and heat intensity, heat risk may be higher for residents in these areas. Eagle Hill experiences long heat events (35 hours) and intense heat (7°F hotter than areas like Franklin Park).

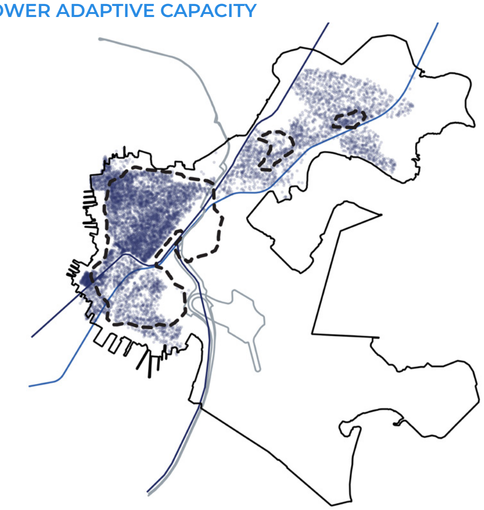
YOUNG CHILDREN (<5 YRS)
HIGHER SENSITIVITY

OLDER ADULTS (>65 YRS)
LOWER ADAPTIVE CAPACITY

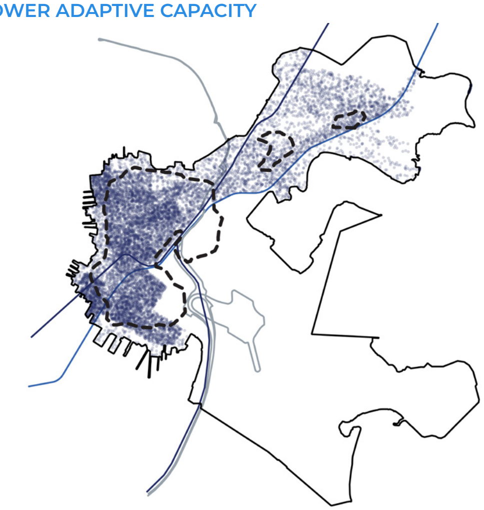
HIGHER SENSITIVITY



LOW-INCOME RESIDENTS
LOWER ADAPTIVE CAPACITY

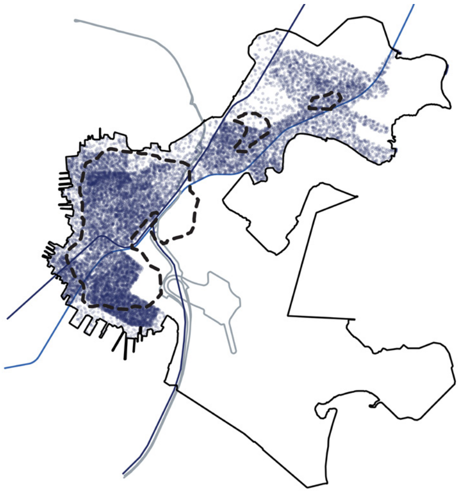


RENTER-OCCUPIED HOUSING
LOWER ADAPTIVE CAPACITY



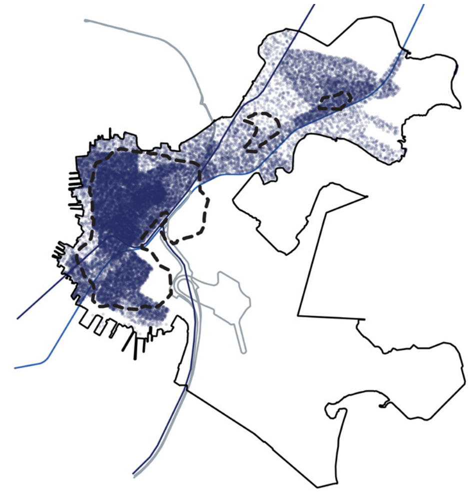
ASIAN

WHITE

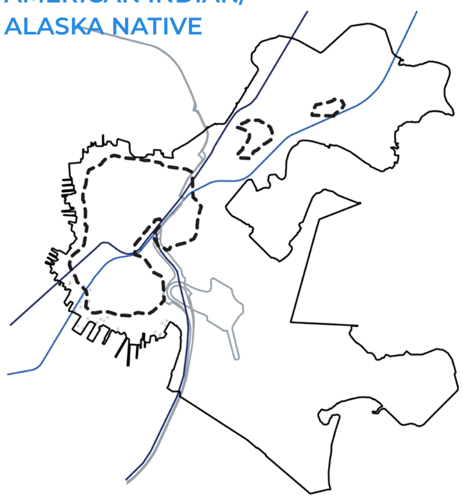


BLACK

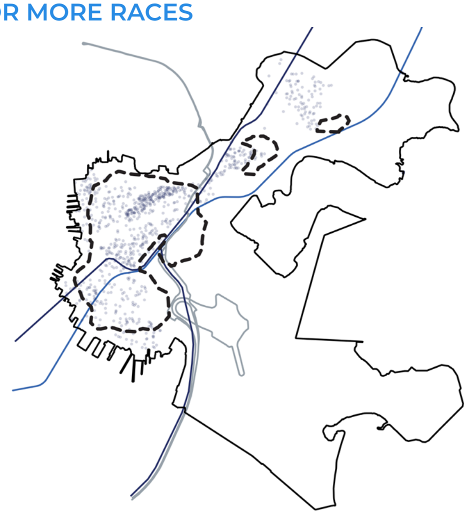
LATINX



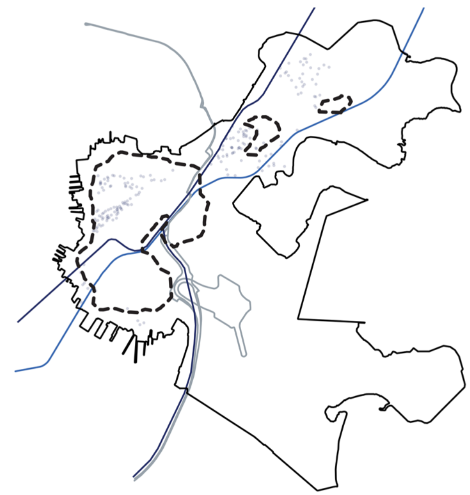
AMERICAN INDIAN/
ALASKA NATIVE



2 OR MORE RACES



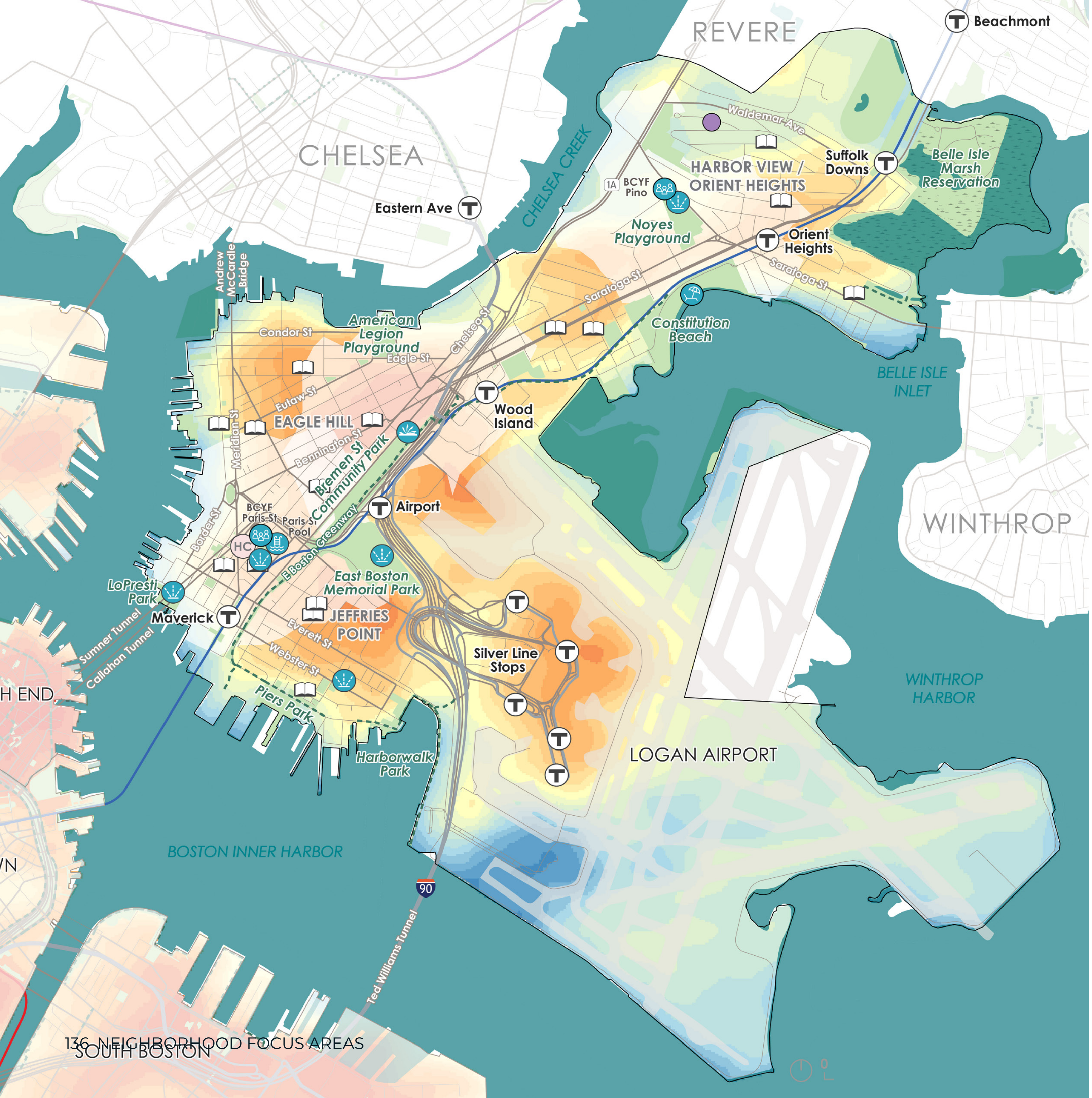
ANOTHER RACE



Data Source: ACS 5-year estimates, 2015-2019

Longest Heat Event (More than 30 hrs)

1 DOT = 1 PERSON



GAPS IN INDOOR COOLING NETWORK

- Schools
- Community Healthy Center
- Indoor Cooling Center
- Pools (BCYF and DCR)
- Tot Sprays
- Beaches
- Libraries

Areas masked in white are within a 10-minute walk of indoor cooling centers and libraries. Areas in orange red experience extreme heat during heat waves, and are not within a 10-minute walk of an indoor cooling center or a library.[i]

3PM:
AIR TEMPERATURE

More than 107°F

Median: 101°F

City median: 99.5°F

Less than 92°F

i BCYF Summer 2020 Cooling centers were used for this map.

0 0.5 MI

COMMUNITY HEAT EXPERIENCES AND COOLING IDEAS

HEAT EXPERIENCES

East Boston residents discussed their heat experiences and cooling ideas during the Neighborhood Ideas Workshop and through responses to the citywide survey. Areas of concern mentioned by participants included the challenges of cooling in older homes, air pollution, dark surfaces, new development increasing temperatures, cooling for young people, hot outdoor spaces and transit stops, and potential barriers to the use of city cooling centers by undocumented community members.

The current system of individual residents requesting street trees in front of their properties only reproduces existing inequities

Cooling centers aren't the most accessible or comfy places: pocket parks as an informal cooling center as alternative

COMMUNITY COOLING IDEAS

East Boston residents suggested cooling strategies that adapt the civic realm to better serve the community on hot days, cool the built environment, and promote equity in access to cooling. Residents shared the following ideas to increase access to cooling in East Boston:

» Accessible public indoor cooling:
Opportunities to increase access to indoor air-conditioned spaces without real or perceived barriers to entry for all community members

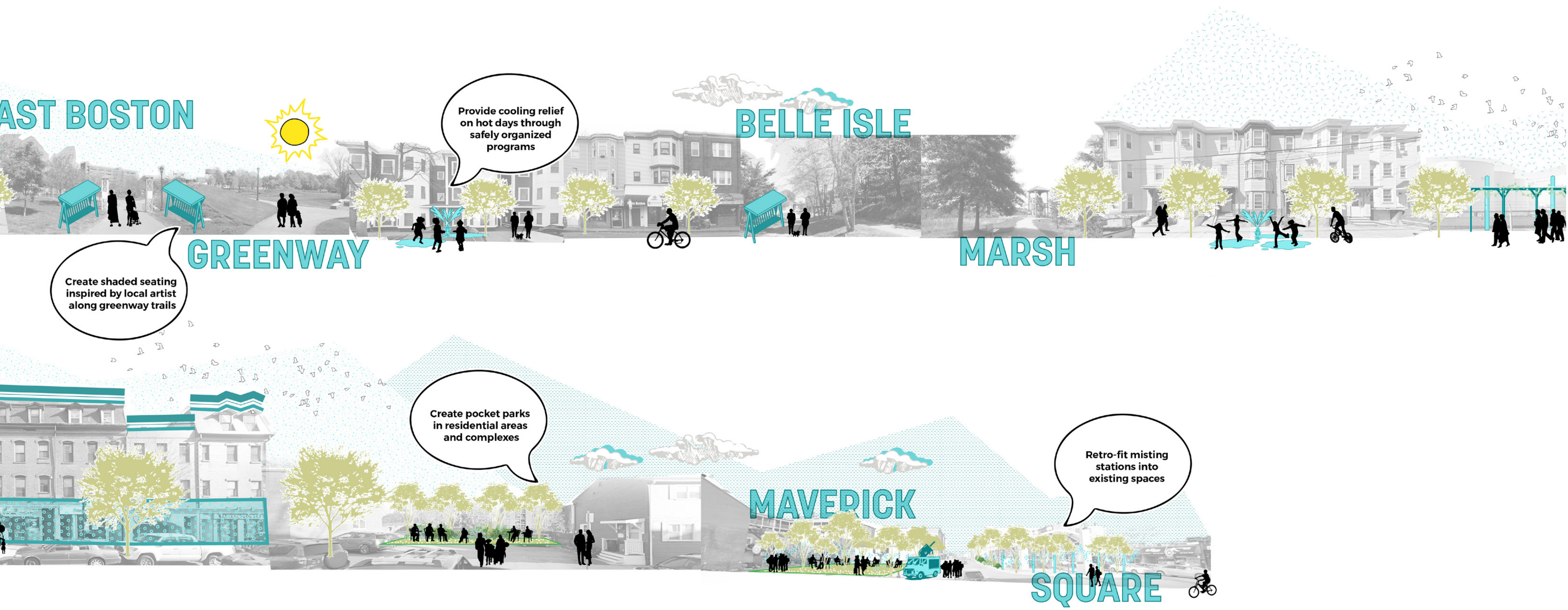
» Staying cool at home:
Opportunities for retrofitting homes

» Cooling the built environment:
Opportunities for additional trees coupled with maintenance strategy, lighter-colored pavement, heat resilient zoning, and development review

» Community partnerships:
Opportunities to partner with and support community-based organizations to advance heat resilience, and partnerships with local entrepreneurs to offer cool beverages or ice cream

» Cooler outdoor gathering places:
Opportunities for more hydration stations, cooler playgrounds, shaded bus stops, cooling strategies implemented in neighborhood squares, and shade and fans at bus stops and T stations

OPPORTUNITIES FOR A COOLER EAST BOSTON


AST BOSTON
GREENWAY
Create shaded seating inspired by local artist along greenway trails
Provide cooling relief on hot days through safely organized programs
BELLE ISLE
MARSH
Create pocket parks in residential areas and complexes
MAVERICK
SQUARE
Retro-fit misting stations into existing spaces

HEAT RESILIENCE OPPORTUNITIES

This section describes key needs for heat reduction or increasing access to cooling resources and opportunities to integrate resilience, based on neighborhood-level heat analysis and community feedback.

While all the strategies may be relevant to each neighborhood, each section lists specific heat resilience strategies that respond to the particular needs that have been identified. More details on the strategies listed below can be found in Chapter 6: Citywide Heat Resilience Strategies.

SHADED, VEGETATED, COOL WALKS TO LOCAL DESTINATIONS

Many residents mentioned uncomfortable conditions for transit riders, in part due to less tree canopy than in other Boston neighborhoods. Specific hot streets named by residents included Bennington Street, Lexington Street, and Meridian Street. Buses stop along those corridors, so people are more likely to use these streets to walk to other local destinations. Streets with higher levels of pedestrian and transit uses are particularly appropriate for additional shade and cooling strategies like vegetation and shade structures.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 7.1: COOL COMMUTES

STRATEGY 7.3: COOL MAIN STREETS

COOL, SHADED PAVEMENT AND SURFACE PARKING

Many of East Boston's hottest areas include large surface parking lots and parking structures with limited tree canopy. The neighborhood heat modeling shows shading pavement can reduce surface and air temperatures by 11 to 24°F and 3 to 12°F, respectively, depending on the material and opacity of the shade structure.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 6.1: ENHANCED COOLING IN POCKET PARKS AND STREET-TO-PARK CONVERSIONS

STRATEGY 6.2: INCREASED SHADE ON MUNICIPAL SITES

COOL SCHOOLS

Many of East Boston's schools are located in areas with high daytime air temperatures, based on the heat analysis. Opportunities for indoor and outdoor cooling—like air conditioning upgrades, outdoor shading structures and vegetation, and educational information on heat—could be prioritized at these schools. For example, Kennedy Patrick Elementary is located in an area where daytime air temperatures reached 105°F in the heat analysis.

RELATED HEAT RESILIENCE STRATEGIES

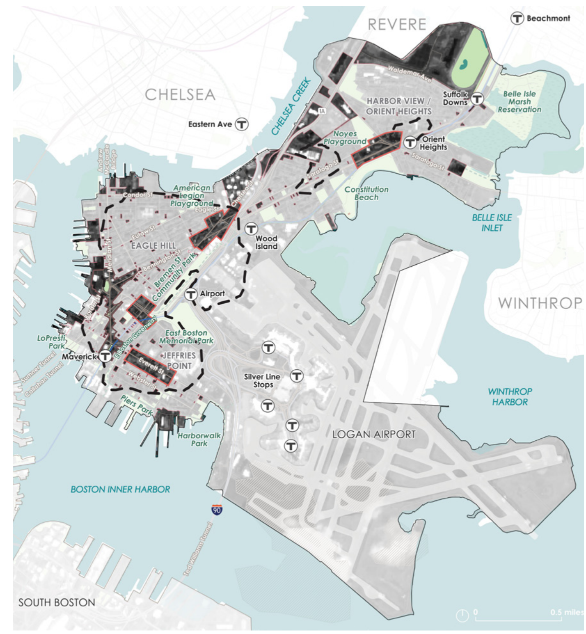
STRATEGY 5.5: COOL SCHOOLS

SHADE AND COOL ROOFS ALONG MAIN STREETS AND IN COMMERCIAL AREAS

Many surfaces along main streets and commercial areas are dark, contributing to high heat exposure. These areas also have higher pedestrian volumes. Better thermal performance in roofs, as well as more vegetation along primary corridors, would help reduce air temperatures. Programs to support small businesses and community organizations along main streets and commercial areas can reduce air temperatures and increase pedestrian safety.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 5.2: COOL ROOFS PROGRAM



SURFACE REFLECTANCE

High Albedo
Light surfaces or highly reflective roofs

Low Albedo
Very dark roofs or water

Many roofs and surfaces in mixed-use neighborhood centers and corridors are dark, contributing to hotter temperatures.

Longest Heat Event (More than 30 hrs)

COOL HOMES

Providing support for homeowners and landlords to make improvements could help people stay cool in their homes. This strategy could especially benefit areas of East Boston beyond a 10-minute walk from cooling centers or that experience the longest duration heat events, based on the heat analysis.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 5.1: HOME COOLING RESOURCES DISTRIBUTION

STRATEGY 5.3: HOME ENERGY RETROFITS

STRATEGY 5.4: AFFORDABLE HOUSING RESOURCES AND RETROFITS

MORE SHADED GATHERING SPACES WITH NATURAL PLAY SPACE

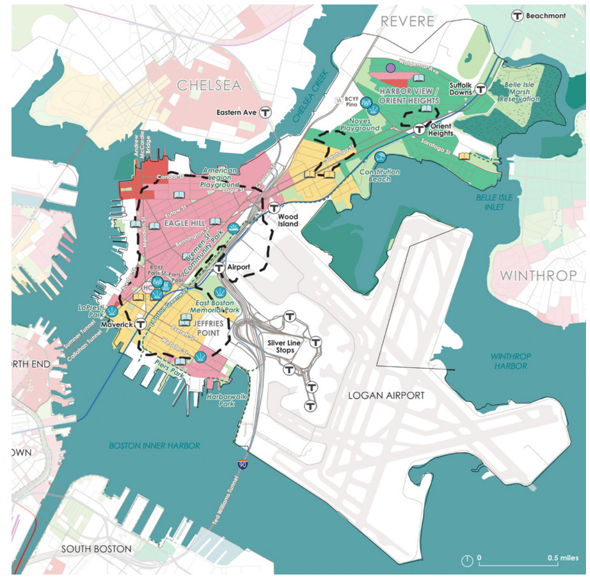
Some parks are hotter than others, and some areas of East Boston have less park and greenspace access. The heat analysis measured daytime temperatures at Noyes Playground at 102°F, 4°F higher than Piers Park. Noyes Playground has a hard surface playground and three large fields with few trees and shade. Hotter areas of East Boston, like the Eagle Hill neighborhood, could be cooler with additional vegetation trees and open spaces.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 2.1: POP-UP HEAT RELIEF

STRATEGY 6.1: ENHANCED COOLING IN POCKET PARKS AND STREET-TO-PARK CONVERSIONS

STRATEGY 6.4: PLANNING FOR FUTURE PARKS



PARK ACCESS PER 1000 RESIDENTS

- 0 Acres
- 0-2 Acres
- 2-5 Acres
- 5-10 Acres
- 10-50 Acres
- 50+ Acres

Many areas of East Boston that experience longer duration high-temperatures also have less public open space per capita.

Longest Heat Event (More than 30 hrs)

INDOOR COOLING NETWORK

East Boston has two BCYF centers: Paris Street and Pino. Based on a 10-minute walk analysis from indoor BCYF cooling centers and libraries, some East Boston residents have little access to public indoor cooling centers. Of East Boston's two BCYF centers, only one (Paris Street) functioned as a designated public cooling center in heat emergencies during 2021.[35] The East Boston Branch of the BPL provides another public air-conditioned option. Additional alternatives for indoor cooling could expand, especially for areas not currently within a 10-minute walk of a library or community center. An expanded network could increase cooling options for low-income residents and renters in hotter areas of East Boston, such as northwest of Eagle Hill. The expanded network could also include community cooling network partners, such as churches, community recreation providers, and other community-based organizations. Community cooling network spaces could expand access by providing spaces that residents will feel comfortable visiting, while exploring ways to adjust potential barriers like registration that may concern some residents who are recent immigrants.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 2.2: ENHANCED AND EXPANDED CITY-RUN COOLING CENTERS

STRATEGY 2.3: CITYWIDE COOLING NETWORK

RESILIENT DESIGN FOR NEW DEVELOPMENT

Like many Boston neighborhoods, East Boston has been experiencing increasing development pressures in many parts of the neighborhood. Chapter 6 of this document includes three strategies related to development review, zoning, and heat resilience design guidelines. Continuing to support and expand affordable housing options is a priority throughout Boston.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 8.1: UPDATED CLIMATE RESILIENCY CHECKLIST

STRATEGY 8.2: HEAT RESILIENCE BEST PRACTICE GUIDELINES

STRATEGY 8.3: ZONING REVISIONS TO SUPPORT COOLER NEIGHBORHOODS

MATTAPAN


HUNT ALMONT PLAYGROUND


MATTAPAN SQUARE
BLUE HILL AVE
AMERICA'S LARGEST INJURY LAW FIRM
MORGAN & MORGAN


MATTAPAN
OMMUNITY
ALTH CENTER
BLUE HILL BOYS & GIRLS CLUB
HARAMBEE PARK


RYAN WADING POOL

NEIGHBORHOOD CONTEXT

Although Mattapan experiences daytime and nighttime temperatures similar to Boston's median temperatures, its history and land use patterns have increased the neighborhood's vulnerability to extreme temperatures.

Mattapan is a medium-density neighborhood in the southwestern part of Boston. It is a family-centric neighborhood where 68% of households identify as families, compared with only 48% of households in the city as a whole.[36] Over 40% of the housing units are single family residences, and 50% of the housing units are in two-family or three-family buildings. Several large churches and a tight-knit Hatian immigrant community contribute to neighborhood stability and strong community ties.

Mattapan's civic and commercial destinations are in some of the neighborhood's hottest areas. Mattapan Square lies at the intersection of River Street and Blue Hill Avenue, and is home to many local shops and restaurants, but relatively few street trees or other shade features. Many of these places are often the sites of outdoor gatherings but are also surrounded by impervious surfaces, which tend to be surfaces that heat up throughout the day if unshaded. Along Blue Hill Avenue, community institutions such the library, schools, and community centers provide touchpoints for community members throughout the neighborhood. Neighborhood parks and open spaces, like Almont Playground, the Mattahunt Woods, and Ryan Playground, offer recreational opportunities for Mattapan residents and a place to cool down.

Commuting directly relates to Mattapan residents' heat experience. Over 50% of Mattapan residents take personal vehicles to work. Local sections of arterial roads in Mattapan are more congested than other sections of the same road.[37] The traffic congestion on local roads generates more air pollution, which can affect the health of residents and can make it harder to breathe during hot weather, especially for residents with asthma. The areas around Mattapan Square and Morton Street Station experience the hottest daytime temperatures in the neighborhood and have some of the least amount of shade and vegetation. These conditions affect the health and comfort of many of Mattapan's many transit riders who walk to the stations daily.

Housing affordability is a major concern for residents, but recent development pressure may create opportunities to address these and other concerns. In response to housing demand, new housing is being proposed near several of Mattapan's transit stops. As in communities across Boston, residents of Mattapan are advocating for new developments to include streetscape and public realm improvements, which would not only benefit residents of the new development but community members who pass the new development on their way to other local destinations.

RECENT AND ONGOING PLANNING EFFORTS

» PLAN: Mattapan

» Blue Hill Avenue Transportation Action Plan

» Blue Hill Avenue/Cummins Highway Station Area Plan

» Cummins Highway Design Trial

- Parks
- Greenways
- Major Roads
- Mattapan Trolley
- MBTA Red Line
- MBTA Commuter Rail
- MBTA Station

COMMUNITY ASSETS

- School
- Libraries
- Police Station
- Fire Station
- Hospital
- Community Health Center
- 1 Mattahunt Community Center
- 2 Mildred Avenue Community Center
- 3 Gallivan Community Center
- BHA Public Housing: Elderly/Disabled
- BHA Public Housing: Family

Mattapan's community assets and landmarks are well-distributed throughout the neighborhood.

HEAT ANALYSIS

Hot Days, Cooler Nights.
Mattapan's daytime and nighttime median temperature were 97.6°F and 81°F in the heat analysis, respectively, both of which were cooler than the city's median (daytime is 99.5°F and nighttime is 81.9°F). Of the five environmental justice neighborhoods, Mattapan had the coolest temperatures based on the heat analysis.

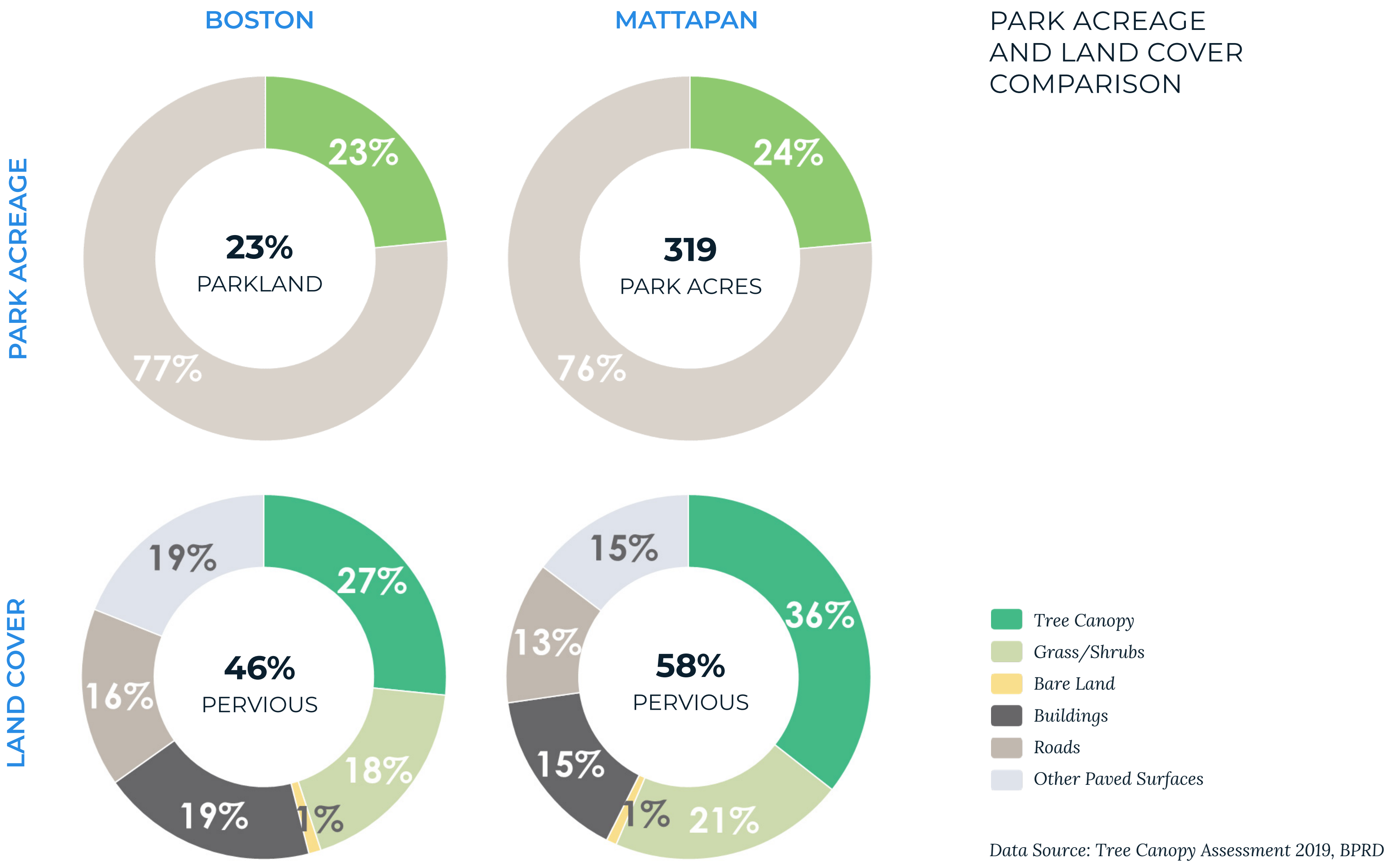
Importantly, even though the temperatures do not climb as high in Mattapan during a heat wave as in the other neighborhoods, heat resilience and access to cooling is still important. On average, Mattapan experienced 29 hours of extreme temperature conditions that exceeded Boston's heat emergency level (above 95°F and nighttime lows above 75°F) based on the week-long heat analysis.[38] Heat exposure (i.e., intensity and duration), sensitivity, and adaptive capacity are critical factors that contribute to the risk of heat-related health problems. While Mattapan is not Boston's hottest environmental justice neighborhood, heat still poses significant risks for some residents, especially for residents with elevated risk factors: those who are younger or older, lack air conditioning or access to cooling, experience limited mobility, or have preexisting health conditions. See Chapter 3 for more details on factors that increase heat-related health risks.

Temperatures vary across the neighborhood. The hottest part of the neighborhood is around Morton Street Station, where daytime temperatures were measured over 100°F in the heat analysis. The western part of Mattapan remains relatively cool during both daytime and nighttime, with temperatures of 94°F and 80°F, respectively. However, nighttime temperatures above 80°F can still be uncomfortable for people, especially those at higher risk of heat-related illness.

The temperatures experienced in different parts of Mattapan reflect different patterns of building density, tree canopy, and green space.
Of the five neighborhoods, Mattapan has the lowest percentage of impervious surfaces at 42%, which is lower than the citywide percentage. Approximately 51% of the land cover is tree canopy, grass, or shrubs, and 24% of the neighborhood is dedicated to parks.[39] These factors can help moderate temperature increases, especially in the parts of the neighborhood that are closest to green space and forests. Mattapan's relatively low-density development pattern in some residential areas allows for significant tree canopy coverage in backyards, though sidewalks and local streets remain largely unshaded.

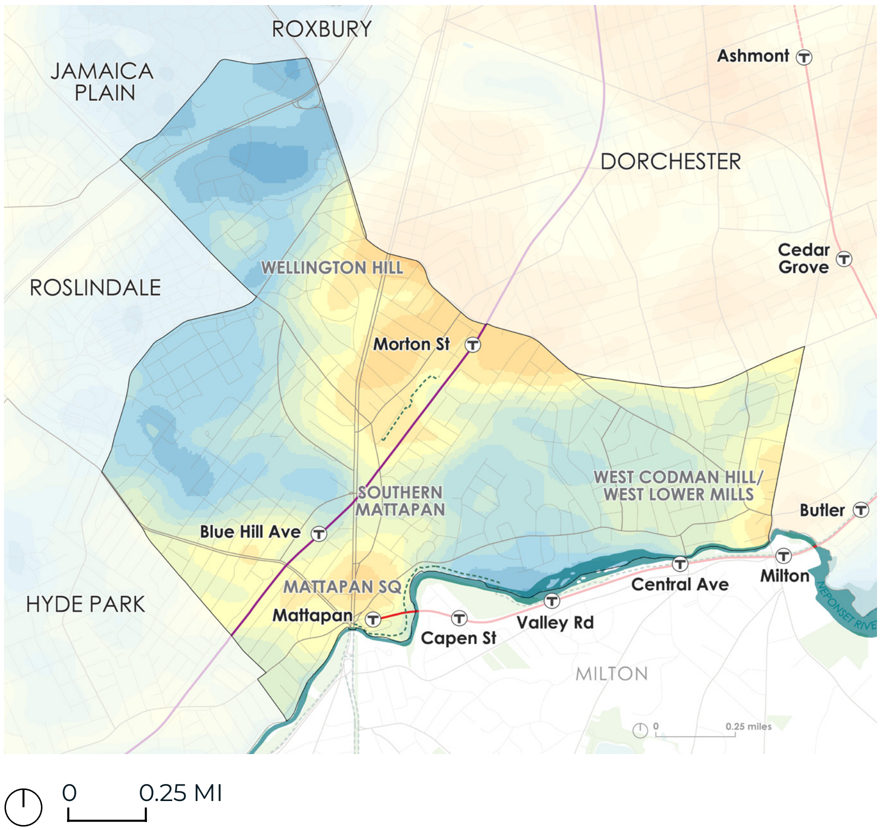
Factors contributing to hotter temperatures in other parts of the neighborhood include unshaded pavement and streets. Arterial streets, especially wider ones like Blue Hill Avenue and Cummins Highway, have few street trees to shade the pavement, which heats up during the day. In addition, large paved areas, mostly for parking, serve the commercial, religious, and community institutions in Mattapan, but absorb heat and offer little shade for pedestrians.

PARK ACREAGE AND LAND COVER COMPARISON

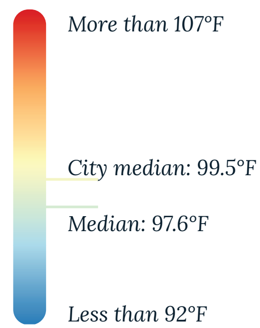


Data Source: Tree Canopy Assessment 2019, BPRD

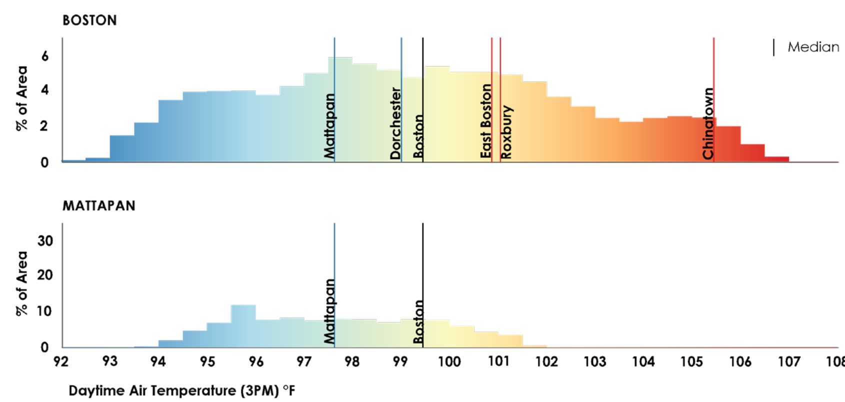
DAYTIME TEMPERATURES



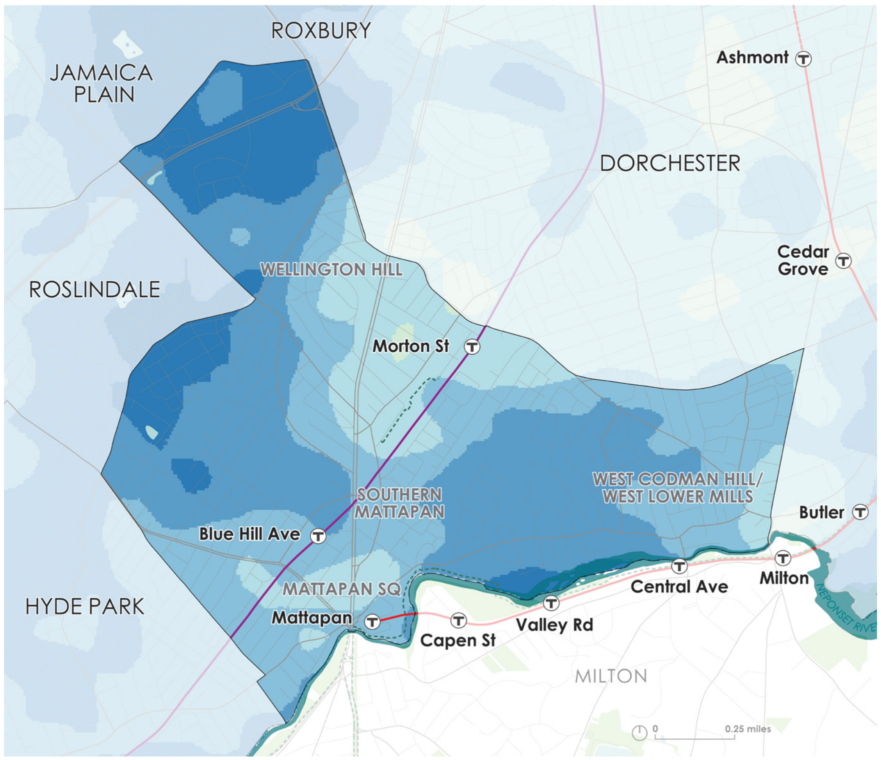
3PM:
AIR TEMPERATURE



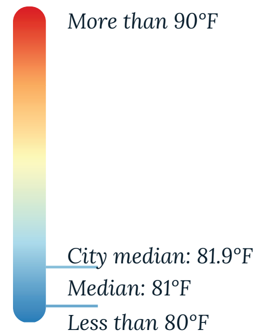
Daytime Air Temperature (3 p.m.): Daytime air temperature is hottest near the Morton Street and Mattapan T stations.



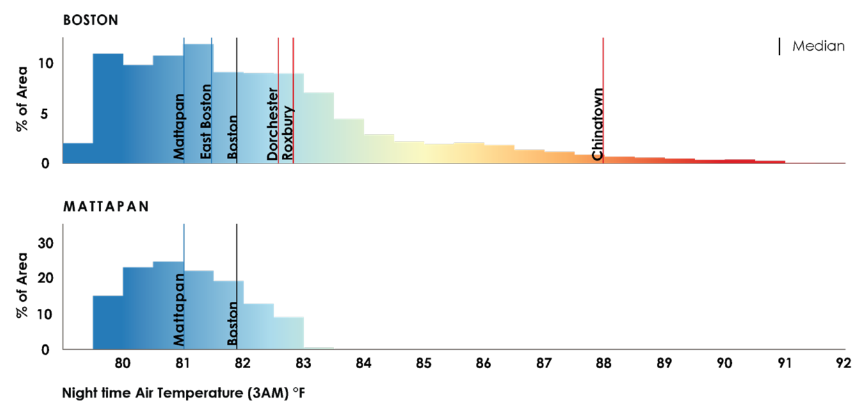
NIGHTTIME TEMPERATURES



0 0.25 MI



Nighttime Air Temperature (3 a.m.): Nighttime air temperatures are relatively cool in the residential areas of the neighborhood.



SAMPLE OF HEAT FINDINGS

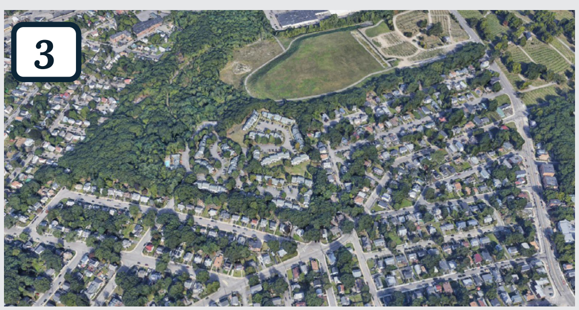
These three areas illustrate examples of how Mattapan's land use affects daytime and nighttime temperatures, based on the citywide heat analysis.

1. TRANSIT HUBS

The areas around transit hubs are hotter because they are often surrounded by large, unshaded paved areas and nearby development is often higher density with dark roofs, as seen near Morton Street Station. Based on the heat analysis, the Morton Street Station measured air temperatures around 100°F during the day. At night, the temperatures cooled to 82°F, similar to the city median.

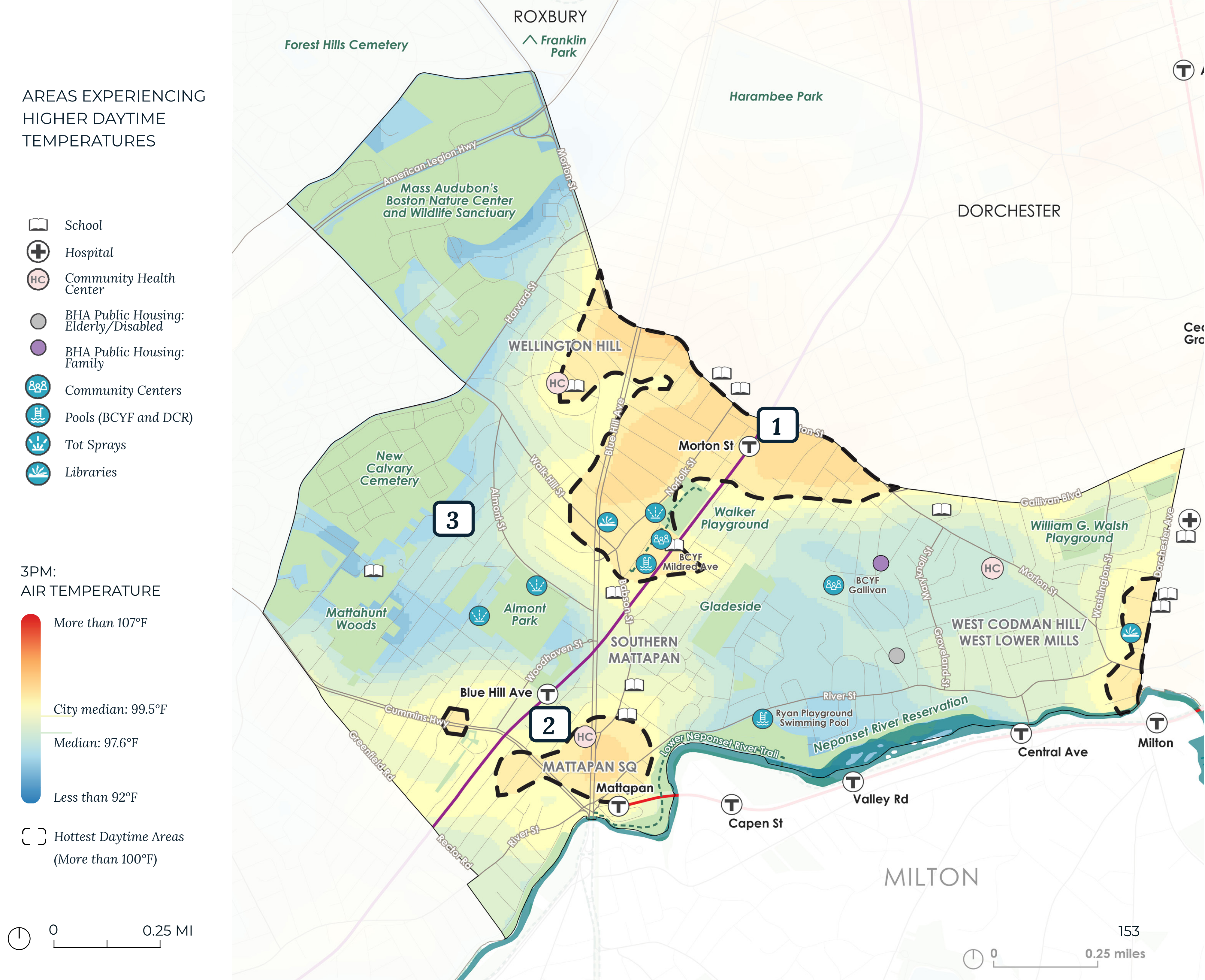
2. SQUARES AND CORRIDORS

Active squares and corridors like Mattapan Square have significant paved areas and a high density of buildings with dark roofs and limited tree canopy in the commercial area. These factors all contribute to higher daytime temperatures. Proximity to the forested areas on the Neponset River corridor helps cool the area to the south of Mattapan Square at night.



3. LOWER DENSITY RESIDENTIAL NEIGHBORHOODS

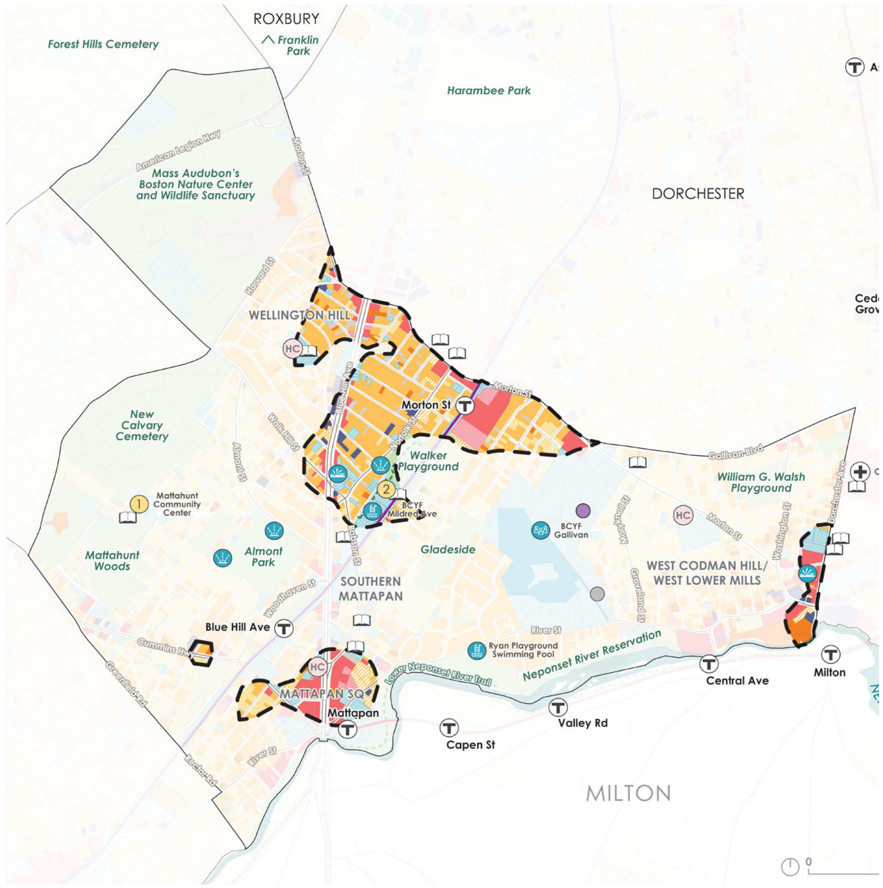
During the day, lower density residential neighborhoods, like the western areas of Mattapan, are significantly cooler than the median temperature in Boston, and remain cooler at night. Temperatures do not climb as high in this area because of the significant tree canopy, and the neighborhood development pattern of single-family homes offers more space between buildings, which increases airflow. Many homes have lighter roofs which reflect the sun during the day.


AREAS EXPERIENCING HIGHER DAYTIME TEMPERATURES
School
Hospital
Community Health Center
BHA Public Housing: Elderly/Disabled
BHA Public Housing: Family
Community Centers
Pools (BCYF and DCR)
Tot Sprays
Libraries
3PM:
AIR TEMPERATURE
More than 107°F
City median: 99.5°F
Median: 97.6°F
Less than 92°F
Hottest Daytime Areas (More than 100°F)
0
0.25 MI
ROXBURY
Forest Hills Cemetery
Franklin Park
Harambee Park
DORCHESTER
American Legion Hwy
Mass Audubon's Boston Nature Center and Wildlife Sanctuary
Morton St
Harvard St
WELLINGTON HILL
HC
1
Morton St
Blue Hill Ave
Walk Hill St
Norfolk St
New Calvary Cemetery
3
Almont St
Walker Playground
BCYF Mildred Ave
Gallivan Blvd
William G. Walsh Playground
BCYF Gallivan
HC
Morton St
Washington St
Dorchester Ave
Mattahunt Woods
Almont Park
Babson St
Gladeside
WEST CODMAN HILL/ WEST LOWER MILLS
SOUTHERN MATTAPAN
Woodhaven St
Blue Hill Ave
Cummins Hwy
Greenfield Rd
River St
Ryan Playground Swimming Pool
Neponset River Reservation
2
HC
MATTAPAN SQ
Lower Neponset River Trail
Mattapan
Central Ave
Milton
Valley Rd
Capen St
River St
Rector Rd
MILTON
0
0.25 miles

LAND USE AND PEOPLE

Denser multi-family residential buildings and commercial or mixed-use areas experience the hottest temperatures in Mattapan. Density, some brick buildings, and the lack of vegetation contribute to higher heat experiences by residents, workers, and neighborhood visitors.

As previously described, hot weather can create disproportionate health risks for some people, especially for those who are younger or older, who have preexisting health conditions, or who are exposed to heat for longer periods of time. In Mattapan, young children (under 5 years) make up 7% of neighborhood residents (compared to 5% citywide), and older adults (over 65 years) make up 13% of neighborhood residents (compared to 12% citywide).[40] Of Mattapan residents, 19% are low-income (compared to 16% citywide), and 62% of housing units are renter-occupied (compared to 64% citywide).[41] Low-income residents and renters may face barriers to home retrofits or affording cooling options.



Data Source: Analyze Boston

Land Use Map: The hottest and most intense areas in Mattapan include a mixture of residential and commercial land use.

LAND USE

- *Single-family Housing*
- *Multi-family Housing*
- *Apartment (7+ Units)*
- *Condo*
- *Mixed Use*
- *Residential Land*
- *Commercial*
- *Commercial Land*
- *Industrial*
- *Exempt (Chapter 121A)*
- *Exempt*
- *Hottest Daytime Areas (More than 100°F)*

0 0.25 MI

POPULATION DENSITY AND HIGH-HEAT EVENT DURATION

School

Hospital

Community Health Center

BHA Public Housing: Elderly/Disabled

BHA Public Housing: Family

Community Centers

Pools (BCYF and DCR)

Tot Sprays

Libraries

The areas experiencing longer and more intense heat are also the areas that have the highest population density.

1 DOT = 5 PEOPLE

3PM:
AIR TEMPERATURE

More than 107°F

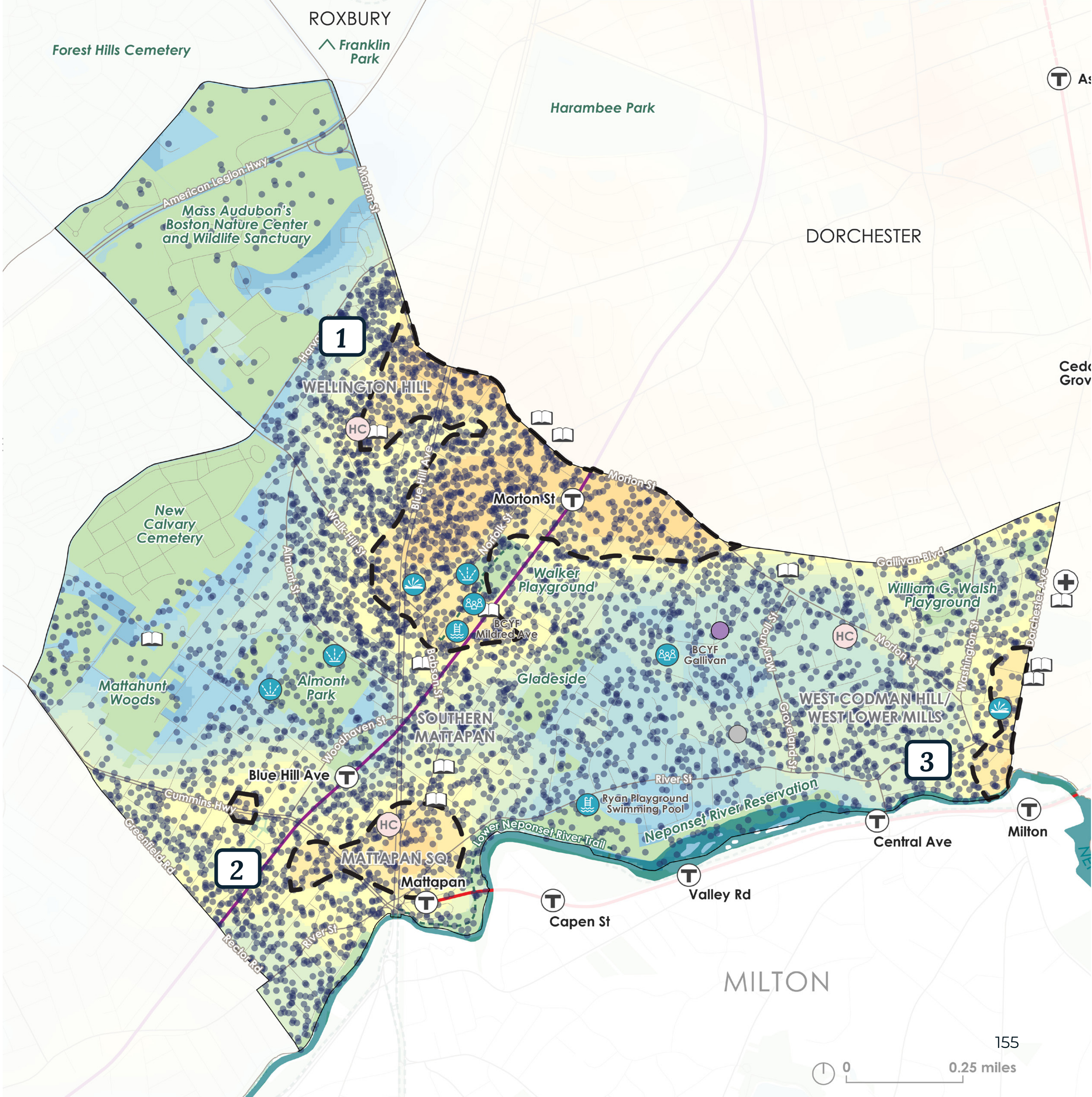
City median: 99.5°F

Median: 97.6°F

Less than 92°F

Hottest Daytime Areas (More than 100°F)

0 0.25 MI



RESIDENT DEMOGRAPHICS AND HEAT DURATION

These maps compare the density of Mattapan residents to the areas in Mattapan that experience the hottest daytime temperatures in the heat analysis. The areas experiencing longer and more intense heat are also the areas that have a high density of low-income and renter-occupied housing. Due to longer heat event duration (29 hrs) and intensity (3.7 to 4.5°F above Franklin Park), heat risk may be higher for residents in these areas. Strategies that increase adaptive capacity should be prioritized in areas such as around the Morton Street Station, Mattapan Square, and the eastern Dorchester border.

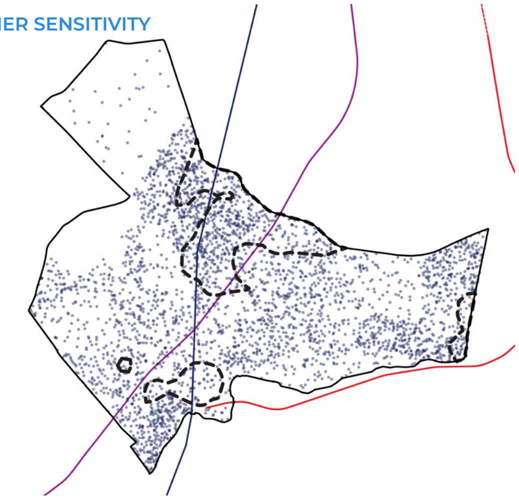
YOUNG CHILDREN (<5 YRS)

HIGHER SENSITIVITY

OLDER ADULTS (>65 YRS)

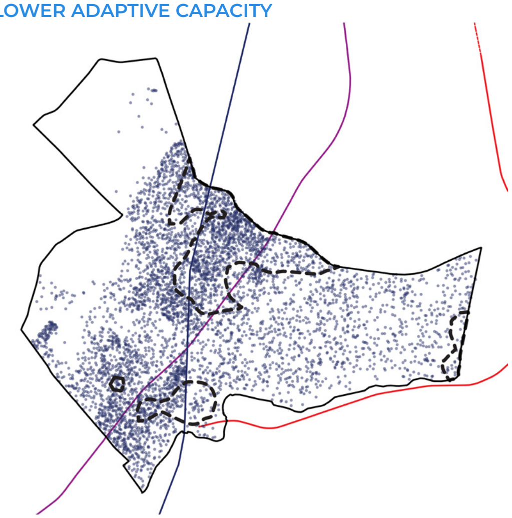
LOWER ADAPTIVE CAPACITY

HIGHER SENSITIVITY



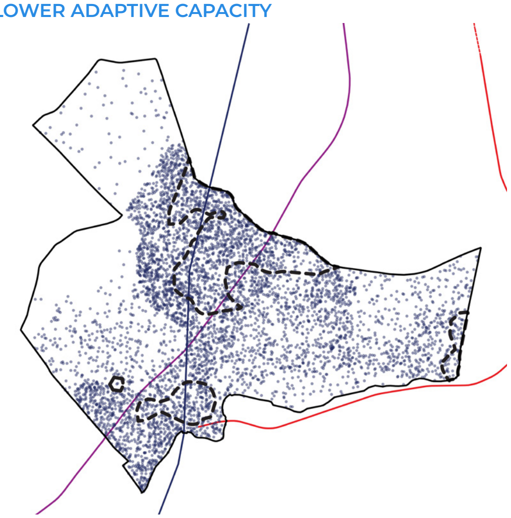
LOW-INCOME RESIDENTS

LOWER ADAPTIVE CAPACITY



RENTER-OCCUPIED HOUSING

LOWER ADAPTIVE CAPACITY



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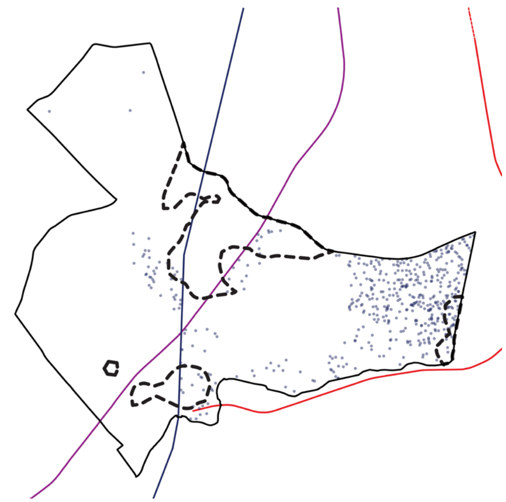

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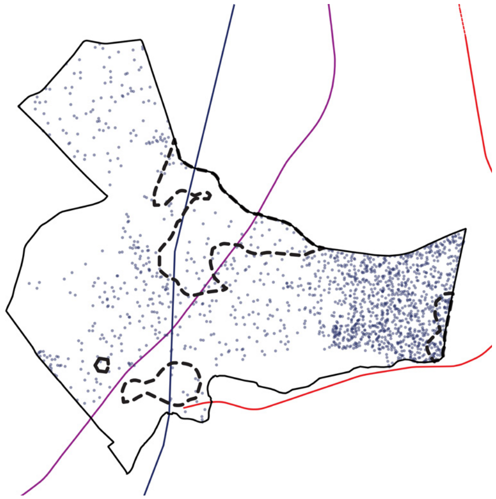

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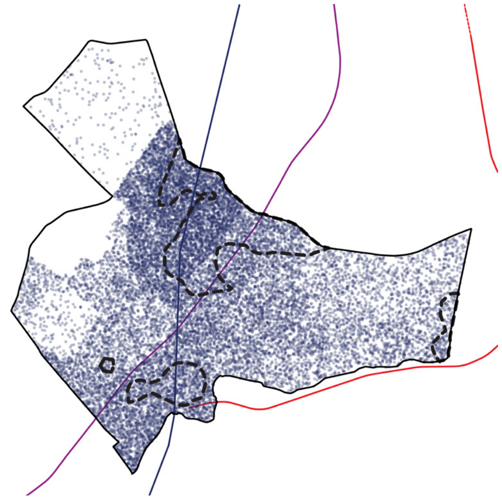
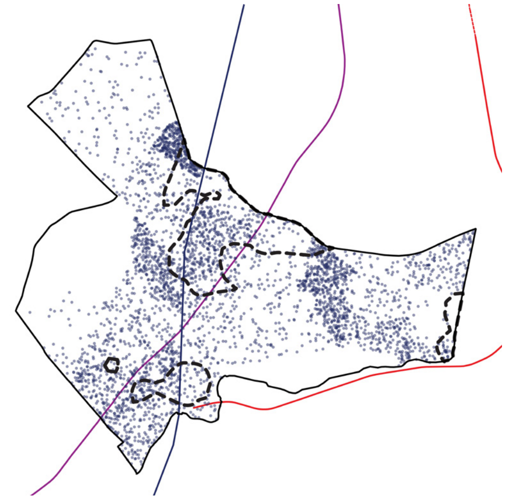
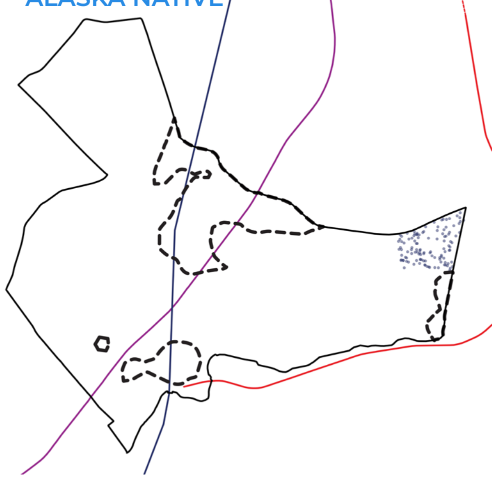


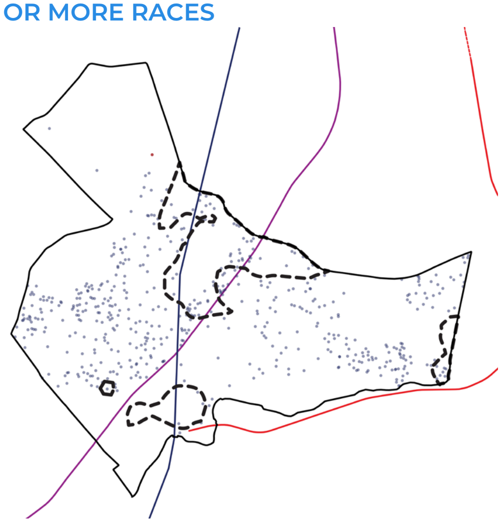
LATINX



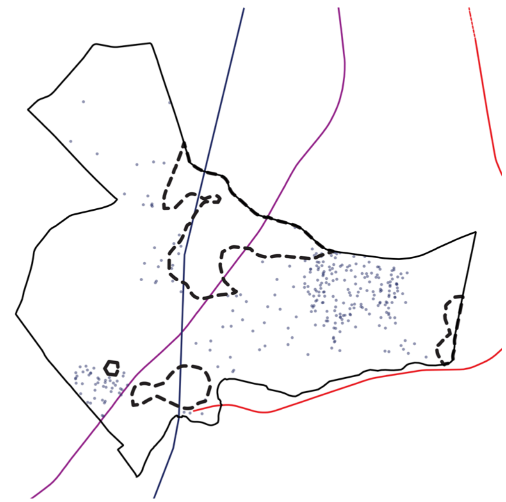
AMERICAN INDIAN/
ALASKA NATIVE



2 OR MORE RACES



ANOTHER RACE



Data Source: ACS 5-year estimates, 2015-2019

Hottest Daytime Areas (More than 100°F)

1 DOT = 1 PERSON

GAPS IN INDOOR COOLING NETWORK

- School
- Hospital
- Community Health Center
- BHA Public Housing: Elderly/Disabled
- BHA Public Housing: Family
- Indoor Cooling Center
- Pools (BCYF and DCR)
- Tot Sprays
- Libraries

Areas masked in white are within a 10-minute walk of indoor cooling centers and libraries. Areas in orange red experience extreme heat during heat waves, and are not within a 10-minute walk of an indoor cooling center or a library.[i]

3PM:
AIR TEMPERATURE

- More than 107°F
- City median: 99.5°F
- Median: 97.6°F
- Less than 92°F

i BCYF Summer 2020 Cooling centers were used for this map.

0 0.25 MI

COMMUNITY HEAT EXPERIENCES AND COOLING IDEAS

HEAT EXPERIENCES

Mattapan residents discussed their heat experiences and cooling ideas during the Neighborhood Ideas Workshop and through responses to the citywide survey. Areas of concern mentioned by participants included hot streets and sidewalks, hot homes and cooling affordability, limited cool social spaces, and effects of development on airflow patterns and trees.

COMMUNITY COOLING IDEAS

Mattapan residents suggested cooling strategies that reduce heat in the civic realm, support local businesses, and beautify the neighborhood. Residents shared the following ideas to increase access to cooling in Mattapan:

» Cool Streets:
Opportunities for street trees, shade structures, seating, awnings, planters, and cooler bus stops, with suggestions for cooling options like planters that would also beautify the neighborhood

» Cool Homes and Energy Affordability:
Opportunities for home cooling, including energy assistance for community members with elevated heat sensitivity

» Cool Community Spaces:
Opportunities for new cool, social outdoor gathering spaces, especially in commercial areas, including misters, greenery, seating, and shade structures or fabric shading; opportunities for cool indoor spaces for gathering, including community centers, cafes with outdoor seating, art spaces, and more public cooling centers with programming during heat events; and opportunities for public art and murals to increase visibility of cooling places

» Heat Resilience and Economic Development:
Opportunities to work with local business owners and entrepreneurs to improve heat resilience, support businesses, and keep money in the community; and opportunities for vouchers for residents to use at locally-owned businesses with air conditioning during heat events

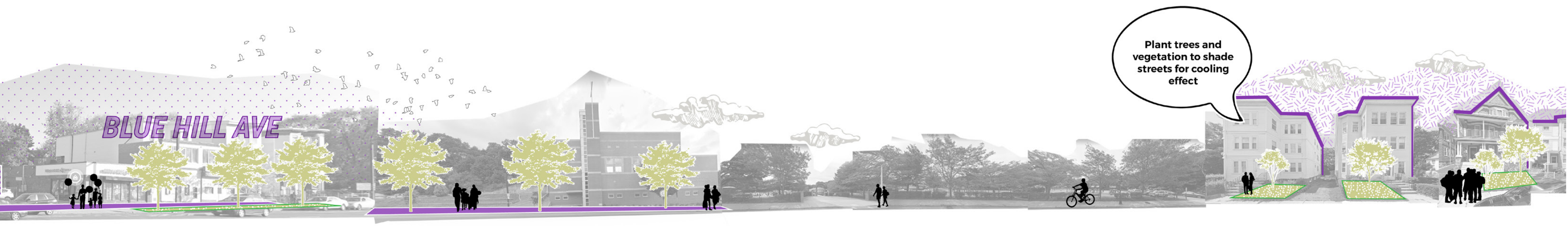
> *More public places that are open all day and in the evenings that have activities for kids and space for adults that have air conditioning*

> *Sun shade sails are inexpensive to install on streets where there may not be enough space for trees.*

> *Hottest place in Mattapan: Morton Street and River Street*

OPPORTUNITIES FOR A COOLER MATTAPAN


Public art and local artists to build awareness of cooling center locations and resources
Retro-fit busshelters with solar-powered mist systems and vegetation to promote cooling effects
Dense tree canopy plantings at parks and cooling centers
CENTER
HARAMBEE
PARK


Plant trees and vegetation to shade streets for cooling effect
BLUE HILL AVE

HEAT RESILIENCE OPPORTUNITIES

This section describes key needs for heat reduction or increasing access to cooling resources and opportunities to integrate resilience, based on neighborhood-level heat analysis and community feedback.

While all the strategies may be relevant to each neighborhood, each section lists specific heat resilience strategies that respond to the particular needs that have been identified. More details on the strategies listed below can be found in Chapter 6: Citywide Heat Resilience Strategies.

COOL HOMES

Participants shared concern over the costs of home cooling. Enhancing the energy efficiency of homes and larger multi-family housing could help reduce the operational costs of air conditioning. In addition, programs to distribute air conditioners and window fans could help residents overcome the initial cost barrier.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 5.1: HOME COOLING RESOURCES DISTRIBUTION

STRATEGY 5.3: HOME ENERGY RETROFITS

STRATEGY 5.4: AFFORDABLE HOUSING RESOURCES AND RETROFITS

EXPAND ACCESS TO INDOOR COOLING OPTIONS

One concern voiced by Mattapan residents during the planning process was the limited availability of free, indoor cool places that are open all day and in the evenings. Mapping 10-minute walk access from BCYF cooling centers and libraries reveals gaps in access, including residential areas southwest of Mattapan Square and east of Morton Street Station—two of the hottest parts of the neighborhood. Opportunities exist to expand the indoor cooling network.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 2.2: ENHANCED AND EXPANDED CITY-RUN COOLING CENTERS

STRATEGY 2.3: CITYWIDE COOLING NETWORK

SHADED, VEGETATED, COOL WALKS TO LOCAL DESTINATIONS AND MAIN STREETS

Limited vegetation, shade, and other cooling strategies along some streets in Mattapan can contribute to hotter conditions for pedestrians and bikers in the neighborhood. Wide streets with limited street trees, heavy pedestrian use, or bus stop locations could be opportunities for cooling strategies. Higher-traffic streets, like Morton Street, River Street, and Blue Hill Avenue, were mentioned by participants as opportunities for shade, vegetation, shaded bus stops, and other approaches to provide heat relief. High-activity areas, like Mattapan Square, often present opportunities for shading pavement, including surface parking lots, and increasing cool outdoor gathering spaces.

RELATED HEAT RESILIENCE STRATEGIES

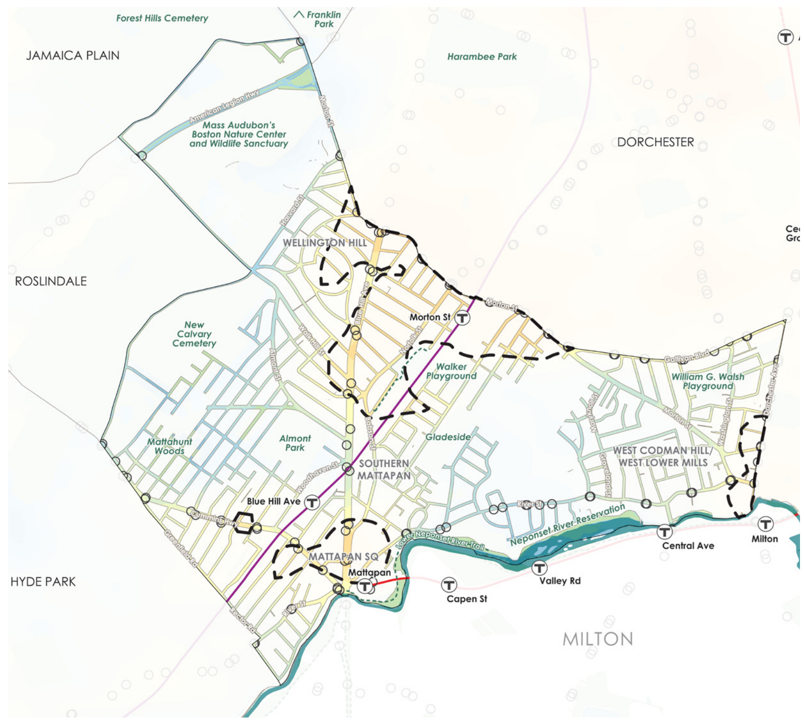
STRATEGY 2.1: POP-UP HEAT RELIEF

STRATEGY 6.1: ENHANCED COOLING IN POCKET PARKS AND STREET-TO-PARK CONVERSIONS

STRATEGY 6.4: PLANNING FOR FUTURE PARKS

STRATEGY 7.1: COOL COMMUTES

STRATEGY 7.3: COOL MAIN STREETS



Mattapan's primary streets and streets in denser residential areas are hotter than streets in its lower density areas.

DAYTIME AIR TEMPERATURE

More than 107°F

City median: 99.5°F

Median: 97.6°F

Less than 92°F

Hottest Daytime Areas (More than 100°F)

ROXBURY


NUBIAN SQUARE


FORT HILL
DUDLEY BRANCH BOSTON PUBLIC LIBRARY


MELNEA CASS BIKE PATH
HORATIO HARRIS PARK


DUDLEY SQUARE PLAZA

NEIGHBORHOOD CONTEXT

Roxbury's heat experiences reflect development patterns, neighborhood history, and proximity to large parks. Many parts of the neighborhood experience higher temperatures than other places in Boston.

Roxbury is often described as a central hub of Black culture in Boston,[42] and approximately 50% of Roxbury's 53,000 residents identify as Black, compared with 23% of residents of Boston as a whole.[43] Prominent wall murals of African American leaders and the Roxbury Memory Trail, an official two-mile tour through Roxbury showcasing twentieth century African American history, visibly reinforce the neighborhood's cultural identity. Roxbury has been shaped by the legacy of redlining, which has led to low rates of home ownership (80% of Roxbury residents rent, compared with 65% in the city as a whole), lower median household income ($27,721 in Roxbury, compared with $62,021 in Boston as a whole). [44]

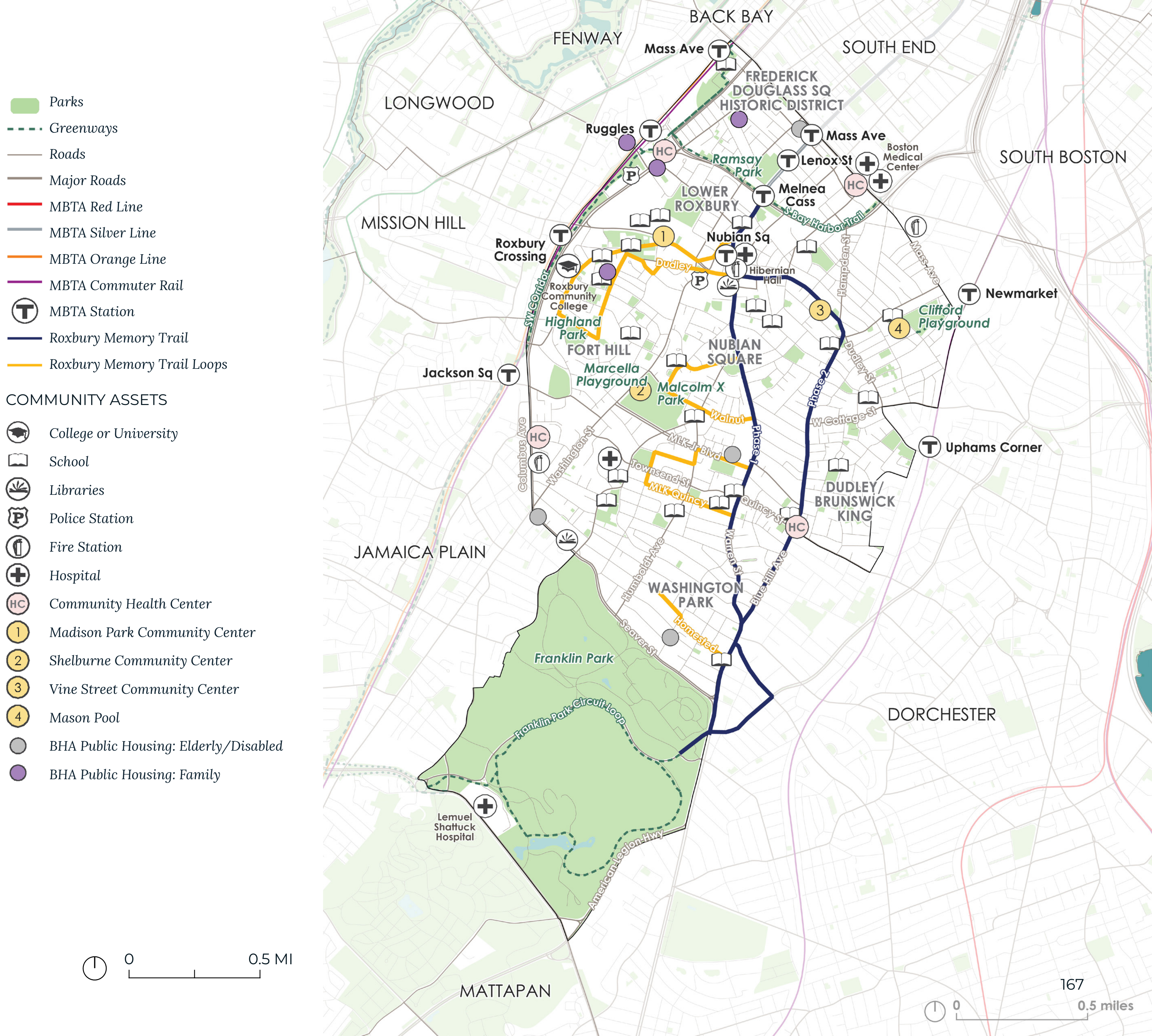
Median housing prices in Roxbury increased 80% between 2010 and 2015,[45] and Roxbury's high percentage of renters means neighborhood residents are much more vulnerable to displacement as housing costs increase. In 1970, Roxbury was 75% Black. By 2000, Black residents comprised 65% of the neighborhood, and today, Black residents compose 50% of neighborhood residents.

Air pollution in Roxbury directly relates to residents' heat experience. In 1997, half of the diesel-operated public transit vehicle fleet was stored within 1.5 miles of Dudley Square. This contributed to an asthma hospitalization rate more than five times the state average.[46] Since having asthma increases an individual's sensitivity to heat, Roxbury residents are disproportionately affected by extreme heat.

In light of these external pressures, like many neighborhoods in Boston, many Roxbury residents are deeply engaged in planning and advocacy to improve the neighborhood for current residents. Increasing access to affordable and energy-efficient housing, developing community renewable energy, and improving air quality remain central to ongoing planning and community organizing efforts, and would all directly or indirectly improve heat resilience for Roxbury residents.

RECENT AND ONGOING PLANNING EFFORTS

- Roxbury Strategic Master Plan
- PLAN: Nubian Square: Parcel P3
- Nubian Square Plan
- PLAN: Newmarket, the 21st Century Economy Initiative
- Roxbury Neighborhood Design Overlay District

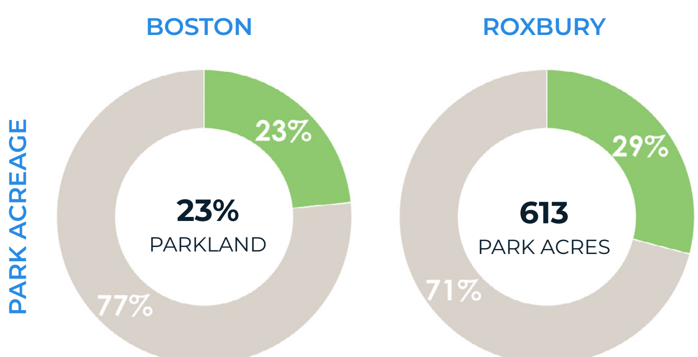

Parks
Greenways
Roads
Major Roads
MBTA Red Line
MBTA Silver Line
MBTA Orange Line
MBTA Commuter Rail
MBTA Station
Roxbury Memory Trail
Roxbury Memory Trail Loops
COMMUNITY ASSETS
College or University
School
Libraries
Police Station
Fire Station
Hospital
Community Health Center
Madison Park Community Center
Shelburne Community Center
Vine Street Community Center
Mason Pool
BHA Public Housing: Elderly/Disabled
BHA Public Housing: Family
0
0.5 MI
BACK BAY
FENWAY
SOUTH END
LONGWOOD
SOUTH BOSTON
MISSION HILL
FREDERICK DOUGLASS SQ HISTORIC DISTRICT
Mass Ave
Ruggles
Lenox St
Boston Medical Center
Ramsay Park
Melnea Cass
LOWER ROXBURY
S Bay Harbor Trail
Roxbury Crossing
Nubian Sq
Dudley
Hibernian Hall
Roxbury Community College
Highland Park
FORT HILL
Newmarket
Clifford Playground
Jackson Sq
NUBIAN SQUARE
Marcella Playground
Malcolm X Park
Walnut
Phase 1
Phase 2
Dudley St
W Cottage St
Uphams Corner
MLK Jr Blvd
Townsend St
MLK Quincy
Quincy St
Columbus Ave
Washington St
Hampden St
Mass Ave
SW Corridor
DUDLEY/ BRUNSWICK KING
JAMAICA PLAIN
Humboldt Ave
Warren St
Blue Hill Ave
WASHINGTON PARK
Homestead
Seaver St
Franklin Park
Franklin Park Circuit Loop
DORCHESTER
Lemuel Shattuck Hospital
American Legion Hwy
MATTAPAN
0
0.5 miles

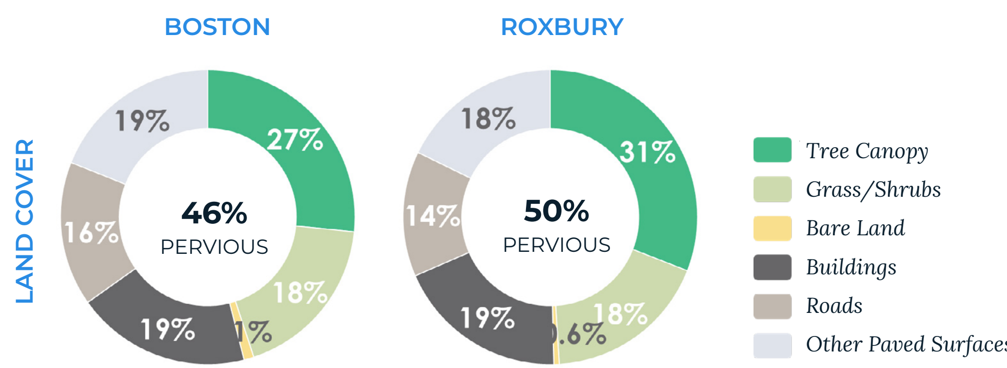
HEAT ANALYSIS

Roxbury experiences elevated temperatures in many parts of the neighborhood, especially areas of the neighborhood that are a greater distance from Franklin Park. Roxbury has some of the hottest daytime temperatures of the five neighborhoods. In the heat analysis, Roxbury's daytime and nighttime median temperatures measured 101°F and 82.8°F, respectively, both of which are hotter than the city's median (daytime is 99.5°F and nighttime is 81.9°F). The hottest part of the neighborhood is around Newmarket and Frederick Douglass Square Historic District where daytime temperatures can reach 105°F, and nighttime temperatures reach 88°F. In comparison, Franklin Park had daytime temperatures around 90°F in the heat analysis. The southern part of Roxbury cools down significantly at night due to the proximity to Franklin Park, but the cooling effect only extends a few blocks out from the park.

Factors including uneven park access and land use patterns contribute to why many areas of Roxbury experience intense heat. Of the five neighborhoods, Roxbury has one of the lowest percentages of impervious surfaces at 50%, but much of that open space is concentrated in Franklin Park. Franklin Park accounts for 80% of the neighborhood's park space acreage, and outside of Franklin Park, only 6% of the neighborhood is park space, lower than the citywide average (23%).[49] The uneven distribution of green space means many areas of the neighborhood do not benefit from the cooling benefits of parks.

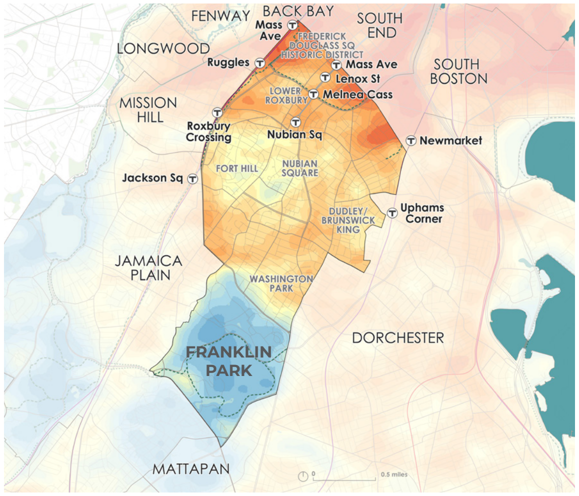
The neighborhood's land use context and density also play roles. Neighboring large institutions have larger, more dense buildings, which contribute to increased heat in the surrounding area. Extreme heat conditions are concentrated around more densely developed areas of Roxbury. The areas along Massachusetts Avenue, from Newmarket to Frederick Douglass Square Historic District, include large-scale commercial buildings, industrial land uses, and dense mixed-use buildings. Many of these building typologies typically have flat black roofs, are surrounded by impervious surfaces, and have few trees, which all contribute to hotter temperatures.





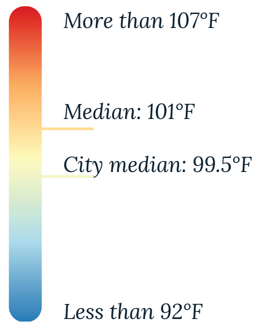
Data Source: Tree Canopy Assessment 2019, BPRD

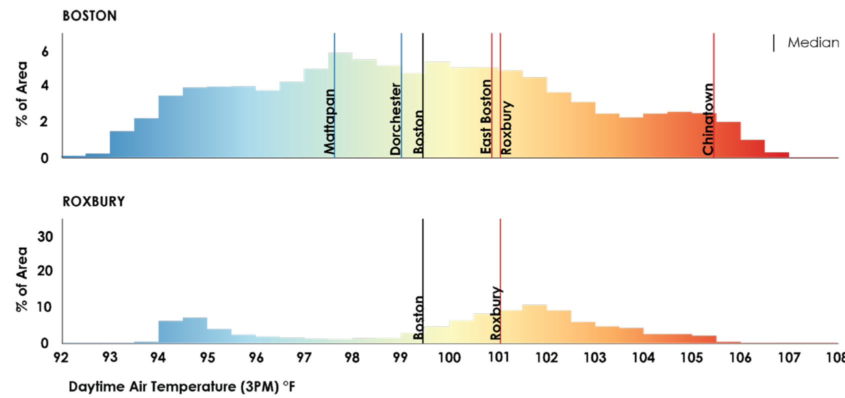
DAYTIME AIR TEMPERATURES



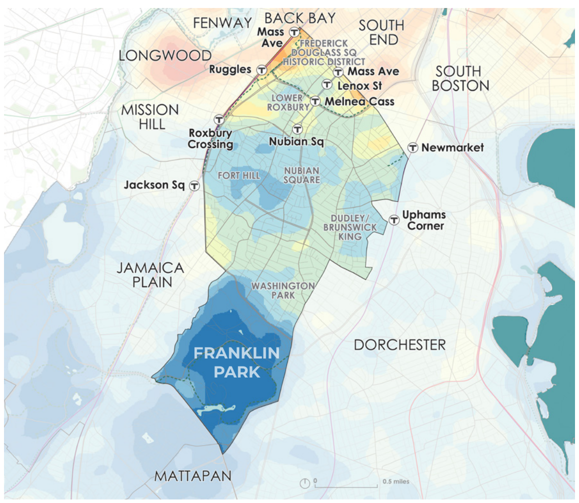
Daytime Air Temperature (3 p.m.): *Median neighborhood air temperature at 3 p.m. is 1.5°F hotter than the Boston median.*

3PM:
AIR TEMPERATURE



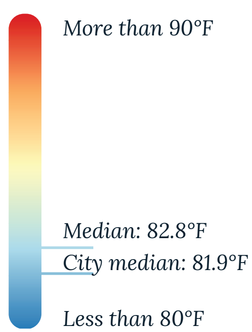


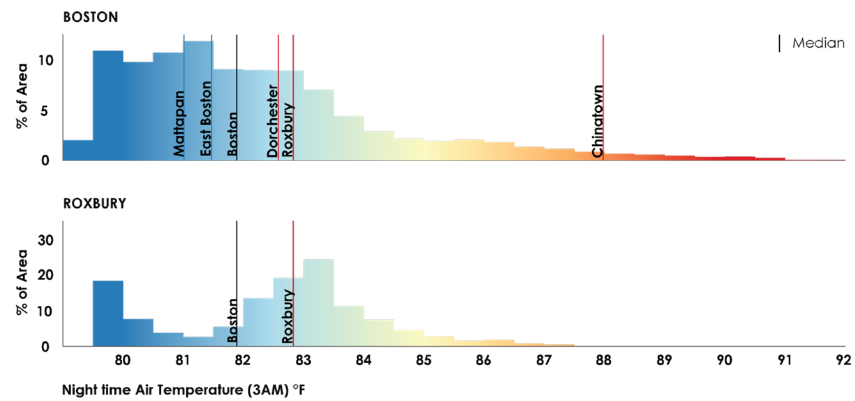
NIGHTTIME AIR TEMPERATURES

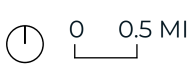


Nighttime Air Temperature (3 a.m.): *Median neighborhood air temperature at 3 a.m. is about 1°F cooler than the Boston median.*

3AM:
AIR TEMPERATURE





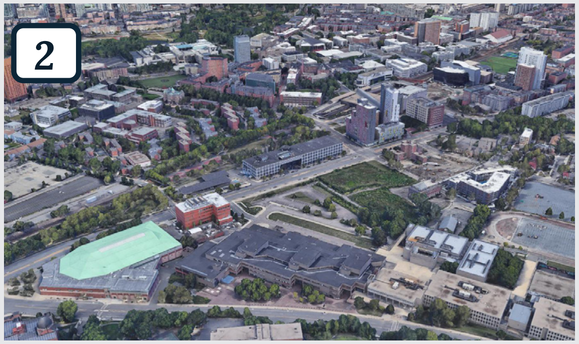


SAMPLE OF HEAT FINDINGS

These three areas illustrate examples of how Roxbury's land use affects daytime and nighttime temperatures, based on the citywide heat analysis.

1. DENSE HISTORIC DISTRICTS

Dark roofs and brick building facades in historic districts like the Frederick Douglass Historic District absorb heat during the day, and denser buildings limit air movement which could help cool the neighborhood down at night. Limited tree canopy on parking lots, trees, and institutional athletic fields contribute to extremely long and intense heat events in this part of Roxbury.



2. CIVIC AND INSTITUTIONAL USES

Institutional areas like those around Madison Park High can be very hot, as they often have large dark roofs and significant paved areas in the immediate vicinity, both of which absorb heat. The large buildings and parking lots also limit tree canopy coverage.

3. MEDICAL CAMPUSES

Like civic and institutional uses, medical campuses often have significant paved areas, dense development, some dark roofs, and a surrounding context that is also hot due to extensive paving and dense development, which contribute to sustained high daytime and nighttime temperatures. These hotter temperatures could affect people who are coming to the area to seek medical treatment.

AREAS EXPERIENCING LONGER HIGH-HEAT EVENTS

- School
- Hospital
- Community Health Center
- BHA Public Housing: Elderly/Disabled
- BHA Public Housing: Family
- Community Centers
- Pools (BCYF and DCR)
- Tot Sprays
- Libraries

Heat Event Duration is the sum of all the hours during the analysis week (a heat wave week in July 2019) that the local modeled heat index is above 95°F, for days that the nighttime temperature does not drop below 75°F,

HEAT EVENT HOURS

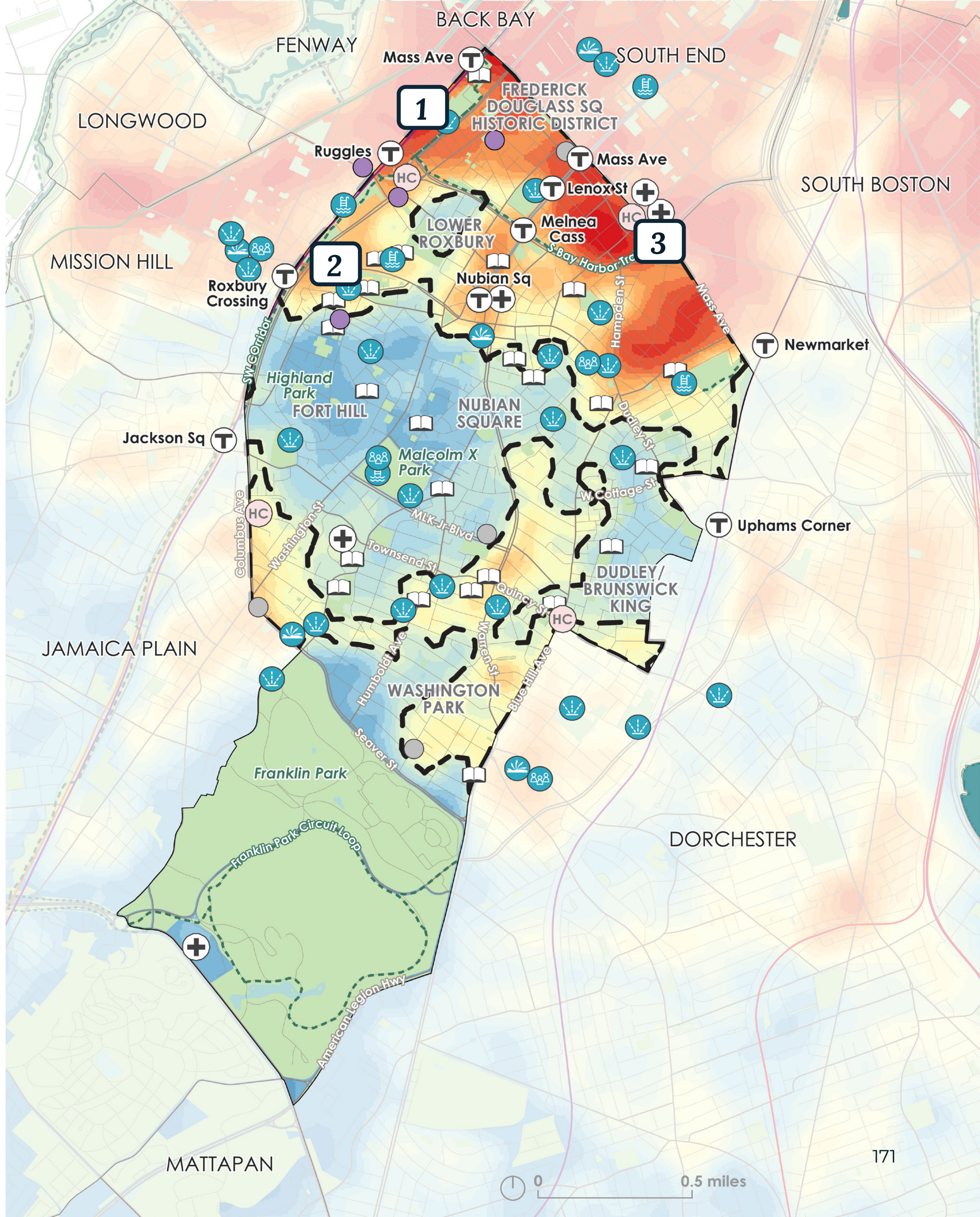
More than 37hrs

30 hrs

Less than 25 hrs

Longest Heat Event (More than 30 hrs)

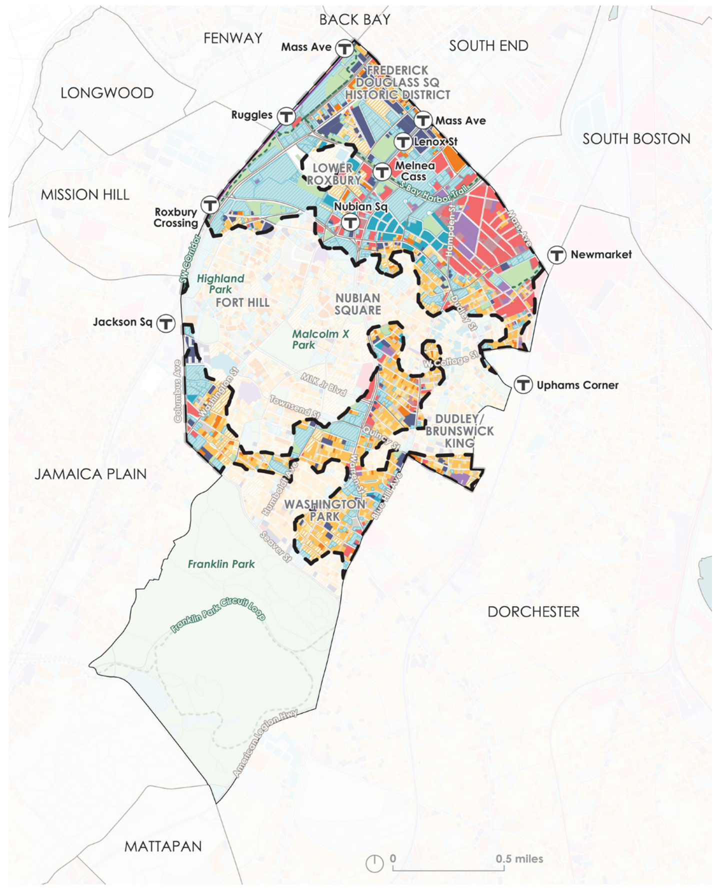
0 0.5 MI



LAND USE AND PEOPLE

The parts of Roxbury that experienced the most intense and longest heat events in the heat analysis include a mixture of residential, institutional, and commercial land uses. These areas include parts of the neighborhood generally north and northeast of Malcolm X Boulevard and Dudley Street as well as central parts of the neighborhood, including Egleston Square and the Warren Street corridor south of Washington Park Mall. A higher population density along Massachusetts Avenue near the T stops is due to the presence of larger, mixed-use buildings.

As described in Chapter 3, hot weather can create disproportionate health risks for some people, especially for those who are younger or older, who have preexisting health conditions, or who are exposed to heat for longer periods of time. In Roxbury, young children (under 5 years) make up 6% of neighborhood residents (compared to 5% citywide), and older adults (over 65 years) make up 12% of neighborhood residents (same as the citywide percentage).[50] Of Roxbury residents, 30% are low-income (compared to 16% citywide), and 78% of housing units are renter-occupied (compared to 64% citywide).[51] Low-income residents and renters may face barriers to home retrofits or affording cooling options.



Data Source: Analyze Boston

Land Use Map: The hottest and most intense areas in Roxbury includes a mixture of residential, institutional, and commercial land uses.

LAND USE

- *Single-family Housing*
- *Multi-family Housing*
- *Apartment (7+ Units)*
- *Condo*
- *Mixed Use*
- *Residential Land*
- *Commercial*
- *Commercial Land*
- *Industrial*
- *Exempt (Chapter 121A)*
- *Exempt*

Longest Heat Event (More than 30 hrs)

0 0.5 MI

POPULATION DENSITY AND HIGH-HEAT EVENT DURATION

Higher density in areas with longer heat exposure and intensity including Frederick Douglass Square and Nubian Square.

1 DOT = 5 PEOPLE

HEAT EVENT HOURS

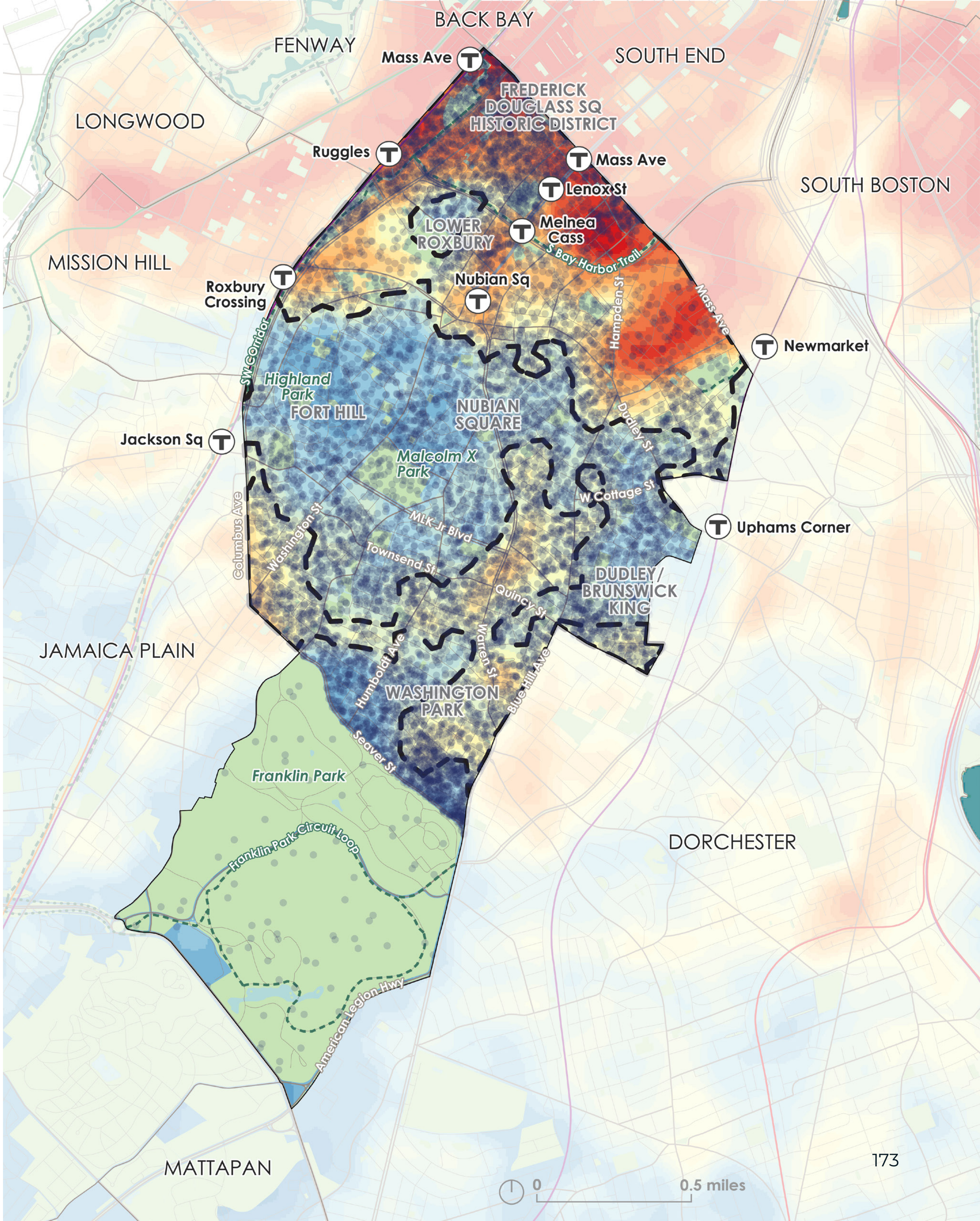
More than 37hrs

30 hrs

Less than 25 hrs

Longest Heat Event (More than 30 hrs)

0 0.5 MI

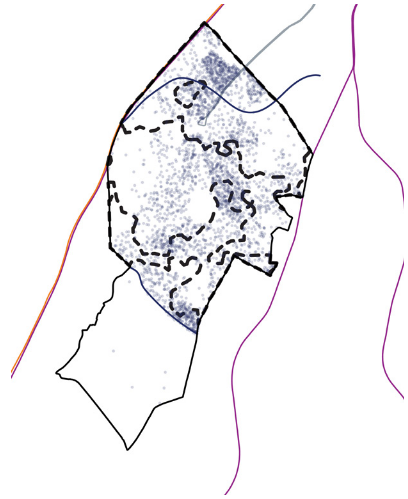


RESIDENT DEMOGRAPHICS AND HEAT DURATION

The following maps compare the density of Roxbury residents to areas with the longest duration event in the heat analysis. Due to longer heat events and higher heat intensity, heat risk may be higher for residents in many parts of the neighborhood, including the Frederick Douglass Historic District, Lower Roxbury, Newmarket, Nubian Square, Egleston Square, Warren Street corridor, and Boston Medical Center area. For example, the Frederick Douglass Historic District experiences long heat events (34 hrs) that are 5 hours above the neighborhood median (29 hrs). In terms of heat intensity, the Frederick Douglass Historic District is 7°F degrees hotter than Franklin Park.

YOUNG CHILDREN (<5 YRS)

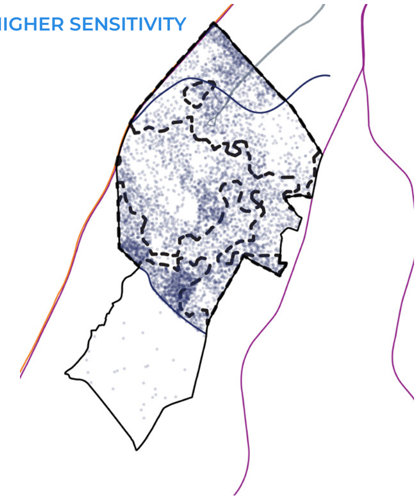
HIGHER SENSITIVITY



OLDER ADULTS (>65 YRS)

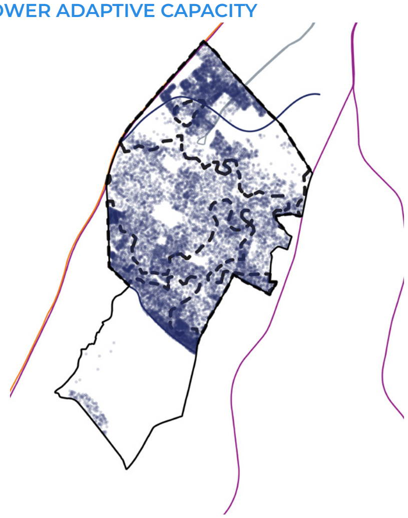
LOWER ADAPTIVE CAPACITY

HIGHER SENSITIVITY



LOW-INCOME RESIDENTS

LOWER ADAPTIVE CAPACITY



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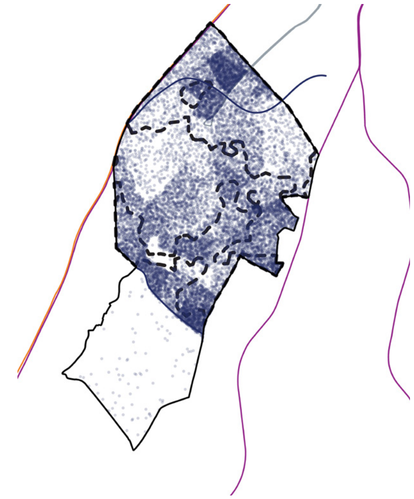
LOWER ADAPTIVE CAPACITY

ASIAN

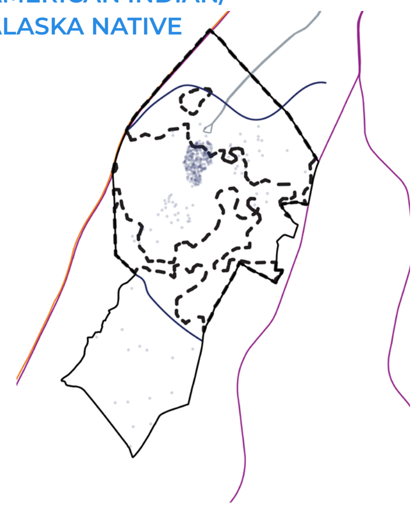
WHITE

BLACK

LATINX

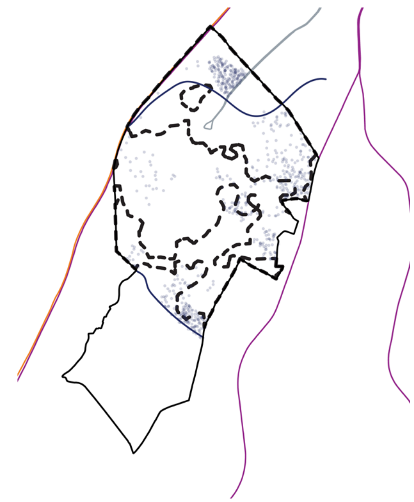


AMERICAN INDIAN/
ALASKA NATIVE



2 OR MORE RACES

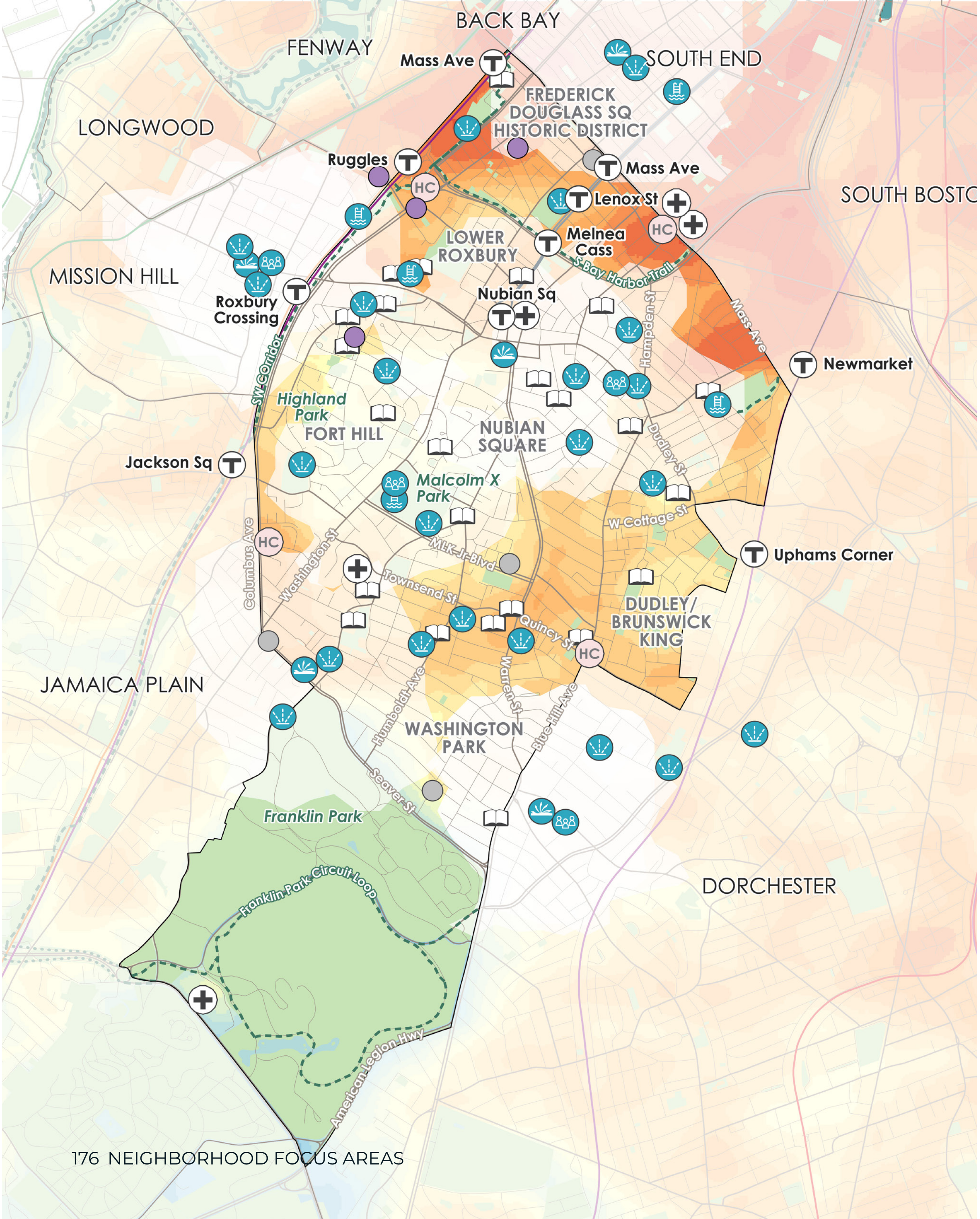
ANOTHER RACE



Data Source: ACS 5-year estimates, 2015-2019

Longest Heat Event (More than 30 hrs)

1 DOT = 1 PERSON



GAPS IN INDOOR COOLING NETWORK

- School
- Hospital
- Community Health Center
- BHA Public Housing: Elderly/Disabled
- BHA Public Housing: Family
- Indoor Cooling Centers
- Pools (BCYF and DCR)
- Tot Sprays
- Libraries

Areas masked in white are within a 10-minute walk of indoor cooling centers and libraries. Areas in orange red experience extreme heat during heat waves, and are not within a 10-minute walk of an indoor cooling center or a library.[i]

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More than 107°F

Median: 101°F

City median: 99.5°F

Less than 92°F

i BCYF Summer 2020 Cooling centers were used for this map.

0 0.5 MI

COMMUNITY HEAT EXPERIENCES AND COOLING IDEAS

HEAT EXPERIENCES

Roxbury residents discussed their heat experiences and cooling ideas during the Neighborhood Ideas Workshop and through responses to the citywide survey. Areas of concern mentioned by participants included financial and information barriers to accessing cooling, temperatures in schools, the amount of hardscape in commercial areas, hot sidewalks, air pollution, displacement risks, cooling for residents in BHA communities, and preserving and maintaining street trees.

COMMUNITY COOLING IDEAS

Roxbury residents suggested cooling strategies that would cool the neighborhood, keep students cool, and increase access to cooling and information during heat waves. Participants shared the following ideas to increase access to cooling in Roxbury:

» Green Neighborhood Network:
Opportunities for a network of green spaces, connected via cool routes with trees, awnings, shade structures, light-colored pavement, and misters

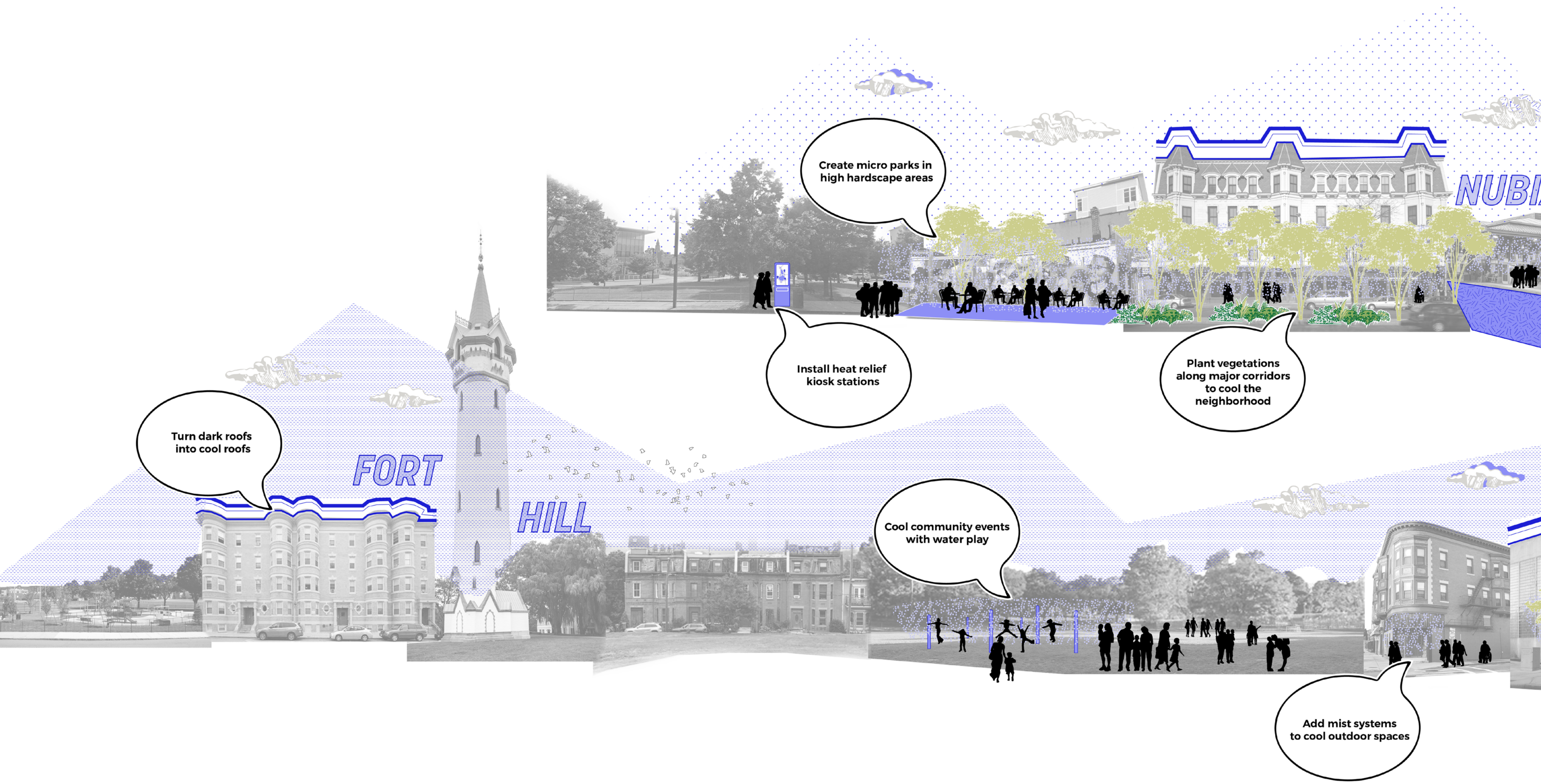
» Cool Schools and Heat Education:
Opportunities for schools to offer a safe, comfortable learning environment, as well as shaded outdoor green space, and to share best practices for staying cool and other heat resilience teachable moments

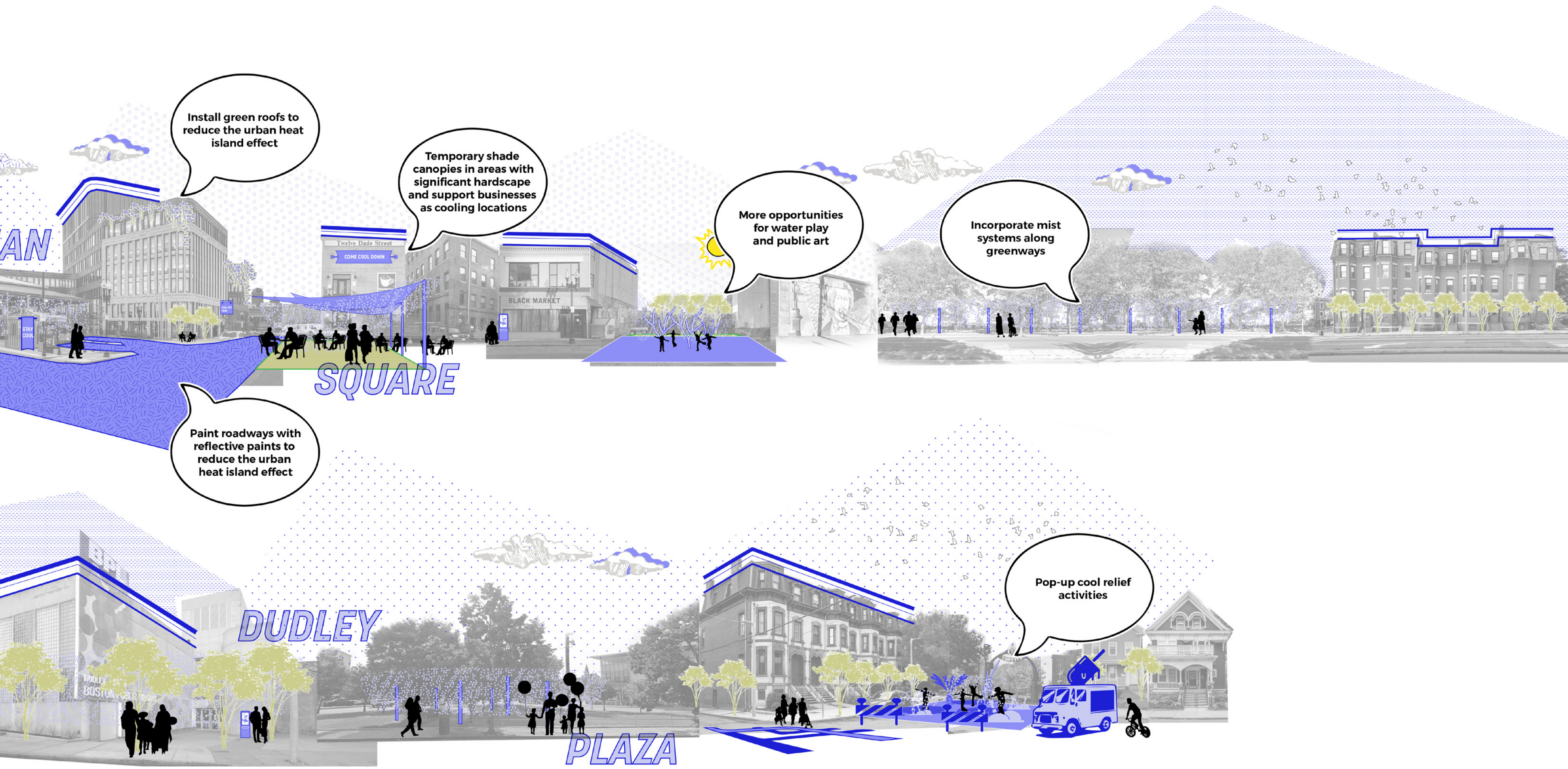
» Heat Wave Preparedness:
Opportunities to increase access to ways to stay cool, including programs to expand the distribution of personal and home cooling devices; and opportunities for improved information sharing including early notifications and alerts of imminent heat waves

> *People love being around water, but there aren't many places with water in Roxbury (other than Scarborough Pond in Franklin Park)—unlike other neighborhoods*

> *Allowing the wholesale removal of the tree canopy is contributing to the heat issues. Melnea Cass is an example. New trees are not as efficient as older more mature trees. The 1:1 tree exchange is not accurate, age matters.*

OPPORTUNITIES FOR A COOLER ROXBURY




AN
Install green roofs to reduce the urban heat island effect
Twelve Dade Street
COME COOL DOWN
Temporary shade canopies in areas with significant hardscape and support businesses as cooling locations
BLACK MARKET
SQUARE
More opportunities for water play and public art
Incorporate mist systems along greenways
Paint roadways with reflective paints to reduce the urban heat island effect
DUDLEY
PLAZA
Pop-up cool relief activities

HEAT RESILIENCE OPPORTUNITIES

This section describes key needs for heat reduction or increasing access to cooling resources and opportunities to integrate resilience, based on neighborhood-level heat analysis and community feedback.

While all the strategies may be relevant to each neighborhood, each section lists specific heat resilience strategies that respond to the particular needs that have been identified. More details on the strategies listed below can be found in Chapter 6: Citywide Heat Resilience Strategies.

INDOOR COOLING NETWORK

Mapping 10-minute-walk access from indoor BCYF cooling centers and libraries revealed gaps in access to indoor cooling centers. Residents in the Frederick Douglass Square Historic District, including those in BHA housing communities, live in one of Boston's hottest areas. Parts of this neighborhood are within a 10-minute walk of cooling centers in the South End, but it is unclear if Roxbury residents would feel as comfortable visiting them given their location across neighborhood boundaries. Other parts of the neighborhood are outside of a 10-minute walk from cooling centers altogether. Opportunities exist to expand access to indoor cooling options, including through partnerships with community organizations.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 2.2: ENHANCED AND EXPANDED CITY-RUN COOLING CENTERS

STRATEGY 2.3: CITYWIDE COOLING NETWORK

RELIEF DURING HEAT WAVES

As shared by participants in this process, extreme heat is already a challenge for neighborhood residents, workers, and students. While longer-term mitigation strategies are appealing, near-term help is needed. Pop-up heat relief, extended hours for existing public indoor cooling centers, and expanded alerts about upcoming heat events could help provide support and cooling.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 1.2: PRE-HEAT WAVE RESOURCES MOBILIZATION

STRATEGY 2.1: POP-UP HEAT RELIEF

STRATEGY 4.1: HEAT RESILIENCE PUBLIC EDUCATION CAMPAIGN

COMMERCIAL BUILDINGS WITH COOL ROOFTOPS AND INDOOR OR SHADED OUTDOOR SOCIAL SPACES

Many surfaces along main streets, commercial, areas and industrial areas are dark, contributing to high heat exposure. For example, in the heat analysis, the Newmarket and South Bay Center areas are some of the hottest in the city. Opportunities for more shade, pocket gathering spaces, vegetation, and parks could help the neighborhood stay cooler.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 5.2: COOL ROOFS PROGRAM

COOL, SHADED PAVEMENT AND SURFACE PARKING

Large surface parking lots in several areas of the neighborhood contribute to heat exposure. Areas like the Frederick Douglass Square Historic District, Nubian Square, Egleston Square, and the area around Washington Park Mall could be opportunity areas for increased shade and vegetation.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 6.1: ENHANCED COOLING IN POCKET PARKS AND STREET-TO-PARK CONVERSIONS

STRATEGY 6.2: INCREASE SHADE ON MUNICIPAL SITES

COOL SCHOOLS

Several participants expressed that youth have some of the greatest needs for heat relief in Roxbury. Madison Park High, Orchard Gardens K-8 School, and Mason Elementary are schools within areas experiencing longer heat events, based on the heat analysis. Creating comfortable learning environments and schoolyards will help support the health and learning outcomes of students.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 5.5: COOL SCHOOLS

RESILIENT DESIGN FOR NEW DEVELOPMENT

Like many Boston neighborhoods, Roxbury has been experiencing increasing development pressures in many parts of the neighborhood. Chapter 6 of this document includes three strategies related to development review, zoning, and heat resilience design guidelines. Continuing to support and expand affordable housing options is a priority throughout Boston.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 8.1: UPDATED CLIMATE RESILIENCY CHECKLIST

STRATEGY 8.2: HEAT RESILIENCE BEST PRACTICE GUIDELINES

STRATEGY 8.3: ZONING REVISIONS TO SUPPORT COOLER NEIGHBORHOODS

MORE SHADED GATHERING SPACES

Franklin Park provides cooling relief for nearby areas, while some parks reach higher temperatures. In the heat analysis, Clifford Playground was measured at 102°F during the day, 4°F higher than Malcolm X Park. The area around the park includes significant unshaded parking and buildings with dark roofs, which contribute to the higher temperatures. Ramsay Park reached about 102°F during the heat analysis, despite having a fair number of trees in it. The park has a splash pad and a variety of other amenities. Roxbury residents who participated in the planning process expressed a desire for more outdoor gathering spaces with vegetation, trees, shade, and cooling throughout the neighborhood.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 2.1: POP-UP HEAT RELIEF

STRATEGY 6.1: ENHANCED COOLING IN POCKET PARKS AND STREET-TO-PARK CONVERSIONS

STRATEGY 6.4: PLANNING FOR FUTURE PARKS

COOL WALKS TO LOCAL DESTINATIONS AND MAIN STREETS

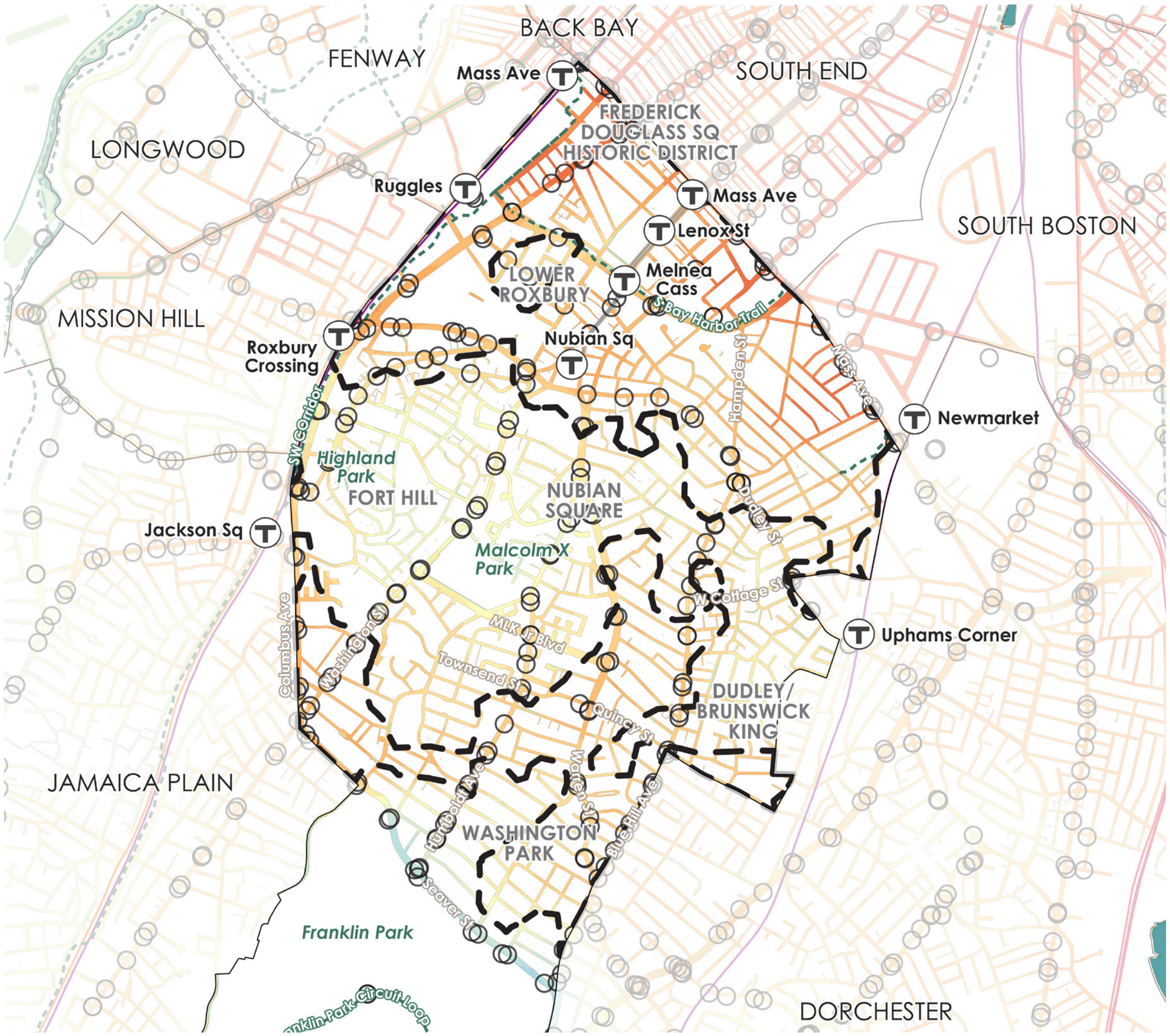
Limited shade and vegetation along some Roxbury streets can create hot walks for residents, as they are moving to local destinations or waiting at bus stops. Streets with higher temperatures and bus stops include Warren Street, Blue Hill Avenue, Dudley Street, Humboldt Avenue, Tremont Street, and Washington Street. Cooling strategies could be prioritized on these streets through strategies like street trees, shade, vegetation, and shaded bus stops.

RELATED HEAT RESILIENCE STRATEGIES

STRATEGY 6.3: EXPANDED DRINKING FOUNTAIN NETWORK

STRATEGY 7.1: COOL COMMUTES

STRATEGY 7.3: COOL MAIN STREETS



Street Daytime Air Temperature: This map illustrates air temperature along Roxbury's streets.

3PM:
AIR TEMPERATURE

More than 107°F

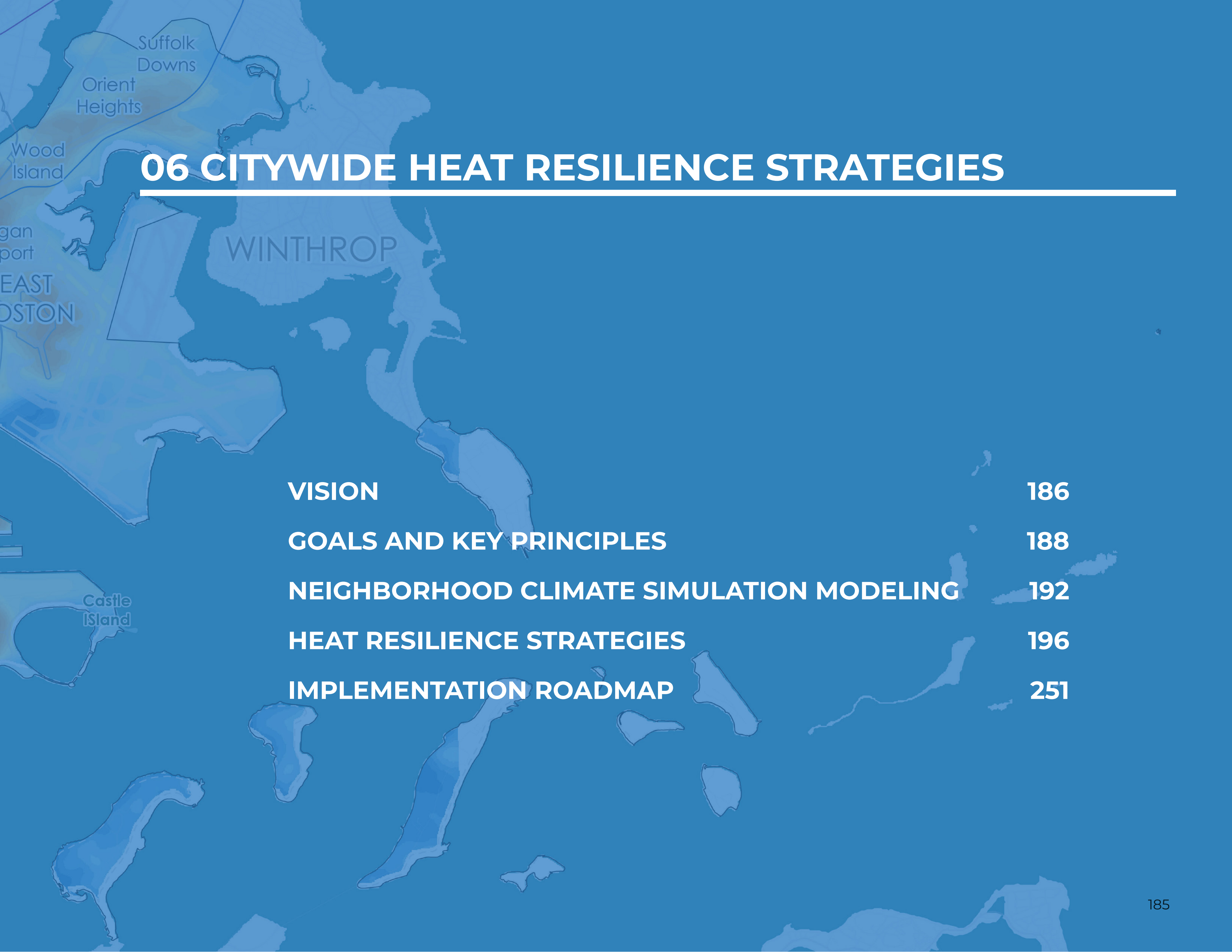
Median: 101°F

City median: 99.5°F

Less than 92°F

Longest Heat Event (More than 30 hrs)


EVERETT
SOMERVILLE
CHARLESTOWN
3
28
CAMBRIDGE
WATERTOWN
East Boston Memorial Park
Maverick
DOWNTOWN
ALLSTON/ BRIGHTON
90
20
Packards Corner
CHINATOWN
90
Tufts Med
Brighton
FENWAY/ KENMORE
SOUTH END
NEWTON
Mass Ave
SOUTH BOSTON
Brigham Circle
BROOKLINE
Ruggles
Roxbury Crossing
Nubian Sq
Newmarket
9
Joe Moakley Park
Jackson Sq
ROXBURY
JFK/UMass
Jamaica Pond
Uphams Corner
Savin Hill
JAMAICA PLAIN
Four Corners/ Geneva



06 CITYWIDE HEAT RESILIENCE STRATEGIES

VISION

Heat Resilience Solutions for Boston brings together Bostonians' ideas and responds to our communities' priorities.

We can build a more just, equitable, and resilient Boston, while protecting the health and safety of all residents. Delivering on equitable heat resilience requires well-coordinated collaboration across City, state, federal, community, and regional partners. Through leadership and collaboration, Boston can help prepare our communities, buildings, infrastructure, and natural spaces for the impacts of climate change, including extreme heat, while putting Boston on a path to becoming a Green New Deal city.

Building a better, more resilient Boston can create cooler communities and also support broader benefits for justice, equity, and basic improvements to everyday life. Through strategies in the *Heat Plan*, the City of Boston can also help deliver on the broader and complementary goals of the Green New Deal strategy, such as the following:

- Improving public health outcomes, including indoor and outdoor air quality
- Growing new categories of green jobs and workforce opportunities
- Strengthening social connections and resilience within communities
- Reducing Boston's greenhouse gas emissions and other pollution and waste
- Launching policies that improve income, wealth, educational, and racial equity
- Engaging and involving residents to support community climate leadership
- Delivering all-of-government, all-of-city operations to take comprehensive climate action
- Managing and treating stormwater to improve water quality and reduce flooding
- Ensuring greater comfort and safety for a wider range of transportation options
- Protecting and expanding high-quality affordable housing options

The strategies presented in this chapter represent the City of Boston's plans to increase heat resilience and address the impacts of climate change. These strategies will help ensure all Bostonians, especially those most disadvantaged and overburdened, can thrive in the face of climate change.

GOALS AND KEY PRINCIPLES

The *Heat Plan* centers Bostonians' heat experiences with three goals and three key principles that are informed by the vision and insights from Boston communities and stakeholders. The goals define what this plan aims to achieve and address. The strategies that follow will help bring the City of Boston closer to these goals. The key principles provide considerations that will guide the implementation of strategies.

GOALS

Reduce heat vulnerability for Bostonians and recognize the challenges that heat can bring to their quality of life, including negative health outcomes and physical or mental stress.

Reduce Heat Exposure

Reduce indoor and outdoor urban heat exposure, intensity, and duration by enhancing the capacity of the built environment to recover from daytime heat.

Adapt to Heat

Expand choices for staying cool during heat waves and improve awareness of actions residents can take to stay safe and cool.

Reduce Sensitivity and Foster Healthy, Connected Communities

Create healthier, more connected neighborhoods that help reduce underlying social determinants of health that increase heat risk.

KEY PRINCIPLES

Implement heat resilience goals and strategies to align with the following key principles.

Lead with an Environmental Justice and Equity Lens

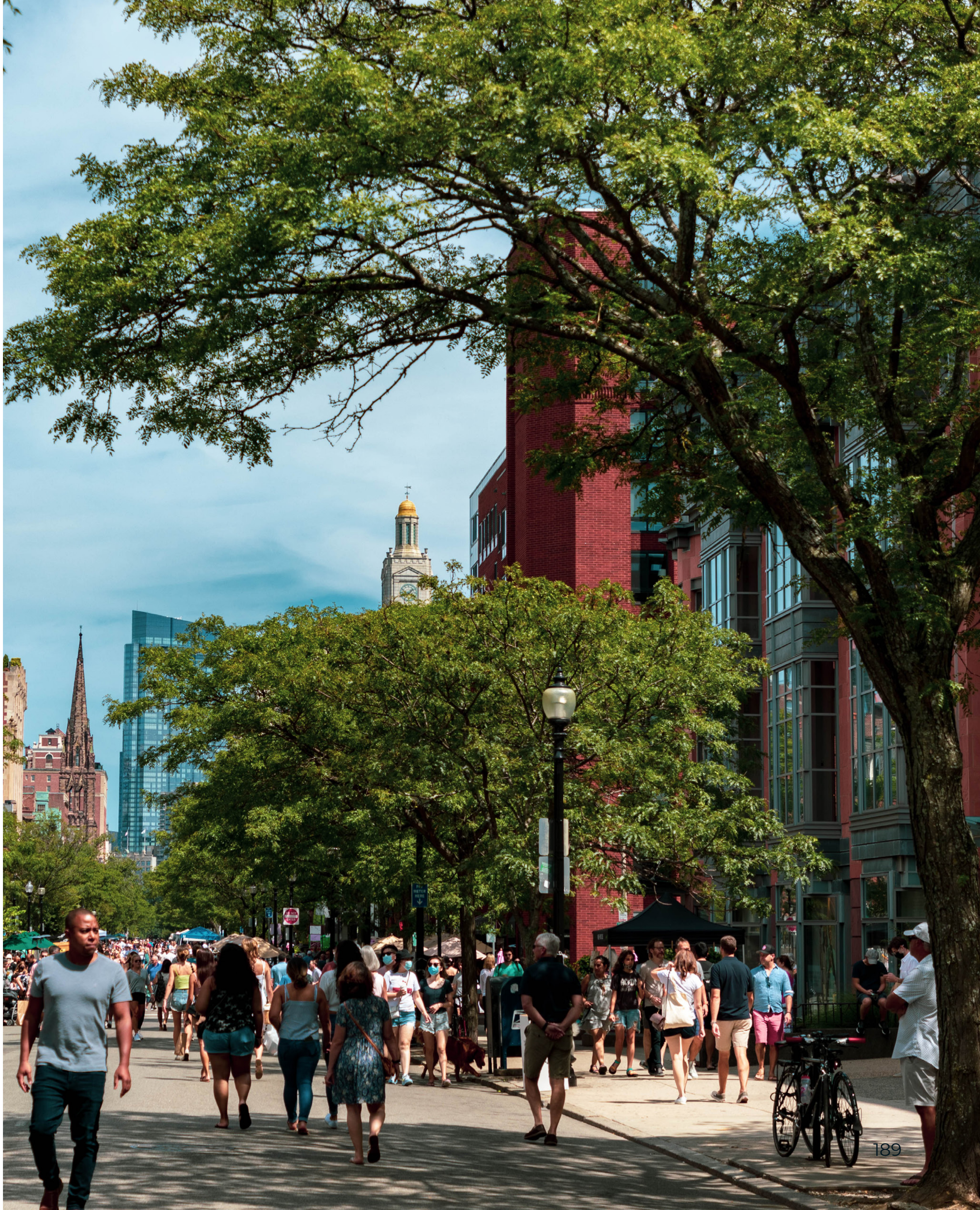
The *Heat Plan* highlights the disproportionate burdens of extreme and chronic heat that coincide with systemic and historical injustices and inequities. This plan provides strategies that are relevant to all neighborhoods and residents of Boston, while providing additional focus on those strategies that can provide relief for those who face the greatest burdens from extreme heat and the greatest barriers to fair, equitable access to cooling and healthy neighborhoods. The plan integrates a wide range of elements to advance environmental justice and equity across Boston, including a focus on the sensitivity and adaptive capacity of residents to climate change. By centering environmental justice and equity, Boston can better address root causes of increased risk and vulnerability in communities who are disproportionately affected by climate change—and ensure the City of Boston equitably protects all residents and effectively addresses the needs of the most overburdened residents.

Prioritize Multiple Benefits

Leverage heat resilience to advance economic opportunity, reduce carbon emissions, increase green spaces, and improve health for Bostonians and our environment.

Use Data-driven Planning

Continue to refine temperature models and utilize them alongside robust community engagement to help inform decisions.



HEAT RESILIENCE BENEFITS

Strategies target multiple facets of the goals and key principles.
The following benefits help to identify how a strategy is working towards the City's goals.

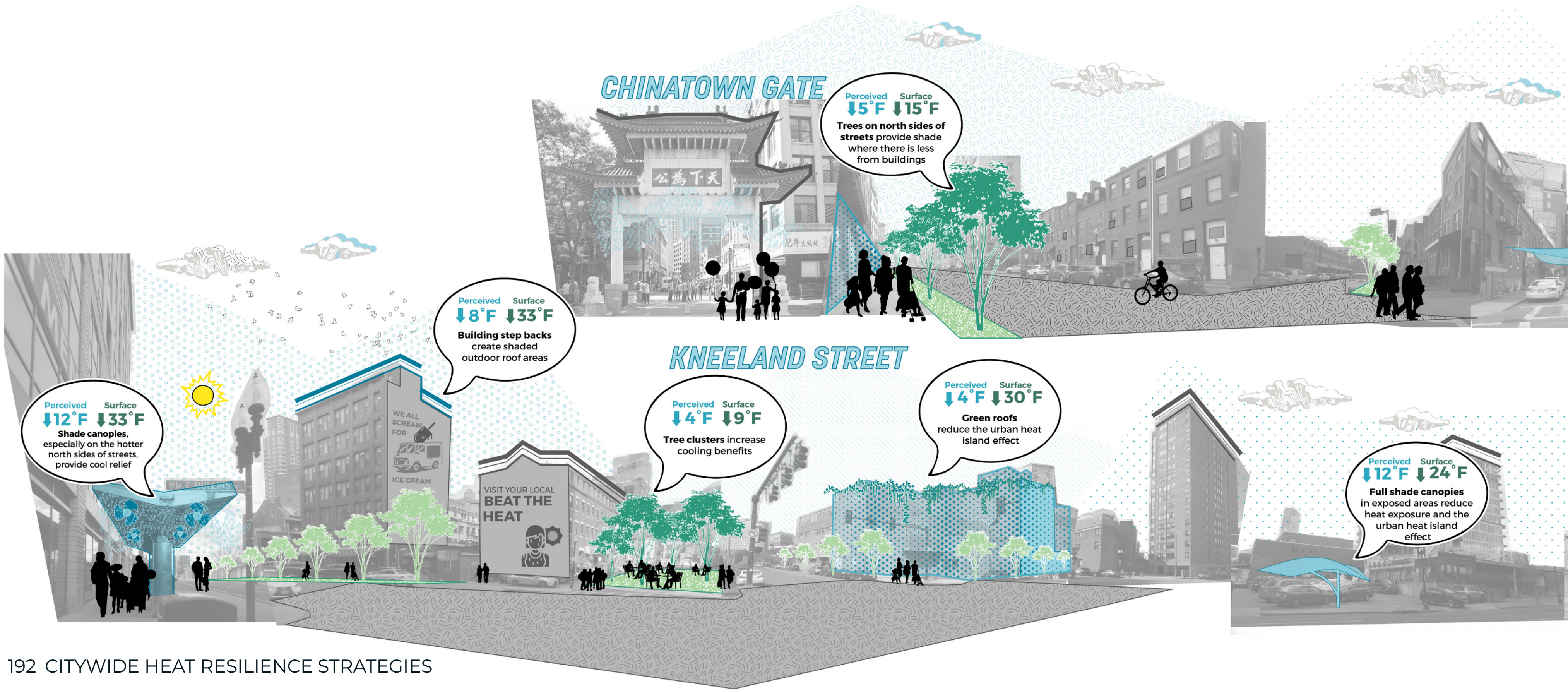
CATEGORY	CONSIDERATIONS
Heat Reduction Is the solution effective at reducing heat exposure for people—especially people with elevated heat risk—and infrastructure by *reducing temperatures*?	» Reduction in surface or perceived temperature » People supported, with a focus on people with elevated heat risks » Reduced heat exposure for infrastructure *Example: Planting trees to provide shade for both people and pathways, reducing perceived and surface temperatures*
Heat Relief Is the solution effective at reducing heat exposure for people—especially people with elevated heat risk—*by providing respite from existing heat*?	» Increased options for indoor and outdoor heat relief » Improved access to heat relief » People supported, with a focus on people with elevated heat risks *Example: A shaded bus stop (outdoor heat relief) or cooling center (indoor heat relief) providing respite*
Increased Adaptive Capacity Does the solution strengthen or improve a person's ability to cool off, such as increasing the accessibility of cooling solutions?	» Social resilience » Community partnerships *Example: Increasing wealth or transportation access to cool places, giving people more opportunities to cool off*
Improved Public Health Does the solution reduce heat sensitivity and improve public health to reduce heat-related illness?	» Improved public health related factors, with the potential to reduce prevalence of chronic health conditions that contribute to elevated risk of heat-related illness *Example: Improving air quality, which reduces the prevalence of asthma in a community so that when it's hot, it's less dangerous for health*

CATEGORY	CONSIDERATIONS
Economic Opportunity Does the solution help close the wealth gap? Is it creating new economic opportunity, especially for Bostonians who face barriers to employment due to systemic racism and injustices?	» Educational opportunities and workforce development » Job creation, preservation, and improvement » Small business, women and minority-owned businesses, and immigrant-owned business support *Example: Creating a job training program for young people that gives them access to jobs at businesses implementing heat resilience strategies*
Environmental Benefits What are the benefits of the solution to the to the health of natural communities and systems over time? Does the solution help reduce environmental pollution?	» Water and air quality improvements, including stormwater capture » Habitat creation and protection » Carbon storage » Reduced carbon emissions » Waste minimization *Example: Adding trees and green infrastructure, which improve air and water quality, and provide cooling with a lower carbon footprint than air conditioning*
Environmental Justice and Equity Does the solution increase the accessibility and affordability of heat relief for overburdened communities? Does the solution help address the drivers of disproportionate exposure to heat?	» Advances in environmental justice, including addressing disproportionate impacts among residents » Strengthened community identity and cohesion, which improves adaptive capacity » Recreational and cultural improvements and access » Mitigation against displacement or other unintended consequences from heat resilience strategies *Example: Prioritizing heat resilience strategies where needs are highest, especially as a result of past planning injustice*

NEIGHBORHOOD CLIMATE SIMULATION MODELING

The citywide heat analysis (Chapter 4) helped to identify urban heat islands across the city. This neighborhood climate simulation model zoomed into a neighborhood scale to give an idea of how effective built strategies might be in lowering surface and perceived temperatures. The project conducted two scenarios to calculate the difference between existing conditions and when heat resilience strategies are applied. While surface temperature gives an idea of how much heat a surface is absorbing, perceived temperature is equally important because it is the feels-like temperature people experience. Perceived temperature is more reflective of how hot a person might be feeling, which impacts how their body reacts to high heat exposure and heat-related illnesses.

Based on the citywide daytime and nighttime air temperature results, the project selected Chinatown as the neighborhood to run in this simulation. However, the results of a strategy's effectiveness can generally apply to other neighborhoods and locations. The team selected areas for the analysis based on streets of concern that came up during community engagement conversations (such as Tyler Street), as well as key landmarks like the Chinatown Gate. The different strategies applied for the cooling strategies scenario include light-colored roads, solar canopy, shade canopy, canopy on roofs, green roofs, and cool roofs. The simulation model also added trees along streets where appropriate.



KEY TAKEAWAYS:

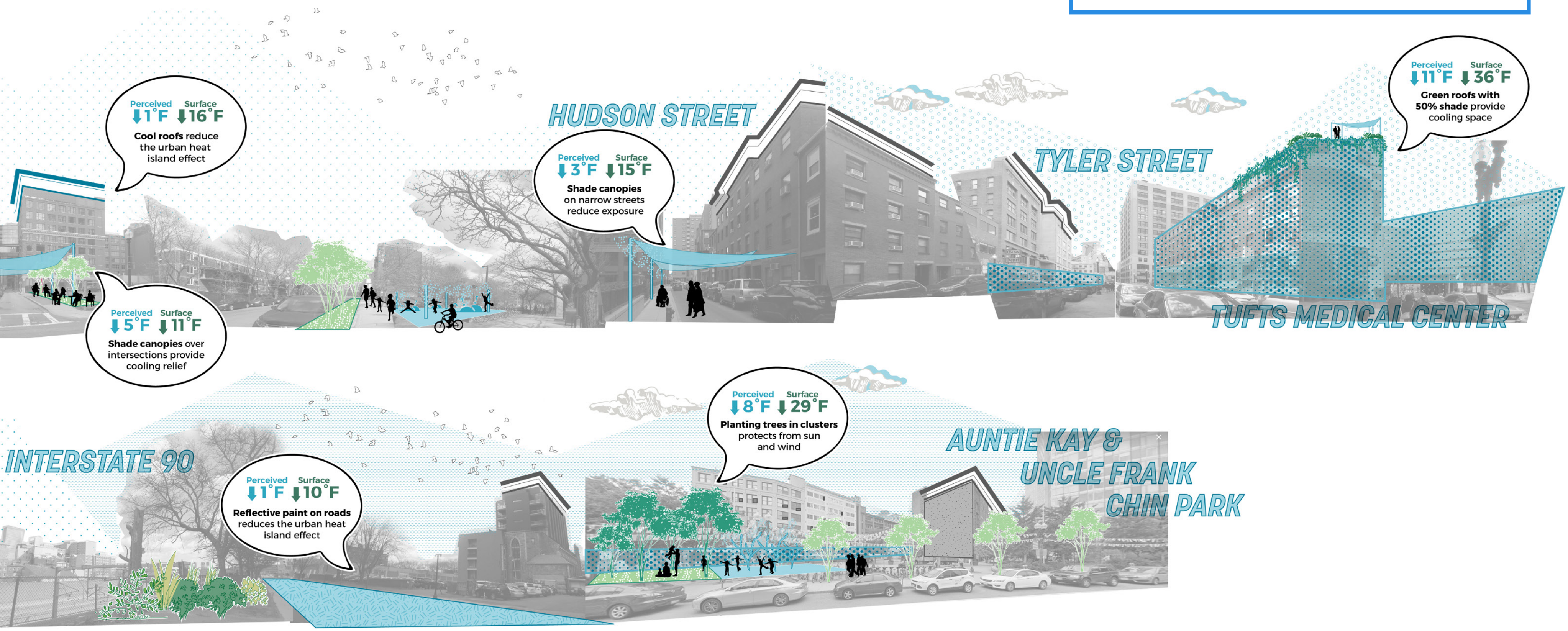
- Providing **full-shade canopies** reduces perceived and surface temperatures the most.
- **Green roofs** provide a significant decrease in surface temperature, but not as much decrease for perceived temperature. This can be improved by installing **50% shade canopies** (such as fabric canopies) which could create a cooler environment for people.
- **Building form** is an important factor, and having a step-back does provide a good amount of relief from heat for people.
- **Trees planted on the north side of streets** provide greater cooling benefits, as the north side is usually more exposed to the sun compared to the south side, where buildings provide more shade.
- **Planting trees in clusters** (rather than spaced out too far) provides a good amount of cooling of surfaces and perceived temperatures.
- **Light-colored surfaces** or highly reflective surfaces are great at decreasing surface temperature, but they aren't as effective at decreasing perceived temperature.

DEFINING TEMPERATURE

Air Temperature: Influenced by humidity, wind flow, building form, surfaces (ground, walls, and roofs), and the surrounding atmosphere. This report uses typical annual hourly meteorology data for Boston from Logan International Airport. Boston's average summer dry-bulb temperature is 72.5°F.

Perceived Thermal Comfort: What the surrounding temperature feels like to the human body. It takes into account humidity, temperature, and solar and wind exposure.

Universal Thermal Climate Index: Measurement used for perceived thermal comfort. Boston's average summer perceived temperature is 73°F. Summer daytimes are generally warm to hot with moderate to high heat stress (over 86°F).



NEIGHBORHOOD CLIMATE SIMULATION SAMPLE RESULTS

The neighborhood climate simulation model results include maps of surface and perceived temperature for the existing conditions scenario (baseline conditions) and the strategies scenario (with cooling strategies). A detailed analysis of these maps is available in Appendix 2, Technical Memo on Neighborhood Climate Simulation Modeling.

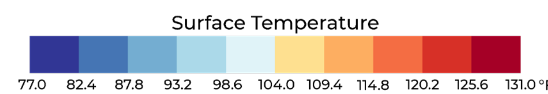
SUMMER AFTERNOON SURFACE TEMPERATURE

BASELINE CONDITIONS

Josiah Quincy Elementary

WITH COOLING STRATEGIES

Josiah Quincy Elementary



The map on the left shows the surface temperature of ground and rooftop surfaces in the existing conditions scenario. The map on the right shows the surface temperature of surfaces after applying a variety of cooling strategies. Generally, the combination of cooling strategies modeled can reduce surface temperatures.

For example, cool roof strategies can greatly decrease surface temperatures, like the rooftop strategies of cool and green roofs modeled at Josiah Quincy Elementary.

At the ground level, light roads, shade canopies, and trees can also decrease surface temperature, as seen around Chinatown Gate and Beach Street.

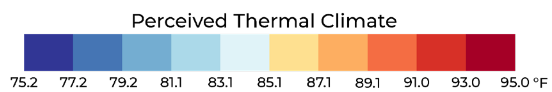
SUMMER AFTERNOON PERCEIVED TEMPERATURE

BASELINE CONDITIONS

Josiah Quincy Upper

WITH COOLING STRATEGIES

Josiah Quincy Upper



The map on the left shows the perceived temperature in the existing conditions scenario. The map on the right shows the perceived temperature after applying a variety of cooling strategies. Generally, the combination of cooling strategies modeled can reduce perceived temperatures. Some strategies modeled are more effective than others, but a combination helps to decrease how hot it feels.

Strategies modeled for roofs show that canopies and green roofs are more effective at decreasing perceived temperatures than light colored roofs (as seen at Josiah Quincy Upper). At the ground level, full shade canopies, building step-backs, and clustered trees are most effective at decreasing perceived temperatures (as seen at the parking lot along Tyler Street).

HEAT RESILIENCE STRATEGIES

HOW TO READ THIS SECTION

The *Heat Plan* includes a wide range of strategies for the City of Boston to take action and address the risks of extreme heat in a changing climate. The heat resilience strategies are organized into two sections: Relief During Heat Waves and Cooler Communities. The *Heat Plan* includes a total of 26 strategies, some of which tackle heat resilience in the short-term, while others are more systemic and may require a longer time frame to see the benefits.

For each strategy, the following elements are included: rationale and description, benefits, next steps. Some strategies also include call-outs describing related programs and additional cost and benefits analysis.

Rationale and Description: A description of why the strategy is relevant to Boston, the goals of the strategy, and steps to address issues or gaps revealed in the heat analysis. For successful implementation, the plan provides key partners and considerations. Since many of the strategies are interconnected and build off each other, the plan identifies related strategies to consider for coordination.

Next Steps: A concise overview of the immediate steps the City will take to implement the strategy.

Heat Resilience Benefits: A ranking of how the strategy targets the multiple facets of the goals and key principles of the *Heat Plan*.

Call Outs: An overview of relevant existing programs, policies, and projects mentioned in the strategy rationale and description.

Heat Resilience Costs and Benefits: An assessment of the costs for three projects—Cool Homes, Cool Schools, and Cool Main Streets. The analysis used a methodology that estimates costs for strategy elements over a 50-year period, including strategy elements such as cool pavements, cool roofs, shade devices, trees, and air conditioners. The *Heat Plan* qualitatively summarizes the benefits of implementing these strategies.

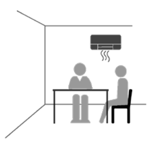
RELIEF DURING HEAT WAVES

1. OPERATIONS AND COMMUNICATIONS

1.1 BOSTON EXTREME TEMPERATURES RESPONSE TASK FORCE

1.2 PRE-HEAT WAVE RESOURCES MOBILIZATION

1.3 HEAT SENSOR NETWORKS

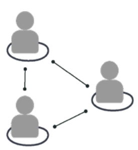


2. COOLING DURING HEAT WAVES

2.1 POP-UP HEAT RELIEF

2.2 ENHANCED AND EXPANDED CITY-RUN COOLING CENTERS

2.3 CITYWIDE COOLING NETWORK



3. LOOKING OUT FOR NEIGHBORS

3.1 EXPANDED COMMUNITY CLIMATE LEADERSHIP

3.2 EXTREME TEMPERATURE PLANS FOR OUTDOOR WORKERS

4. AWARENESS, EDUCATION, AND TRAINING

4.1 HEAT RESILIENCE PUBLIC EDUCATION CAMPAIGN

4.2 HEAT SURVEY

4.3 EXPANSION OF GREEN WORKFORCE DEVELOPMENT FOR HEAT RESILIENCE

COOLER COMMUNITIES

5. BUILDINGS

5.1 HOME COOLING RESOURCES DISTRIBUTION

5.2 COOL ROOFS PROGRAM

5.3 HOME ENERGY RETROFITS

5.4 AFFORDABLE HOUSING RESOURCES AND RETROFITS

5.5 COOL SCHOOLS

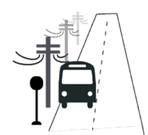
6. PARKS, TREES, AND OUTDOOR SPACES

6.1 ENHANCED COOLING IN POCKET GREEN SPACES AND STREET-TO-GREEN CONVERSIONS

6.2 INCREASED SHADE ON MUNICIPAL SITES

6.3 EXPANDED DRINKING FOUNTAIN NETWORK

6.4 PLANNING FOR FUTURE PARKS



7. TRANSPORTATION AND INFRASTRUCTURE

7.1 COOL COMMUTES

7.2 ENERGY RESILIENCE UPGRADES AND MICROGRIDS

7.3 COOL MAIN STREETS

8. PLANNING, ZONING, AND PERMITTING

8.1 UPDATED CLIMATE RESILIENCY CHECKLIST

8.2 HEAT RESILIENCE BEST PRACTICE GUIDELINES

8.3 ZONING REVISIONS TO SUPPORT COOLER NEIGHBORHOODS

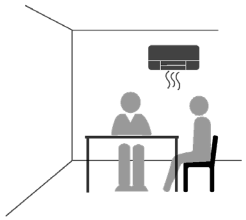
East Boston Public Library Cool Spot: In summer 2021, the team installed two Cool Spot pilots at the East Boston and Egleston Square Branches of the Boston Public Library. These cool spots worked with the free WiFi zone program to bring misted tents, hammocks, chairs, and tables for the public to hang out and cool off.

RELIEF DURING HEAT WAVES

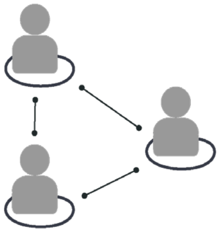
Apply a robust, integrated heat-wave response and deepen understanding of heat risks to build awareness, increase access to cooling, support social resilience, and build capacity.

Reducing heat vulnerability for Bostonians and making a more heat resilient city begins with effective communication, education, a tight-knit community, and equitable distribution of resources and access to cooling opportunities. This section includes eleven strategies to improve people's heat experiences.

1. OPERATIONS AND COMMUNICATIONS



2. COOLING DURING HEAT WAVES



3. LOOKING OUT FOR NEIGHBORS

4. AWARENESS, EDUCATION, AND TRAINING

1. OPERATIONS AND COMMUNICATIONS

1.1 BOSTON EXTREME TEMPERATURES RESPONSE TASK FORCE

Form an interdepartmental group that meets regularly to coordinate integrated responses to weather-related climate hazards including extreme temperatures.

RATIONALE AND DESCRIPTION

Boston knows how to mobilize around winter storms. Similarly, a unified all-of-government and all-of-city approach will help advance strategic actions that address chronic high temperature conditions and prepare the city in advance of extreme heat events. The Boston Extreme Temperatures Response Task Force will help increase the effectiveness of the City's mobilization and response operations. The goal for the task force is to deepen coordination across departments for extreme temperatures response that will positively impact residents' health and safety outcomes. The OEM and BPHC play critical coordinating roles for emergency response during heat emergencies in Boston.

Through engagement with residents, civic organizations, and others, the City will explore ways to most effectively communicate and expand the reach of emergency alerts and resources. For example, communicating neighborhood-specific heat advisories and emergencies may help residents identify resources specific to their neighborhood or community. The task force will engage a wide range of stakeholders to identify barriers Bostonians face to accessing resources needed for cooling or heating. It will help coordinate resources among public, civic, and private organizations to support Pre-heat-wave Resources Mobilization (Strategy 1.2). Additionally, lessons and best practices from an ad-hoc interdepartmental working group that addressed impacts of extreme summer temperatures and the COVID-19 pandemic (see Strategy 1.1 call out) will inform operations and strategies identified by the Extreme Temperatures Task Force. This will support interdepartmental coordination, messaging on available resources, and help for residents to stay cool in their homes.

HEAT RESILIENCE BENEFITS

Heat Reduction	●○○○○
Heat Relief	●●●●○
Adaptive Capacity	●●○○○
Public Health	●●●○○
Economic Opportunity	●○○○○
Environmental Benefits	●○○○○
Environmental Justice & Equity	●●●●○

NEXT STEPS

The task force will be established and will define roles and goals to inform mobilization around strategic actions. To inform strategic actions and track progress towards goals, the City will identify community needs through needs assessments and progress tracking.

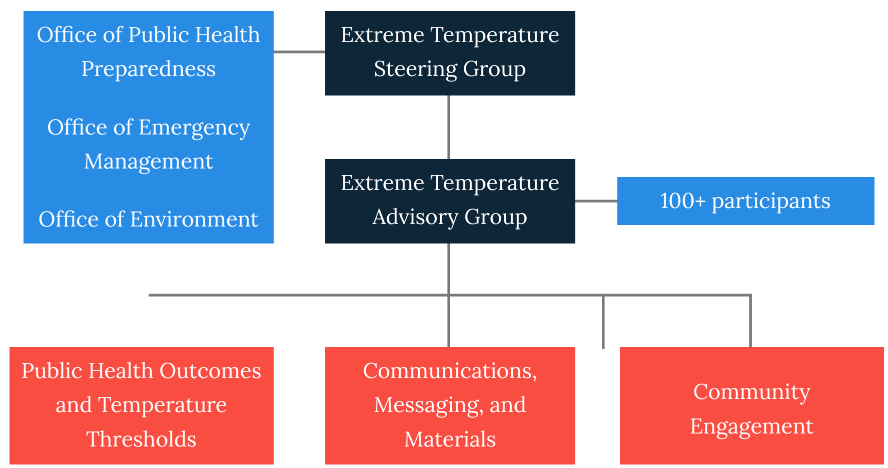
EXTREME HEAT AND COVID-19 WORKING GROUP

An ad-hoc interdepartmental working group to address compounding impacts of extreme summer temperatures and the COVID-19 pandemic was active during the summers of 2020 and 2021. At this time, many indoor and outdoor spaces that would normally provide refuge from extreme summer temperatures were closed. Residents were encouraged to self-isolate at home during quarantine; however, for many residents, staying cool and safe indoors was difficult.

The working group's goals and priorities included identifying critical needs of residents at risk of extreme heat and COVID health impacts, coordinating messaging about open and accessible cooling centers and COVID safety guidelines, helping residents stay cool in their homes through fan and air conditioner giveaways, amplifying information about utilities and rental assistance, and safely reopening cooling resources.

From an operational perspective, the BPHC Extreme Temperatures Response Plan aims to reduce heat-related health risks and outcomes for Boston residents, especially people most vulnerable to extreme heat. The Extreme Temperatures Response Plan shifts management of extreme heat and cold events to the BPHC, including coordination of the respective City of Boston departments, to communicate and engage with communities to enhance preparedness to extreme temperatures.

Planning Structure of the Extreme Temperatures Steering Group



Source: Adapted from Collaborative Planning for Extreme Temperature Response in the City of Boston. Accessed March 2022. https://delvalle.bphc.org/mod/wiki/view.php?pageid=159

1. OPERATIONS AND COMMUNICATIONS

1.2 PRE-HEAT-WAVE RESOURCES MOBILIZATION

Preposition resources to support residents and other stakeholders before heat waves.

RATIONALE AND DESCRIPTION

As the City of Boston does before major winter storms, additional Citywide plans to mobilize a wider range of resources ahead of extreme heat events can help ensure that all Bostonians can access the resources they need during any extreme weather event. Since the City monitors long-range forecasts for extreme weather, the City can deploy resources before extreme heat events. The City will build on existing efforts to deepen coordination across departments and define concrete, pre-heat-wave action plans to identify and distribute cooling resources and information to residents.

The City will distribute information on how to stay cool at home and in neighborhoods, including the Resource Guides (Chapter 7). Partnerships with community organizations and the use of diverse digital and in-person communications channels will be critical to ensuring information reaches residents and prepares them for upcoming heat events. The City will also explore approaches to share data from long-range forecast monitoring to give community organizations additional time to mobilize their own efforts and to give residents additional time to prepare and seek out resources. Through this strategy, the City aims to integrate activation of coordinated support and prepositioned resources with City, state, and community implementation partners when a heat advisory or heat emergency is likely. For example, the City will explore how the concept of the Healthy Places air conditioner and fan delivery pilot program (see Strategy 1.2 call out) can move forward in the future.

Community partnerships are key to better understanding community needs, meeting these needs, and building community power. The City will identify opportunities to coordinate with and support community-based organizations to build awareness and codevelop additional resources and programs. Prioritization will focus on increasing and improving heat relief for overburdened Bostonians with elevated heat risks. This strategy will be coordinated with the Heat Resilience Public Education Campaign (Strategy 4.1) to disseminate alerts and resources.

Other connections and partnerships to leverage include senior centers and senior housing, schools, daycare facilities, emergency shelters, community health centers, hospitals, congregant shelters, and transportation partners. This strategy will also be coordinated with Enhanced and Expanded City-run Cooling Centers (Strategy 2.2), so that residents can access cooling resources and information about complementary city services in cooling centers.

HEAT RESILIENCE BENEFITS

Heat Reduction	●○○○○
Heat Relief	●●●●●
Adaptive Capacity	●●●○○
Public Health	●●●○○
Economic Opportunity	●○○○○
Environmental Benefits	●○○○○
Environmental Justice & Equity	●●●●○

NEXT STEPS

Convening Boston's Extreme Temperatures Response Task Force (Strategy 1.1) is a critical next step to operationalize some of the goals identified in this section. Additionally, expanding usage of AlertBoston (the City's emergency alert system), 311 (the City's constituent services system), and other ways to engage residents will build awareness around existing resources in the near-term.

HEALTHY PLACES AIR CONDITIONER AND FAN DELIVERY PILOT PROGRAM

The Healthy Places air conditioner and fan delivery pilot program provided direct support to residents of Boston facing increasing high average temperatures and extreme heat events. In 2021, Boston had 24 days over 90°F and four separate heat waves. Over that summer, the pilot program distributed 400 air conditioning units and 700 box fan units free of charge to income-eligible residents who live in neighborhoods that experience higher average summer temperatures, who did not have the resources to stay healthy and cool during heat waves, and who were more sensitive to heat stress due to their age and chronic health conditions like asthma. The pilot program was developed in collaboration with multiple City departments, commissions, and agencies, including the Environment Department, Age Strong Commission, BPHC, OEM, BHA, and the Public Works Department (PWD).

Fan distribution as part of the pilot Healthy Places initiative in summer 2021

Hampton House Apartments in Roxbury

Eva White Apartments in the South End

1. OPERATIONS AND COMMUNICATIONS

1.3 HEAT SENSOR NETWORKS

Deploy targeted networks of heat sensors to inform ongoing planning and measure progress.

RATIONALE AND DESCRIPTION

Heat sensor networks aim to support heat warnings, inform design guidelines and capital planning decisions that center heat resilience and health equity, and increase education and awareness of heat risk. This strategy supports other initiatives that benefit from a data-driven approach, as it will allow the City the ability to measure trends over time as heat resilience and health equity investments are made. MONUM is a key partner in guiding this strategy, as they work across departments to deploy innovative improvements on streets, online, and in schools using technology and design.

In coordination with residents, civic organizations, data privacy experts, and other key stakeholders, the City will identify opportunities to coordinate with public and private implementation partners to assess potential outdoor and indoor heat sensor deployment sites focused on limited and targeted sites that are directly tied to a specific design guideline or capital planning need of the City. These deployment sites will only gather data that is necessary to allow for localized understanding of outdoor hot spots and indoor heat exposure, while maintaining the privacy standards of the City. The data collected through this network will be open source, where appropriate, to support research and innovation in compliance with the City's data standards. Since existing health conditions, like asthma, are exacerbated both by heat and air pollution, the City will also integrate air pollution mitigation and monitoring initiatives.

To support regional heat resilience in Greater Boston, the City will continue to explore additional opportunities to collaborate with regional partners and municipalities on monitoring and modeling that can help inform design guidelines and capital planning decision making in the region.

HEAT RESILIENCE BENEFITS

Heat Reduction	●●○○○
Heat Relief	●○○○○
Adaptive Capacity	●●●●○
Public Health	●○○○○
Economic Opportunity	●○○○○
Environmental Benefits	●●○○○
Environmental Justice & Equity	●●●○○

NEXT STEPS

PWD, in partnership with MONUM and the Environment Department, installed outdoor air quality sensors on street lights along Cummins Highway. Data collected before and after construction will help to understand the impact of the corridor redesign on near-field air quality. The City expects to learn how different built environment conditions, such as green infrastructure, influence air quality on a corridor, as well as how design interventions can affect air quality. Learning from this pilot, the City is exploring other opportunities to install air quality and temperature sensors on street lights and bus stops to better understand the relationship between urban heat, street design, and air pollution, and to inform corridor redesigns and management strategies elsewhere in Boston.

In fiscal year 2022, the Air Pollution Control Commission also piloted a Community Clean Air Grant program to support community-based initiatives to address sources of air pollution in Boston's neighborhoods. The pilot program sought to provide up to $50,000 in direct financial support, and offered multilingual application submission and review, over the course of three rounds of review. As examples, the pilot program is supporting two projects in East Boston to monitor air quality in community hubs, home daycares, and homes of residents with respiratory issues, in conjunction with the deployment of HEPA filters.

Boston Public Schools (BPS) recently launched the Indoor Air Quality (IAQ) Management Program, which includes thousands of new indoor air quality sensors installed in classrooms across the district to help protect the health and learning outcomes of students. This program records, monitors, and analyzes air quality and temperature in real-time.

The City will continue to explore strategies to define and prioritize sensor locations throughout Boston, with a focus on outdoor and indoor high heat exposure areas and elevated heat vulnerability that will be undergoing capital improvements that could affect heat resilience.

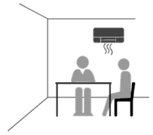
COMPLEMENTARY HEAT MEASURING EFFORTS IN BOSTON

In 2019, the Museum of Science's Wicked Hot Boston program engaged community participants to collect ambient air temperature to investigate extreme heat and urban heat islands throughout the city. In 2021, this program expanded to Wicked Hot Mystic, where volunteer scientists collected high resolution temperature and air quality data within the Mystic River Watershed. Collaboration with the Museum of Science's Citizen Science, Civics, and Resilient Communities (CSCRC) education project can provide additional community engagement and citizen-created data that will improve heat measurement and modeling.

Wicked Hot Boston's mobile sensor on a car
Source: Museum of Science

2 COOLING DURING HEAT WAVES

A well-connected and accessible network of trusted community spaces that provide shade or air conditioning is critical to keeping residents safe and out of the heat. Currently, BCYF provides cooling centers across Boston when a heat emergency is declared. Other public community spaces such as libraries, parks, tot sprays, pools, and beaches serve as critical resources that also provide cooling. Additionally, malls, grocery stores, and other community-identified spaces also serve as spaces that residents often frequent to keep cool.



2. COOLING DURING HEAT WAVES

2.1 POP-UP HEAT RELIEF

Create an expanded network of free-to-access cooling locations.

RATIONALE AND DESCRIPTION

In partnership with community organizations, the City will activate public spaces during warmer seasons with pop-ups that provide cooling relief in high exposure areas within communities. Pop-ups are temporary, ad-hoc installations that are used to provide a service or program at the right place and at the time it is needed. The sites can be distribution points for heat resources and opportunities to sign up for emergency alerts. This strategy will engage youth and community organizers, increase social interaction and community building, and engage local economies. Pop-ups will be prioritized in locations that have high heat exposure, especially areas with limited access to green spaces or cooling centers.

Pop-up heat relief locations would provide multiple benefits in addition to heat resilience:

» Employment opportunities to support the local economy by working with small businesses and community organizations

» Awareness of and access to additional City services and programs for pop-up attendees

» An opportunity to celebrate culture, heritage, and identity at each site

NEXT STEPS

In partnership with MONUM, Boston Public Library (BPL) will launch the second year of pop-up Cool Spots at branches in summer 2022. BPL outdoor spaces will expand to nine locations with an emphasis on multi-seasonal placemaking with cooling measures where possible.

To expand pop-up heat relief, the City will distribute pop-up cooling kits to eligible organizations with active summer programming and resident engagement to integrate features like shade and mist tents in their regular programming. The City will continue to explore ways to provide support and resources to communities looking to establish additional pop-ups for heat relief.

HEAT RESILIENCE BENEFITS

Heat Reduction	●○○○○
Heat Relief	●●●●○
Adaptive Capacity	●●○○○
Public Health	●●○○○
Economic Opportunity	●●○○○
Environmental Benefits	●○○○○
Environmental Justice & Equity	●●●●○

SUMMER 2021 COOL SPOTS

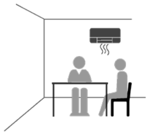
In summer 2021, two pop-up Cool Spots were installed by the Environment Department in partnership with MONUM and BPL's broader outdoor WiFi zone pop-ups pilot program. One was located at the Egleston Square Branch in Roxbury, and the other was at the East Boston Branch. These pop-up Cool Spots included shaded tents, misters, hammocks, and seating for people of all ages to enjoy, as well as heat sensors reporting real-time temperature readings.

Hammocks and tents at the East Boston Branch Cool Spot

Misters installed under tents at the East Boston Branch

Shade, tables, and chairs at the Egleston Square Branch Cool Spot for people to hang out

Cool Spot and free WiFi zone at the Egleston Square Branch of the BPL



2. COOLING DURING HEAT WAVES

2.2 ENHANCED AND EXPANDED CITY-RUN COOLING CENTERS

Develop dedicated programming and clear messaging for public cooling centers and identify opportunities to expand services.

RATIONALE AND DESCRIPTION

During heat emergencies, designated BCYF community centers become cooling centers in each neighborhood. Cooling centers are open to everyone to cool off inside with air conditioning. Through dedicated programming and other opportunities to enhance and expand cooling centers, utilization of this important resource can grow.

The City will explore a range of options for network expansion, which may include identifying public buildings to serve as additional cooling centers. The City will prioritize areas with higher vulnerability, such as areas with high numbers of residents experiencing homelessness, children, older adults, and other high risk populations. The City will assess whether other public buildings with the appropriate climate controls, such as schools with HVAC systems that are not in session, could serve as cooling centers during heat emergencies. Additionally, the City will explore partnering with property owners and local community organizations to provide resources to temporarily repurpose vacant storefronts in neighborhood commercial districts for pop-up storefront cooling spots, and other opportunities to augment pop-up heat relief (Strategy 2.1).

Currently, when cooling centers activate during a heat emergency, existing scheduled activities and programming at BCYF community centers are rearranged or canceled. The City will explore the feasibility of providing free, diversified activities and programming which are co-located with other attractive programs, such as free WiFi spots. To support the capacity of BCYF staff during emergency operations, the City will consider ways to add capacity, such as working with small businesses and community organizers (coordinate with Strategy 4.3: expansion of green workforce development for heat resilience, and Strategy 3.1: expand community climate leadership) to support programming at BCYF cooling centers or Cool Spots. The City will prioritize supporting local women- and minority-owned small businesses, where appropriate, such as in the procurement of goods or services like hiring local educators or artists to run hands-on workshops.

Other improvement opportunities for cooling centers include developing a recognizable and consistent brand to use on exterior signage (for example, sandwich boards) in multiple languages.

The City will explore extending opening hours to accommodate access to cooling during the day and night. This is especially important for people living in neighborhoods that are hot in the day and night, like Chinatown. Transportation has also come up as a barrier to accessing cooling centers. The City will identify gaps in transportation access and work to close them through improvements around cooling centers (such as cool paths, added pedestrian connections to expand access, and other improvements).

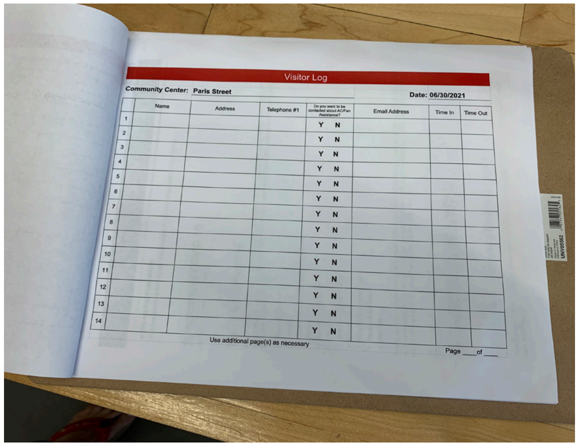
HEAT RESILIENCE BENEFITS

Heat Reduction	●○○○○
Heat Relief	●●●●●
Adaptive Capacity	●●●●○
Public Health	●●●○○
Economic Opportunity	●○○○○
Environmental Benefits	●○○○○
Environmental Justice & Equity	●●●○○

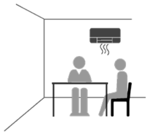
NEXT STEPS

First, the City will conduct an assessment, including a community survey and focus groups, to understand what programming, barriers, and needs should be addressed. An analysis of the results will determine how to address barriers, including how cooling services are provided and whether to prioritize additional indoor cooling opportunities (Strategy 2.3).

BCYF Paris Street served as a cooling center in 2021. Sandwich boards and other advertising strategies can be implemented at cooling centers across the City.



The visitor log at BCYF Paris Street is a much simpler form than a typical registration form for community center use. This might still pose a barrier for some people.



2.3 CITYWIDE COOLING NETWORK

Expand Boston's network of free-to-access outdoor and indoor cooling locations.

RATIONALE AND DESCRIPTION

Project survey results showed that 60% of respondents would like to see more cooling centers in their neighborhood. To expand the existing network of cooling spaces in Boston over time, this strategy aims to create a citywide cooling network that will include several tiers, such as the following:

- **City cooling centers**: BCYF community centers as official cooling centers with other public buildings where available and needed to close cooling network gaps
- **Public outdoor spaces:** tot sprays, pools, parks, beaches, and other public outdoor spaces that provide relief from heat
- **Community cooling partners:** expanded network that provides additional trusted indoor cooling spaces in partnership with organizations like churches, community organizations, businesses, and institutions
- **Pop-up heat relief spots:** outdoor cool destinations that are deployed and accessible during heat waves offering an impactful role for blocks, individuals, and community organizations, with support from the City
- **Additional small-scale cool spots:** smaller-scale indoor spaces, pop-up indoor centers in underused areas, kits for residents to support cooling, building-level retrofits for shared cooling areas, and more

The City will explore opportunities to support and expand the capacity of community organizations to participate in the network, providing additional options for cooling relief where people already gather or hang out. Potential opportunities for collaboration include religious institutions, community organizations, local businesses, local health centers, and higher education institutions. BPHC, OEM, and the Office of Neighborhood Services (ONS) are key to ensuring successful implementation of this strategy as they coordinate mutual aid and provide emergency information and overall support for communities and neighborhoods.

The City will define guidelines and priority locations to address existing gaps for each tier of the cooling network, including best practices for hours of operation, amenities, back-up power expectations, staffing, and other resources to ensure network participants have the necessary resources and guidance to help keep residents cool and safe. Consistent signage and branding for participating locations will help residents identify which locations are part of the cooling network.

Priorities for growth and expansion of the citywide cooling network in areas of the city that experience elevated air temperatures will focus on providing relief for Bostonians with elevated heat risk who are disproportionately affected by high-heat days and who may not otherwise have the capacity to obtain access to cooling.

Minimizing barriers to entry, such as cost, providing individual information, and creating a welcoming environment are essential to an expanded cooling network that will be beneficial to the community. The City will develop communication and marketing to promote the citywide cooling network, with consistent, accessible communication and signage. The City will identify opportunities to coordinate with existing well-known programs and emerging initiatives and trusted community organizations, which is complementary with expanded community climate leadership (Strategy 3.1).

NEXT STEPS

The City will assess existing formal and informal networks in the community and neighborhoods to identify community partners and needs for support.

HEAT RESILIENCE BENEFITS

Heat Reduction	●○○○○
Heat Relief	●●●●●
Adaptive Capacity	●●●○○
Public Health	●●●○○
Economic Opportunity	●●●○○
Environmental Benefits	●●○○○
Environmental Justice & Equity	●●●●●

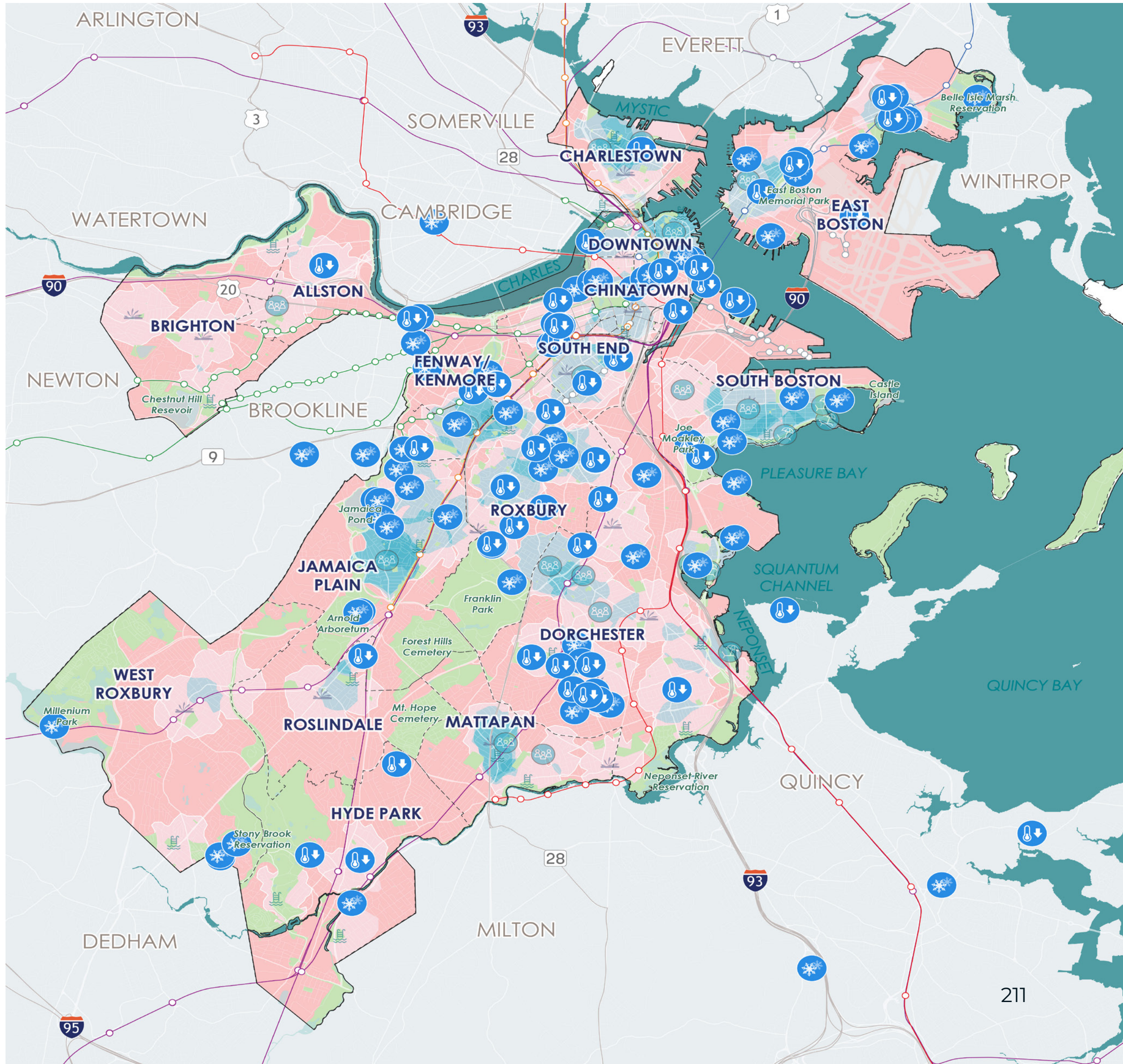
PUBLIC COOLING LOCATIONS (NO TOT SPRAYS)

PUBLIC PLACES TO COOL OFF

Pools (BCYF and DCR)
Libraries
Beaches
Community Centers
No Cooling Centers
More Cooling Centers Within 10-minute Walk

SURVEY RESULTS: WHERE DO YOU...

Go to cool off inside
Go to cool off outside



3. LOOKING OUT FOR NEIGHBORS

3.1 EXPANDED COMMUNITY CLIMATE LEADERSHIP

Support leadership development and community-identified heat resilience priorities.

RATIONALE AND DESCRIPTION

The effectiveness of heat resilience strategies can be greater when they incorporate partnership approaches across an equally broad range of community leaders, small businesses, young people, and organizations. This strategy aims to broaden involvement in heat resilience strategies, while also providing leadership development opportunities for residents. The Environment Department will expand community climate leadership to support existing community leaders and grow a broader community network of residents with a diverse range of backgrounds and skill sets to promote climate resilience in their neighborhoods. This effort intends to create opportunities for community members to build local ties, strengthen small businesses' ability to foster creative resilience improvements, and expand the network of climate resilience information sharing and action. Trusted local ambassadors will share information about how to stay cool during heat waves to close gaps in the reach of official City communications, along with other climate resilience information.

Other anticipated participants of the community climate leadership program include youth leaders and small business owners. This strategy will build upon other local education and climate advocacy programs and heat sensor networks (Strategy 1.3).

For small businesses and nonprofits, this program will be a network-based approach to promoting climate resilience among small businesses. It may include education and preparedness resources, support for resilience operational planning, and guidance on eligibility for grants supporting climate resilience investments and retrofits. This strategy connects to the BPHC's Safe Shops Program, which provides technical assistance to small businesses, and cool Main Streets (Strategy 7.3), which identifies opportunities for cooling interventions in Boston's neighborhood commercial hubs. Interested businesses may become staging points for pre-heat-wave resources mobilization (Strategy 1.2) and offer water and cooling resources during heat waves that also support their customer engagement and retention goals.

Leaders from youth and small business cohorts may meet together a few times annually or during key moments in the year, such as before the summer season begins, to share best practices and build a sense of community among participants. The program will also support mentorship and help develop career pathways and other learn-and-earn opportunities.

HEAT RESILIENCE BENEFITS

Heat Reduction	●○○○○
Heat Relief	●○○○○
Adaptive Capacity	●●●○○
Public Health	●○○○○
Economic Opportunity	●●○○○
Environmental Benefits	●○○○○
Environmental Justice & Equity	●●●○○

NEXT STEPS

The Environment Department will gauge interest in the broader community, refine the program scope and goals based on feedback, and convene an initial cohort to pilot the program. The City will focus recruitment on people who understand the problem and are being affected most significantly, emphasizing diverse backgrounds among the cohort. Recruitment will proceed through multiple media platforms and languages, with broad reach to provide inclusive participation opportunities.

3. LOOKING OUT FOR NEIGHBORS

3.2 EXTREME TEMPERATURE PLANS FOR OUTDOOR WORKERS

Provide information and guidelines about summer safety for outdoor workers.

RATIONALE AND DESCRIPTION

Outdoor workers are at elevated risk of heat-related illness. They have little flexibility to adjust their work schedule or activities, even during a hot day, and consequently they are particularly vulnerable during a heat wave. In coordination with other state and federal efforts, the City will explore opportunities for developing, where appropriate, local guidelines, plans, best practices, and policies for outdoor employment on hot days. The City will share resources with employers and employees, where appropriate, to increase awareness of ways to reduce heat risk and maintain a safe and healthy workplace.

Information sharing will include providing large construction projects and other outdoor worker employers with best practices information for extreme heat, covering topics such as work hours and breaks, shade, hydration, training for crews to recognize symptoms of heat-related illness, and limits on work during heat waves. These resources will highlight the benefits to the employer of protecting worker health in the heat, including fewer days lost to heat-related illnesses, improved worker retention and job satisfaction, and a healthier workforce overall. Additional resources are available in the Occupational Safety and Health Administration (OSHA)'s Heat Illness Prevention campaign, launched in 2011.

The City will seek to engage with the state to help inform state-level policy guiding outdoor work on excessive heat days, such as policies on temperature thresholds, shade, and water provision, and training to recognize heat-related illness symptoms. Additionally, OSHA is in the process of considering a federal heat standard, which will provide further guidance around outdoor worker safety. In October 2021, OSHA issued an Advance Notice of Proposed Rulemaking for Heat Injury and Illness Prevention in Outdoor and Indoor Work Sessions.[1]

HEAT RESILIENCE BENEFITS

Heat Reduction	●○○○○
Heat Relief	●●●●○
Adaptive Capacity	●●●○○
Public Health	●●●○○
Economic Opportunity	●○○○○
Environmental Benefits	●○○○○
Environmental Justice & Equity	●●●●○

NEXT STEPS

Through engagement with key stakeholders, such as workforce safety organizations, unions, worker centers, City and state regulators, and others, the City will explore opportunities to provide training, best practice guides, and other resources to vulnerable outdoor workers. Building upon existing methods and identifying additional means of reaching outdoor workers and their employers ahead of a heat wave will be important to increasing awareness.

4. AWARENESS, EDUCATION, AND TRAINING

4.1 HEAT RESILIENCE PUBLIC EDUCATION CAMPAIGN

Launch a multi-pronged public education campaign to increase awareness of heat risks and cooling options.

RATIONALE AND DESCRIPTION

Even though heat is the number one cause of weather-related deaths in the United States, many people are unaware of the dangers of extreme heat. Building on existing City resources for excessive heat, this multi-pronged public education campaign would focus on increasing awareness of heat risks and how to stay cool.

The heat resilience public education campaign will include a broad coalition of public, civic, and private organizations to expand awareness. The core focus of the campaign will be to share the risks of heat, best practice behavior in hot weather, and cooling opportunities through many outlets. The current COVID-19 response and information campaigns provide lessons and best practices that inform how to most effectively share information.

To increase awareness broadly among Boston residents, the public education campaign would take many forms, ranging from signage, television and radio messages, education programs, public art, social media, and more. Messengers may include youth influencers, teachers, radio and news personalities, primary care physicians, home health aids, and compensated community-based organizations, nonprofits, or small businesses (see also Strategy 3.1, expanded community climate leadership). Information will be available in multiple languages, with culturally adapted content. Importantly, the Public Education Campaign will integrate with other education efforts and City programs to maximize its reach, effectiveness, and consistency with other messages.

Design of the public education campaign will build in opportunities for bidirectional communication with residents to improve actions taken and participate in government decision making, as well as build community capacity around getting engaged in other supportive programs.

Along with other strategies in the *Heat Plan*, this effort will help expand sign-ups and reach of existing emergency alert communications (AlertBoston) and increase awareness of 311 as a one-stop connection to heat relief resources.

While the campaign will be designed to increase general awareness of heat risks, it will also place a special focus on providing information to residents and workers who are at greatest risk. This could include distributing information in high-heat neighborhoods, in collaboration with service providers supporting unhoused residents, at construction sites (see also Strategy 3.2, extreme temperature plans for outdoor workers), and to older adults, families with young children, and residents with disabilities or underlying health conditions that increase their health risks in hot weather.

This strategy will be coordinated with the Boston Extreme Temperatures Response Task Force (Strategy 1.1) to utilize established public education channels for pre-heat-wave resources mobilization (Strategy 1.2).

HEAT RESILIENCE BENEFITS

Heat Reduction	●○○○○
Heat Relief	●●○○○
Adaptive Capacity	●●●○○
Public Health	●●○○○
Economic Opportunity	●○○○○
Environmental Benefits	●○○○○
Environmental Justice & Equity	●●●●○

NEXT STEPS

One existing opportunity is to revamp the City's climate leadership program to engage local communities in ways residents can take action on climate and extreme heat. In parallel, the City will assess opportunities to expand sign-ups for AlertBoston, including the feasibility of switching to an opt-out system and including more opportunities for residents to learn about and sign up for AlertBoston when engaging the City in other programs or services.

Finally, the City will review 311's heat-related information and consider expanding language access to extend this citywide resource to additional residents.

The Heat Plan table at the Chinatown Block Party

4. AWARENESS, EDUCATION, AND TRAINING

4.2 HEAT SURVEY

Deploy a citywide survey to measure public perceptions about heat risks and barriers to accessing cooling, and to improve access to resources and services.

RATIONALE AND DESCRIPTION

Tailored resources and assistance programs are critical to ensure all of Boston's diverse communities can access the necessary resources to stay cool. While the danger of heat is perceived as generally underestimated by many residents, the specifics of knowledge and resource gaps—and how they vary across different demographic and cultural lines—are not well known.

The City will launch a citywide survey, available in multiple languages, to measure public perceptions about heat risks and barriers to accessing cooling. This strategy aims to ensure that City services to stay cool are responsive to community needs. Survey data will allow tracking changes over time and measuring effectiveness. Data will be open access to support research and innovation, in compliance with City of Boston data standards.

This strategy serves as a critical initial step for multiple strategies including pre-heat-wave mobilization resources (Strategy 1.2) and home cooling resources distribution (Strategy 5.1). This strategy would support the creation of more targeted priority messages in the public education campaign (Strategy 4.1).

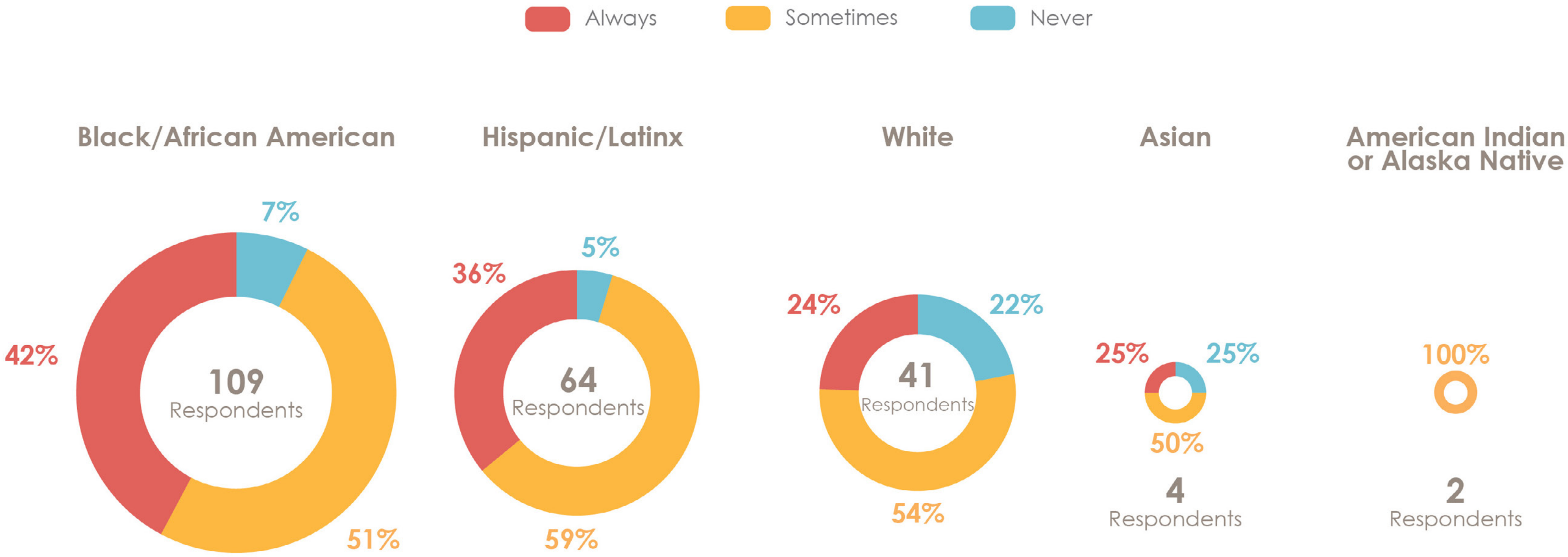
NEXT STEPS

Convening the Boston Extreme Temperatures Response Task Force (Strategy 1.1) is a critical next step to advance the survey. Through the task force, the City will determine data collection goals and survey design.

HEAT RESILIENCE BENEFITS

Heat Reduction	●○○○○
Heat Relief	●●○○○
Adaptive Capacity	●●○○○
Public Health	●○○○○
Economic Opportunity	●●○○○
Environmental Benefits	●○○○○
Environmental Justice & Equity	●●●○○

When it is very hot outside, how often do you feel too hot at home?



In public surveys conducted during the *Heat Plan*, the disproportionate exposure of people of color to heat risk in their own homes is visible.

The citywide survey showed that the majority of respondents feel too hot in their home. However, the burden of heat exposure at home falls disproportionately on Black and Latinx communities. Of Black respondents, 42% always feel hot in their home (represented by the red segment in the graph), while the percentage of white respondents that always feel hot is just over half of that. While 5% of Latinx respondents said they never feel hot in their home (represented by blue in the graph above), the percentage of white respondents that said they never feel hot in their home is about four times higher.

4. AWARENESS, EDUCATION, AND TRAINING

4.3 EXPANSION OF GREEN WORKFORCE DEVELOPMENT FOR HEAT RESILIENCE

Provide career pathways in green jobs including energy retrofits, cool roof installations, and tree planting and maintenance.

RATIONALE AND DESCRIPTION

As the City takes action to meet carbon neutrality goals and build a better, more resilient Boston, new systems and infrastructure will need to be built. These projects will expand new green job opportunities in industries such as building energy retrofits, building operations and maintenance, roadway construction and improvements, tree planting and maintenance, and more. This strategy aims to ensure that the workforce gains the skills needed to support these changes and increased need for capacity in an equitable manner.

The strategy of expanding green workforce development will require supporting incumbent worker training, creation and support of new career pathways, and buy-in of the full workforce development ecosystem. The City will continue to develop additional green workforce training programs with program participants, such as apprenticeship programs, high schools, community colleges and other higher education institutions, vocational training programs, community-based organizations, workforce development organizations, and worker centers that already offer workforce training programs. To ensure equity and sustainability, new programs will consider ways to proactively reduce barriers to participation, such as support services for transportation, child care, and language accessibility during training programs.

New programs will look for ways to work with potential employers and industry leaders to understand their needs. This type of outreach can provide a broad range of opportunities through mentorship, internships, fellowships, and employment pathways for program participants, as well as improved hiring practices and talent pipelines for employers facing new and increasing needs for a green workforce.

This strategy would also coordinate with expanded community climate leadership (Strategy 3.1) to upskill or educate community nonprofit members on climate resilience job opportunities, especially women- and minority-owned businesses. New and existing green workforce training programs will incorporate awareness of the dangers of extreme heat and heat stress, and how their industry's work could mitigate the impacts or adapt systems and infrastructures to be resilient to heat. Program participants may become ambassadors in their future role.

HEAT RESILIENCE BENEFITS

Heat Reduction	●○○○○
Heat Relief	●○○○○
Adaptive Capacity	●○○○○
Public Health	●○○○○
Economic Opportunity	●●●●●
Environmental Benefits	●●●○○
Environmental Justice & Equity	●●●●●

WHAT ARE GREEN JOBS?

Green jobs are jobs in the following:

- Energy efficiency
- Carbon-reduction
- Natural resource conservation or climate hazard mitigation sectors

These industries include but are not limited to the following:

- Construction trades, including weatherization, HVAC, electrical, plumbing, engineering, carpentry, roofing, estimation, and pipefitting
- Building operations, building automation, and facilities management
- Green stormwater infrastructure, tree care, and horticulture

Learn more: https://www.boston.gov/environment-and-energy/green-jobs

NEXT STEPS

In fiscal year 2022, the City began this process by allocating $1 million to support the City's Green Jobs initiative[2] and $500,000 for mobility jobs. This initial funding was used to expand existing green jobs and mobility jobs training programs implemented by community organizations.

The City has also allocated $3 million of federal funding received through the American Rescue Plan Act of 2021 for green workforce development. The City is developing a Boston green jobs training program, modeled off the City of Philadelphia's PowerCorpsPHL program. The Boston program will coordinate with related workforce development programs of the Mayor's Office of Workforce Development (OWD) and recommendations coming out of the Boston Parks and Recreation Department (BPRD)'s *Urban Forest Plan*. These programs ensure that the expansion of these training opportunities incorporate wrap-around support services to lower the barriers of entry into the program for participants.

Charlestown Navy Yard

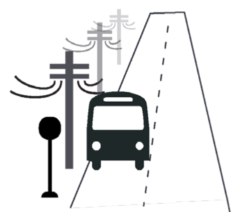
COOLER COMMUNITIES

Create cooler indoor and outdoor environments, buildings, and neighborhoods.

The built environment influences how hot a neighborhood can get during the summer. This section includes 15 strategies to create more energy efficient buildings through retrofits and incentive programs, cooler outdoor spaces for people to enjoy, and policies that encourage future development to contribute to a more heat-resilient city.

5. BUILDINGS

6. PARKS, TREES, AND OUTDOOR SPACES



7. TRANSPORTATION AND INFRASTRUCTURE

8. PLANNING, ZONING, AND PERMITTING

COORDINATION WITH STATE PARTNERS

Continue collaboration with state partners as they incorporate cooling strategies into state-owned infrastructure, policy, and operations.

State-owned and -operated infrastructure—including subway stations, airports, parks, and more—is critical for residents of and visitors to the Boston metropolitan area. Designing for heat resilience can improve people's heat experience when using these busy facilities, and positively impact neighboring communities as well as the environment. The City seeks to coordinate with the State on the following actions.

OPPORTUNITIES TO COORDINATE TRANSPORTATION INFRASTRUCTURE

» Identify how opportunities to address heat resilience align with existing or planned capital improvements, such as life safety and ventilation improvements in subway stations.

» Explore opportunities to coordinate with planned improvements around subway stations to incorporate heat relief and reduction strategies that promote cooling and accessibility along paths.

» Explore opportunities to implement shaded bus shelter areas at existing bus stops and to expand the bus shelter network in hotter neighborhoods of Boston.

OPPORTUNITIES TO COORDINATE LAND DEVELOPMENT

» Collaborate to help inform heat resilience strategies in state resiliency guidelines, in addition to existing guidelines on cool and permeable pavement.

» Collaborate to analyze opportunities to reduce offsite heat impacts of state-owned assets in Boston neighborhoods.

» Collaborate to explore feasibility of increased tree planting and buffer zones at state-owned properties in Boston neighborhoods to provide shade and heat reduction.

OPPORTUNITIES TO COORDINATE IN PARKS

» Explore opportunities to expand cooling features, drinking fountains, and other access, safety, and comfort improvements in state-owned parks and open spaces.

» Collaborate to improve cool walks to parks and between parks.

OPPORTUNITIES TO COORDINATE ON POLICY

» Explore opportunities to coordinate with the State on building code, sanitary code, and related regulatory opportunities to integrate heat and health into regulatory standards

» Explore opportunities to coordinate with the State on safety regulations and guidelines for workers and for organizations that serve vulnerable residents such as daycares, senior services, and schools

» Explore opportunities to inform how heat resilience could be integrated into the State's existing or planned energy efficiency, public health, and emissions-reduction programs

5. BUILDINGS

5.1 HOME COOLING RESOURCES DISTRIBUTION

Distribute resources to support cooler homes.

RATIONALE AND DESCRIPTION

Despite feeling hot at home, two-thirds of stakeholders from the *Heat Plan* surveys reported staying home on very hot days. Helping people stay cool in their homes is a high-impact way of mitigating individual heat risk, especially for people who have factors that make leaving home more difficult or unsafe. This strategy focuses on distributing resources to support cooler homes. This strategy builds on previous efforts to provide air conditioning and fans to income-eligible residents, older adults, persons with disabilities, and other high-risk residents through the Healthy Places air conditioner and fan distribution during summer 2021.

Active cooling resources such as air conditioners and fans provide short-term and immediate cooling. These resources have an associated energy use, carbon emissions impact, and utility costs. For these reasons, it is critical to ensure the distribution of fans or air conditioners is also integrated with longer-term passive heat and energy retrofits (see Strategy 5.3, home energy retrofits). For example, building weatherization, cool roofs, and trees integrate into building and site design to provide passive cooling. These elements may incur higher costs upfront, but over time, are cost effective and advance resilience and sustainability goals. Additionally, increasing awareness of affordable building retrofit resources, utilities assistance information, and ways to maximize the benefits of active cooling (see Strategy 4.1, heat resilience public education campaign) will support a holistic approach to addressing both immediate needs and long-term resilience.

ONS, BPHC, Environment Department, and OEM, alongside other community-based organizations, are critical to providing resources where they are needed most—residents with greatest heat exposure and sensitivity, and less financial capacity or other adaptive capacity to address their needs to stay safe and cool.

HEAT RESILIENCE BENEFITS

Heat Reduction	●○○○○
Heat Relief	●●●●○
Adaptive Capacity	●●●○○
Public Health	●●○○○
Economic Opportunity	●●○○○
Environmental Benefits	●○○○○
Environmental Justice & Equity	●●●○○

NEXT STEPS

The formation of the Boston Extreme Temperatures Response Task Force (Strategy 1.1) is a key next step. The task force will define an integrated process for pre-heat wave mobilization into the broader heat relief strategy. The task force will identify how to improve speed and targeting of distribution to ensure resources are going to the residents with highest need. Lessons learned from COVID-19 relief efforts as well as other City distribution efforts like food access could also improve implementation of this strategy.

5. BUILDINGS

5.2 COOL ROOFS PROGRAM

Invest in cool roofs to reduce heat: white roofs that reflect solar radiation, green planted roofs that insulate and absorb rainwater, and solar roofs that generate renewable energy and shade.

RATIONALE AND DESCRIPTION

Dark-colored roofs that are exposed to the sun absorb more heat than lighter-colored roofs. In urban spaces, this can often contribute to urban heat island impacts. Implementing cool roofs can reduce localized extreme temperatures.

Results from the online survey show that community members (45% of respondents) would like to see more cool roofs in their neighborhoods. The Environment Department will launch a cool roofs program with the goal of providing grants to a nonprofit organization in Boston to install cool roofs. Over time, the program will support additional job training and green job creation (similar to the NYC CoolRoofs program). The City will assess opportunities for guidelines, incentives, or requirements to encourage property owners and developers to include cool roofs in substantial building improvements and new construction. Buildings in areas with elevated heat exposure and increased prevalence of Bostonians with heat-related health risks will be prioritized, along with affordable housing that lacks central air conditioning.

This program is also an opportunity to conduct research on the effectiveness of different cool roof strategies. The City will coordinate with heat sensor networks (Strategy 1.3) to identify potential pilot locations for ongoing data collection of cool roof effectiveness.

NEXT STEPS

The City will launch a cool roofs program, which will provide grants to a nonprofit organization to complete cool roof installations on eligible properties. The City will explore additional near-term opportunities to demonstrate large-scale cool roofs on public buildings.

HEAT RESILIENCE BENEFITS

Heat Reduction	●●●○○
Heat Relief	●●○○○
Adaptive Capacity	●○○○○
Public Health	●○○○○
Economic Opportunity	●●●○○
Environmental Benefits	●●○○○
Environmental Justice & Equity	●●●○○

UNIT COSTS

Cool Roof Type	Unit Cost
Flat light-colored roofs + insulation	$44/SF
Pitched light-colored roofs (white asphalt shingles) + insulation	$13/SF
Pitched light-colored roofs (profiled metal roofing) + insulation	$62/SF
Light-colored roofs	$7/SF
Green roofs	$35/SF

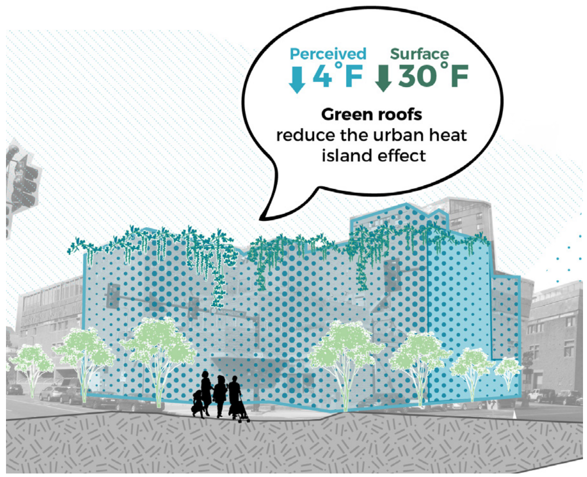
See Appendix 3 Unit Costs for additional details.

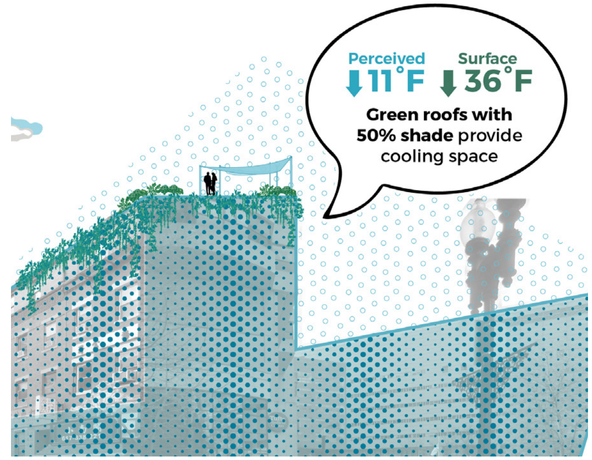
NYC COOL ROOFS PROGRAM

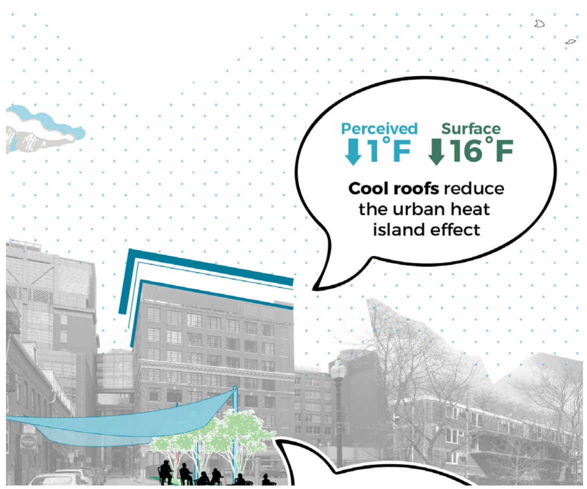
Launched in 2009 and transitioned to a training program in 2015, the NYC CoolRoofs program engages nonprofits, city agencies, and building owners to provide volunteers and job seekers with training on installing cool roofs. The program aims to install one million square feet of cool roofs annually by providing cool roof installations at no cost or low cost to eligible buildings, prioritizing nonprofits and affordable housing developments.[3]

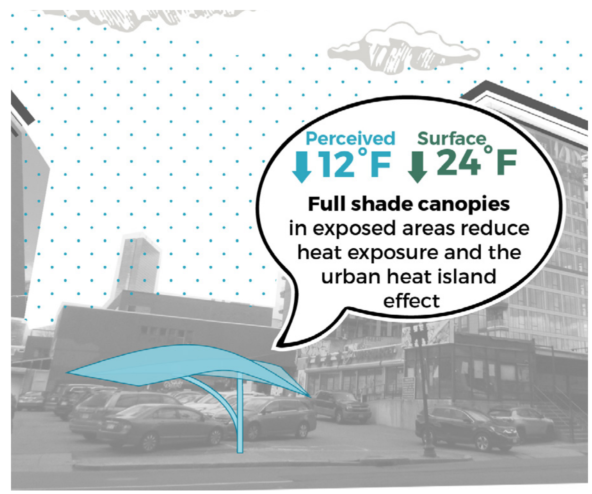
RESULTS FROM THE NEIGHBORHOOD CLIMATE SIMULATION MODEL: COOL ROOFS AND CANOPIES

The results from the neighborhood climate simulation modeling shows that green roofs provide a significant (30°F) decrease in surface temperature, but not as much of a decrease (4°F) in perceived temperature. The decrease in surface temperature can have potential energy saving benefits for heating and cooling buildings as it acts as an insulator. To create a more comfortable outdoor environment, 50% shade canopies (such as fabric canopies) can be added to green roofs that serve as gathering spaces to decrease perceived temperatures by 11°F. Turning dark roofs into white roofs also reduces the surrounding urban heat island by reducing surface temperatures by an estimated 16°F. Solar canopies that provide full shade in an exposed area also reduce heat exposure by decreasing surface temperatures by 24°F and perceived temperatures by 12°F.









5. BUILDINGS

5.3 HOME ENERGY RETROFITS

Improve energy efficiency and indoor thermal comfort, and reduce energy cost burdens by facilitating home energy retrofits.

RATIONALE AND DESCRIPTION

Energy efficiency must go hand in hand with heat resilience for buildings. The 58% of Bostonians who rent their homes face further challenges to accessing efficiency improvements. Residents living in affordable housing, specifically, may have limited opportunities to implement improvements that increase indoor thermal comfort and reduce energy use. The cost of running air conditioning and fans can be a burden to some residents trying to stay cool at home. Additionally, increased need and use of cooling appliances will increase emissions and may introduce strain on the energy grid on very hot days. As extreme heat increases in Boston, integrating energy efficient appliances into existing buildings will help residents reduce operational costs and save energy, while reducing City emissions and increasing energy resilience.

The strategy of home energy retrofits will require collaboration with organizations, state agencies, and community representation. Working with energy efficiency-focused organizations, the City will share information with residents to highlight existing state and federal incentives, as well as explore strategies to support and incentivize retrofits for eligible rental properties (see Strategy 5.4, affordable housing resources and retrofits). See Chapter 7, Resource Guides, for information on utilities assistance programs. The focus of the strategy is to support both property owners and tenants on ways to invest in resilient energy retrofits to protect resident health and safety while increasing climate resilience.

The City will continue to build and distribute resources with direct outreach to prequalified residents in high-priority areas. Sharing information around home retrofits will support the goals of the heat resilience public education campaign (Strategy 4.1), while connecting property owners with existing City, state, and federal programs that offer significantly subsidized energy retrofits (e.g., the Mayor's Office of Housing Landlord Incentive Program). Other programs to share information and collaborate with existing or new programs include working with the Low-Income Home Energy Assistance Program participants, as well as Mass Save, which supports insulation improvements, air conditioning purchase and installation, and other measures. The City will also publicize state and federal incentives for installing solar panels. The City's existing Retrofit Resource Hub consolidates technical and financial information to help building owners, tenants, and contractors make climate resilience and low-carbon building improvements. The Retrofit Resource Hub serves as a go-to information resource on home energy retrofits for tenants and large- to medium-sized buildings. Through the heat resilience best practices guidelines (Strategy 8.2), the City will explore guidance for retrofits that integrate heat resilience and emissions reduction.

HEAT RESILIENCE BENEFITS

Heat Reduction	●●●○○
Heat Relief	●●●●○
Adaptive Capacity	●●●○○
Public Health	●●●○○
Economic Opportunity	●●●●●
Environmental Benefits	●●●○○
Environmental Justice & Equity	●●●●○

NEXT STEPS

The City of Boston is partnering with Mass Save through their Community First Partnership. Within the next year, the goal is to increase Mass Save's program participation and achieve 600 projects per year in environmental justice communities across Dorchester, East Boston, Mattapan, and Roxbury with an emphasis on the following priority groups: renters, low- to moderate-income residents, English-isolated residents, and small businesses.

Some people and communities face greater barriers to installing home energy retrofits and wealth-building due to environmental factors and the legacy of past investment decisions. The City will use existing data under the Building Energy Reduction And Disclosure Ordinance (BERDO) to identify and engage with large multi-family affordable residential buildings with higher energy use. By connecting early with organizations who are doing work related to utility affordability, housing affordability, and green jobs, the City aims to further understand existing barriers and resource needs.

COOL TRIPLE-DECKER RESIDENTIAL BUILDING

COSTS	BENEFITS
» Trees	» Reduced heat-related mortality
» Cool roofs: flat	» Reduced heat-related hospitalizations
» Air conditioning (3 window units/building)	» Energy efficiency improvements
» Fabric awnings: windows and porch	
» Building performance: windows	
» Blinds	

TOTAL COSTS OVER 45 YEARS ONE TRIPLE-DECKER (UNDISCOUNTED 2021$)

Category	Cost
Capital & Design	$95,660
Annual Replacement	$4,303
Total Costs	**$289,293**

Costs include capital costs that consist of preliminary design, engineering, and construction for the first five years, and replacement costs of cooling strategies over 45 years.

5.4 AFFORDABLE HOUSING RESOURCES AND RETROFITS

In public and affordable housing communities, invest in energy retrofits and climate resilient design.

RATIONALE AND DESCRIPTION

Integrating climate resilience strategies and energy efficiency into building design can reduce fossil fuel usage, while improving indoor air quality and thermal comfort and lowering energy costs for residents. However, the cost of conducting deep energy retrofits may preclude some building owners from accessing these benefits.

Energy efficiency and resilient design can and should be accessible. This strategy aims to advance energy efficiency and resilient design in Boston's affordable housing stock by identifying ways to reduce barriers and increase awareness of retrofit opportunities and their benefits to both owners and tenants.

To increase awareness, the City will develop and distribute resources on how to approach and successfully complete resilient energy retrofits, and share information about existing programs and guidelines to support cooler homes. The guidelines will include ways to integrate energy efficient HVAC systems with passive and nature-based cooling to maximize benefits. These resources will be developed in partnership with industry experts, academic institutions, community development corporations, and building owners.

In addition to increasing awareness of existing information resources, the City will develop programs for building retrofits through this strategy. By providing incentives for landlords to make upgrades, this strategy aims to increase accessibility of implementing retrofits to support cooler homes for all Bostonians. The Mayor's Office of Housing (MOH) is responsible for developing affordable housing in Boston and works to ensure that renters and homeowners can find, maintain, and stay in their homes. MOH is investing in programs to ensure that all residents have the opportunity to live in more energy efficient and climate resilient homes.

Programs through this strategy may include the following:

» Energy retrofits, including weatherization and heat pump installation, which can provide energy-efficient indoor comfort improvements in both summer and winter seasons (utilizing resources developed under Strategy 5.3, home energy retrofits)

» Air conditioner installation for tenants with additional subsidies (such as utility bill assistance) for income-qualified residents

» Exterior shade improvements like trees and awnings

HEAT RESILIENCE BENEFITS

Heat Reduction	●●●●○
Heat Relief	●●●●○
Adaptive Capacity	●●●○○
Public Health	●●●○○
Economic Opportunity	●●●●●
Environmental Benefits	●●●○○
Environmental Justice & Equity	●●●●●

NEXT STEPS

Early implementation opportunities the City will explore include incorporating heat resilience metrics and best practices into planned redevelopment and renovation projects. Additionally, the City will continue to share information on existing resources for affordable housing owners and renters and explore developing additional City resources, including programs that reduce the cost of improvements for eligible buildings.

COOL LARGE MULTI-FAMILY RESIDENTIAL BUILDING

COSTS

- Trees
- Cool roofs
- AC: building-wide air conditioning system
- Steel parking canopy
- Cool pavements
- Freestanding fabric awnings
- Building performance enhancements (e.g., windows)
- Blinds

BENEFITS

- Reduced heat-related mortality
- Reduced heat-related hospitalizations
- Energy efficiency improvements

TOTAL COSTS OVER 45 YEARS ONE LARGE MULTIFAMILY HOUSING BUILDING (UNDISCOUNTED 2021$)

Category	Cost
Capital & Design	$9.8M
Annual Replacement	$573.202
Total Costs	**$35.5M**

Costs include capital costs that consist of preliminary design, engineering, and construction for the first five years, and replacement costs of cooling strategies over 45 years. A large multifamily housing building in this analysis was defined as a building with 80 units.

5. BUILDINGS

5.5 COOL SCHOOLS

Improve energy efficiency, indoor and outdoor thermal comfort, and outdoor shading in schoolyards, and promote education about heat resilience.

RATIONALE AND DESCRIPTION

Exposure to high heat in schools affects a child's ability to learn and be successful in a classroom setting. A study found that relative to school days with temperatures in the 60s (°F), each additional school day with temperatures in the 90s (°F) reduces achievement by one-sixth of a percent of a year's worth of learning.[4] To ensure that all Boston youth can thrive in cool and safe learning environments, the cool schools strategy proposes building additional design guidelines and resources to support the following strategies:

» Building envelope and HVAC energy efficiency capital improvements and retrofits

» Shaded schoolyards, natural and built shading, trees, and design for breezes

» Solar canopies and shade structures for parking

» Locations for outdoor heat sensors

» Water stations with bottle filling[i]

» Cool roofs (see Strategy 5.2)

BPS, the Public Facilities Department (PFD), and the Environment Department are critical to ensure successful implementation of this strategy. The City will explore opportunities, where appropriate, to make energy efficiency upgrades, emissions reduction, and climate resilience elements (such as solar and cool roofs) through Renew Boston Trust (RBT).[ii] Planned capital projects and annual programs offer opportunities for integrating heat resilience and improved indoor and outdoor comfort at schools and schoolyards. A co-benefit of the cool schools strategy is that upgraded schools could also double as cooling shelters for neighborhood residents in underserved areas when school is out of session (see Strategy 2.3, citywide cooling network). As part of the heat resilience best practices guidelines (Strategy 8.2), the City will develop resources and guidance that support heat resilience for climate-ready schools.

BPS has also recently launched a program that installs IAQ sensors in all classrooms in schools.[5] The sensors not only collect information about air quality, but also temperature and relative humidity. BPS's leadership in building out a comprehensive sensor network in Boston schools may create a teaching opportunity for children to learn about the relationship between heat and air quality, and to collaborate with heat sensor networks (Strategy 1.3). The City will analyze data from IAQ sensors installed through the BPS Indoor Air Quality and Ventilation Plan to inform the heat resilience best practices guidelines (Strategy 8.2). The temperature comfort standard for BPS is 68 to 78°F.[6] Schools that regularly fall above this threshold can then be identified for opportunities for creating cooler indoor environments.

The teaching environment in schools is also an opportunity for bringing heat resilience education into children's homes. For example, youth science programs with heat sensors, or lessons on how to incorporate heat resilience best practices at home are potential educational programs that can support greater climate literacy and engagement. Heat and climate resilience could also integrate into existing curriculums, building upon the BPS Healthy and Sustainable Schools program and the Office of Health and Wellness' efforts.

HEAT RESILIENCE BENEFITS

Heat Reduction	●●●●○
Heat Relief	●●●●○
Adaptive Capacity	●●●○○
Public Health	●●●○○
Economic Opportunity	●●●●○
Environmental Benefits	●●●○○
Environmental Justice & Equity	●●●●○

i BPS received a recent grant from EPA program for $6.2M for water fountains and bottle filling stations.
ii Renew Boston Trust is an existing initiative that conducts energy audits and installs energy conservation measures in municipal buildings.

NEXT STEPS

The City is pursuing energy efficiency and resiliency in the City owned buildings. RBT is an ongoing initiative that facilitates energy conservation measures like installing efficient LED light bulbs or water conservation upgrades that reduce the amount of water used. These upgrades are made in schools, community centers, libraries, parks, and police and fire stations across Boston. The City will identify opportunities to integrate appropriate resilience investments into City-owned buildings within the RBT portfolio.

COOL SCHOOLS

COSTS

- Trees
- Cool roofs
- HVAC upgrades
- Steel canopies
- Cool pavements
- Drinking fountains
- Energy-efficient windows
- Blinds
- Steel parking canopy
- Cool pavement

BENEFITS

- Avoided reduction in lifetime income due to fewer school days missed
- Avoided head of household income lost due to fewer school days missed
- Improved learning and achievement
- Improved energy efficiency
- Reduction in heat-related health issues

TOTAL COSTS OVER 45 YEARS (UNDISCOUNTED 2021$)

Category	Cost
Capital Costs	$3,916,762
Replacement Costs	$8,376,404
Total Costs	**$12,293,166**

Costs include capital costs that consist of preliminary design, engineering, and construction for the first five years, and replacement costs of cooling strategies over 45 years. A cool school in this analysis was defined as an average public school with 425 students enrolled and no HVAC system installed.

6 PARKS, TREES, AND OUTDOOR SPACES

Boston's green spaces and outdoor open spaces are critical to the city's network of cooling resources.

Trees and outdoor green spaces are among the most effective nature-based heat mitigation strategies. Trees reduce temperatures by providing shade and through ambient cooling radiated from their leaves. Green spaces, tot sprays, pools, and waterfronts provide outdoor places to find relief on hot days. Of the 225 survey respondents who shared the cooling interventions they would like to see in their neighborhood, 59% said more tree plantings, 51% wanted to see more gardens, and 54% said more green spaces.

Boston's green network exists across land in private and public ownership. The City, the state, nonprofits organizations, developers, and other property owners all play a critical role in preserving existing trees, expanding the urban forest, and improving comfort in outdoor spaces.

BPRD is leading the way in implementing cooling features and shade through park renovations, including through the ongoing Urban Forest Plan process to set a vision for expanding and preserving the City's tree canopy. Additionally, BPRD's Parcel Priority Plan will identify opportunities to grow the network of permanently protected open space in Boston. These forthcoming paths will provide additional strategies to employ cooling strategies in parks and open spaces in Boston and increase and maintain the City's tree canopy. BPRD maintains more than 2,000 acres of Boston's diverse park system with another 2,500 acres managed by the State Department of Conservation and Recreation. BPRD properties include playgrounds and athletic fields, two golf courses, squares, fountains, game courts, urban wilds, and a number of historic and active cemeteries. BPRD is responsible for the care of trees within those parks and over 38,000 street trees. In addition, BPRD, Boston Conservation Commission, and other departments also manage Boston's 29 urban wilds. Goals for these important natural areas include long-term stewardship and permanent protection. These provide passive recreation, environmental education, and preservation of ecological value. Heat resilience is among many needs BPRD balances in planning for the future of the system. Current projects to improve heat resilience have included adding tot sprays, misters, and interactive water elements at existing parks in areas not served by water elements today.

As part of the *Heat Plan* and BPRD's community engagement, stakeholders have raised priorities of expanding cool outdoor spaces, developing maintenance partnerships, preserving existing tree canopy, supporting the preservation and expansion of the tree canopy during the development review process, increasing safety and safe access to parks, and supporting parks expansion and equity strategies in the context of displacement and the need for additional affordable housing in Boston.

Expanding parks, trees, vegetation, and open space will be a team effort

Improving the natural cooling capacity of our cities will require partnerships across public and private sectors. Expanding the park system is only one piece of the puzzle. Planning for more vegetation around the city in an intentional manner can deliver multiple benefits, including cooling, air quality, stormwater, and more. There are many ways to increase vegetation that each present different opportunities and constraints in terms of investment and policy, as well as long-term public access, ownership, and the on-the-ground experience.

City-owned Parks	Trees in Parks and Public Rights-of-way	Privately Owned Public Spaces	Other Trees and Vegetation E.g., green roofs, extra vegetation, conversion of pavement to green space, green infrastructure, green balconies and stoops	Other Public Open Space Partners
Parks and Recreation Department		Business owners, developers, residents, other City departments, etc.		E.g., DCR and other state agencies, conservancies, and nonprofits
City-owned parks, recreation, and street trees are within BPRD's purview. Additional funding, staffing, and other resources will be needed to further expand the park system, expand the urban forest along Boston's streets, and increase heat resilience measures.		*These strategies will require additional partnerships, along with funding, staffing, maintenance and operations strategy, etc.*		

HOW WILL BOSTON GROW THE URBAN FOREST?

Urban Forest Plan (UFP)

Trees are critical to cooling the City. The UFP will outline Boston's vision for a 20-year vision for canopy protection and expansion across all property types, understanding that canopy care and management is an all-hands-on-deck effort. The UFP outlines goals and priorities for the urban forest, solutions to overcome challenges to maintenance and expansion, and strategies to expand awareness and engagement.

HOW WILL BOSTON MAINTAIN AND EXPAND ITS PARKS SYSTEM?

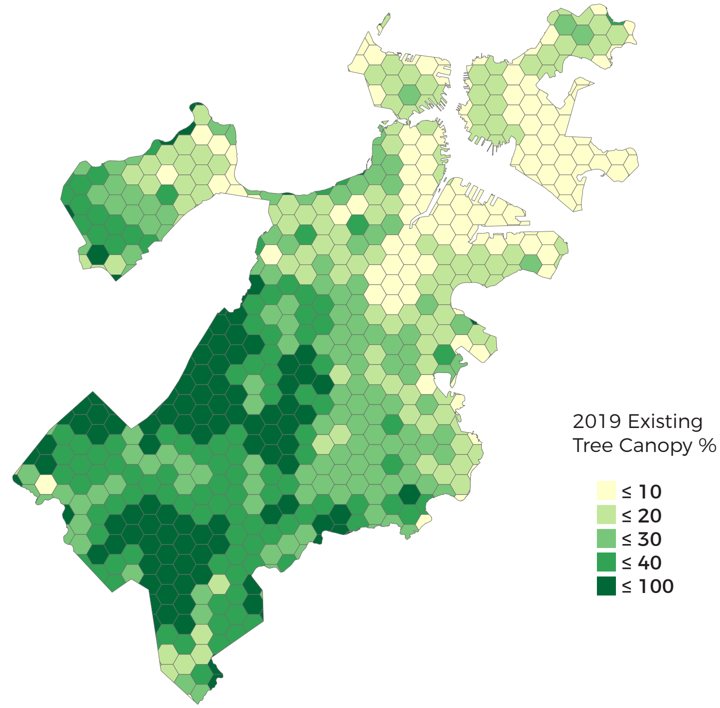
The *Heat Plan* is part of a broader set of initiatives—Healthy Places—to expand cooling, open space access, and a sustainable urban forest. Together these plans will build a safe, healthy, resilient, and accessible city for everyone. Strategies in these complementary efforts will provide further guidance on how urban forests, parks, and open space can support cooling.

Open Space and Recreation Plan (OSRP)

The OSRP outlines the needs of stewarding and improving the park system based on public input, analysis of existing resources, and demographics factors. The OSRP is a state-mandated plan that provides the most comprehensive overview of the state of the park system. The plan looks at park needs broadly, including maintenance, shade trees, climate resilience, development pressure, recreation, park access, design, and more. The plan also informs critical priorities and action items for Boston's park system.

Parcel Priority Plan (PPP)

The PPP focuses on one aspect of the OSRP's comprehensive park system vision: expanding access to the park system through acquisition and protection. Developing a park system expansion program will both meet residents' needs and align with City goals, including climate resilience and environmental justice.



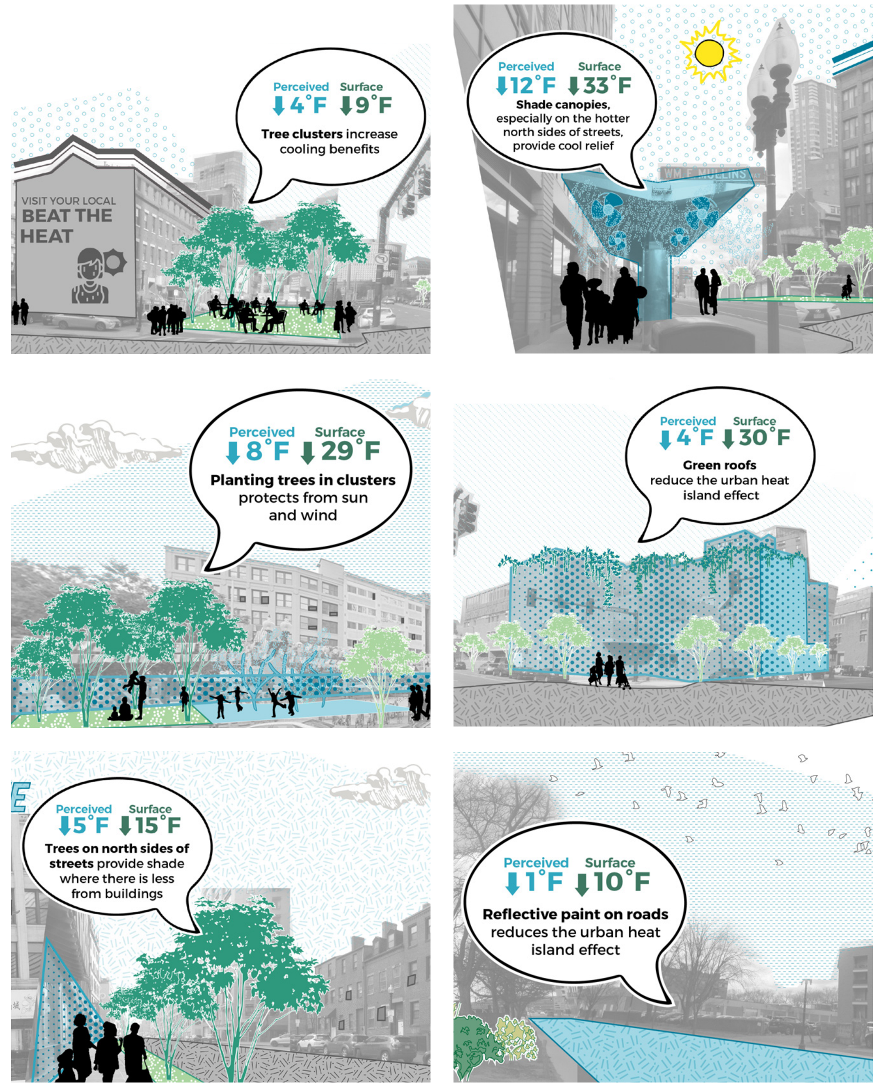
EXISTING CANOPY

Graphic from the Urban Forest Plan team

RESULTS FROM THE NEIGHBORHOOD CLIMATE SIMULATION MODEL: TREES AND OUTDOOR SPACES

The *Heat Plan* presents quantitative findings of the cooling effect of trees and green spaces. Existing efforts to add canopy trees and shade structures provide cooling. The neighborhood urban climate modeling shows that planting trees in clusters can increase the cooling benefits. The impact of a medium tree canopy cluster in a sun- and wind-exposed grass open space demonstrated a larger decrease in surface temperatures (30°F) and perceived temperature (8°F) compared to trees that were more spaced apart (8°F and 3°F reduction in surface and perceived temperatures, respectively). In addition, full shade structures can reduce the effect of heat more significantly than a fabric shade canopy that still lets some light through. The decrease in perceived temperature (12°F) under a full shade canopy in an exposed area is more than two times higher than if it were a 50% shade canopy (only 5°F reduction).

Existing efforts to replace dark impervious paved surfaces with lighter color, pervious, and vegetated surfaces reduce surface and perceived temperatures. The neighborhood urban climate modeling shows that vegetated surfaces reduce surface and perceived temperatures more than highly reflective surfaces. The impact of a highly reflective surface is mainly in surface temperature (10°F reduction, compared to only a 1°F drop in perceived temperature), while vegetated surfaces see a larger decrease in both surface temperature (reduction of 29°F) and perceived temperature (reduction of 4°F).



6. PARKS, TREES, AND OUTDOOR SPACES

6.1 ENHANCED COOLING IN POCKET GREEN SPACES AND STREET-TO-GREEN CONVERSIONS

Integrate opportunities to add new green space into street improvement projects.

RATIONALE AND DESCRIPTION

Green space, especially with trees, is one of the most effective ways to increase neighborhood thermal comfort. Yet, available space for tree plantings and new parks can be limited, especially in the densest neighborhoods. This strategy focuses on identifying additional green spaces to address heat vulnerability in the densest neighborhoods with the highest heat vulnerability that are underserved for existing park access and tree canopy.

Some immediate projects will be advanced by aligning with existing corridor studies and capital projects that are already identified and funded. Other publicly-accessible shaded or green open spaces are often created or preserved during development review processes (see Strategy 8.3, zoning revisions to support cooler neighborhoods).

The City will assess opportunities to add pocket parks and other critical green infrastructure along and adjacent to streets, where appropriate. Streets today experience a range of competing pressures—cars, parking, bike infrastructure, stormwater infrastructure, rideshare drop-off, deliveries, emergency access needs, and service vehicles. It's critical to maintain the safety of streets for all users, the ability of emergency services to respond effectively, and the services and amenities valued by residents and businesses. The City will analyze opportunities for repurposing existing pavement, where appropriate. For example, street conversions or parking space consolidation and replacement, and the reuse of vacant lots or other underutilized spaces into new cool parks, pocket parks, or other green infrastructure especially in dense, high-heat areas. The City will consider opportunities to include plantings, misting, mini tot sprays, and shaded seating in appropriate areas, balancing other needs and uses to provide cooling and other public health and safety benefits (e.g., safer streets or slower neighborhood streets). These green spaces can also serve as new social spaces that strengthen community connections.

HEAT RESILIENCE BENEFITS

Heat Reduction	●●●●○
Heat Relief	●●○○○
Adaptive Capacity	●●○○○
Public Health	●●○○○
Economic Opportunity	●○○○○
Environmental Benefits	●●●○○
Environmental Justice & Equity	●●●○○

HOW DO COMPLETE STREETS AND POCKET PARKS WITHIN THE PUBLIC RIGHT-OF-WAY RELATE TO PARK SYSTEM EXPANSION?

"Lands which are primarily used for transportation are not typically classified as open space (i.e., roads and right-of-ways), but these spaces can offer public value for active and passive uses in addition to their transportation services... Transform[ing] this traditional infrastructure into green infrastructure offer[s] multiple benefits for city residents including plantings, gathering areas, bikeways, and walkways in addition to traditional transportation and utility needs. The roadway system has the potential to provide green connections to and between parks which enhances the value of all open spaces. In some ways, these links between green space and roadway space increase the value of each as shade; pedestrian access and animated activity nodes are spread throughout the city."[7]

-2015-2022 Open Space and Recreation Plan

NEXT STEPS

The City will continue to coordinate across relevant departments to integrate green infrastructure into planned capital improvement projects along streets and other publicly-owned assets.

ONGOING PLANS THAT OFFER OPPORTUNITIES TO FURTHER ADVANCE HEAT RESILIENCE:

- Coastal Resilience Plans
- Neighborhood Plans
- Open Space and Recreation Plan 2022-2028
- Urban Forest Plan
- Parcel Priority Plan
- Corridor Studies
- Complete Streets Projects

6.2 INCREASED SHADE ON MUNICIPAL SITES

Lead by example by ensuring municipal sites are supporting and contributing to cooler neighborhoods.

RATIONALE AND DESCRIPTION

This strategy looks for opportunities for the City to lead by example by increasing shade on City-owned sites. Increasing shade on municipal sites will improve indoor and outdoor thermal comfort, reduce energy use in buildings through shade and passive cooling, and support off-site cooling effects for the surrounding neighborhood.

This strategy proposes a suite of elements that can be implemented on municipal properties to reduce heat exposure, including tree planting, shade structures, and solar canopies. The heat resilience best practice guidelines (Strategy 8.2) process will also help to identify elements on municipal properties to incorporate heat resilience strategies. Based on the results of the neighborhood climate model, full-shade structures (including solar canopy) should be used, as the decrease in perceived temperature is two times higher than a shade canopy (like a fabric shade) that would allow about 50% of light to pass through. To measure progress towards heat reduction goals and the effectiveness of planting strategies, the City will explore the strategic installation of heat sensors at appropriate sites. These sensors would be integrated into the heat sensor network (Strategy 1.3). Large parking lots and garages with uncovered rooftop parking, and other properties with low vegetation are example locations to prioritize.

NEXT STEPS

The City will analyze the portfolio of municipal sites to identify sites that have high exposure and low vegetation, and prioritize municipal sites that are regularly visited by constituents to maximize public benefits.

HEAT RESILIENCE BENEFITS

Heat Reduction	●●●●○
Heat Relief	●●●○○
Adaptive Capacity	●●○○○
Public Health	●○○○○
Economic Opportunity	●●○○○
Environmental Benefits	●●○○○
Environmental Justice & Equity	●●●○○

6. PARKS, TREES, AND OUTDOOR SPACES

6.3 EXPANDED DRINKING FOUNTAIN NETWORK

Increase public access to water with additional drinking fountains and water bottle fillers in areas with high heat exposure.

RATIONALE AND DESCRIPTION

Staying hydrated is an important action during heat waves, yet some communities may have less access to outdoor drinking fountains to stay cool while outside. This strategy focuses on adding more drinking fountains and water bottle fillers in parks and open spaces, especially in parks with active recreation features where heat exposure is high. The City will also evaluate locations to identify priority locations for additional features such as pet-friendly fountains.

Drinking fountain installation requires identifying existing potable water supply lines, and installing new potable water lines, meters, back-flow preventers, and frost-protection.

NEXT STEPS

Data on existing drinking fountain locations is limited, so an initial step is to develop a dataset of locations across parks and open spaces in Boston. To identify gaps and inform implementation, the City will complete an analysis of heat risk alongside the existing infrastructure analysis.

HEAT RESILIENCE BENEFITS

Heat Reduction	●○○○○
Heat Relief	●●○○○
Adaptive Capacity	●●○○○
Public Health	●●○○○
Economic Opportunity	●○○○○
Environmental Benefits	●○○○○
Environmental Justice & Equity	●●○○○

6. PARKS, TREES, AND OUTDOOR SPACES

6.4 PLANNING FOR FUTURE PARKS

Enhance and enlarge Boston's network of resilient community parks.

RATIONALE AND DESCRIPTION

Parks play critical roles in resident health and wellbeing, social connections, ecological health, and resilience, including cooler communities. The City's goal is to enhance and enlarge Boston's network of resilient community parks. It looks to do this first by identifying where the park system might expand, and then evaluating policies, funding, and processes that can realize that vision. BPRD aims to take the capital-funded Parcel Priority Plan and transform it into a long-term program called Planning for Future Parks. The goal is to invest in a dedicated park system expansion program with an emphasis on permanent protection and public access. This effort is envisioned to go beyond the pocket parks described in Strategy 6.1 and aspires to expand park access even in densely populated areas.

As neighborhoods develop and grow in density, the City will continue to provide access to high quality parks throughout Boston alongside that growth. The City aims to lay out a vision that recognizes a diverse landscape in terms of culture, environmental justice, climate change, and development pressure.

Expanding the park system will rely on acquisition or protection by BPRD as well as other departments, state agencies, nonprofits, private landowners, and more.

A strong public park system relies on the following:

» Renovating our existing park system to better serve existing and new needs

» Acquiring or protecting new parklands and natural areas to fill in gaps where there are no such spaces, or to enhance existing spaces where there is growing population pressure

» Increasing funding for high quality park maintenance to match growing maintenance responsibilities

BPRD has established the Open Space Acquisition Program to proactively acquire land. With initial funding from the Community Preservation Act, BPRD can begin to negotiate the purchase of land for future open spaces in a timely manner. Sites may be donated to BPRD, purchased from a property owner, or transferred to BPRD from another City department.

NEXT STEPS

The City has launched a long-term visioning plan to prioritize parcels of land to acquire and protect for public use. The next step to launching this strategy includes completing the visioning process and integrating this planning into the 2022-2028 Open Space and Recreation Plan.

HEAT RESILIENCE BENEFITS

Heat Reduction	●●●●●
Heat Relief	●●●●○
Adaptive Capacity	●●●○○
Public Health	●●●○○
Economic Opportunity	●●○○○
Environmental Benefits	●●●●●
Environmental Justice & Equity	●●●●○

7 TRANSPORTATION AND INFRASTRUCTURE

TRANSPORTATION, CORRIDOR, AND STREETS PROJECTS AND PLANS IN THE FIVE FOCUS NEIGHBORHOODS

Projects under the umbrella of the City's Streets Cabinet, consisting of the Boston Transportation Department (BTD) and PWD, are able to address heat resilience through street trees, reduced blacktop roadway surface, shaded bus shelters, benches, and, where maintenance is possible, planted areas along sidewalks and medians. Citywide initiatives that are focused on maintaining a state of good repair, such as roadway resurfacing and sidewalk repairs (the Walkable Streets program). District yards and municipal lots are annual programs that also provide opportunities for heat resilience measures.

The following is a list of select projects led by the Streets Cabinet in the five focus areas of the *Heat Plan*, which can offer opportunities to employ cooling strategies in these neighborhoods.

Major corridor projects include the following:

- Blue Hill Avenue including Mattapan Square up to Grove Hall
- Cummins Highway
- Melnea Cass Boulevard
- Warren Street and Malcolm X Boulevard, connecting Nubian Square to Grove Hall and Roxbury Crossing respectively
- Columbus Avenue from Jackson Square to Ruggles
- Bennington Street and Day Square
- Massachusetts Avenue (Melnea Cass to Columbia Road) and Theodore Glynn Way
- Columbia Road

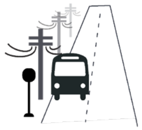
Design and construction work is also ongoing at specific locations, including the following:

- Egleston Square and Amory Street
- Eagle Square
- Neighborhood Slow Streets zones (various)
- Roxbury Safe Routes to Schools Safety Project

Transportation Action Plans currently undertaken by BTD and the Mayor's Office of Planning/BPDA that will result in design and construction projects in the coming years include the following:

- Bowdoin Geneva Action Plan
- PLAN: Mattapan
- PLAN: Nubian Square
- PLAN: Glovers Corner


28 RIDE FOR FREE
1255



7. TRANSPORTATION AND INFRASTRUCTURE
7.1 COOL COMMUTES

Create cooler commutes through shaded bus stops, cool pathways, and other mobility improvements.

RATIONALE AND DESCRIPTION

In Boston, almost half of all workers take public transit (31.4%), walk (14.6%), or bike (2.2%) to work.[8] Shaded places to wait at bus stops are critical to reduce direct exposure for residents and visitors who use public transportation. Results from an online survey show that community members (61% of respondents) would like to see more shaded bus stops in their neighborhoods. This strategy aims to implement cooling strategies benefitting public transit riders, including a focus on cooler bus stops along high-use routes in areas with elevated heat exposure and limited street tree cover.

To increase shade and cooling at bus stops and create cooler commutes, the City will seek to collaborate regionally to consider elements like the following:

- Bus shelters that promote safety and accessibility
- Increased tree planting around bus stops where possible to increase shade in the long-term
- Misters or cooling fans during heat waves, similar to the City of Phoenix's light rail surface level stops which have misting stations
- Targeted outreach and awareness around existing cooling resources through analysis of bus passenger data for least and most used bus stops on days during heat waves
- Operational and service improvements to reduce heat exposure for riders and improve level of service

Moving to and from bus and other transit stops is also part of the cool commute experience and provides an opportunity to integrate cooling into accessible walking paths and bike lanes. These cool routes could make walking to transit stops more comfortable for regular bus riders or for residents looking to find cool spaces outside of their homes. Well-coordinated implementation with the state and related City departments is critical to integrating cool commutes with planned transportation improvements for redesign and reconstruction projects and ongoing improvement programs.

HEAT RESILIENCE BENEFITS

Heat Reduction	●●●○○
Heat Relief	●●●●○
Adaptive Capacity	●●●○○
Public Health	●●●○○
Economic Opportunity	●●○○○
Environmental Benefits	●●●○○
Environmental Justice & Equity	●●●●○

NEXT STEPS

2022 marks the 20th anniversary of the SL4 and SL5 routes of the Silver Line. In celebration, BTD will facilitate a community-wide design challenge for a bus stop this fall. The design that best meets the site-specific criteria and integrates heat resilient design elements like shade, temperature and air quality sensing, and strategic reflective coatings, will inform the implementation of a new bus shelter.

ONGOING PLANS THAT OFFER OPPORTUNITIES TO ADVANCE HEAT RESILIENCE:

- Neighborhood plans
- Corridor studies
- Complete Street projects

7.2 ENERGY RESILIENCE UPGRADES AND MICROGRIDS

Implement energy grid upgrades, district energy microgrids, and other strategies to reduce risk of power outages during heat waves.

RATIONALE AND DESCRIPTION

Boston will see an increasing number of extreme heat days with more households and buildings using air conditioning to stay cool. Extreme heat strains the power grid, increasing the chance of power outages (see Infrastructure Vulnerabilities in Chapter 3). Building on Climate Ready Boston's Strategy 7.1 to conduct feasibility studies for community energy solutions, the City will identify critical building loads and needs and develop a microgrid strategy that works to support those loads during periods of outages. Extreme heat factors including areas of high heat exposure in combination with social vulnerability metrics will be integrated into identification and prioritization of microgrid locations. The process used for the Chinatown Community Microgrid Feasibility Assessment (2021) provides a good model for engaging communities early in the process and educating them about how microgrids can benefit the community.

This work will be tightly coordinated with implementation of the Boston Smart Utilities Policy.

NEXT STEPS

The Mayor's Office of Planning/BPDA, in partnership with BPHC, OEM, and the MassCEC Clean Energy and Resiliency (CLEAR) Program[9] conducted an assessment to analyze the cost and system design of resilient facilities in Mattapan. The assessment evaluated critical loads and feasibility for microgrid solutions to reduce the economic impacts of power outages and utilities service. Mayor's Office of Planning/BPDA will release the assessment report in 2022.

HEAT RESILIENCE BENEFITS

Heat Reduction	●○○○○
Heat Relief	●●●○○
Adaptive Capacity	●●●●●
Public Health	●●●○○
Economic Opportunity	●●○○○
Environmental Benefits	●○○○○
Environmental Justice & Equity	●●●○○

EXISTING MICROGRID STUDIES AND RELATED PROGRAMS AND STANDARDS:

» Chinatown Community Microgrid Feasibility Assessment
» Boston Community Energy Study
» Boston Smart Utilities Program
» Microgrid Ready Building Design
» Zero Net Carbon Standard and Energy Efficiency Goals

CHINATOWN COMMUNITY MICROGRID FEASIBILITY ASSESSMENT 2021

Through the MassCEC Community Microgrids Program, the Chinatown Community Microgrid Feasibility Assessment aimed to not only increase access to clean energy technology, but also foster social cohesion. Community members were involved from the beginning of the project, empowering them to influence the design, contracting, and operation of the microgrid resources.[10]

7. TRANSPORTATION AND INFRASTRUCTURE

7.3 COOL MAIN STREETS

In streets and public spaces, reduce localized extreme heat and increase access to cooling resources while supporting local businesses.

RATIONALE AND DESCRIPTION

The strategy of cool Main Streets aims to advance heat resilience and support local businesses. This strategy includes integrating resilient design with programmatic and educational elements. The Office of Small Business Development and the Boston Main Streets Foundation are critical in successfully implementing this strategy. The Office of Small Business Development works with business owners and entrepreneurs to provide tools and guidance needed to support thriving business in Boston.

The cool Main Streets strategy encourages physical improvements, such as using cool pavements and light-colored pavement treatments, identifying cool roof locations, and shading pedestrian pathways and parking areas. Programmatic and education elements include resource distribution and pop-up cooling serves to increase awareness of and access to cooling resources.

The cool Main Streets strategy integrates multiple heat strategies to help deliver climate-ready streets. Cool Main Streets builds on cool commutes (Strategy 7.1), which includes nearer-term strategies like shaded and misting bus stops, as well as longer-term strategies focused on planned transportation improvements like square and street redesign and street reconstruction projects. Through the cool Main Streets strategies, the City will explore collaboration with small businesses and local community groups to provide resources to activate public gathering spaces. These spaces can serve as cooling resource distribution points and mobile cooling pop-ups as part of the pre-heat-wave resources mobilization (Strategy 1.2) and pop-up heat relief (Strategy 2.1). This is also an opportunity for expanded community climate leadership (Strategy 3.1) to build local ties and promote heat resilience, possibly training heat ambassadors to look out for people with signs of heat stress and direct them to a nearby cooling resource.

To support local small businesses implementing cooling strategies, the City will consider creating a grant program for awnings, umbrellas, and other shade devices, prioritizing businesses located in higher-heat areas that are income-eligible, women- and minority-owned, and participants in expanded community climate leadership (Strategy 3.1).

Additionally, the City will continue to incorporate cooling strategies into the Complete Streets initiative through the Neighborhood Slow Streets initiative. The Neighborhood Slow Streets initiative aims to improve street safety through small scale improvements,[11] such as road diets and narrow lane widths that expand sidewalk dimensions to accommodate street trees and plantings. When dimensions are too narrow for street trees, the City will consider guidelines for shade structures with seating and green infrastructure opportunities.

HEAT RESILIENCE BENEFITS

Heat Reduction	●●○○○
Heat Relief	●●●●○
Adaptive Capacity	●●○○○
Public Health	●●○○○
Economic Opportunity	●●●●○
Environmental Benefits	●●○○○
Environmental Justice & Equity	●●●○○

NEXT STEPS

The City will explore near-term opportunities to integrate resilient design into ongoing and future studies and capital projects, and develop a process to identify areas to pilot cooling strategies for streets.

ONGOING PLANS THAT OFFER OPPORTUNITIES TO FURTHER ADVANCE HEAT RESILIENCE

- Neighborhood plans
- Corridor studies
- Complete Streets projects
- Open Space and Recreation Plan
- Urban Forest Plan

TOTAL COSTS OVER 45 YEARS (UNDISCOUNTED 2021$)

Category	Cost
Capital Costs	$834,954
Replacement Costs	$46,628
Total Costs	**$2.9M**

Costs include capital costs that consist of preliminary design, engineering, and construction for the first five years, and replacement costs of cooling strategies over 45 years. A cool Main Street in this analysis was generalized to a 100-foot east-west street. The minimum width between the buildings includes two 12-foot lanes, two 10-foot parking lanes, two 5-foot bicycles lanes, and two 6-foot sidewalks.

COOL MAIN STREETS

COSTS

- Trees, spaced 20 feet apart, alternating on each side of corridor, shading street and sidewalk
- Shade canopy-storefront awnings, both sides of corridor, 60 feet of length (not necessarily continuous)
- Cool bus stop: pavement marking, one side of corridor, 80 feet by 10 feet
- Cool drive lanes, two center lanes
- Cool bus stop: 6-foot by 8-foot bus shelter with pavement
- Cool on-street parking pavement, 10-foot wide roadway shoulders, both sides
- Shade awning over street (fabric), one 50 feet by 20 feet, at a crosswalk
- Green roofs, one building rooftop area
- Cool roofs, on all non-green roofs, SRI value greater than 72
- Roof canopy (permanent), one location

BENEFITS

- Decreased perceived temperature,
- Better quality of life (including mental and physical wellbeing)
- Economic and workforce development
- Education and saving of resources for communities
- Improved energy efficiency for buildings along corridor
- Reduction in heat-related health issues

8 PLANNING, ZONING, AND PERMITTING

It is necessary to understand the impact that developments have on ambient temperature and surface temperature in order to ensure that new development and redevelopment contributes to the reduction of localized extreme temperatures. Development review is an opportunity to encourage heat resilience measures that provide relief during heat waves and long-term benefits of heat reduction. By integrating provisions for heat resilience, new developments can mitigate heat impacts, improve thermal comfort, and increase enjoyment of public spaces in Boston. The Mayor's Office of Planning/ Boston Planning and Development Agency (BPDA) and Inspectional Services Department are critical to successful implementation of these strategies.

8. PLANNING, ZONING, AND PERMITTING

8.1 UPDATED CLIMATE RESILIENCY CHECKLIST

Ensure new development assesses heat resilience impacts and benefits.

RATIONALE AND DESCRIPTION

Article 37 provides standards and guidance to support green buildings and climate-resilient construction (see Strategy 8.1 call out). To further integrate heat resilience into Article 37, the City will incorporate updated temperature projections into the Climate Resiliency Checklist. The updated Climate Resiliency Checklist will ask proponents to assess heat resilience in development proposals and identify opportunities to increase heat resilience onsite, increase the thermal comfort of pedestrians and other adjacent users, and improve access to cooling spaces and resources within and adjacent to the proposed development.

NEXT STEPS

The City will update the Climate Resiliency Checklist to include provisions for heat resilience.

ARTICLE 37 AND CLIMATE RESILIENCY GUIDELINES:

"Boston Zoning Code Article 37, Green Buildings (Article 37) and the Climate Resiliency - Review Policy Update (Resiliency Policy) ensure that major building projects are planned, designed, constructed, and managed to minimize adverse environmental impacts; conserve natural resources; are resilient to climate change; promote a more sustainable city; and enhance the quality of life in Boston. All proposed projects subject to or electing to comply with Zoning Article 80B, Large Project Review are subject to the requirements of Zoning Article 37 and the Resiliency Policy."

-Article 37 Green Building and Climate Resiliency Guidelines

HEAT RESILIENCE BENEFITS

Heat Reduction	●●○○○
Heat Relief	●●○○○
Adaptive Capacity	●●○○○
Public Health	●●○○○
Economic Opportunity	●○○○○
Environmental Benefits	●●○○○
Environmental Justice & Equity	●●○○○

8. PLANNING, ZONING, AND PERMITTING

8.2 HEAT RESILIENCE BEST PRACTICE GUIDELINES

Create guidelines to incorporate heat resilience strategies into future buildings, building retrofits, and their sites.

RATIONALE AND DESCRIPTION

Property owners planning new construction or renovation may be interested in reducing energy use and creating cooler indoor and outdoor spaces, but may not be aware of what design strategies and best practices may be most effective to improve heat resilience. This strategy proposes the development of best practice guidelines to incorporate heat resilience strategies into the design of new and existing development. Anticipated audiences include property owners, developers, and design teams. Heat resilience best practice guidelines would complement the existing Coastal Flood Resilience Design Guidelines. The Mayor's Office of Planning/BPDA will lead this strategy in collaboration with the Environment Department.

The heat resilience design strategies identified would reference relevant national standards and best practices, as well as applicable flood mitigation co-benefits. By implementing these strategies, new construction and renovation projects would save energy in summer, improve indoor and outdoor thermal comfort for site occupants, and where possible, provide a net negative effect on offsite temperatures.

The best practices should include guidance on topics like the following:

» Passive design strategies

» Building massing and orientation

» Types, effectiveness, and cost of pavement and building materials (roofing, facades, insulation, windows, window treatments, awnings, etc.)

» Site landscaping, including tree and vegetation location considerations for the highest reduction in climate comfort

» Retrofitting existing buildings to improve indoor comfort for building occupants

» Ways to track heat indicators and metrics (see Strategy 1.3, heat sensor networks)

» Strategies for public buildings

» Preferred strategies for building typologies serving vulnerable residents such as schools, medical centers, and senior facilities

HEAT RESILIENCE BENEFITS

Heat Reduction	●●●○○
Heat Relief	●●○○○
Adaptive Capacity	●●○○○
Public Health	●●●○○
Economic Opportunity	●○○○○
Environmental Benefits	●●○○○
Environmental Justice & Equity	●●●○○

NEXT STEPS

The City will launch a process to develop heat resilience design guidelines, including focus groups of technical experts, developers, and industry stakeholders.

8. PLANNING, ZONING, AND PERMITTING

8.3 ZONING REVISIONS TO SUPPORT COOLER NEIGHBORHOODS

Ensure new development supports neighborhood heat resilience.

RATIONALE AND DESCRIPTION

Boston's path to become a Green New Deal city includes efforts to utilize zoning and land use to further the goals of equity, resilience, zero waste, and carbon neutrality. Through this strategy, the City seeks to encourage improvements over time to reduce heat impacts throughout Boston. This strategy presents a suite of approaches that the City will assess for further consideration, including an overlay district approach and citywide zoning code refinements.

Expanding Heat Resilience Through Article 80 (Development Review)

Article 80 provides guidelines for the development review process (see Strategy 8.3 call out). To further heat resilience through the Article 80 process, the City will consider how a temperature analysis, similar to analyses required for wind and shadow, should be integrated into the review process. Coordination with the Smart Utilities Policy to support these goals is key as the policy oversees review of utility infrastructure.

The City will explore quantifiable metrics for heat exposure to determine benchmarks for heat reduction. Standards such as ASHRAE heat resilience standards can serve as a reference for exploring potential standards for indoor cooling. The neighborhood-scale modeling and other similar efforts can also serve as a resource for expected effects of design typologies on outdoor thermal comfort. Strategy 8.2, heat resilience best practices, will be a complimentary resource, providing recommendations on potential heat mitigation strategies. National standards and best practices can inform heat mitigation strategies.

HEAT RESILIENCE BENEFITS

Heat Reduction	●●●●○
Heat Relief	●●●○○
Adaptive Capacity	●●●○○
Public Health	●●●○○
Economic Opportunity	●●○○○
Environmental Benefits	●●●●○
Environmental Justice & Equity	●●●●○

ARTICLE 80

"Adopted in 1996 ... to provide clear guidelines for the development review process relating to large projects (adding/constructing more than 50,000 square feet), small projects (adding/constructing more than 20,000 square feet and/or 15+ net new residential units), planned development areas (new overlay zoning districts for project areas larger than 1 acre), and institutional master plans (projects relating to academic and medical campuses). The Article 80 process may include, but is not limited to, review of a project's impacts on transportation, public realm, the environment, and historic resources. ... Public input is encouraged throughout a project's review timeline." [12]

-Mayor's Office of Planning/BPDA Glossary

Overlay District Approach

An overlay district is a regulatory tool that applies standards in specific areas to guide land use and development. This approach targets additional standards where they are most needed to achieve a specific public purpose. In Boston, there are different types of overlay districts with provisions including but not limited to historic preservation, industrial use, and climate resilience. For climate resilience, the City adopted Article 25A Coastal Flood Resilience Overlay District (CFROD) into the Zoning Code in 2021.

Article 3, Section 3-1A(p) allows for the creation of resilience overlay districts.[13] The City will assess the appropriateness of an overlay district approach for achieving the goals of heat resilience and, if appropriate and effective, explore the development of a comprehensive community process for a heat resilience overlay district to build on previous climate resilience zoning. A significant consideration in whether to develop an overlay district would be how and which areas of elevated heat risk should be defined. While CFROD uses the extent of future flood risk to define the boundaries of the overlay district, a different strategy may be needed to determine boundaries and thresholds for extreme heat, as all of Boston experiences extreme summer temperatures. Specific studies would be needed to define metrics for elevated extreme heat risk to define potential overlay district boundaries, which may follow along commuting corridors, specific hotspots in Boston, or other areas of heat exposure for high risk residents, as determined through future study.

Other Zoning Code Refinements

Some zoning adjustments may be appropriate citywide as all parts of Boston are within an urban heat island and experience excessive heat temperatures during heat waves, compared to non-urbanized areas. Other zoning adjustments may be more appropriate within an overlay district, where excessive heat temperatures are even more extreme and frequent. Under this strategy, the City will undertake a review of existing zoning for any potential barriers and opportunities for heat resilience. This review will also consider potential changes to allow and encourage actions that would improve thermal comfort and reduce the urban heat island effect. Examples of zoning adjustments could include the following:

- Allowing dimensional standard flexibility for shade elements, especially on rooftops, similar to an effort already underway for height exemptions for rooftop solar
- Considering adopting more stringent shade, reflectivity, and open space requirements, either citywide or in areas within the heat overlay district

The City will explore how performance standards and baseline temperatures for heat resilience might be defined for buildings and land use types. This would include defining thresholds to apply of performance standards for new construction and renovations.

Implementation of this strategy must consider the relationship with existing zoning and land use requirements, such as shadow requirements and Chapter 91, which includes provisions for public access to the waterfront. Over time, as the climate shifts, winters are likely to gradually get warmer, but cold snaps are still likely to occur. Integration of heat-related zoning must also consider year-round performance and consider specific design elements that provide both cold and hot weather benefits.

NEXT STEPS

An initial first step includes a regional summit or focus group conversations with various stakeholders to learn from existing related policies and discuss opportunities to integrate heat resilience provisions in the zoning code.

BOSTON HEAT COLLABORATION

The Mayor's Office of Planning/BPDA and Boston University (BU) are working together to explore the cooling effect of different surfaces on land surface temperature across Boston. Coordination with this effort to provide additional data and metrics for heat will be valuable to improving heat models that aim to identify and estimate the most effective cooling strategies.

CITY OF CAMBRIDGE COOL FACTOR

In February 2022, the City of Cambridge released the Climate Resilience Zoning Task Force report. The report presented the task force's recommendations to further integrate flooding and heat mitigation into the Cambridge Zoning Ordinance. Among these recommendations, the task force presented the creation of a performance-based Cool Factor and corresponding new standards to reduce urban heat island impacts. The Cool Factor calculates a weighted score based on site features including shade, cool surface, and planting elements to complement traditional zoning, which includes provisions for open space and permeability. This proposed approach would allow developers the flexibility to choose which strategies are appropriate for their site to meet the minimum Cool Score. If integrated into the Cambridge Zoning Ordinance, the Cool Factor may generally apply to alterations to buildings of 25,000 square feet or more and new development of any size.[14]

SHADE DESIGN STANDARDS

The city of Tucson, Arizona, zoning code includes design standards for shade along streetscapes. The code applies to public and private rights-of-way, new development, and redevelopment projects. The Rio Nuevo Area Zoning Design Standards includes the following shade requirement:

> "Shade shall be provided for at least 50% of all sidewalks and pedestrian pathways as measured at 2:00 p.m. on June 21 when the sun is 82° above the horizon (based on 32°N latitude). Shade may be provided by arcades, canopies, or shade structures, provided they and their location and design characteristics are compatible with the prevailing and design context of the street and the architectural integrity of the building."[15]

IMPLEMENTATION ROADMAP

APPROACH

The implementation of heat resilience strategies is organized into catalytic projects, near-term projects, and long-term solutions. The plan's strategies provide a framework for improved heat resilience across Boston. The timing of implementation considers the impact of each strategy, as represented by the evaluation criteria, the level of coordination needed, ownership and jurisdiction, regulatory review and other factors. Community priorities, articulated by the CAB and through feedback from broader community engagement as well as ongoing and future City initiatives, informed the proposed implementation timeline.

CATALYTIC PROJECTS

Catalytic projects seek to address areas of high vulnerability and immediate need, while informing future strategies and projects. They are identified and prioritized for implementation based on the need for mitigating heat vulnerability, concurrent initiatives and partnerships, and if it is a critical next step to advance related strategies.

ANNUAL PREPARATION FOR EXTREME HEAT

Building heat resilience in Boston means the City will need to get ready before the summer months and be prepared to launch strategies during the summer. To build annual preparation for summer heat into citywide planning, the timeline integrates timing for some strategies into a pre-heat preparation period and summer implementation.

TIMELINE

The timeline summarizes the implementation period of the heat resilience strategies described in the preceding section. Catalytic projects are shown in bright blue. Strategies and programs with a planning and preparation period followed by an implementation period are depicted in dark blue and green, respectively. Ongoing programs are depicted in light green, showing periods of ongoing monitoring and evaluation.

RELIEF DURING HEAT WAVES

		CATALYTIC	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5 & ONWARDS
1. OPERATIONS AND COMMUNICATIONS	1.1 Boston Extreme Temperatures Response Task Force	Catalytic Project	Ongoing Program, Monitoring, and Evaluation	Ongoing Program, Monitoring, and Evaluation	Ongoing Program, Monitoring, and Evaluation	Ongoing Program, Monitoring, and Evaluation	Ongoing Program, Monitoring, and Evaluation
	1.2 Pre-heat-wave Resources Mobilization		Design, Development, and Pilots	Implementation	Implementation	Ongoing Program, Monitoring, and Evaluation	Ongoing Program, Monitoring, and Evaluation
	1.3 Heat Sensor Networks		Design, Development, and Pilots	Design, Development, and Pilots	Implementation	Implementation	Implementation
2. COOLING OFF DURING HEAT WAVES	2.1 Pop-up Heat Relief	Catalytic Project	Implementation	Implementation	Ongoing Program, Monitoring, and Evaluation	Ongoing Program, Monitoring, and Evaluation	Ongoing Program, Monitoring, and Evaluation
	2.2 Enhanced and Expanded City-run Cooling Centers		Design, Development, and Pilots	Design, Development, and Pilots	Implementation	Implementation	Implementation
	2.3 Citywide Cooling Network		Design, Development, and Pilots	Implementation	Implementation	Implementation	Ongoing Program, Monitoring, and Evaluation
3. LOOKING OUT FOR NEIGHBORS	3.1 Expanded Community Climate Leadership		Design, Development, and Pilots	Implementation	Implementation	Implementation	Implementation
	3.2 Extreme Temperature Plans for Outdoor Workers		Design, Development, and Pilots	Design, Development, and Pilots	Implementation	Implementation	Implementation
4. AWARENESS, EDUCATION, AND TRAINING	4.1 Heat Resilience Public Education Campaign			Design, Development, and Pilots	Implementation	Ongoing Program, Monitoring, and Evaluation	Ongoing Program, Monitoring, and Evaluation
	4.2 Heat Survey			Design, Development, and Pilots	Implementation	Ongoing Program, Monitoring, and Evaluation	Ongoing Program, Monitoring, and Evaluation
	4.3 Expansion of Green Workforce Development for Heat Resilience			Design, Development, and Pilots	Implementation	Implementation	Implementation

LEGEND

- *Catalytic Project*
- *Design, Development, and Pilots*
- *Implementation*
- *Ongoing Program, Monitoring, and Evaluation*

COOLER COMMUNITIES

		CATALYTIC	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5 & ONWARDS
5. BUILDINGS	5.1 Home Cooling Resources Distribution						
	5.2 Cool Roofs Program						
	5.3 Home Energy Retrofits						
	5.4 Affordable Housing Resources and Retrofits						
	5.5 Cool Schools						
6. PARKS, TREES, AND OUTDOOR SPACES	6.1 Enhanced Cooling in Pocket Green Spaces and Street-to-Green Conversions						
	6.2 Increased Shade on Municipal Sites						
	6.3 Expanded Drinking Fountain Network						
	6.4 Planning for Future Parks						
7. TRANSPORTATION AND INFRASTRUCTURE	7.1 Cool Commutes						
	7.2 Energy Resilience Upgrades and Microgrids						
	7.3 Cool Main Streets						
8. PLANNING, ZONING, AND PERMITTING	8.1 Updated Climate Resiliency Checklist						
	8.2 Heat Resilience Best Practice Guidelines						
	8.3 Zoning Revisions to Support Cooler Neighborhoods						

EVERETT
SOMERVILLE
CHARLESTOWN
28
3
WATERTOWN
CAMBRIDGE
East Boston
Memorial
Park
Maverick
DOWNTOWN
ALLSTON/
BRIGHTON
90
20
Packards
Corner
CHINATOWN
90
Brighton
Tufts Med
FENWAY/
KENMORE
SOUTH END
NEWTON
Mass
Ave
SOUTH BOSTON
Brigham
Circle
BROOKLINE
Ruggles
Roxbury
Crossing
Nubian Sq
Newmarket
Joe Moakley
Park
9
Jackson
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ROXBURY
JFK/UMass
Jamaica
Pond
Uphams
Corner
Savin Hill
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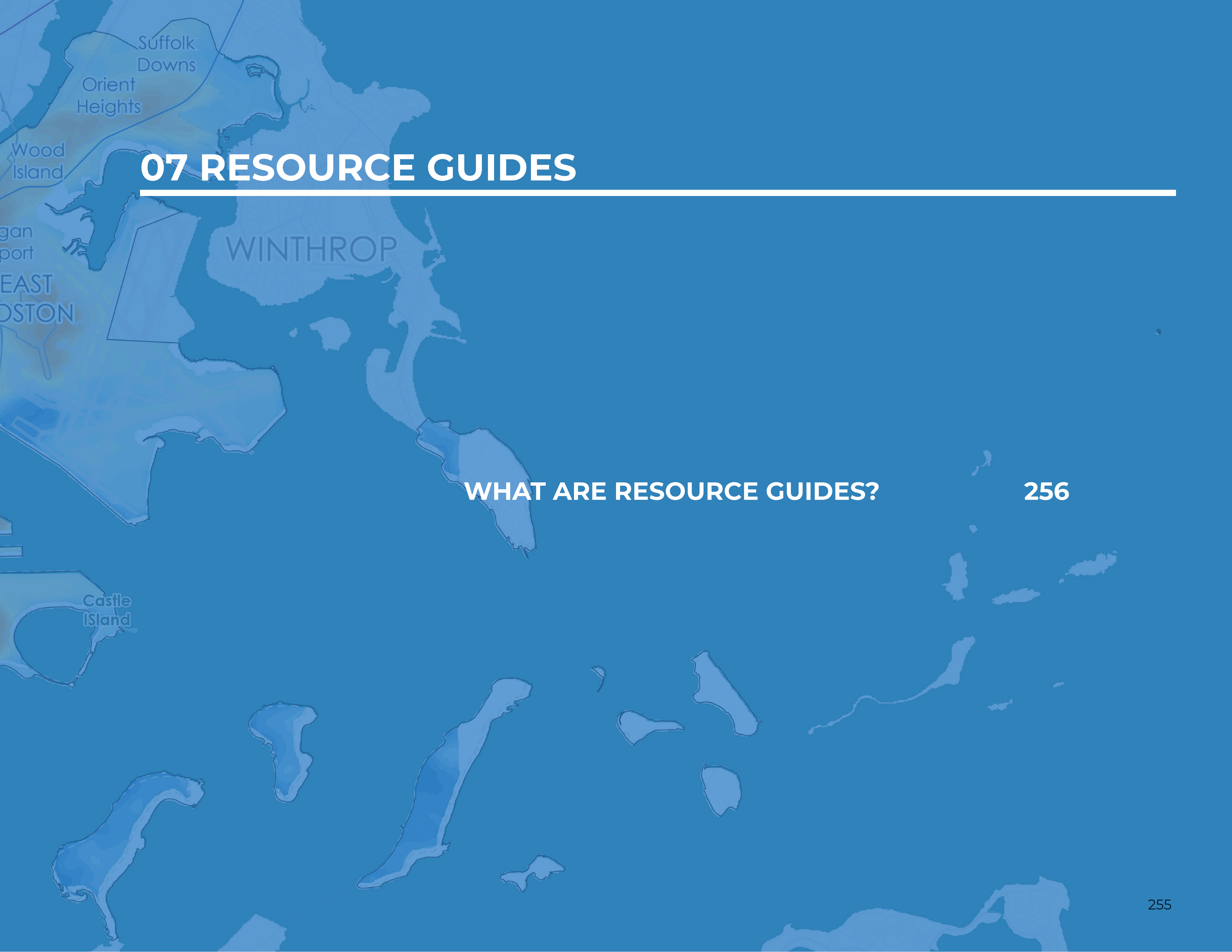


07 RESOURCE GUIDES

WHAT ARE RESOURCE GUIDES?

Raising awareness of existing resources is a critical part of increasing access to cooling. Communities shared throughout the planning process that consolidated information about how residents can apply heat resilient strategies in their own home and communities will help facilitate strong and healthy communities.

Resource Guides are one-page summaries of existing local resources to stay cool in the heat every summer. Resource Guides provide information about how to stay cool and where you can find additional information for a wide range of audiences.

The Community Advisory Board (CAB) identified topics to inform the development of the Resource Guides. The CAB emphasized that for a resource guide to be effective and impactful the topic must align with community interests and encourage residents to integrate heat resilience actions into everyday life. Based on this feedback, three topics were selected for the resource guides:

- **Utilities Assistance Programs:** A summary of what utilities assistance programs are available.
- **Stay Cool At Home:** Five simple ways for people to stay cool at home.
- **Find Cooling in Your Neighborhood:** A summary of where residents can find more information about cooling in their neighborhood, where they can go to cool down, and transportation options for older adults and persons with disabilities.

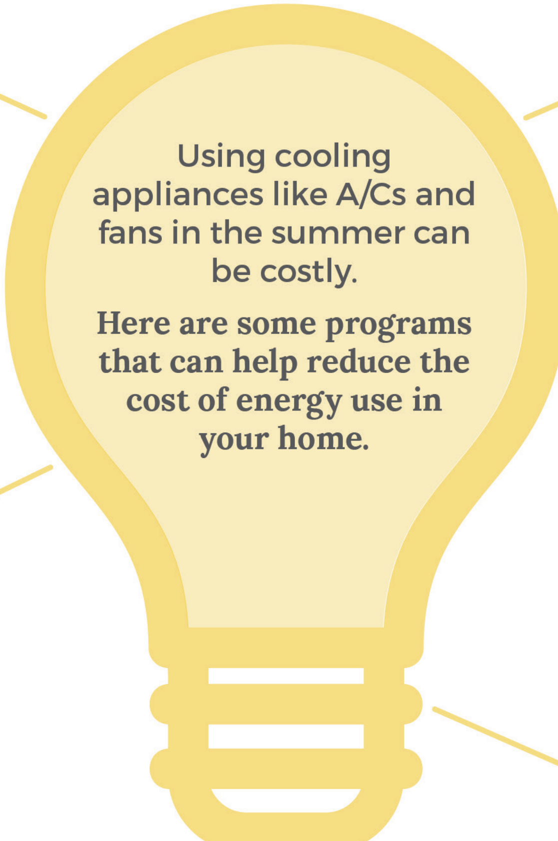
The following pages show the resource guides in English for these three topics. Visit the project website using the QR code on the resource guides to access the resource guides in simplified and traditional Chinese, Vietnamese, Cape Verdean Creole, Haitian Creole, and Spanish.

BEAT THE HEAT BOSTON

Stay cool this summer with these helpful tips.

To learn more about programs to stay cool this summer, use the QR code to visit the project website.

UTILITIES ASSISTANCE PROGRAMS



COMMUNITY CHOICE ELECTRICITY

Opt into **Community Choice Electricity (CCE)**. CCE provides affordable and renewable electricity to program customers. CCE can save Boston residents monthly relative to the Basic Service rate provided by Eversource.

MASS SAVE ENERGY REBATES

The **Mass Save Energy Rebate Program** provides rebates, incentives, training, and resources to help renters, homeowners, and businesses make energy efficiency upgrades and lower energy costs.

Rebates and incentives for insulation and air sealing, heating and cooling equipment, and home appliances are available.

ABCD ENERGY PROGRAMS

The Weatherization Assistance Program (WAP) can weatherize your home to keep cool in the summer and warm in the winter - while lowering your utility bills.

Neighborhood Conservation Action Program can help reduce your electric bill by identifying appliances that need upgrades. You may be eligible to receive new energy efficient light bulbs, window A/Cs, and other appliances.

Utility Build Advocacy can help reduce the cost of overdue utility bills and help you negotiate payment plans with your service provider.

RENTAL RELIEF FUND

Eligible Boston residents who are renters can receive assistance for rent and utilities arrears, current and future rent, and moving-related expenses.

BEAT THE HEAT BOSTON

Stay cool this summer with these helpful tips.

To learn more about programs to stay cool this summer, use the QR code to visit the project website.

STAY COOL AT HOME

CHECK IN ON LOVED ONES
Check on your different communities when it's hot to make sure they're ok.

INCREASE AIR FLOW
Open windows at night to circulate cool air.

BLOCK OUT THE SUN
Close shades and curtains during the hottest part of the day.

USE A FAN AND ICE
Place a bowl of ice in front of your fan to create a cool breeze.

INVEST IN INDOOR PLANTS
Plants naturally cool and clean the air and provide shade. Add plants inside, on your balcony, or door stoop.

FIND COOLING IN YOUR NEIGHBORHOOD

WHERE CAN I FIND MORE INFORMATION?
- *Call 3-1-1: Get information about all non-emergency City services.*
- *Alert Boston: Sign up to get alerts for extreme heat and other emergencies.*

WHERE CAN I GO TO COOL DOWN?
- *Boston Centers for Youth and Families are open as cooling centers during a heat emergency.*
- *Find tot sprays, beaches, and community center pools using the QR code.*

HOW CAN I GET THERE?
Transportation options for older adults and persons with disabilities. Call 617 635 4366 for more information.

- *MBTA's The RIDE: Door-to-door transportation for eligible people who can't use the subway, bus, or trolley due to temporary or permanent disability.*
- *Taxi Coupons for affordable transportation. Purchase coupons at Boston City Hall Room 271.*

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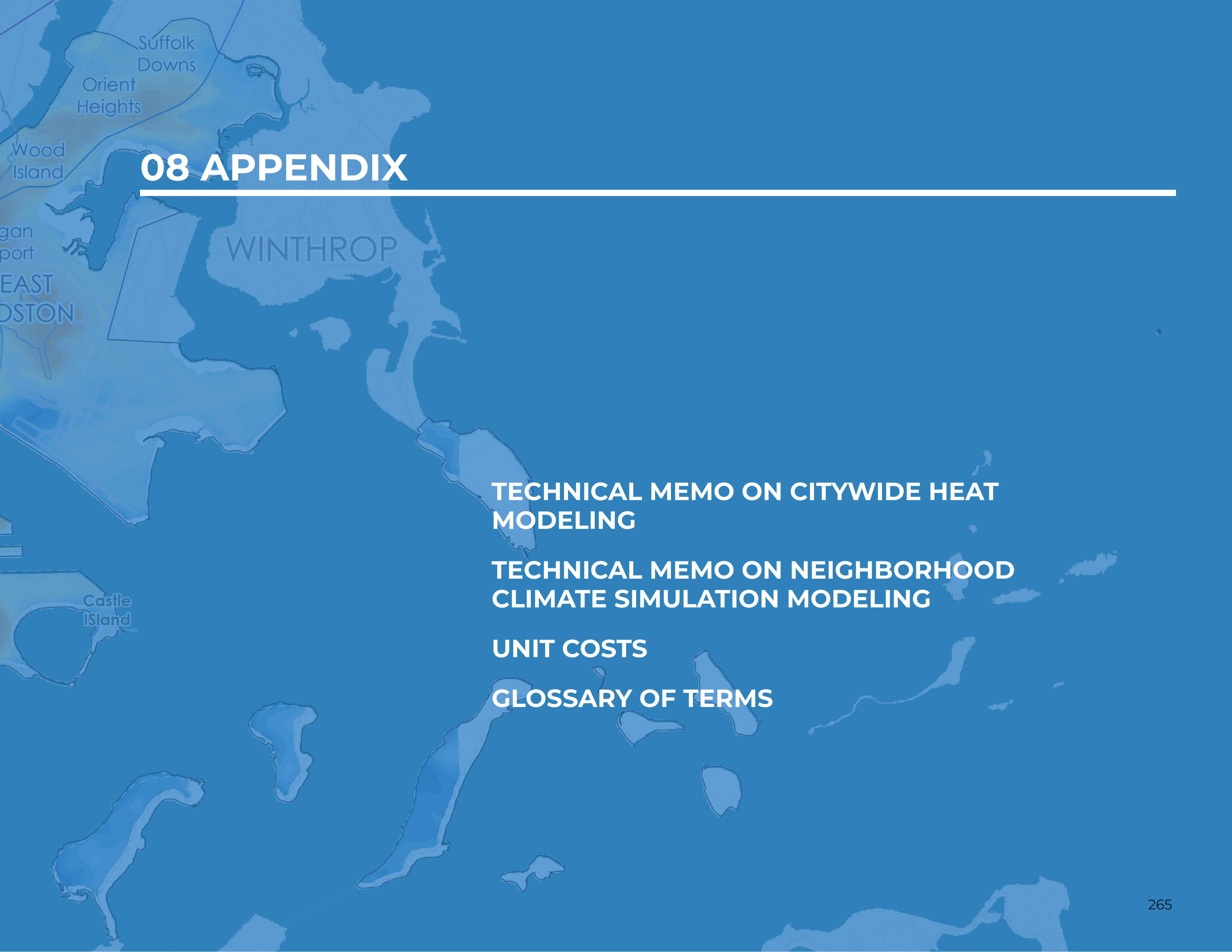
08 APPENDIX



TECHNICAL MEMO ON CITYWIDE HEAT MODELING

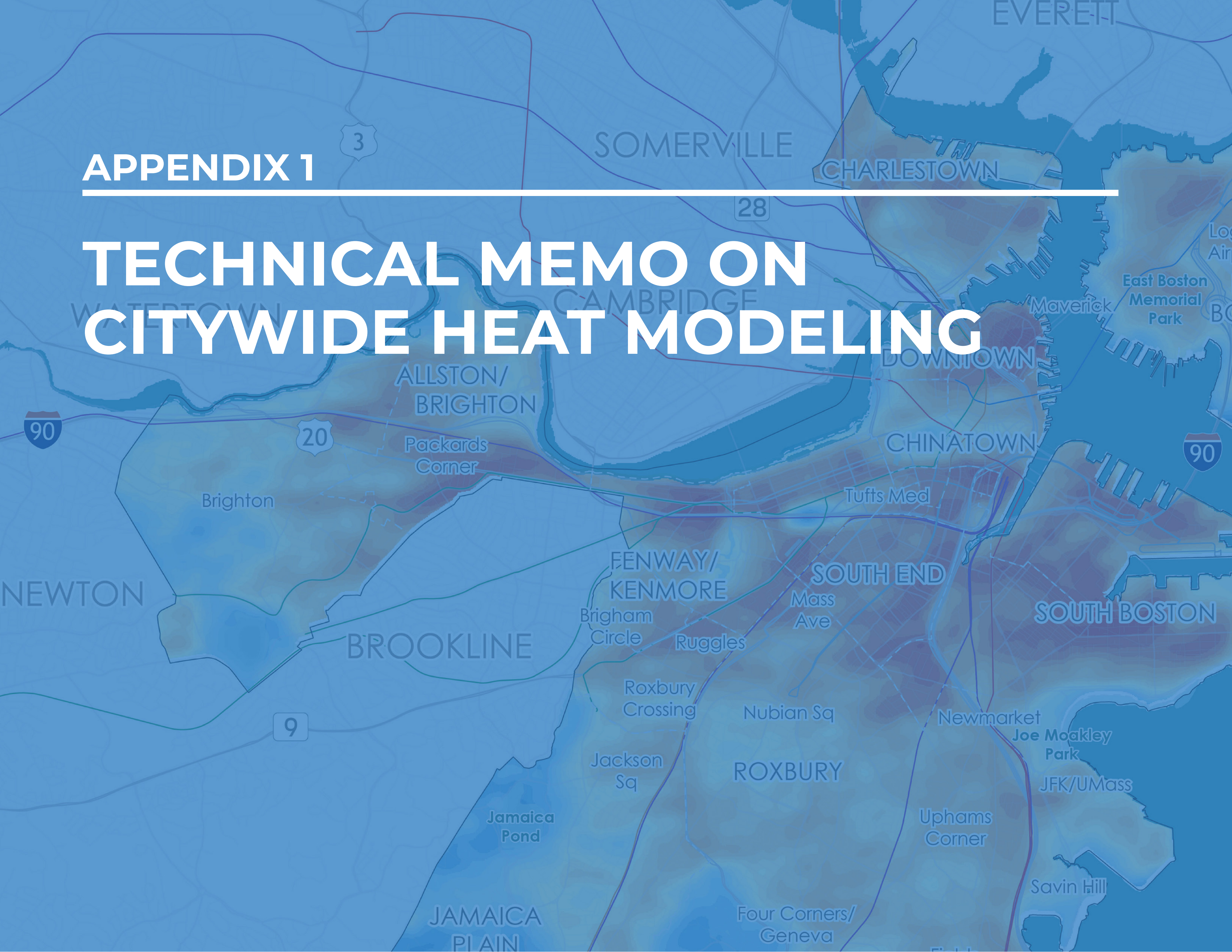
TECHNICAL MEMO ON NEIGHBORHOOD CLIMATE SIMULATION MODELING

UNIT COSTS

GLOSSARY OF TERMS

APPENDIX 1

TECHNICAL MEMO ON CITYWIDE HEAT MODELING



Boston Heat Resilience Study

Technical overview of the urban heat island modelling methodology.

May 12, 2021

For

The City of Boston and Sasaki Associates

By

Klimaat Consulting & Innovation Inc.
Meiring Beyers, PhD, Director
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Summary of Datasets Issued from the Citywide Heat Modeling

The datasets issued and used in the Heat Resilience Strategies for City of Boston is based on a weeklong hourly analysis period for the week of July 18-24, 2019. This period was chosen in collaboration with the City of Boston to model a period that coincided with a reported strong heat wave event in the recent past.

- **Air Temperature (Ta)**: This dataset shows the spatial distribution of the near surface modelled air temperature (°F) during the afternoon (3pm) or night (3am) of the warmest day of the analysis week. This dataset helps to identify the relatively warmer (or cooler) areas during a hot day, and areas that retain (or shed) heat during the night.

- **Heat Event Duration (HED):** The heat event duration is the duration (hours) that modelled heat conditions may exceed a heat alert level for the analysis week. The Boston heat advisory protocol determines whether to issue a heat advisory, alert, or emergency based on forecasted weather conditions exceeding certain heat index thresholds. The HED dataset issued shows the modelled number of hours during the analysis week that the heat index, as defined by the National Weather Service, may exceed a threshold temperature of 95°F for days when the daytime low temperature does not drop below 75°F (heat alert level). The HED dataset is useful to highlight which neighbourhood areas may stay above a heat alert level for the longest period during a hot week.

- **Urban Heat Island Intensity (UHII):** The UHII is a measure of the daily intensity and duration of the urban heat condition relative to the regional (rural) condition. The UHII dataset uses the entire weeklong hourly analysis dataset and sums the hourly difference between the local and rural air temperature before averaging this by day i.e.,

$$UHII = \frac{24}{N}\sum_{1}^{N}(T_{local} - T_{rural})$$

  The issued UHII index divides the UHII by 24 hours to show the UHII as an average daily temperature difference (°F) above the rural temperature. The UHII dataset helps to highlight areas that remain hot and for longer and is therefore reflective of both the intensity and the duration of localised heat within the city during a hot week.

Contents

1. Introduction

This report is part of the work covered in the Boston Heat Resilience study initiated by the City of Boston and led by Sasaki Associates. The report aims to provide a high-level overview of the technical methodology used by Klimaat Consulting & Innovation Inc. ("Klimaat") to model the urban heat island characteristics across the Boston Municipality ("Boston"). The modelling work is performed to help the design team and the city stakeholders visualise and evaluate the spatial and temporal distribution of urban heat across the city. This report does not intend to be a complete scientific description of the urban Land Use and Land Cover (LULC) influences on urban climatic characteristics and focusses mainly on the overview of the heat modelling and mapping methodology as applied to the heat resilience study.

The specific purpose of the work performed here was to generate georeferenced data (map) layers that allow for a spatial and temporal evaluation of the distribution of urban heat island characteristics within and around Boston. It aims to compliment and support the work performed earlier by others as part of the Climate Ready Boston initiatives.

2. Urban Heat Islands

Urban heat island effects are typically evaluated or defined as the difference between localised urban climatic conditions and the conditions further away from the urban centres such as within its suburbs and the rural outskirts. Many textbooks are available that describe these urban climatic processes in detail, such as Oke et al (Oke, 2017). In general, a combination of urban land use and land cover (LULC) characteristic may modify the surface and near surface energy exchanges with the urban atmosphere that causes climatic differences between rural and urban landscapes. These influences include, but are not limited to,

- increased hardscape and or limited or different urban vegetation cover that alters the amount of solar radiation intercepted by the urban fabric and modifies the latent heat contribution to the near surface energy exchange,
- increased urban massing that changes the ventilating wind flow characteristics within urban streets and neighbourhoods and affects the sensible heat contributions within the urban setting,
- increased urban massing and its form alters the shading and sky view factors especially within denser city contexts which affects the shortwave and longwave radiation exchange within the city,
- differences in urban land cover thermal specifications, such as reflectance, emissivity, heat capacity, material density and moisture content, that changes the local heat transfer and thermal storage characteristics within the urban fabric, and

- athropogenic heat sources i.e., the additional energy (heat) released into the urban setting due to human activities such as from heating or cooling of buildings, and from operating transport vehicles, to name a few sources.

When studying urban heat island effects, it is important to distinguish between, at least, surface and canopy heat island characteristics:

- surface urban heat island (SUHI) effects are urban-rural differences of *surface temperatures*, and
- canopy urban heat island (UHI) effects are urban-rural differences of *air temperature* in the near surface urban canopy layer i.e., roughly the layer between the surface and the urban massing height.

This distinction is important. High surface temperatures are often recorded during daytime within urban settings, such as solar exposed areas with low reflectance (albedo). These areas may include dark roof tops, asphalt covered parking lots, or even exposed natural or artificial grass surfaces or bare soil and are often also associated with higher local air temperatures. However, these enhanced daytime surface and air temperature characteristics may exhibit different characteristics at night, as the same exposure can also help it to cool more rapidly and generate cooler air temperatures. Thus, a high daytime surface and air temperature difference (high SUHI & UHI) may often diminish at night. Similarly, areas with dense urban massing may have comparably cooler daytime surface and near-surface air temperatures due to reduced grade level interception of solar radiation and enhanced thermal energy storage in the urban fabric. However, at night the denser urban form may be more effective in trapping the stored thermal energy by limiting re-radiation and sensible heat transfer and thereby heating the near surface atmosphere creating warmer air temperatures at night compared to rural surroundings.

As such there is benefit to evaluate urban heat island characteristics in terms of surface temperature (SUHI) and canopy air temperature (UHI) to identify areas that are hot during daytime, hot during nighttime, or potentially worse for summer heat wave conditions, hot during day and nighttime i.e., prolonged diurnal heat wave conditions. This forms the main purpose of the work; to contribute to the study of the urban heat characteristics in Boston to provide spatial and temporal SUHI and UHI data. In the following section a high-level overview is provided of the urban heat modelling and analysis methodology applied in this work.

2.1 Surface urban heat island (SUHI) analysis

Surface heat island effects are often studied by means of remotely sensed data to generate Land Surface Temperatures (LST) maps from multispectral satellite data such as Landsat 8 (https://landsat.gsfc.nasa.gov/landsat-8/landsat-8-overview). The purpose here was not to generate new LST maps for Boston from Landsat multispectral satellite data, as this effort is thoroughly covered in work performed by other groups. Instead, it aims to compliment the existing Boston heat map datasets, as currently used by the city for understanding its spatial heat distribution characteristics, with additional urban canopy heat island (UHI) information. However, Landsat 8 derived LST datasets were produced in this work but were mainly used to test the performance of the urban canopy urban heat island modelling process (K-UCMv1), described below, as hourly surface temperature data is also one of the resolved and exported variables. This makes it useful for independent comparison between the LST information obtained from Landsat and that derived from the urban canopy modelling.

In the current work a LST map was generated based on a Landsat 8 image data taken on July 13, 2016. The land surface data is derived based on the 30m resolution multispectral bands and the 100m resolution thermal bands. The processing is based on a well-established radiative transfer model approach, as described by Peng et al. (Peng, 2020), to derive the LST. The methodology essentially converts the satellite measured at sensor, top-of-atmosphere radiance (thermal band data) to surface radiance and a land surface temperature. The method employs the local normal difference vegetation index (NDVI), derived from 30m the multi-spectral Landsat 8 bands, to approximate the local surface emissivity, and employs an atmospheric correction for the atmospheric condition at the time that the satellite image was taken (Barsi, 2005) (*https://atmcorr.gsfc.nasa.gov/*) to close the surface radiation energy balance equation and derive the ground level surface black body radiation. This in turn provides the surface temperature according to the Planck formula. More complete details are available in Peng et al. (Peng, 2020). A sample of the resultant LST obtained from the Landsat 8 data is shown in the case study results section below. Alternatively, processed LST data can also be directly obtained from the NOAA Landsat program (*https://www.usgs.gov/core-science-systems/nli/landsat/landsat-surface-temperature*).

Surface heat island effects are also studied using Moderate Resolution Imaging Spectroradiometer (MODIS, *https://modis.gsfc.nasa.gov/about/*) satellite data that can provide daytime and nighttime surface temperature analysis with band resolutions from 250m to 1000m. This was beyond the scope of the current work.

2.2 Canopy urban heat island (UHI) modelling methodology

The main purpose of this work is to derive spatial maps of the near-surface air temperature across the Boston region through modelling of the canopy urban heat island effects. An Urban Canopy Model (UCM) generally refers to a modelling approach that aims to perform spatio-temporal modelling of the climate within the urban canopy layer, the layer between the surface and roughly the height of the urban features. This is usually done by solving a surface and near surface energy balance that describes and parameterises the governing physics within the urban canopy layer, based on urban land use and land cover characteristics and specifications and deliver an approximation of time dependent urban climatic condition.

In the current work, the UCM model developed by Klimaat is used (Klimaat Urban Canopy Model, version 1, "K-UCMv1"). A high-level and simplified overview of the K-UCMv1 modelling approach is given below.

2.3.1 Surface Energy Balance

The UCM model used here solves a local surface energy balance (SEB) based on LULC input and regional meteorological forcing. The modelling approach, its solution process and underlying governing physics generally follows that of other single-layer UCM models (Kusaka, 2001) (Lee, 2008) (Ryu, 2011). The SEB is solved per individual tile (pixel) in the analysis domain with every tile representing a position in a 100m resolution grid array generated from the LULC input. The tile input and its UCM solution therefore approximates an average condition of the urban condition, its form and material specification at a resolution of 100m.

The starting point for the UCM is to determine surface temperatures (ground, walls, roofs) by solving an energy balance at the different surface facets of an approximated urban setting at every grid tile. The surface energy balance includes different energy flux contributions to the overall surface energy balance, i.e.

$$Q^* = Q_H + Q_L + Q_G \tag{1}$$

where Q^*, Q_H, Q_L and Q_G represents the net energy contributions from net all-wave radiation (downwelling and upwelling long and shortwave radiation), sensible, latent and ground heat fluxes, respectively, as shown in Figure 1 below.

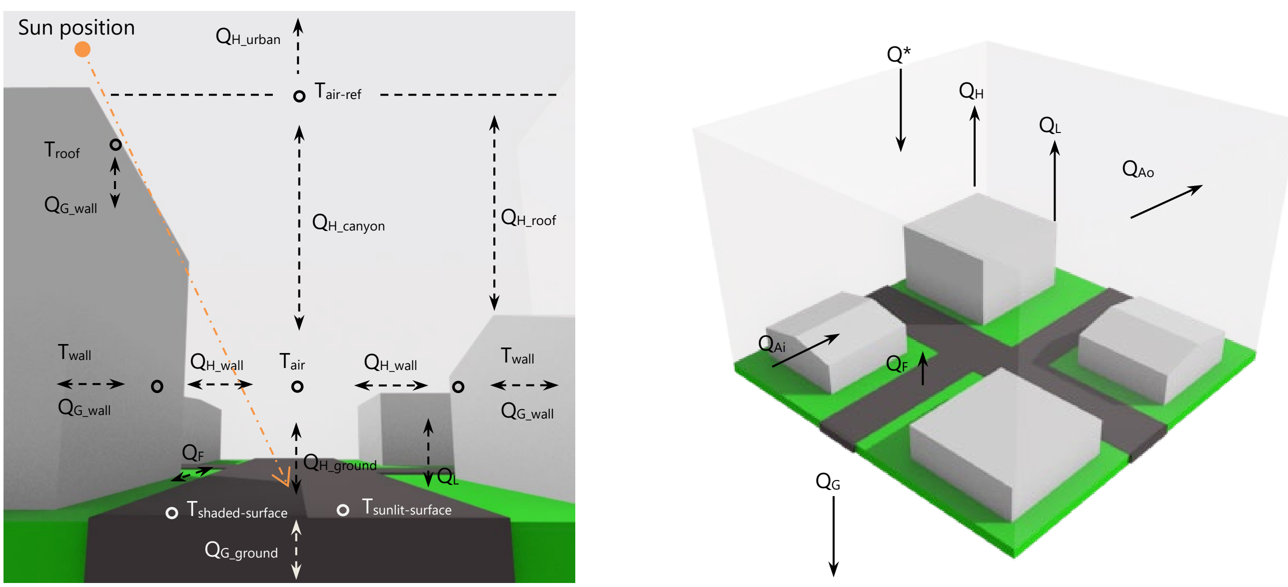

Figure 1: Surface and near surface energy balance components for a single-layer urban canopy model (left) and urban canopy control volume energy balance (right).

An additional energy balance is solved in the air volume that approximates the urban canopy (canyon) that balances the surface fluxes, convective fluxes and local heat sources within the urban canyon to derive the time dependent air properties.

The net all-wave radiation flux, Q^* is the balance of shortwave and long wave radiation components. The shortwave contribution to the surface energy flux is determined by the balance of incoming shortwave radiation contributions from direct and diffuse solar radiation, as per the meteorological forcing, and the reflected shortwave radiation, influenced largely by the solar reflectance of the surface (albedo), the surface orientation intercepting the incoming flux, the exposure of the surface to direct radiation (hourly shading) and the exposure of the surface to diffuse radiation via the local visibility of the sky hemisphere (sky view factor). The longwave contribution is the balance between the incoming longwave radiation (meteorology forcing) and the upwelling longwave radiation exchange between the urban canyon surfaces and the atmosphere.

The sensible heat flux, Q_H, is the heat flux due to the temperature differences between the urban canopy air and its adjacent surfaces and driven by the turbulent exchange between the surfaces of the urban canopy and the air within and above the urban canopy. For one, the turbulent heat exchange between ground or roof surfaces are parameterised according to Monin-Obuhkov similarity theory to derive the near surface heat transfer coefficient, similar to (Ryu, 2011) (Kusaka, 2001) and approximates the near surface canyon wind speed as a function of reference wind speed, the urban aerodynamic roughness and the urban building form (height to width ratio).

The latent heat flux at the surface is the net energy contribution (or sink) due to the evaporation of water at the surface, controlled in the current model through the evapotranspiration moisture source provided by vegetation. The evapotranspiration is determined according to the Penman-Monteith equation (wikipedia, n.d.) modified to employ hourly meteorology data and scaled according to the fraction of vegetation present at the local surface tile.

The ground or surface heat flux contribution, Q_G, is the transport of heat into or from the surface layers through heat conduction, controlled by the properties of the surface facet layer such as its thermal conductivity, thermal heat capacity and density. The surface heat flux contribution requires coupling of the surface energy balance solver with an additional conduction heat transfer model and solver that can approximate the time-dependent temperature profile within the ground or surface facet. This is important so that the thermal energy storage effect of different surface facets (ground, walls, roofs) is properly accounted for when determining the surface temperatures that exchanges its heat and moisture with the urban canopy atmosphere near it.

The surface energy balance therefore constitutes a set of coupled governing equations that control each of these flux contributions, linked with an additional energy balance within an urban canopy layer control volume that describes the exchange of heat (and moisture) between the surfaces and the atmosphere above it. The latter also includes an additional control volume energy balance contribution from anthropogenic heat or moisture sources. The anthropogenic heat flux is the energy contribution due to man-made fluxes such as heat sources (or sinks) from building heat or cooling or operation of vehicles.

The urban canopy control volume energy balance model soves the time dependent evolution of the temperature and humidity of the near surface air layer within an approximation urban canyon form and specification as determined by the tile averaged LULC and the urban massing input. In the current model, the control volume energy balance solution and subsequent derivation of its average air temperature is mainly influenced by turbulent exchanges of heat or moisture between the air volume within the canyon, the surfaces (ground, walls, roofs) adjacent to it and the atmosphere above it. Precipitation or soil moisture effects are not currently included in the model.

The energy balance at the surface and within the urban canopy volume, and the coupled ground heat conduction model is driven (forced) by an hourly meteorological forcing dataset and solved at 1 minute time intervals for the duration of a weekly analysis period. Urban canopy climate characteristics are exported hourly.

2.3.2 Meteorological forcing

An hourly or sub-hourly meteorological dataset is required to drive or force the urban canopy model solution process, i.e., it drives the time-dependent solution of the surface and urban canopy control volume energy balances. The forcing data should be representative of the regional meteorological conditions. In the current work the historical hourly forcing data is obtained from the ERA5 gridded re-analysis product of the European Centre for Medium-range Weather Forecasts (ERA5, 2017). Klimaat uses in-house data handling and analysis processes to download and extract the historical hourly near surface meteorological dataset into suitable and standard formatting for use with the K-UCMv1. The meteorology dataset contains hourly data of the near surface air temperature, humidity, wind speed, wind direction, downwelling shortwave and long wave solar radiation components, among other variables. For the current work, two ERA5 datasets were compiled for the year 2016 and 2019, as described below for the case study work. The meteorological datasets are also provided as supplementary materials as part of the overall project deliverable.

It is important to note that the present UCM modelling process is one-way coupled to the meteorological forcing data, meaning the forcing data drives the UCM solution, but without feedback to change the regional meteorological condition, as is often done with high-resolution weather forecasting modelling approaches. The current method should therefore be considered more as an urban climate downscaling method, rather than a complete urban weather model with full two-way coupling with a mesoscale atmospheric model.

2.3.3 Land-use and Land-cover (LULC) specification

A number of important LULC characteristics are required as inputs for the UCM as these represent the tile averaged condition of the urban canopy layer. These include, but are not limited to, spatial maps of land cover characteristic including surface vegetation, water bodies, surface reflectance, terrain elevation and urban massing (building heights). The majority of the land cover specifications are derived from the Sentinel-2 (Sentinel-2, n.d.) multispectral satellite imagery which delivers its multispectral data at 10m resolution. Terrain elevation data is obtained from NASA SRTM (SRTM, n.d.) at 30m resolution. All the processed LULC spatial data is resampled and averaged into 100m resolution grids (tiles) as required for the UCM.

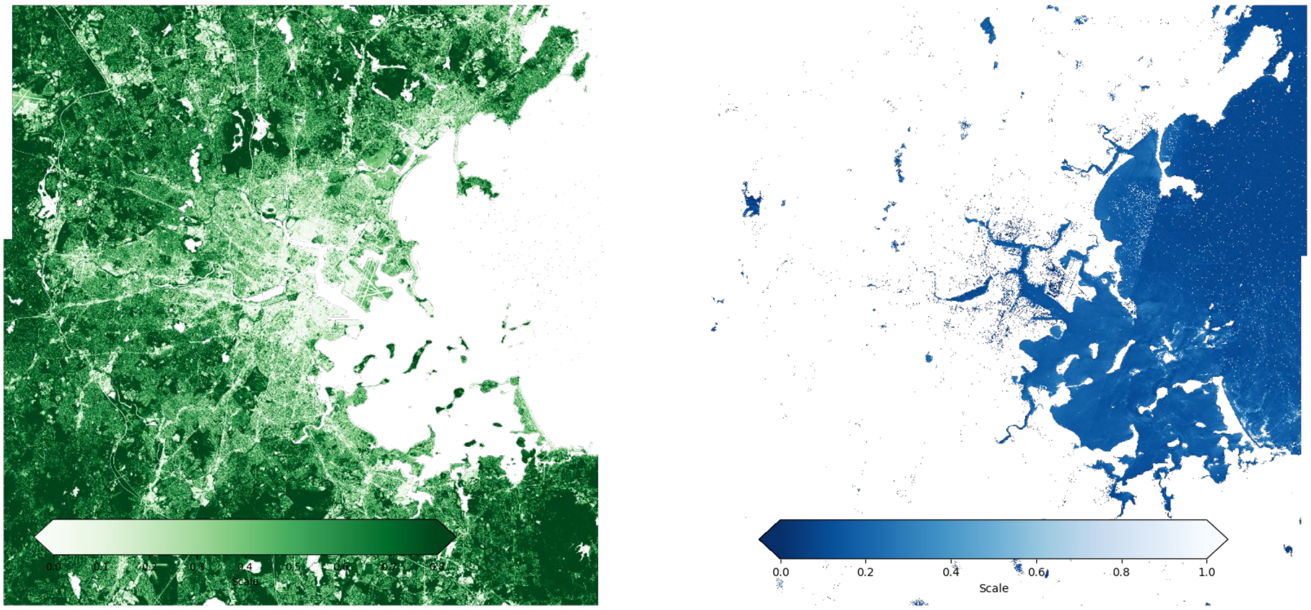

Figure 2: Sample of Sentinel-2 processed data for Normalised Difference Vegetation Index, NDVI (left) and Normalised Difference Water Index, NDWI (right).

The satellite data is processed into different land cover indices used by the UCM through processing of different multispectral band combinations to provide LULC conditions such as Normalised Difference Vegetation Index (NDVI) for vegetation coverage and Normalised Difference Water Index (NDWI) for water bodies i.e.,

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad (2)$$

$$NDWI = \frac{GREEN - NIR}{GREEN + NIR} \quad (3)$$

where NIR, RED and GREEN represent the near infrared, red and green multispectral band data from Sentinel-2. An example of the processed NDVI and NDWI indices for Boston is shown in Figure 2.

For urban massing (building heights) building footprint and elevation data provided by city of Boston (for the Boston Municipality) was combined with older datasets for outlying areas to derive a regional building height map that covers the extents of the model. The building height data is also averaged into a 100m resolution raster tile which is used in the model to mathematically determine the surface sky view factor and hourly shade fractions, among other things that influences the localised surface energy balance solution. Hourly shade fractions at each tile are calculated based on the local hourly solar position, similar to the methodology of (Kusaka, 2001).

Figure 3: Image sample of building footprint and height data for the City of Boston

2.3.4 Additional model thermal specification inputs

Additional modelling inputs and assumptions are required by the model where the information is not provided by the satellite derived LULC tile set, with a selection shown in Table 1.

Table 1: Additional K-UCMv1 land surface specifications

Ground (soil): Specific thermal heat capacity (kJ/m^3/K), thermal conductivity (W/m/K), emissivity	1900, 0.8, 0.9
Walls: Specific thermal heat capacity (kJ/m^3/K), thermal conductivity (W/m/K), albedo	1340, 0.8, 0.94, 0.25
Roofs: Specific thermal heat capacity (kJ/m^3/K), thermal conductivity (W/m/K)	1400, 0.8, 0.94

2.3.5 UCM Modelling Output - Heat indices

The UCM model produces a data array that represents the spatio-temporal climatic variables covered within the model region and for the analysis period. The data array represents the modelled, average hourly urban meteorological condition at 100m spatial resolution. This datasets is further processed into urban heat indices and delivered as georeferenced image layers (geotiff rasters) to the design team (Sasaki) for further processing and integration into the overall study program deliverables. The data layers are resampled to 10m resolution using a bilinear interpolation. This is done purely for visualisation purposes when overlaying the model data with other datasets. The key data layers that were processed and integrated into the main report include:

- **Air Temperature (Ta)**: The near surface air temperature. Four map layers were produced to show the spatial distribution of air temperature across Boston at different time periods on the warmest day of the analysis week. These were air temperatures during the night (3am), morning (10am), afternoon (3pm) and evening (9pm).

- **Urban Heat Island Intensity (UHII):** To better study the temporal effects of the urban heat condition an Urban Heat Island Intensity metric was defined, similar to that described in Taha et al. (Taha, H. and Freed, T., 2015). The UHII uses the entire weeklong hourly dataset and sums the hourly difference between the local and rural air temperature before averaging this by day i.e.,

$$UHII = \frac{24}{N}\sum_{1}^{N}(T_{local} - T_{rural}) \tag{3}$$

  The index therefore provides a daily degree hours (°F-hr.day^{-1}) index as a measure of the overall difference between a local condition and the regional temperature. In effect, the degree hour map helps to highlight areas that remain hot and for longer and is therefore reflective of both the intensity and the duration of localised heat within the city. The design team (Sasaki) have subsequently modified the exported data layer further to show the UHII as an average daily temperature difference above the rural temperature.

- **Land Surface Temperature (LST):** The surface temperature of the ground at 10am of the warmest day during the analysis week. This provides an additional measure of the ground surface temperature condition within the urban context at a similar time stamp when Landsat 8 satellite data is gathered.

- **Heat Event Duration (HED):** The heat event duration is the modelled duration (hours) during which heat conditions exceed heat advisory levels during the analysis week. The Boston heat advisory index determines whether to issue a heat advisory, alert, or emergency based on forecasted weather conditions and uses the heat index, as defined by the National Weather Service (NOAA, n.d.), to determine the heat event level. In this work the HED is calculated as the number of hours during the analysis week that the heat index exceeded a threshold temperature of 95°F (heat alert level) for the days when the daytime low temperatures did not drop below 75°F. This index useful to determine which neighbourhood areas would stay the hottest for the longest during weeks with heat wave events.

3. Urban Heat Modelling Runs

An analysis domain was selected with an extent of approximately 31km by 31km centred over the Boston Municipality. For this domain, two different weeklong historical analysis periods were analysed:

- The first period selected was for a week of July 10-17, 2016. This sample period coincides with a day (July 13, 2016) during which a near cloudless Landsat 8 image was available from which a LST surface map could be generated that is independent of the K-UCMv1 derived land surface temperatures. The purpose here was to compare the Landsat 8 LST map and the K-UCMv1 LST approximation as a measure of the performance of the modelling approach to predict surface temperatures.
- The second period selected was for a week of July 18-24, 2019. This period was chosen in collaboration with the City of Boston to model a period that coincided with a reported strong heat wave event in the recent past. The analysis results and data layers obtained from this modelling period was the main focus and deliverable of the current work. The resultant output data layers were integrated and overlayed with additional datasets by the design team (Sasaki) as shown and discussed in the main report.

A few key output data layers for the analysis periods are provided as samples below. The raw data layers were processed and integrated by the design team (Sasaki) into the main Task 2 report that forms part of the overall Heat Resilience dataset.

3.2 Case Study: July 10-17, 2016

For the current work surface temperature predictions were used to test its performance against Landsat 8 processed data. The modelled land surface temperature obtained from the K-UCMv1 is shown here for comparison to the Landsat 8 derived LST in Figure 4. The K-UCMv1 model land surface temperature map is produced for the same hour during which the Landsat 8 satellite image was taken, between 10am and 11am on the morning of July 13, 2016. As shown in Figure 4, the spatial distribution of the warm and cooler surfaces predicted by K-UCMv1 generally seems to agree with the surface temperature distribution and range found from the Landsat 8 analysis.

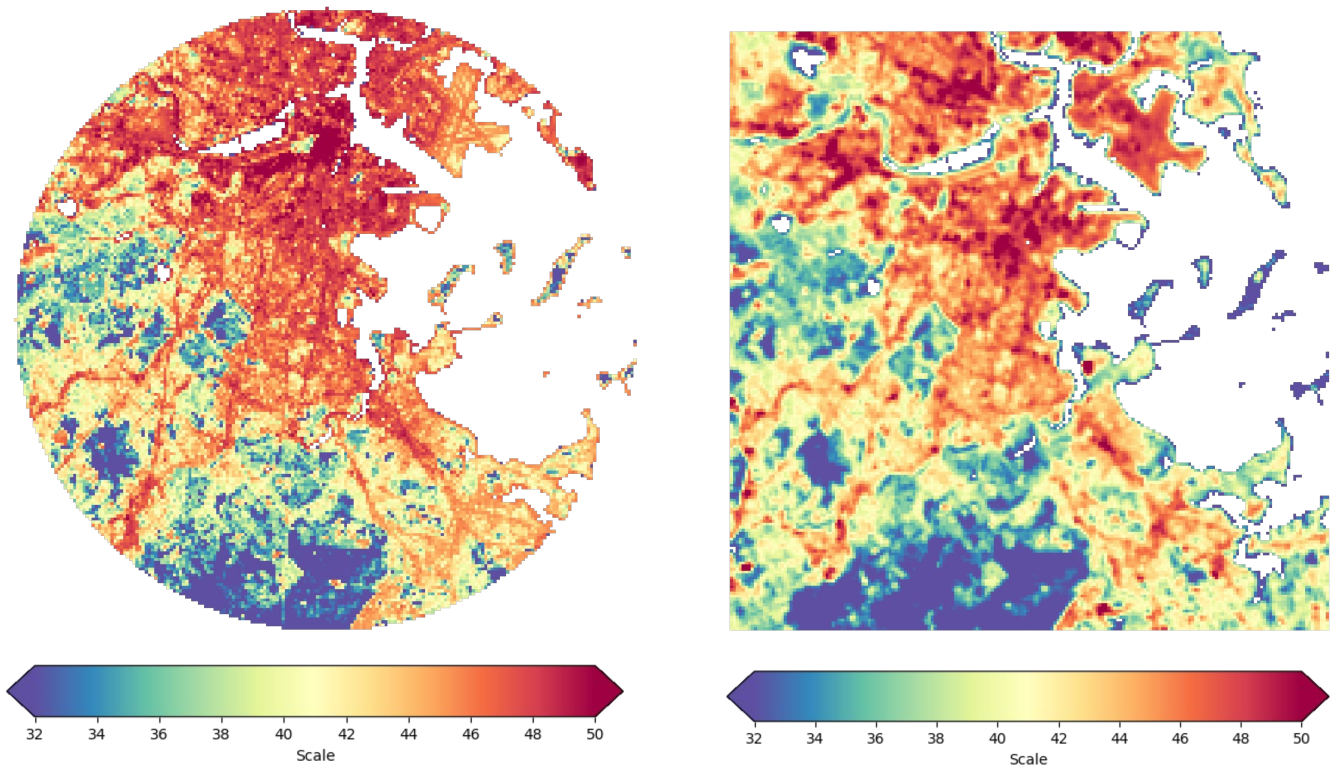

Figure 4: Spatial comparison of the LST as modelled by K-UCMv1 (left) and processed from Landsat 8 data (right) for July 13, 2016, at approximately 10am. Temperature scale is in °C.

Figure 5 shows a pixel-by-pixel comparison between the K-UCMv1 model and the Landsat 8 processed land surface temperature data. This suggests that the K-UCMv1 model is capable of producing similar trends across the analysis region. The correlation between the Normalised Difference Vegetation Index (NDVI) and the surface temperature is also compared in Figure 5. This shows that the K-UCMv1 model generally matches the trend of the Landsat 8 surface temperature variation with NDVI although the Landsat 8 data has more variation across NDVI levels.

The current work and this methodology report do not intend to be a complete validation of the K-UCMv1 method as this is an on-going effort with continuous modelling approach updates and improvements. In particular, the K-UCMv1 model is part of an international comparative study to assess the performance of urban canopy models to predict surface energy fluxes**.**

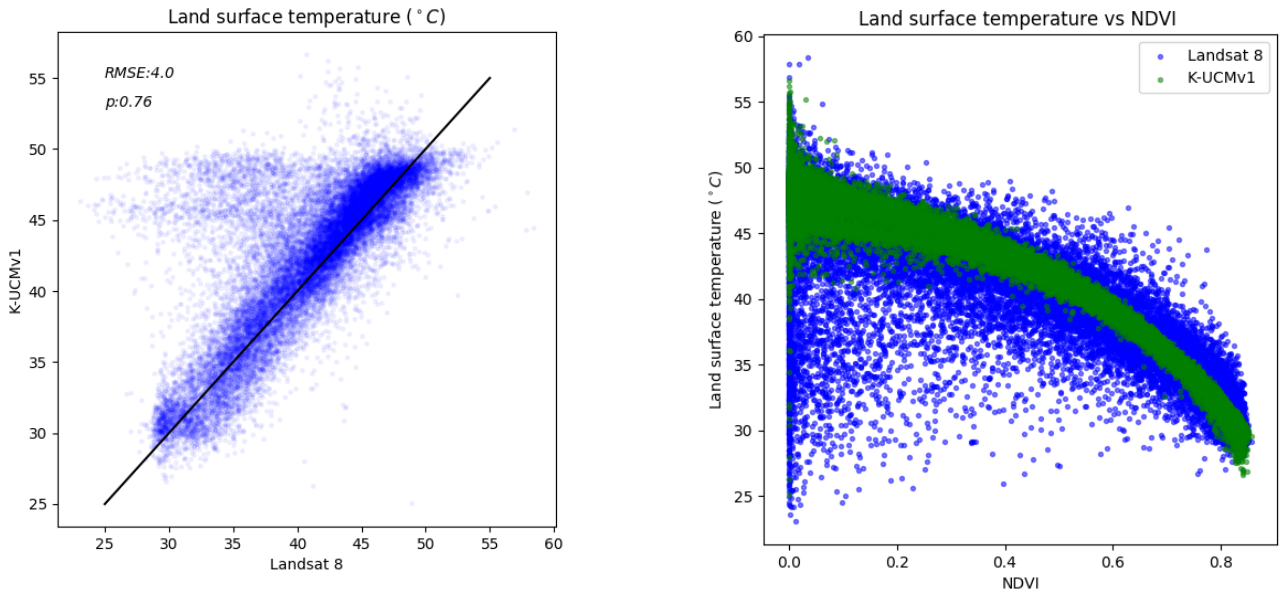

Figure 5: (Left) Correlation between the land surface temperature (°C) modelled by K-UCMv1 and from processed Landsat 8 data for July 13, 2016 10am. (Right) Correlation between the Normalised Difference Vegetation Index (NDVI) and the predicted land surface temperature from K-UCMv1 and Landsat 8.

3.3 Case Study: July 18-25, 2019

Based on discussions with the City of Boston, a weeklong period of July 18 to 24, 2019 was selected to produce the heat characteristics maps for the Boston Heat Resilience Study. This week coincided with a very intense heat wave with peak temperatures of approximately 36°C on July 21 and July 22 measured at the airport. The main output data layer results are discussed in the main report of the Heat Resilience Study as integrated into the design team deliverable by Sasaki. A sample of the set of the data layers provided to the design team is shown below only to highlight the different output data layers with a brief description of the spatial and temporal heat characteristics across the city. The main design report uses the exported data layers to zoom into specific focus areas (neighbourhoods) to examine the urban context that may cause elevated high urban heat island conditions and help identify potential mitigation measures to improve it.

Figure 6 shows a map of the modelled Urban Heat Island Intensity (UHII) index and the Heat Event Duration (HED) index for the week of July 18 to 24, 2019. The UHII index highlights areas that have the hottest and longest departure (difference) from the rural temperature condition. This is also shown in the Heat Event Duration index, which shows that solar exposed neighbourhoods, with extensive hardscape, massing and limited vegetation, stays within heat wave conditions the longest (33 to 36 hours) compared to rural outskirts and forested areas that stay within heat wave conditions the shortest (25 hours) during the analysis week of July 18 to 25, 2019.

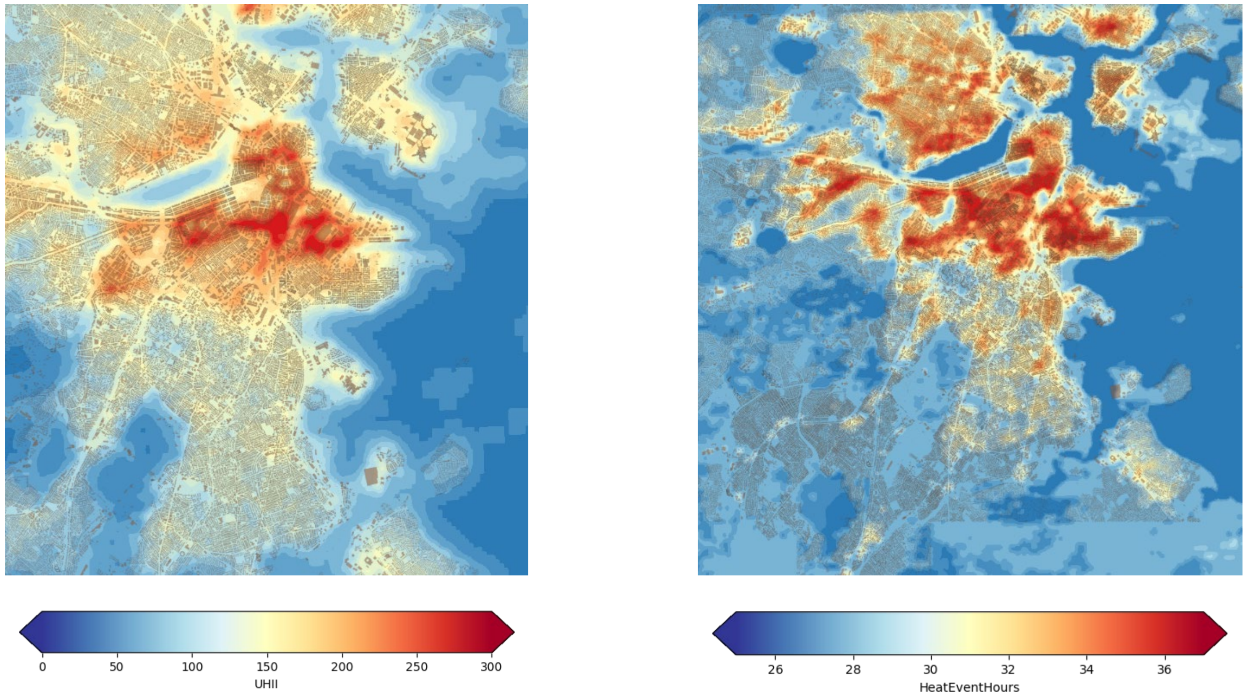

Figure 6: (Left) Urban Heat Island Intensity (°F-hours/day) and (right) Heat Event Duration (Hours/week) for Boston on July 22, 2019.

Figure 7 shows the near surface air-temperature map for July 22, 2019 for four periods during the day namely night (3am), morning (10am), afternoon (3pm) and evening (9pm). This highlights the change of air temperature during the course of one day during the very hot conditions of July 20-22, 2019. Cooler daytime temperatures are modelled for areas within the deeply shaded spaces of the denser urban centre with its tall massing. Daytime temperatures within solar exposed areas with significant hardscape are the highest. During night-time, the suburban outskirts cooled down faster compared to the dense urban core which retains the most heat and becomes the warmest area. One of the main reasons for warmer temperatures occurring within the city core during the night and into the early morning, compared to the cooler outlying suburban and forested areas, is the slower release of heat stored within the urban massing and its land surface. In more exposed areas the heat is released quickly due to the higher night sky exposure and enhanced open area ventilation. The comparably warmer night-time and morning temperatures and cooler afternoon temperatures within the denser urban cores were also found in Portland by Voelkel et al. (Voelkel, 2017).

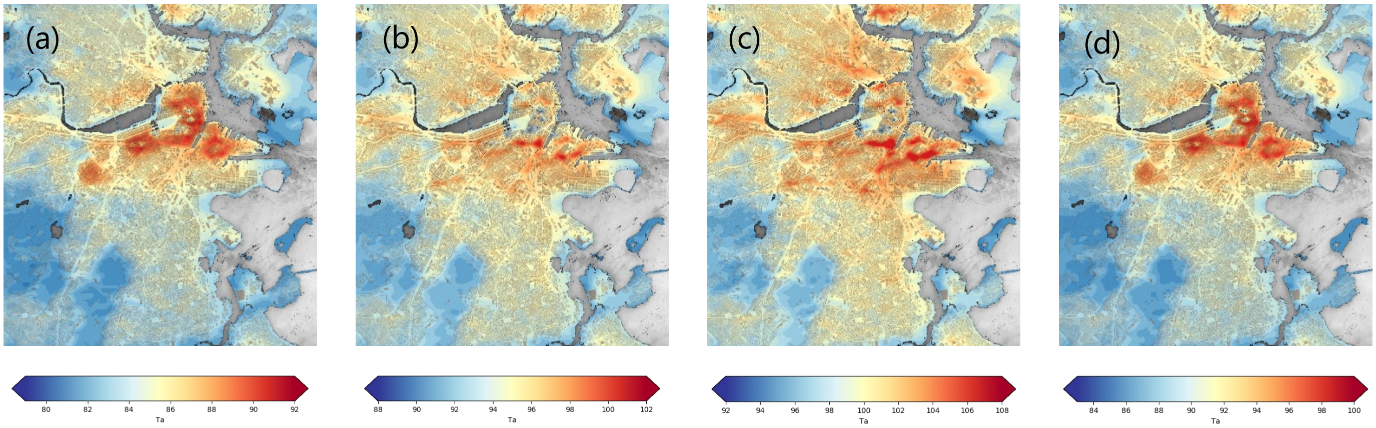

Figure 7: Near surface air temperature (°F) on July 22, 2019 for (a) 3am, (b) 10am, (c) 3pm and (d) 9pm

4. Summary

This report highlights the urban canopy modelling methodology used as part of the City of Boston Heat Resilience Study. It describes the main heat characteristic indices, exported as georeferenced data layers, employed to help visualise the urban heat characteristics across the Boston Municipality and in the neighbourhood focus area heat analysis and mitigation work. The final data layer output and visualisations are provided and discussed in more detail for key Boston neighbourhoods in the main report by the design team.

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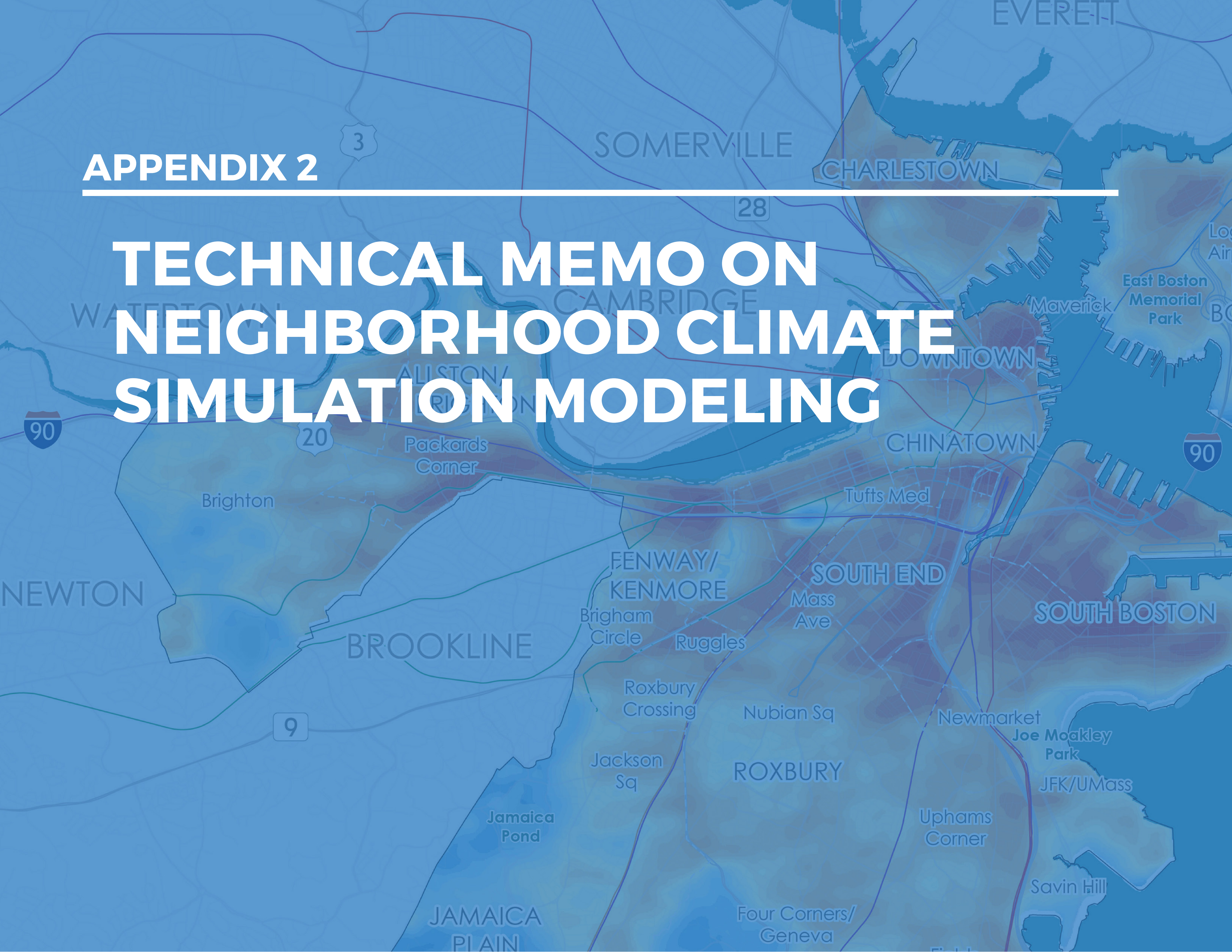
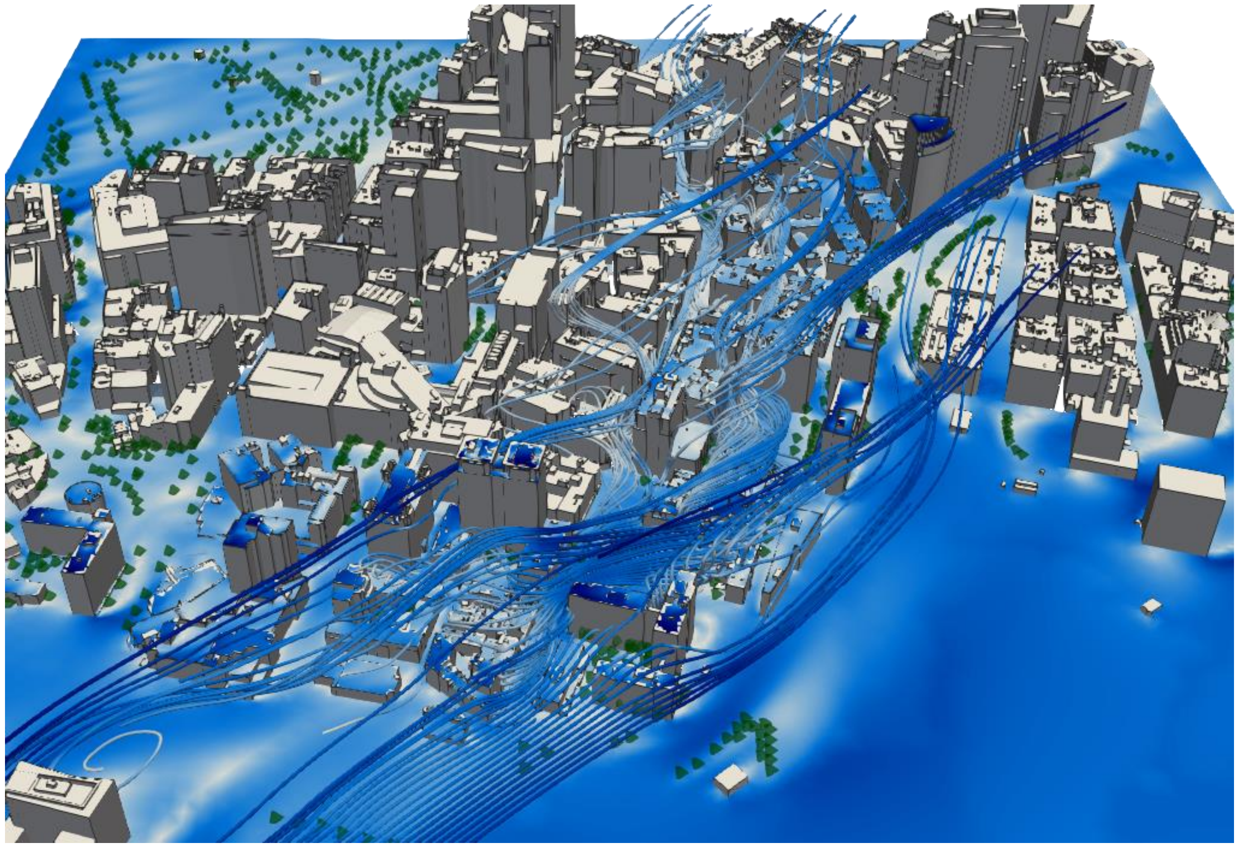
APPENDIX 2

TECHNICAL MEMO ON NEIGHBORHOOD CLIMATE SIMULATION MODELING



Boston Heat Resilience Study

Neighbourhood Urban Climate Simulation



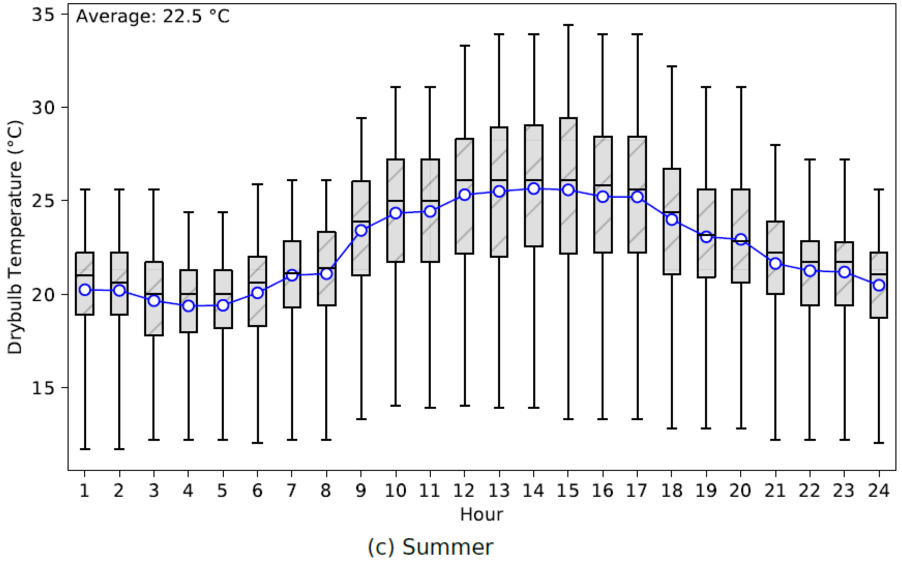
Meiring Beyers
Klimaat
2021-09-24

Typical Climate Characteristics

Climate Characteristics

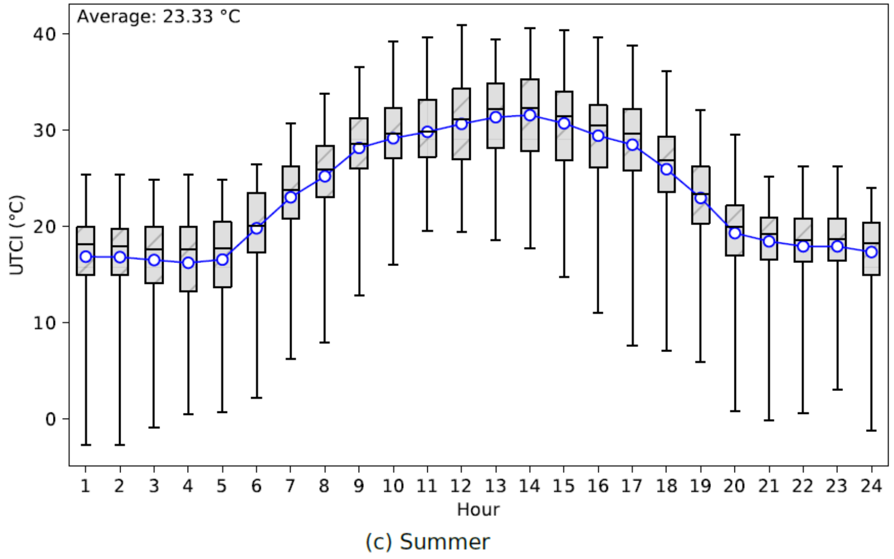
Temperature
Based on typical annual hourly meteorology data for Boston from its Boston Logan International Airport, the average Summer dry-bulb temperature is 22.5°C.

A more detailed meteorology data report of the data used for the urban climate analysis is available as:



Average diurnal range of dry-bulb temperatures for Summer (blue line) with grey boxes indicating 25% and 75% percentile values, and whiskers indicating the maximum and minimum range..

Perceived Thermal Comfort
The combination of humidity, temperature, solar and wind exposure can provide an estimated perceived temperature, or thermal comfort. The current analysis uses the Universal Thermal Climate Index (utci.org) to create an effective or perceived thermal climate. The mean daily perceived temperature for solar and wind exposed terrain for Summer is approximately 23°C (73°F). However, Summer daytimes will generally be considered warm to hot with moderate to high heat stress conditions during the afternoon (>30°C, >86°F).

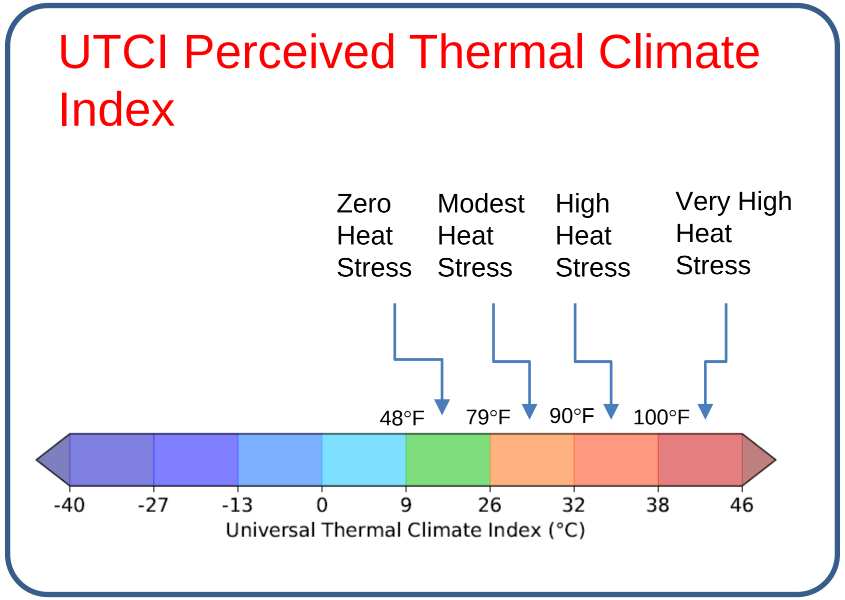


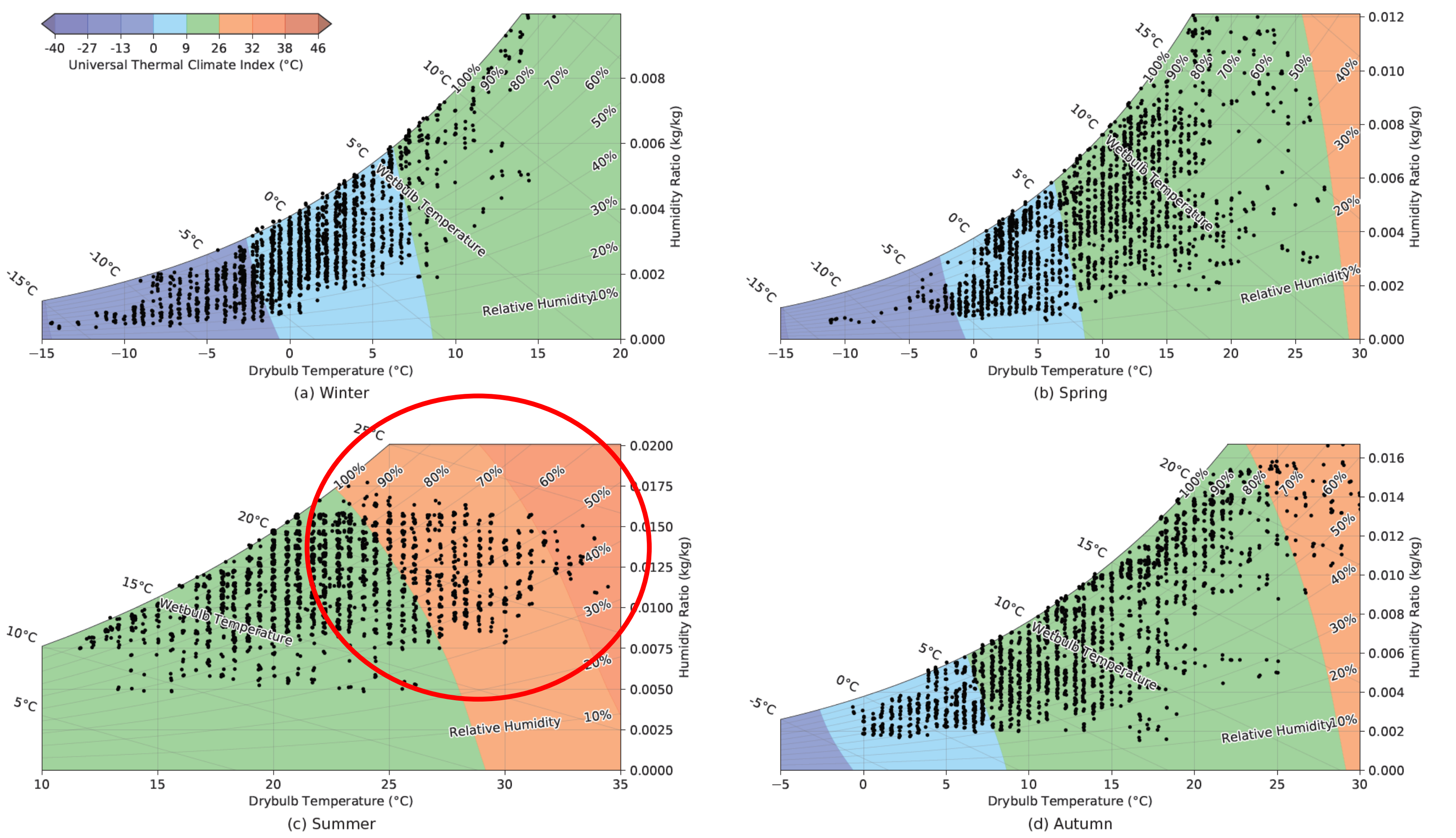
Seasonal average diurnal range perceived temperature (blue line).

Climate Characteristics

Thermal Comfort – Universal Thermal Climate Index

Annual hourly combinations of dry-bulb temperature and relative humidity is shown here on a psychrometric chart, overlaid with the UTCI thermal comfort scale. This shows hours (black dots) during different season that are comfortable (green overlay) or with mild or severe heat stress (orange to red) or mild to high cold stress (light blue to dark blue). For the UTCI, comfortable perceived temperatures are associated with 9ºC < T_{utci}< 26ºC, while warm conditions with moderate heat stress are 26ºC < T_{utci}< 32ºC. High heat stress conditions are associated with $T_{utci>}$32ºC. On average, Summer conditions are mostly associated with comfortable to moderately warm conditions (at the airport). Urban conditions with limited wind ventilation, high solar exposure and higher urban heat island intensities will feel warmer more often.





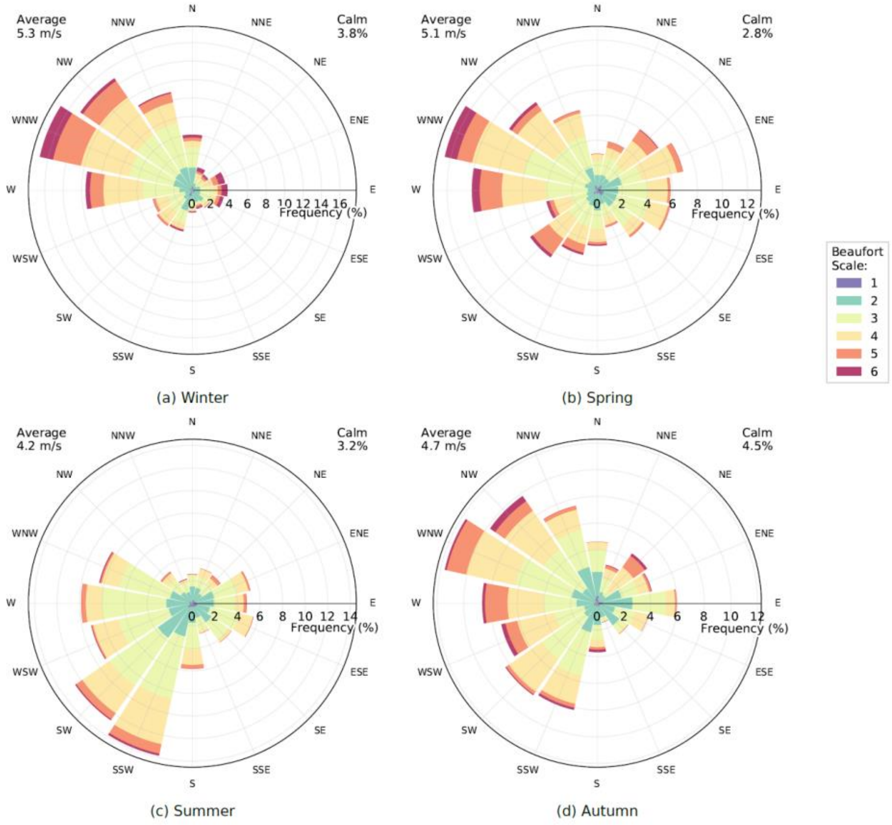
Seasonal psychrometric conditions showing the combination of dry-bulb temperature and relative humidity overlaid on the perceived thermal comfort scale (UTCI)

Climate Characteristics

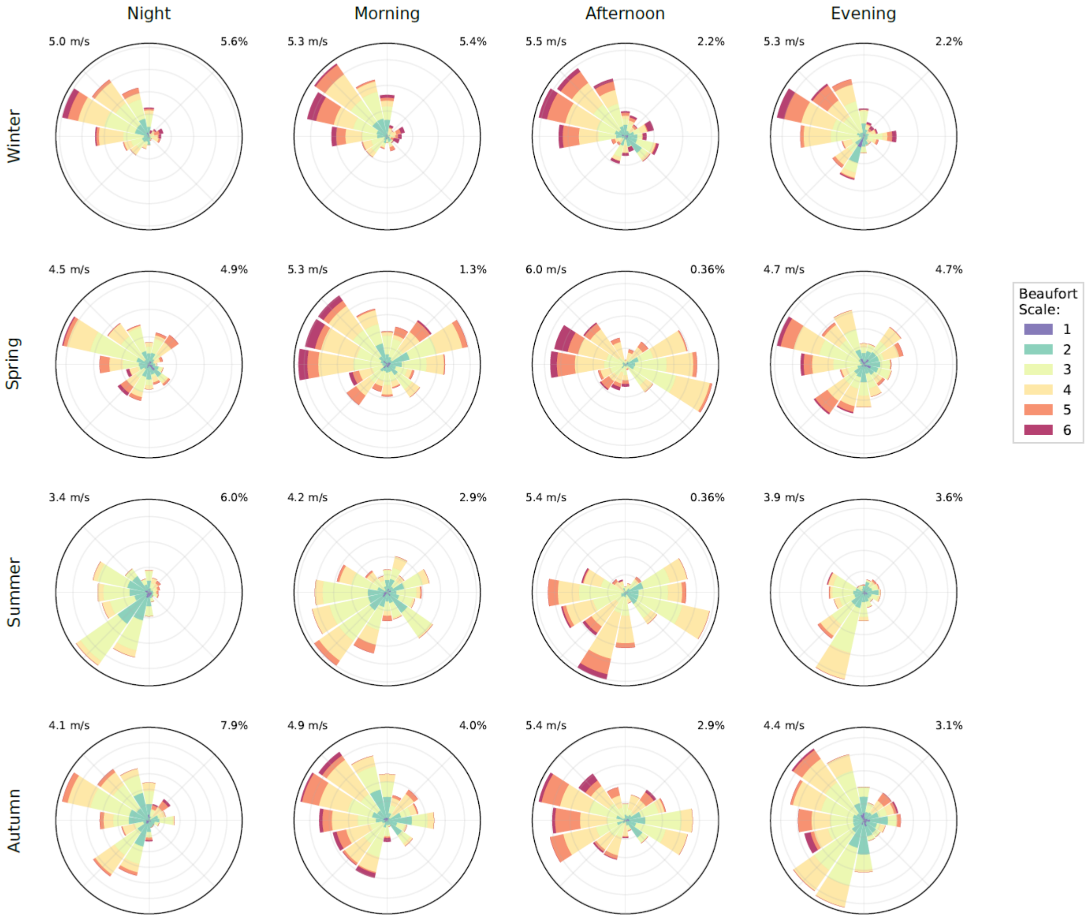
Wind Distribution

Based on typical hourly meteorological data it is expected that Boston will, on average, exhibit wind speeds averaging 5.3m/s to 4.2m/s during Winter or Summer, respectively.

Prevailing winds are frequently from the Southwest in Summer. Wind speeds generally increase during the afternoon.



Seasonal directional wind distribution

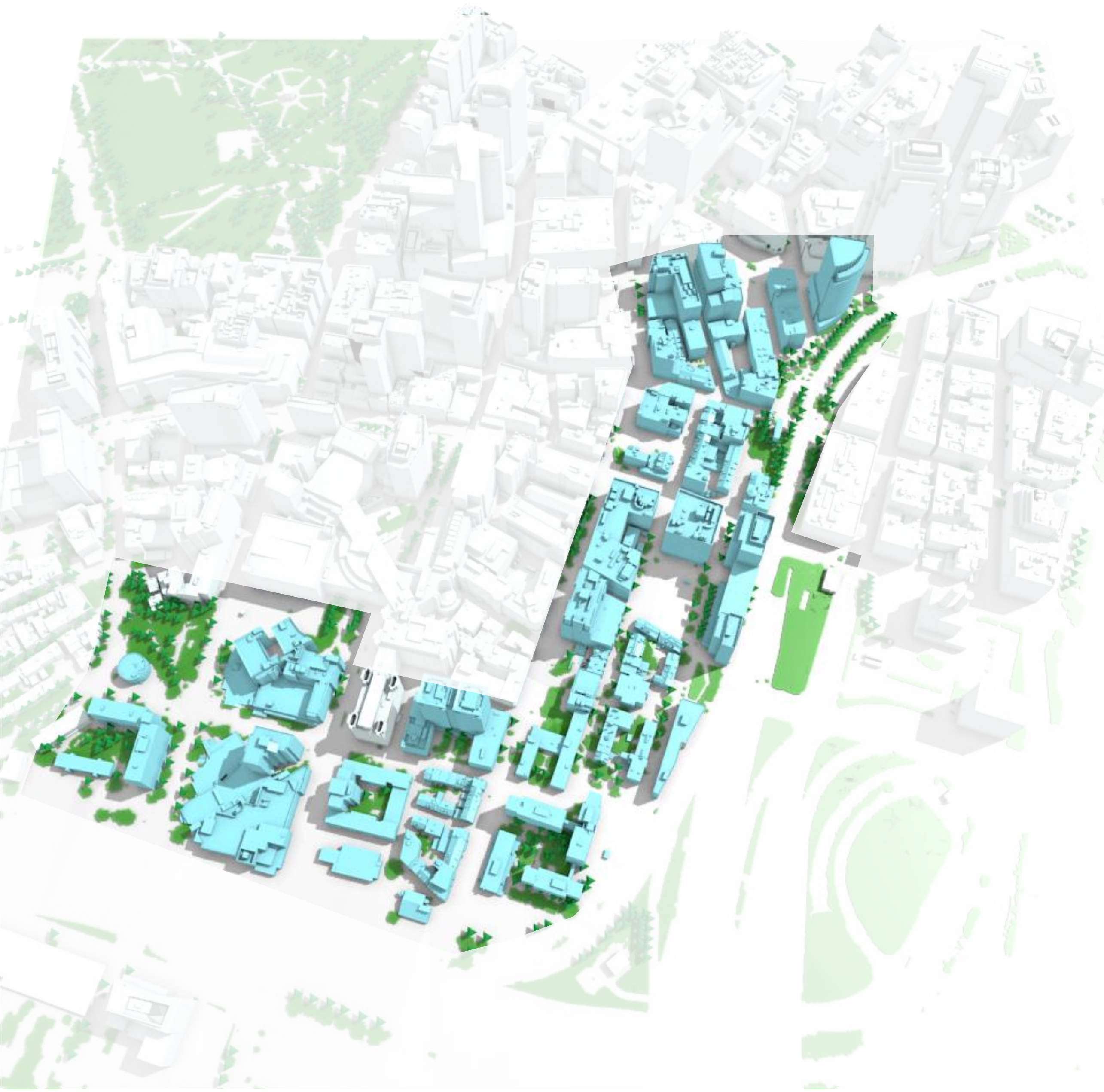


Seasonal and daily directional wind distribution

How the Neighborhood Climate Simulation Model Works

BASELINE Urban climate simulation

An urban climate simulation was performed that couples computational wind simulations and hourly solar exposure modelling, with annual hourly meteorology data reflective of the local climate, to deliver climate performance maps for different seasons during the year. The computational model uses the neighbourhood massing geometry with different surface specifications for site buildings, surrounding buildings, terrain and site ground planes, as well as landscape condition. An initial baseline urban climate simulation was performed to mimic the existing conditions of the site.



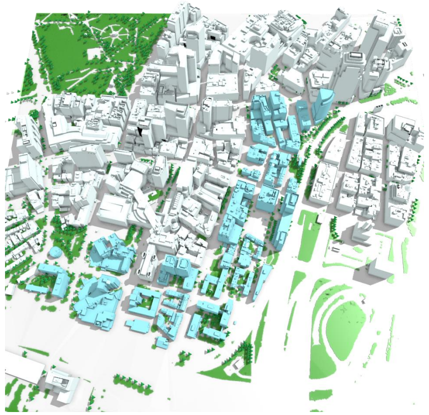
Baseline Neighbourhood: Urban climate simulation geometrical model with site and surrounding buildings and terrain/landscape features.

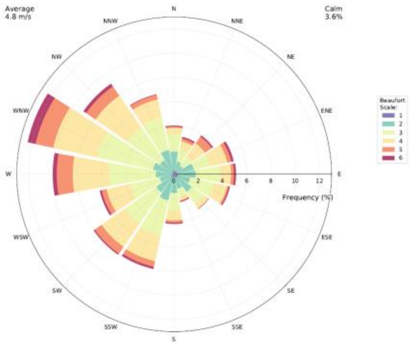
CONCEPT Urban climate simulation

A second urban climate simulation was performed for a modified neighbourhood with different passive urban cooling strategies. The modified urban surface layers, shading strategies and increased urban tree canopy is shown to the right to highlighting additional or modified geometrical layers. Layer surface specifications are provided in Appendix A.

Baseline Neighbourhood: Urban climate simulation geometrical model with site and surrounding buildings and terrain/landscape features.

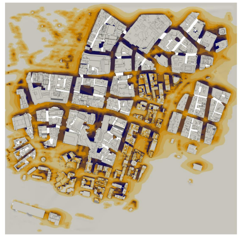
Urban Climate Simulation - Process





Geometrical model for urban massing with different layers for land surface characteristics and urban landscape elements are combined with annual hourly meteorological data in a computational solver.

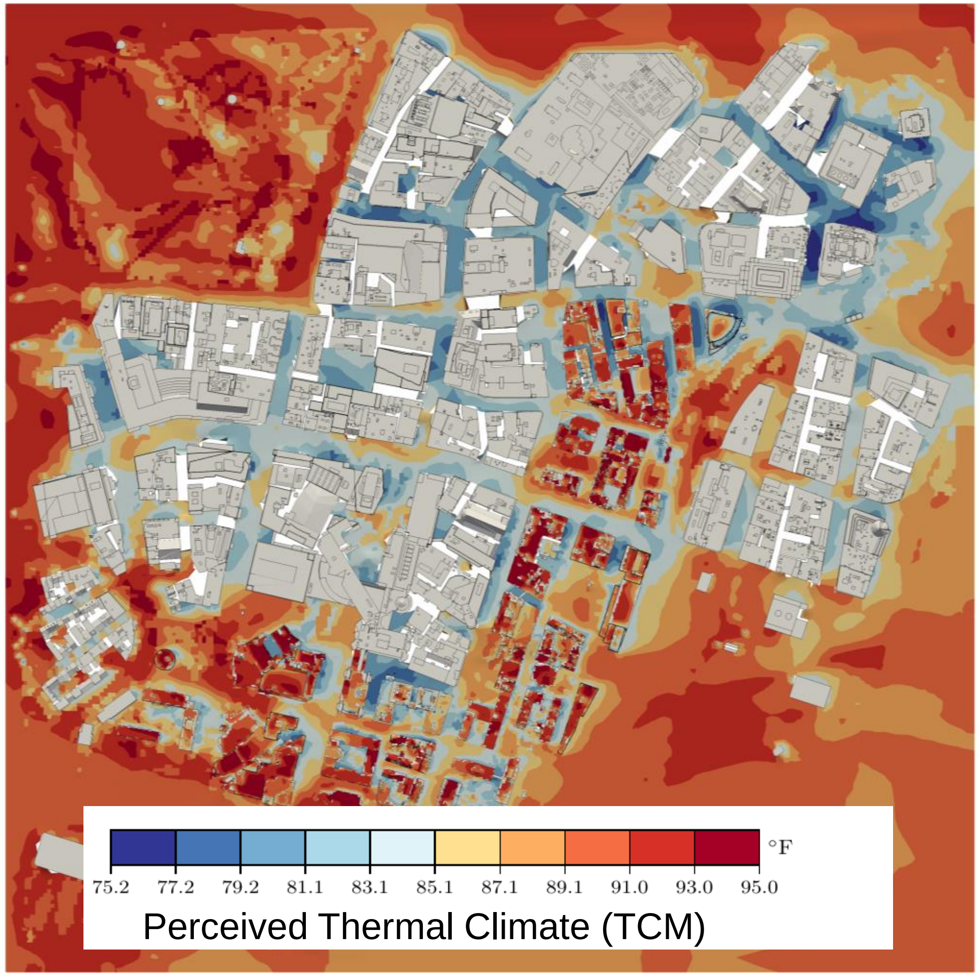
Sky View Factor



Solar Radiation

The solver combines solutions of hourly wind exposure throughout the domain with modelled hourly solar exposure, sky view factors and land surface temperatures to derive local climate performance characteristics

Finally, maps of seasonal average climate performance indicators are produced through statistical averaging of the hourly simulation results. For example, the perceived temperature distribution shown here is a result of the combination of the modelled wind exposure, ambient temperature and humidity condition, solar exposure and evapotranspiration, among other factors.



Climate Performance Indicators (KPI) Legend Definitions

Solar Shading Factor (SHF)

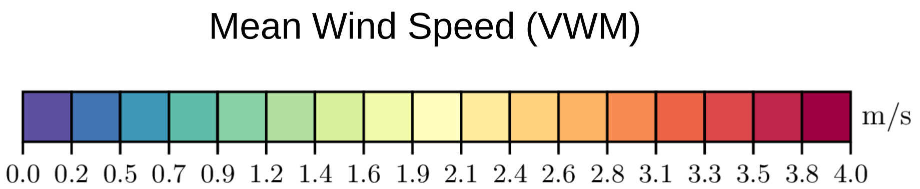
Solar shading factor is the fraction of time that the area is fully shaded

Example: A SHF value of 0.6 for Summer Afternoon means that the area is completely shaded for 60% of the time during Summer Afternoon hours.

Mean Wind Speed (VWM)

Mean wind speed at pedestrian level (1.8m above grade) for the period

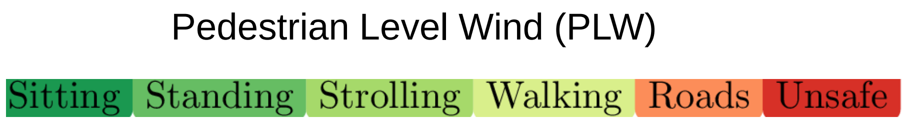
Example: A VWM value of 2.6m/s for Summer Afternoon means the average wind speed at 1.8m above the terrain is 2.6m/s, averaged for all Summer Afternoon hours between 1pm and 6pm



Pedestrian Level Wind (PLW)

Pedestrian level wind comfort activity suitability index, based on the Lawson pedestrian level wind criteria

Example: Standing means local wind conditions will be suitable for standing or lingering activities for most of the time during the season



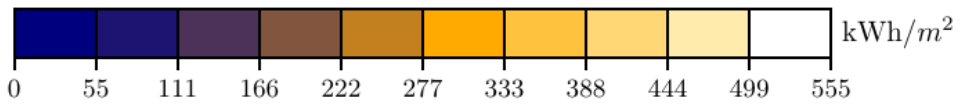
Climate Performance Indicators (KPI) Legend Definitions

Total Solar Insolation (TCF)

Average incident solar insolation on surfaces (kWh/m2)

Example: A TCF value of 200 for Summer All Day means that the seasonal average incident solar insolation per day (direct and diffuse) is 200 kWh/m2.

Solar Insolation (TCF)

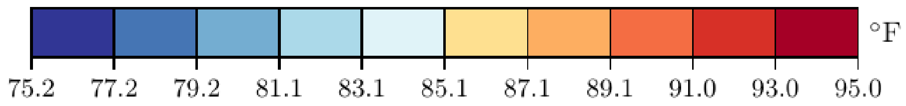


Thermal Climate Mean (TCM)

The mean thermal climate represented as the perceived temperature (thermal comfort) as a combination of the modelled exposure to wind, temperature, humidity, solar radiation, averaged for the period

Example: A TCM value of 95ºF for Summer Afternoon means that the average perceived temperature felt at pedestrian level is 95F due to sun, wind, humidity and temperature exposure

Thermal Climate Mean (TCM)

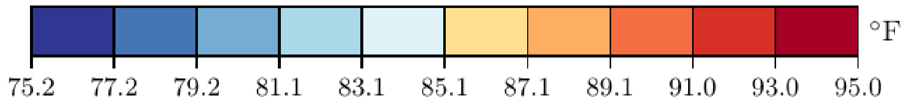


Surface Temperature (TGR)

The average surface temperature for the period

Example: A TGR value of 131ºF for Summer Afternoon means that the surface temperature for the entire Summer season during afternoons is 131ºF.

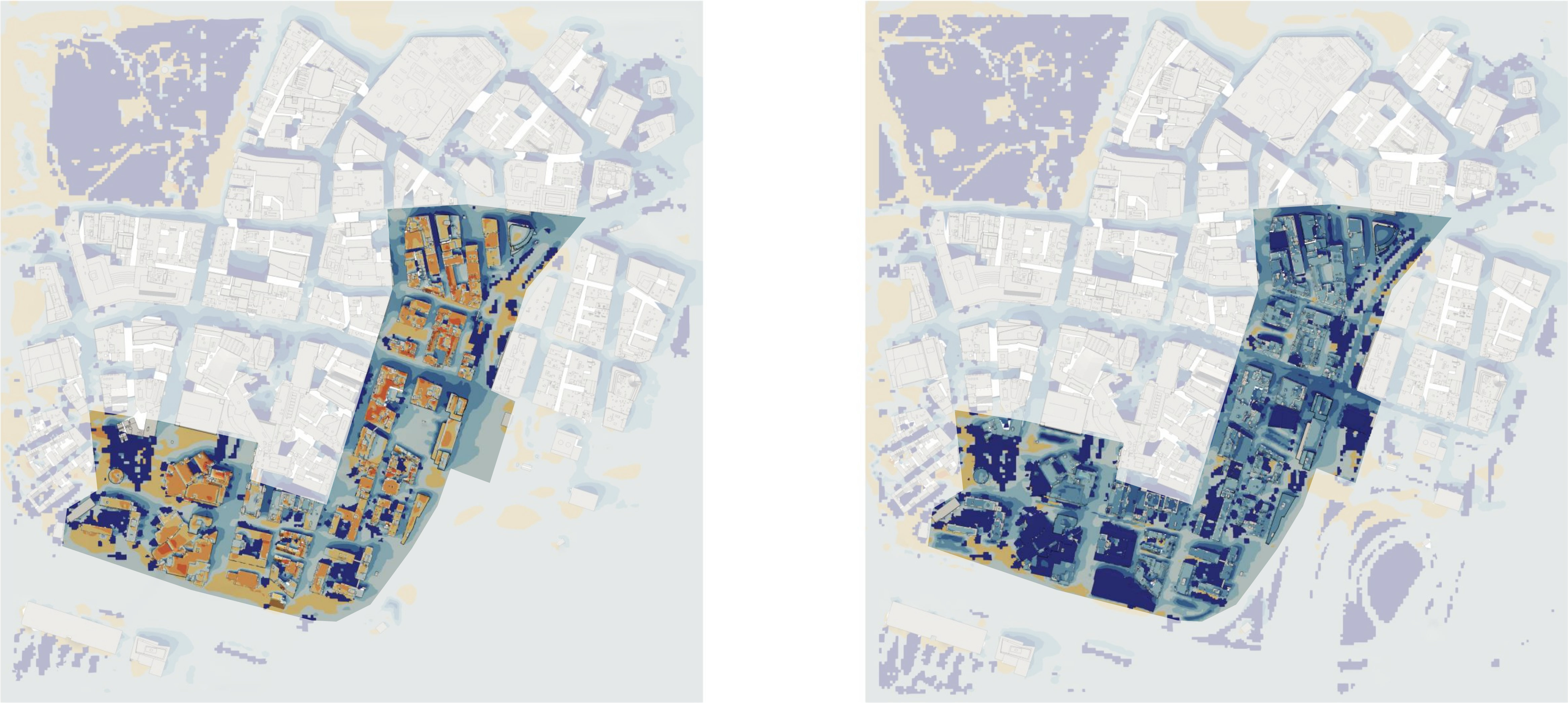
Surface Temperature (TGR)



Baseline and Concept Neighbourhood Comparison

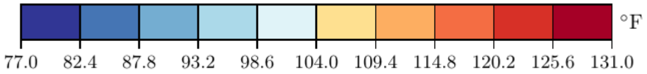
Summer Afternoon - Surface Temperature

In Summer, surface temperatures are significantly reduced through the introduction of combinations of high albedo surfaces for roads and roofs, green roofs and the application of shade and solar canopies. Surface temperature also vary due to differences in different solar and wind exposures within the neighbourhood.



Baseline | Concept

Surface Temperature (TGR)



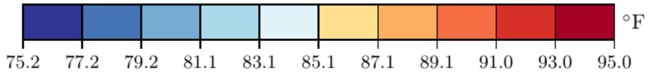
Summer Afternoon - Perceived Temperature

In Summer, perceived temperature reductions are achieved through the introduction of combinations of high albedo surfaces for roads and roofs, green roofs and the application of trees and or shade and solar canopies. Again, perceived temperatures may also vary due to different wind and solar exposures within the neighbourhood.

Baseline

Concept

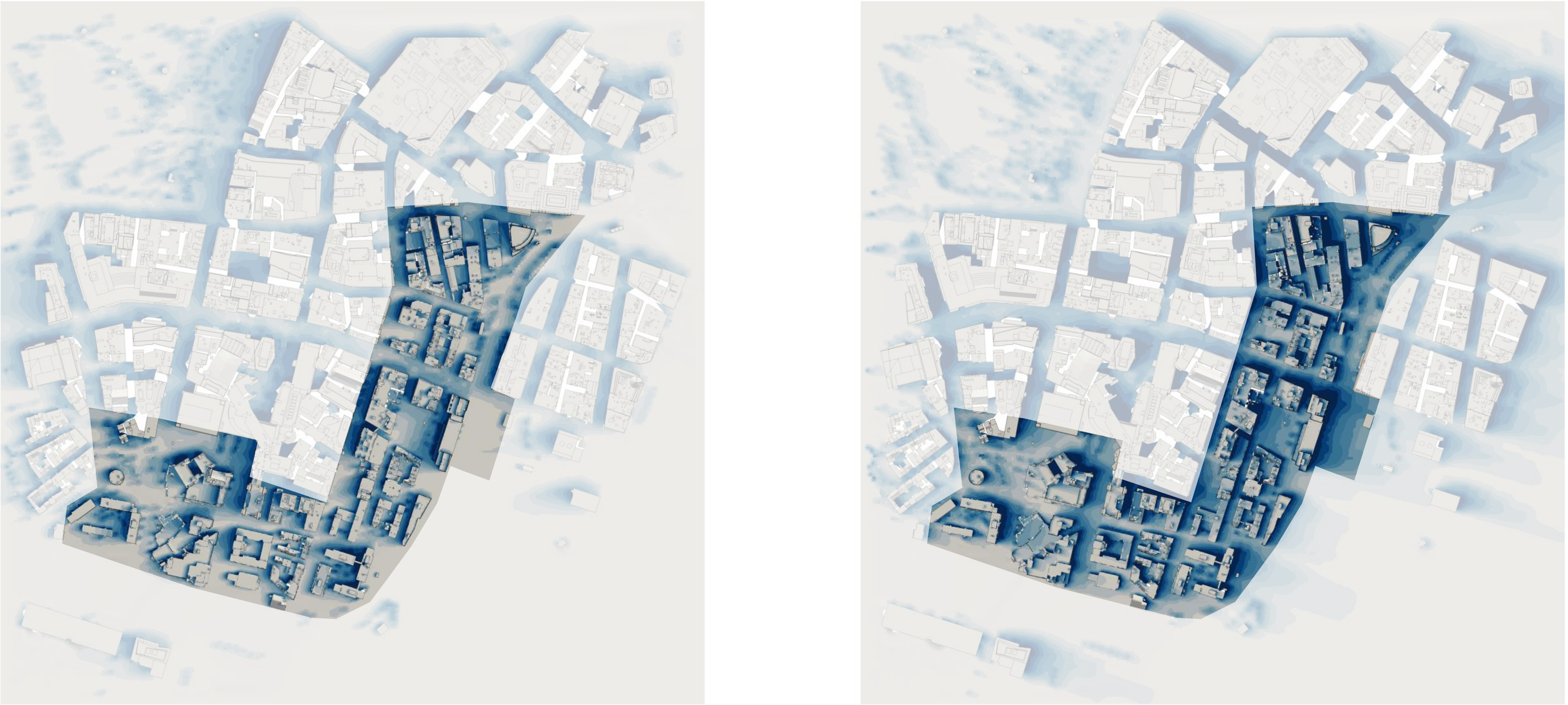
Perceived Thermal Climate (TCM)



Baseline Neighbourhood

Summer – Solar Shading Fraction

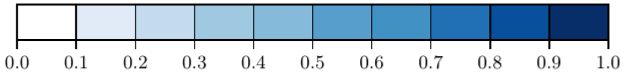
Summer sun exposure creates mostly deeper shade either on the west or east side of buildings during morning and afternoons, respectively.



Morning

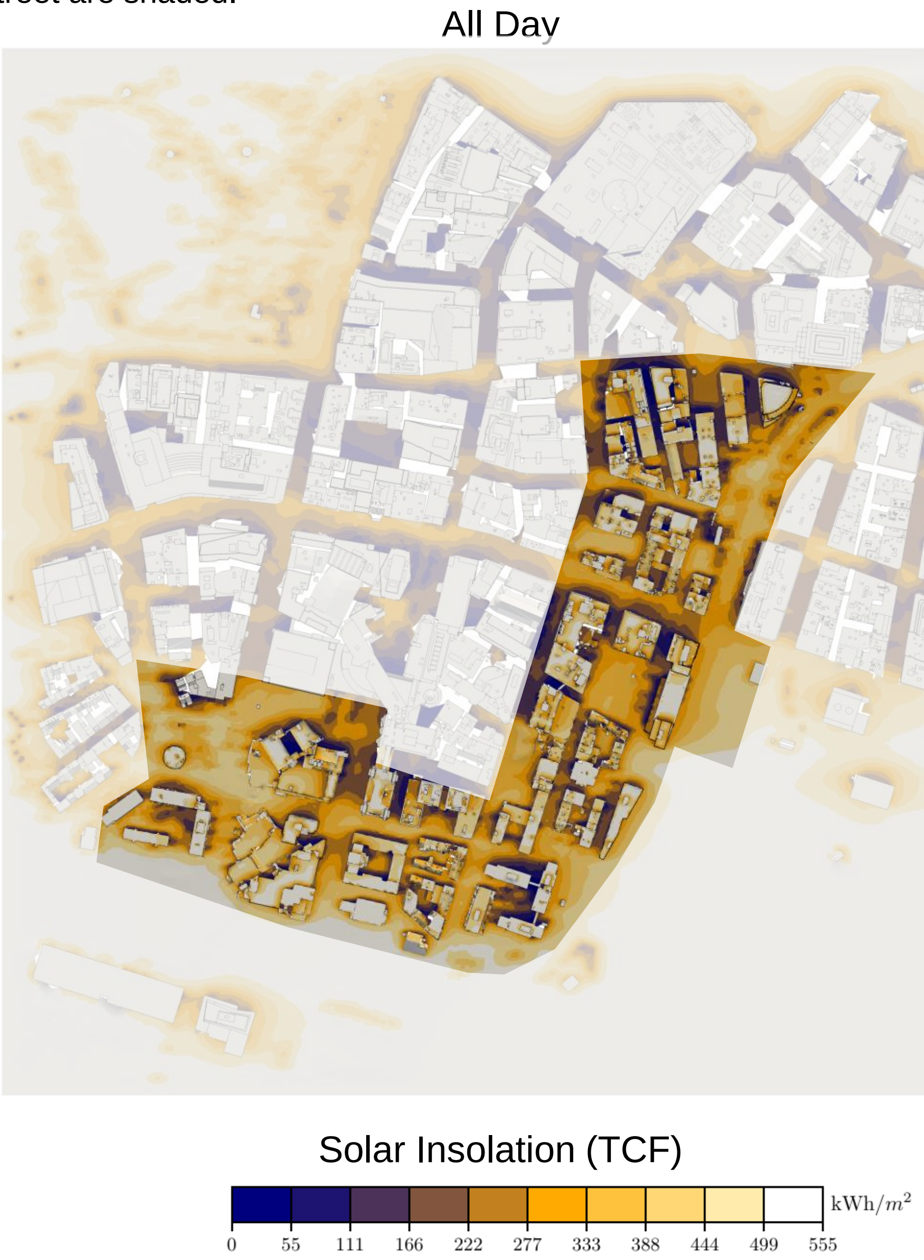
Afternoon

Solar Shading Factor (SHF)



Summer – Total Solar Insolation

During Summer, solar insolation is relatively low along narrow N-S streets, and higher along E-W streets or wide open areas. The north side of E-W streets tends to have the highest solar exposure while the south side of these street are shaded.



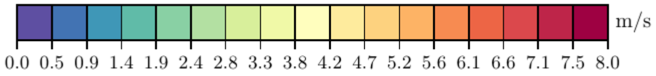
Summer - Mean wind speed distribution

Summer mean wind exposure at pedestrian level and above rooftops. Local wind ventilation is important to help ventilate the urban setting, reduce heat build-up and improve thermal comfort.

Morning

Afternoon

Mean Wind Speed (VWM)



Summer – Pedestrian level wind comfort (PLW)

Mostly comfortable conditions during Summer across the site with localised areas of elevated wind speeds and conditions more suitable for standing or walking on some areas of where flow is channels between taller buildings and at roof level.

All Season

Pedestrian Level Wind (PLW)

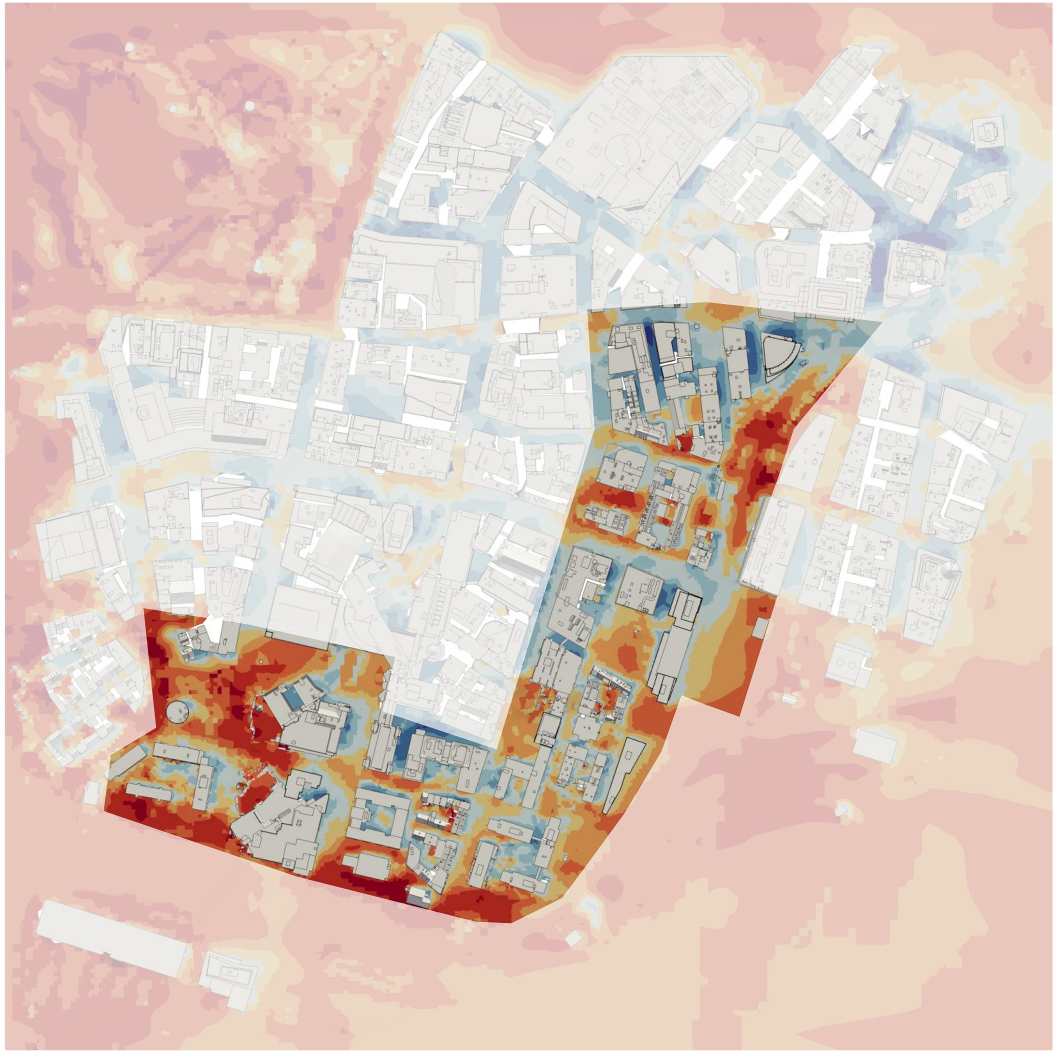
Sitting | Standing | Strolling | Walking | Uncomfortable | Severe

Baseline Neighbourhood - Grade

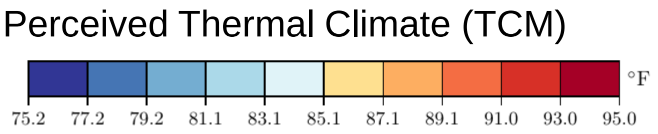
Summer – Thermal comfort

During Summer afternoons, average perceived temperatures will be between 80 and 85ºF in shaded and or wind exposed areas. This will be associated with modest heat stress conditions. More solar exposed areas will be associated with high heat stress conditions.

Morning

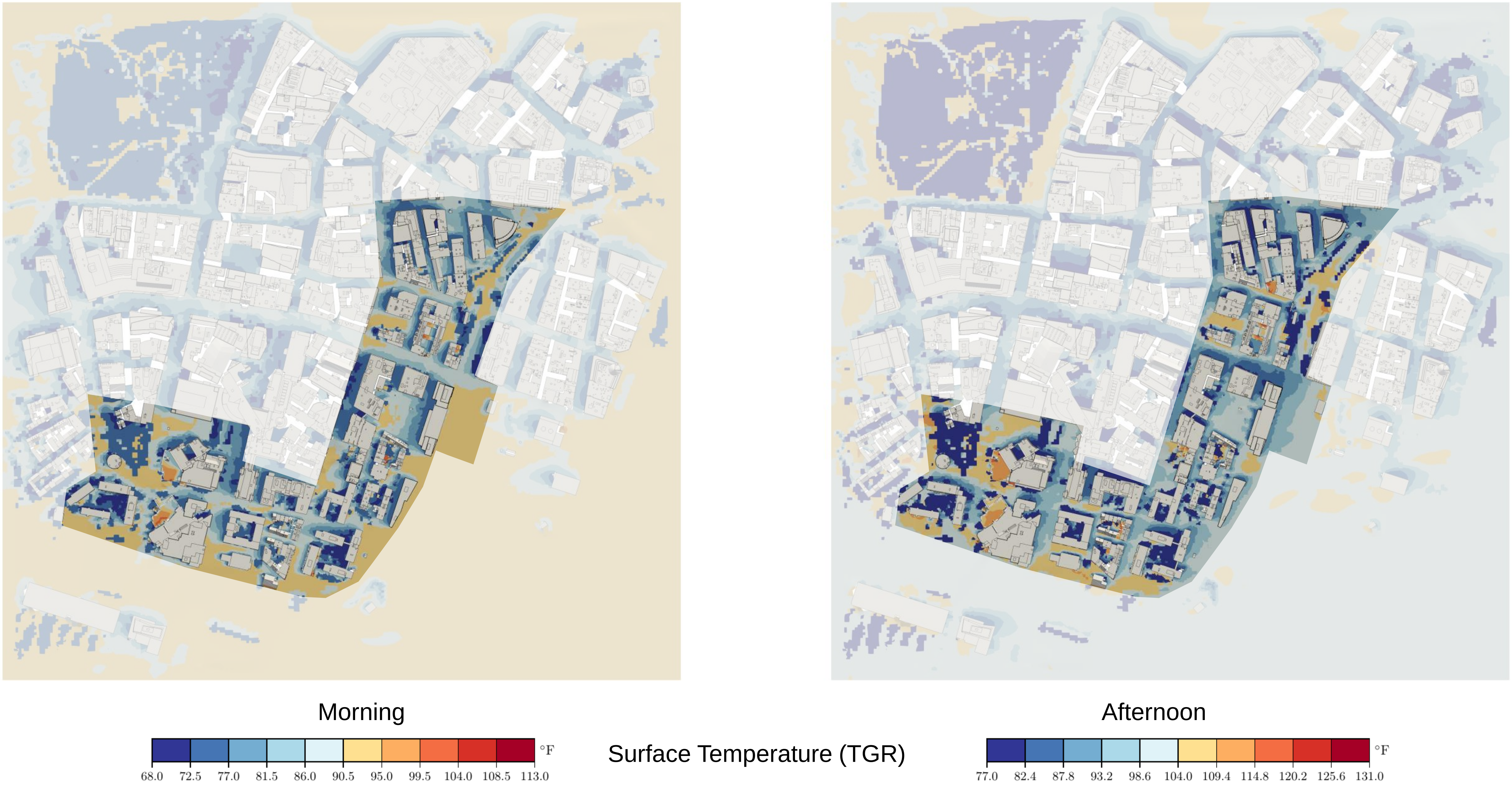


Afternoon



Summer – Surface Temperature

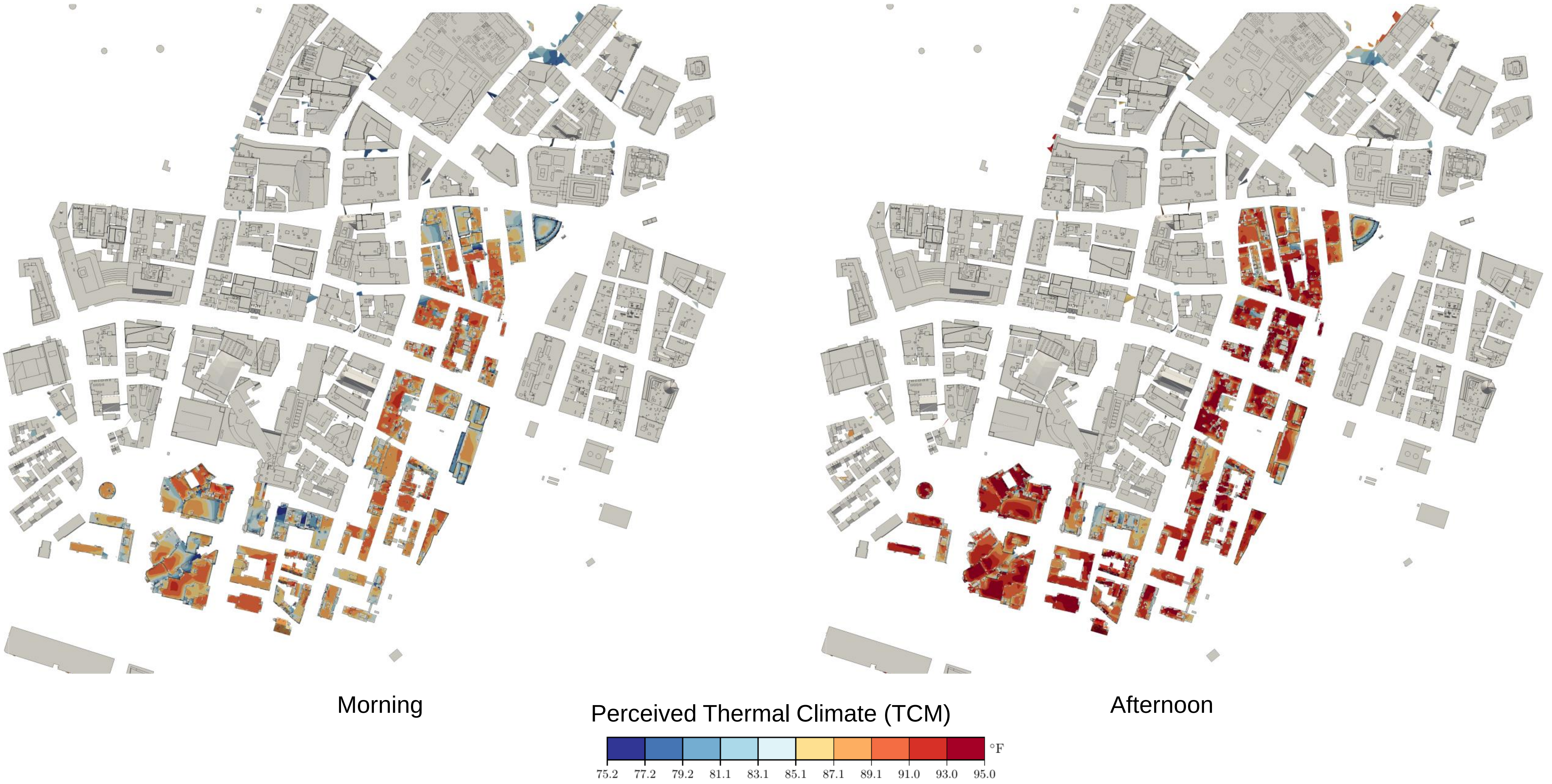
During Summer afternoons, grade level surface temperatures will range between 82ºF and 109ºF depending on the surface material and condition and the local solar and or wind exposure.



Baseline Neighbourhood - Roof

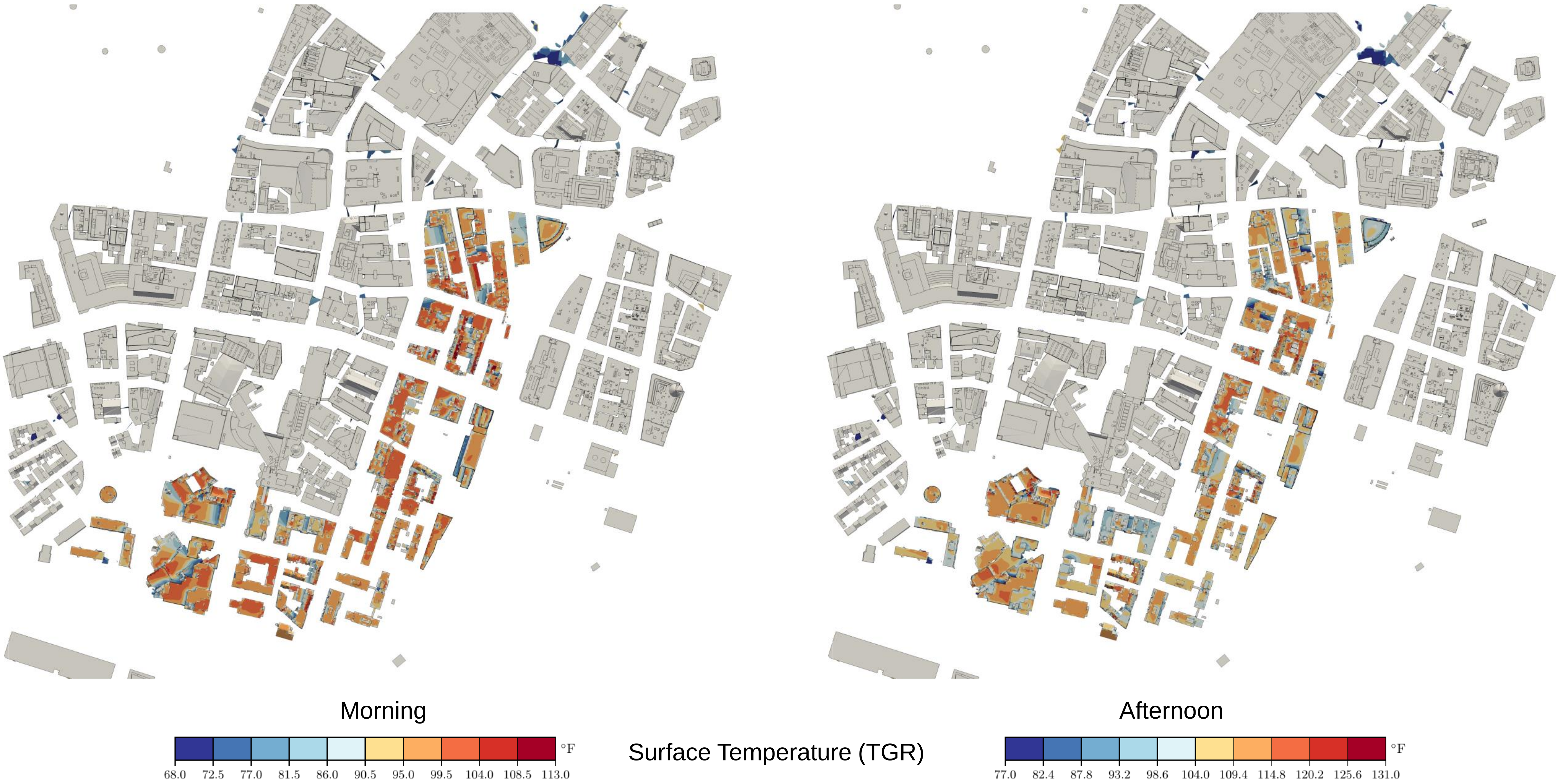
Summer – Thermal comfort

During Summer afternoons, average perceived temperatures will be between 87ºF and 95ºF in shaded and or wind exposed areas. This will be associated with moderate to high heat stress conditions.



Summer – Surface Temperature

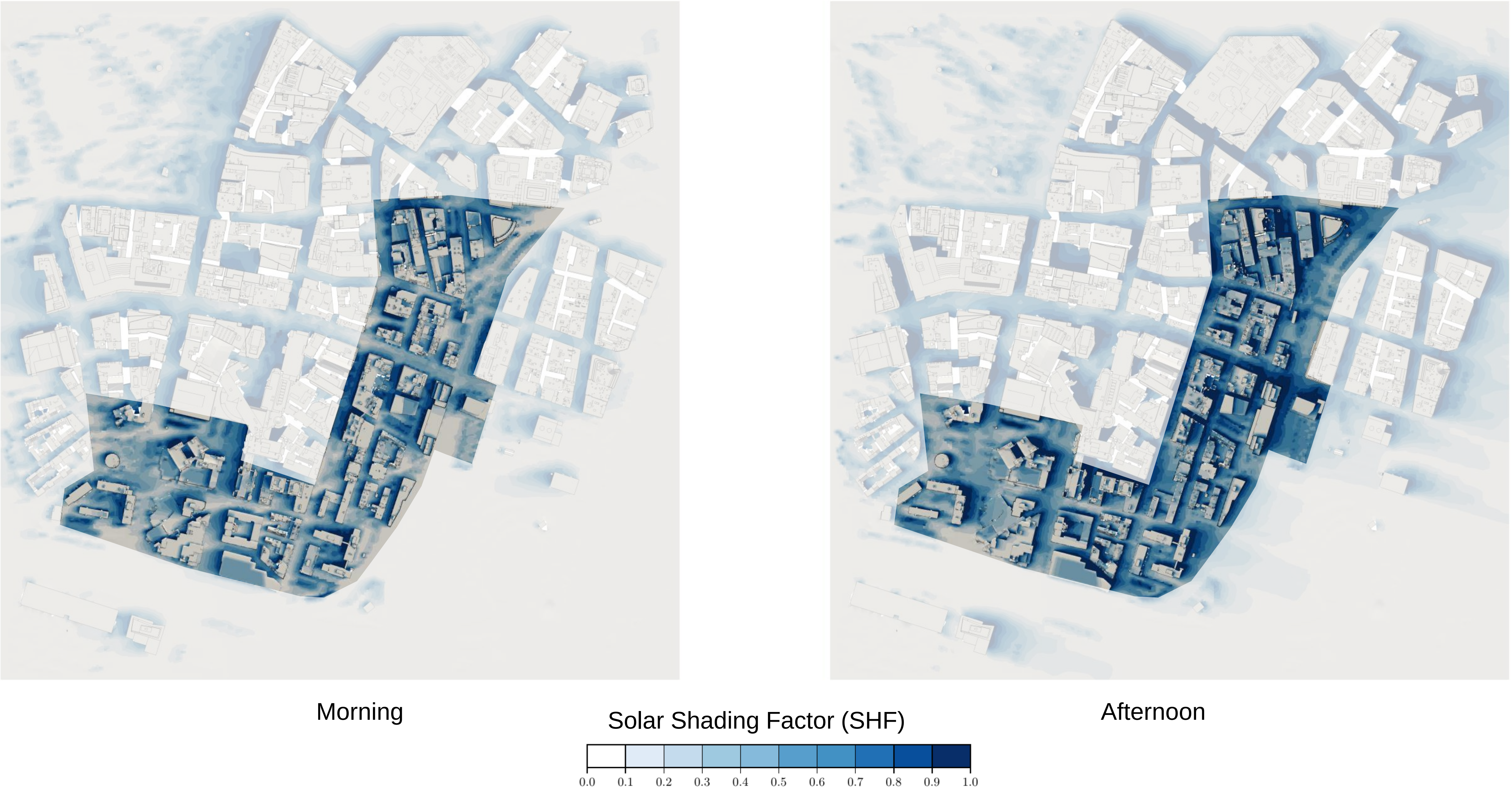
During Summer afternoons, roof level surface temperatures will range between 98ºF and 125ºF depending on the surface material and condition and the local solar and or wind exposure.



Concept Neighbourhood

Summer – Solar Shading Fraction

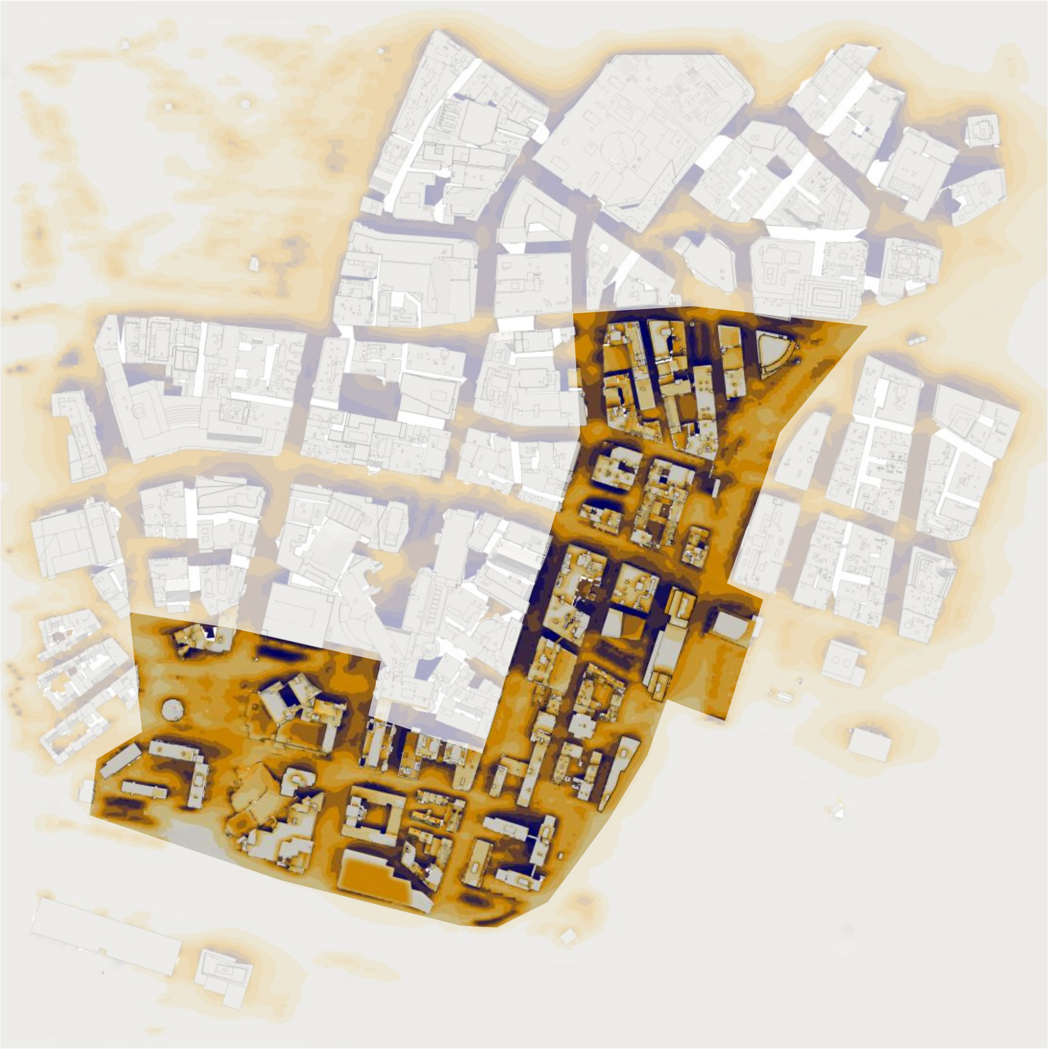
Summer sun exposure creates mostly deeper shade either on the west or east side of buildings during morning and afternoons, respectively. Additional shade is provided by the introduction of variations of shading canopies and tree cover.



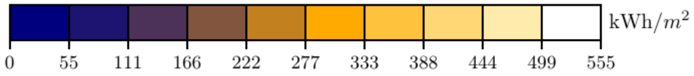
Summer – Total Solar Insolation

During Summer, solar insolation is relatively low along narrow N-S streets, and higher along E-W streets or wide open areas. The north side of E-W streets tends to have the highest solar exposure while the south side of these street are shaded.

All Day



Solar Insolation (TCF)



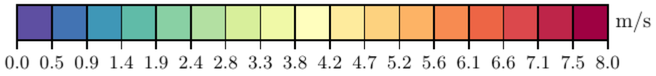
Summer - Mean wind speed distribution

Summer mean wind exposure at pedestrian level and above rooftops. Local wind ventilation is important to help ventilate the urban setting, reduce heat build-up and improve thermal comfort.

Morning

Afternoon

Mean Wind Speed (VWM)



Summer – Pedestrian level wind comfort (PLW)

Mostly comfortable conditions during Summer across the site with localised areas of elevated wind speeds and conditions more suitable for standing or walking on some areas of where flow is channels between taller buildings and at roof level.

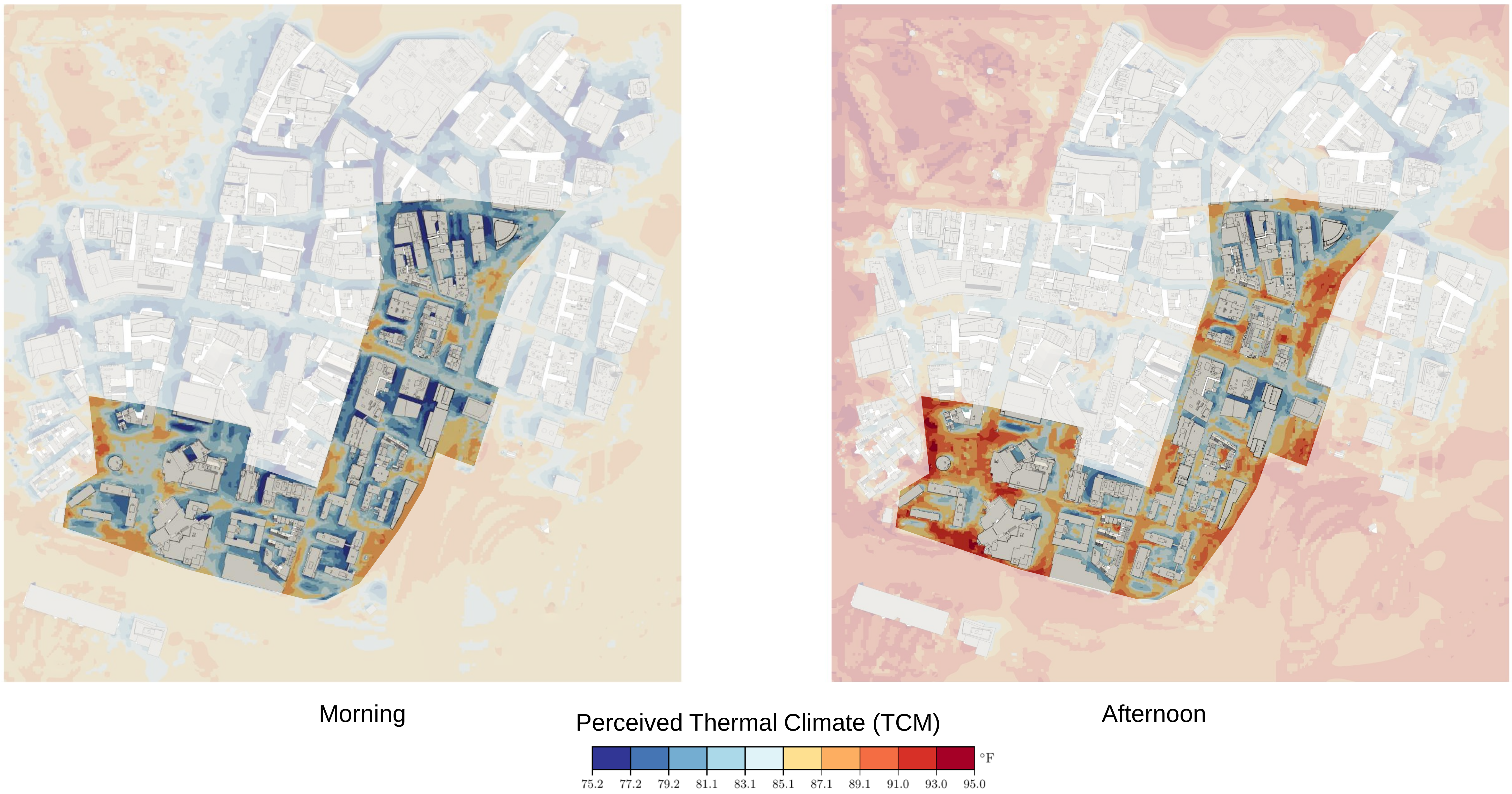
All Season

Pedestrian Level Wind (PLW)

Concept Neighbourhood - Grade

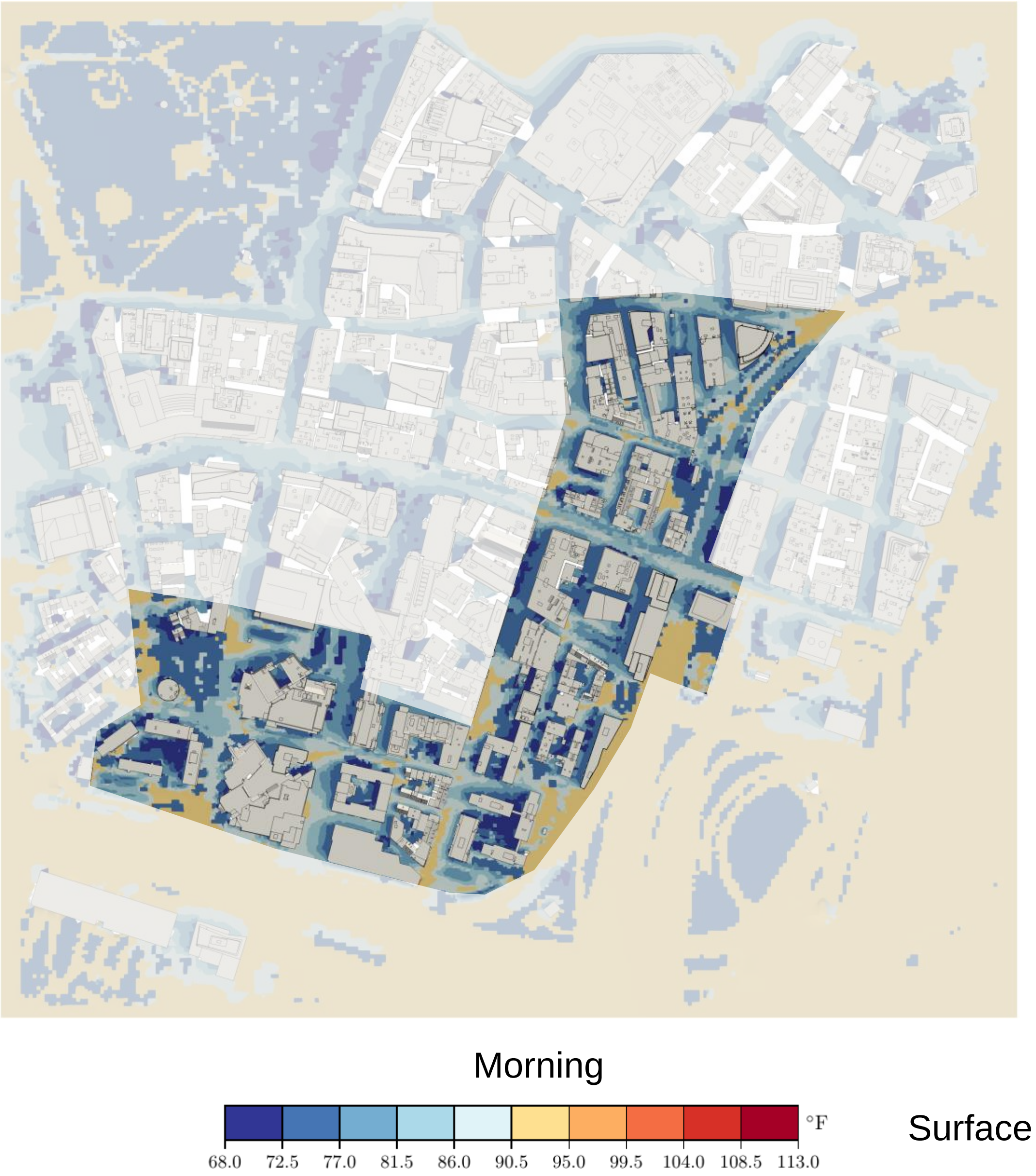
Summer – Thermal comfort

During Summer afternoons, average perceived temperatures will be between 80 and 85ºF in shaded and or wind exposed areas. This will be associated with modest heat stress conditions. More solar exposed areas will be associated with high heat stress conditions.



Summer – Surface Temperature

During Summer afternoons, grade level surface temperatures will range between 82ºF and 109ºF depending on the surface material and condition and the local solar and or wind exposure.



Surface Temperature (TGR)

Concept Neighbourhood - Roof

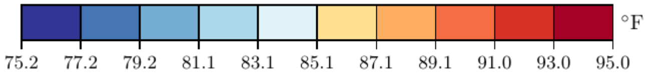
Summer – Thermal comfort

During Summer afternoons, average perceived temperatures will be between 81ºF and 95ºF in shaded and or wind exposed areas. This will be associated with moderate to high heat stress conditions. Reduced perceived temperatures occurs in areas with green or blue roofs, or roofs with shading canopies.

Morning

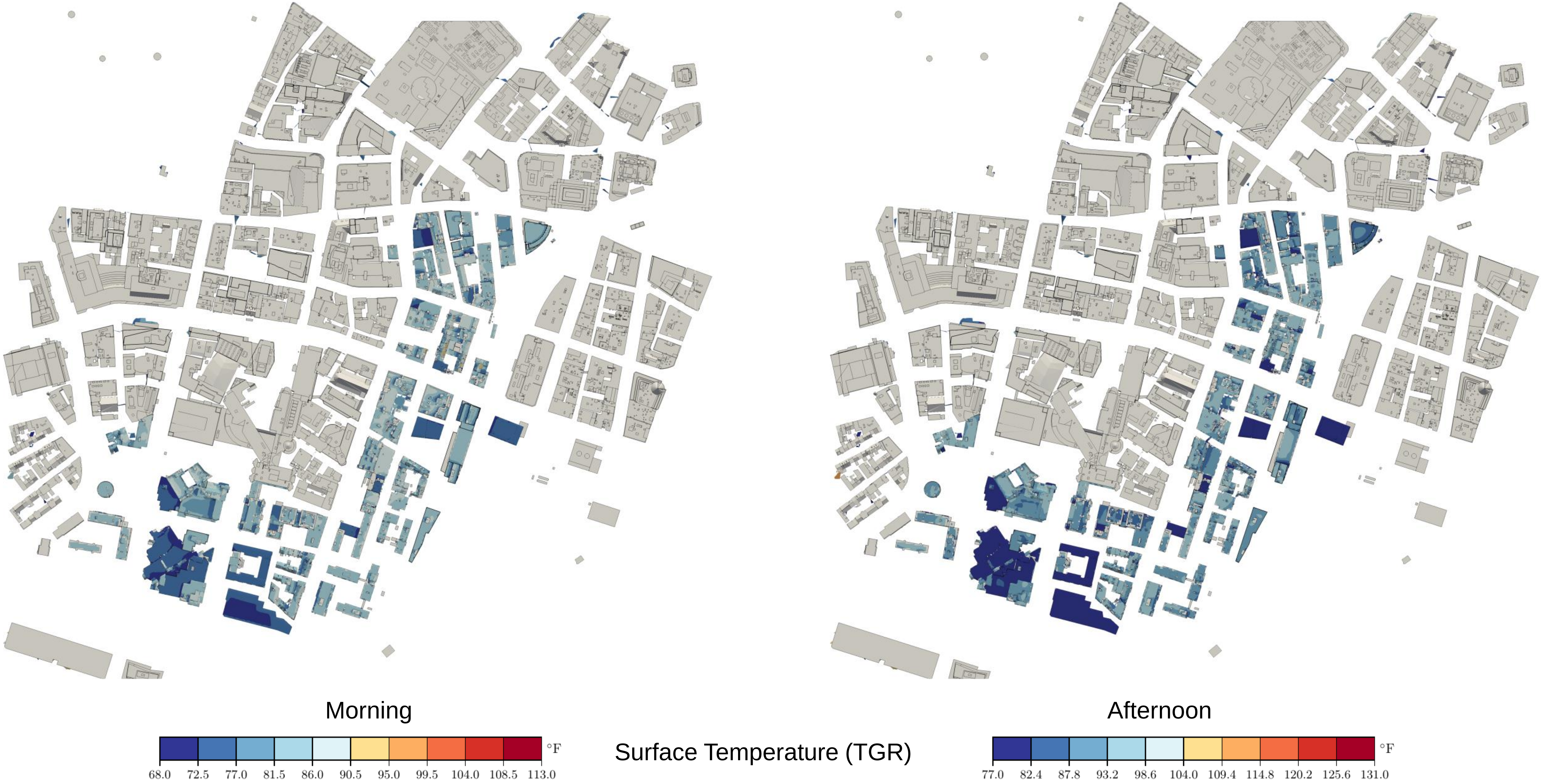
Afternoon

Perceived Thermal Climate (TCM)



Summer – Surface Temperature

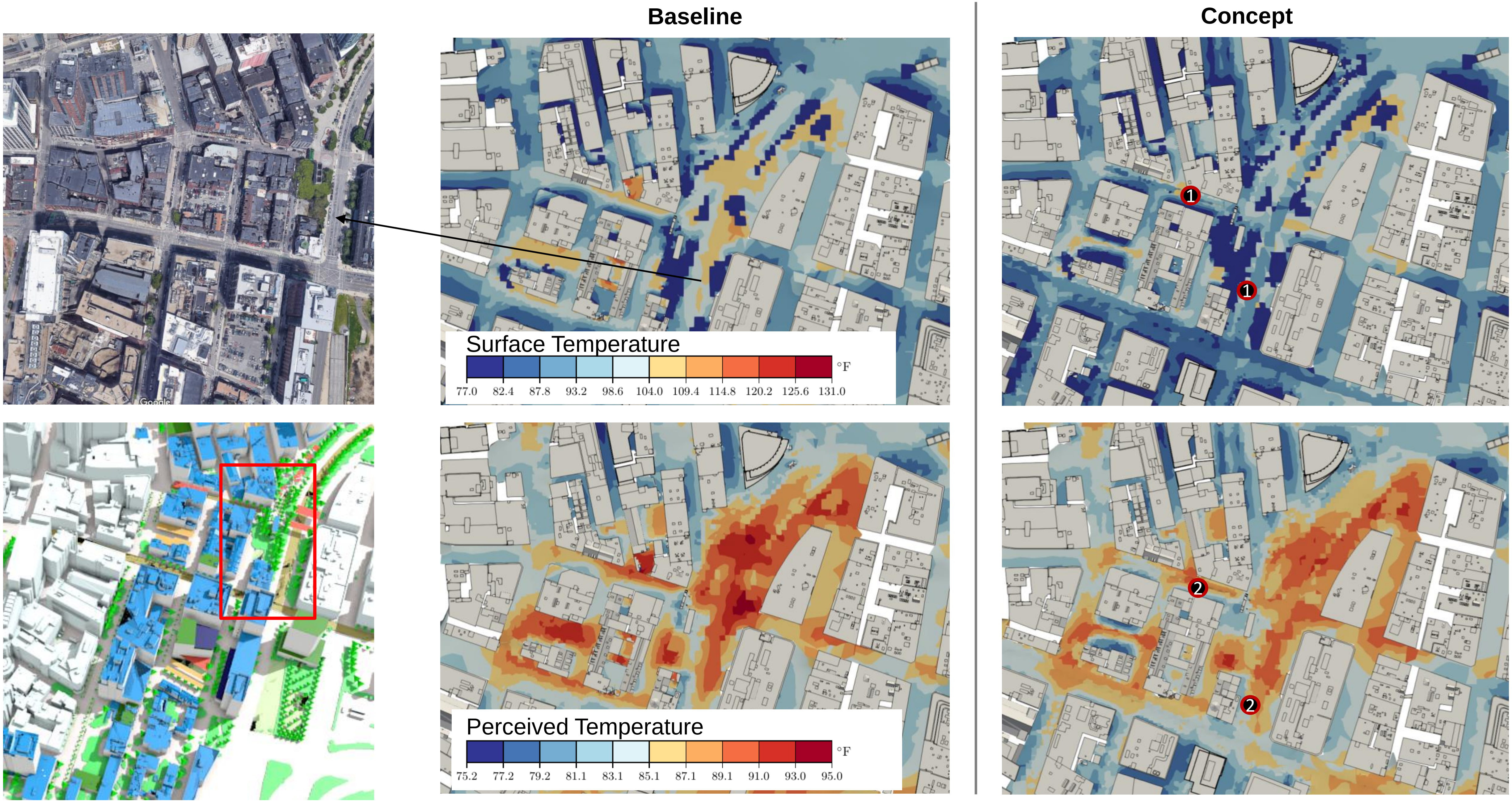
During Summer afternoons, roof level surface temperatures will range between 82ºF and 98ºF depending on the surface material and condition and the local solar and or wind exposure. Roof surface temperatures are significantly reduced with the introduction of cool roof and roof shading strategies.



Detailed Observations

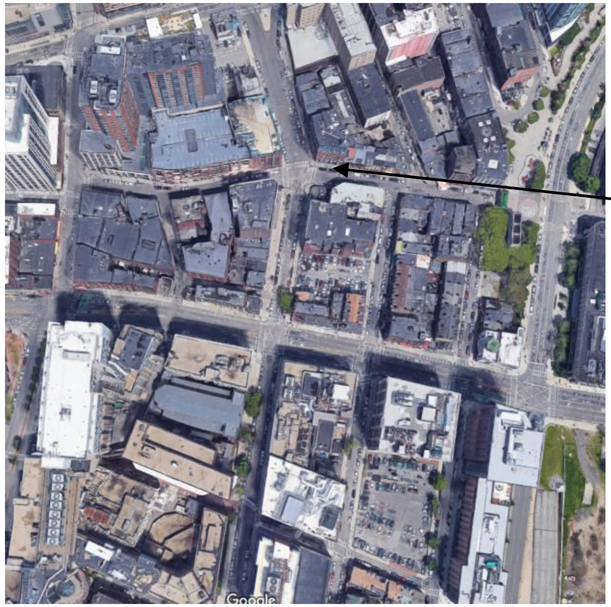
1. High SRI Roads

1) High albedo vs low albedo road reduces afternoon surface temperatures from 104ºF to 93ºF.
2) Effect of lower surface temperatures reduces perceived temperatures from 90ºF to 88.6ºF with high solar exposure still dominating high thermal stress.

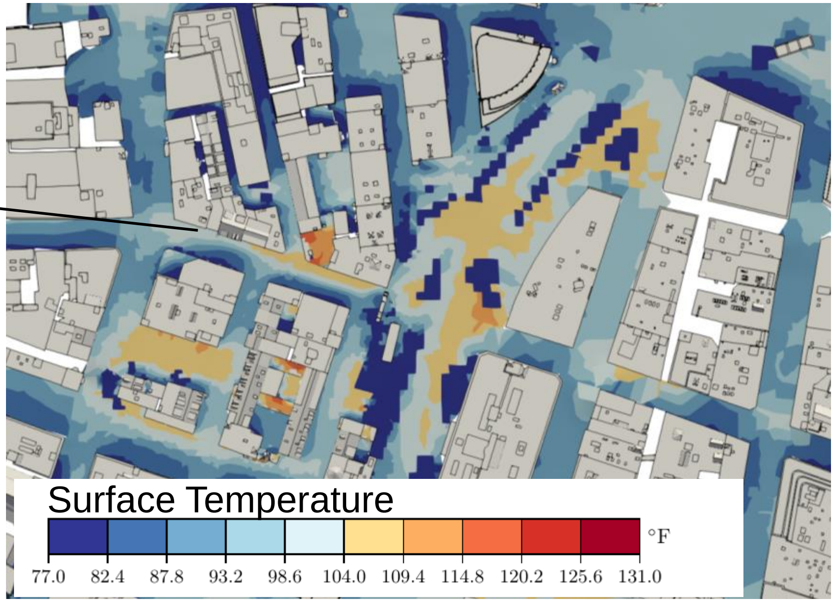


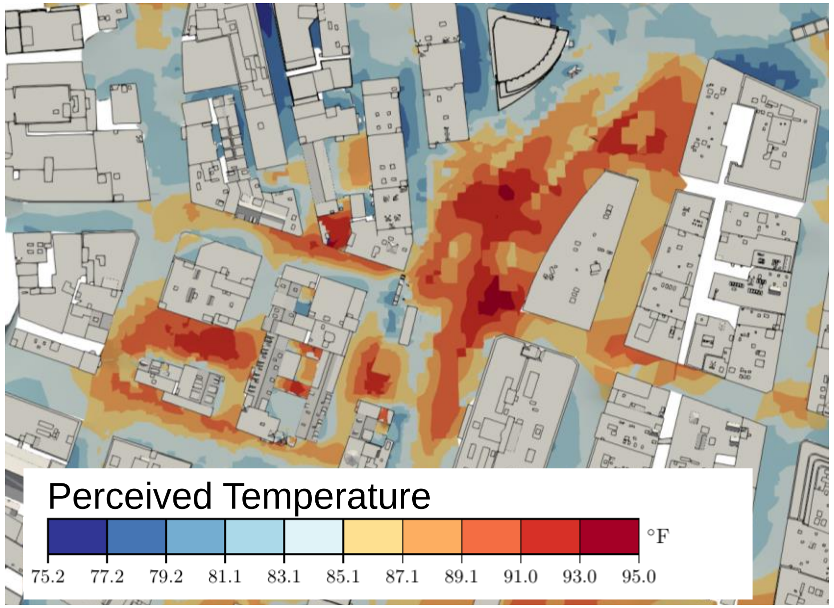
2. Effect of canopy (50%) over E-W street

1) Canopy reduces afternoon surface temperatures on north side of street from 103ºF to 87ºF.
2) Canopy reduces perceived temperatures from 87ºF to 84ºF by reducing solar exposure and surface temperatures.

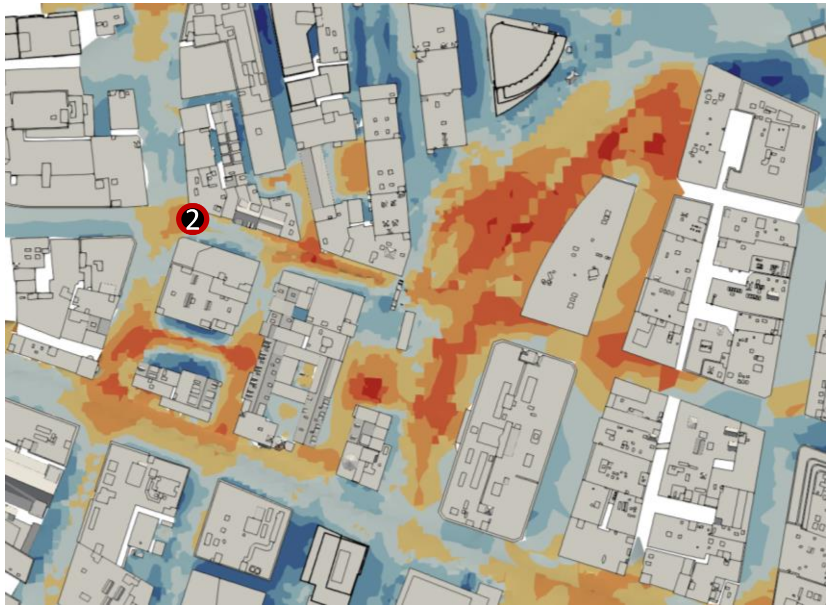


Baseline



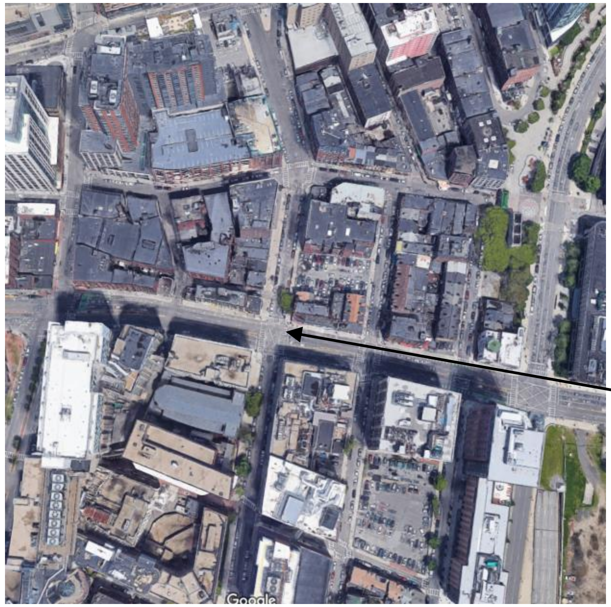


Concept

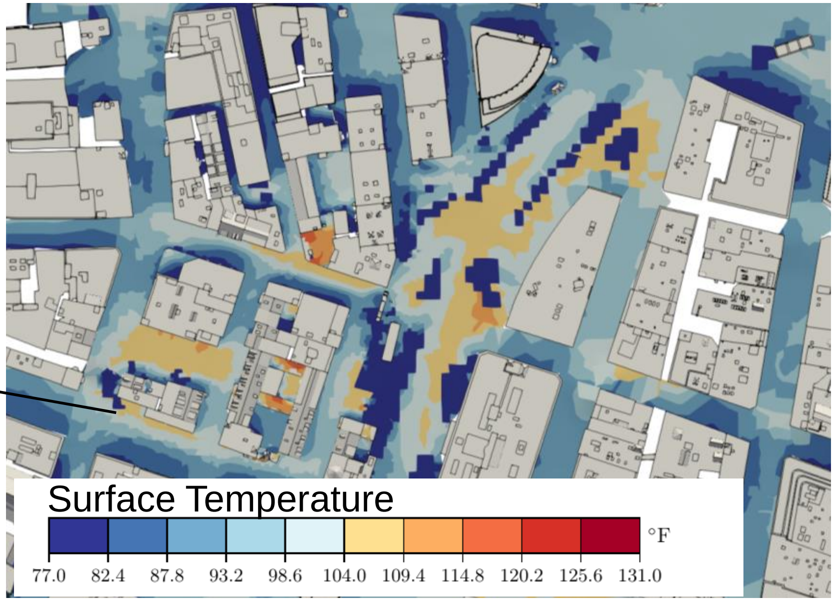


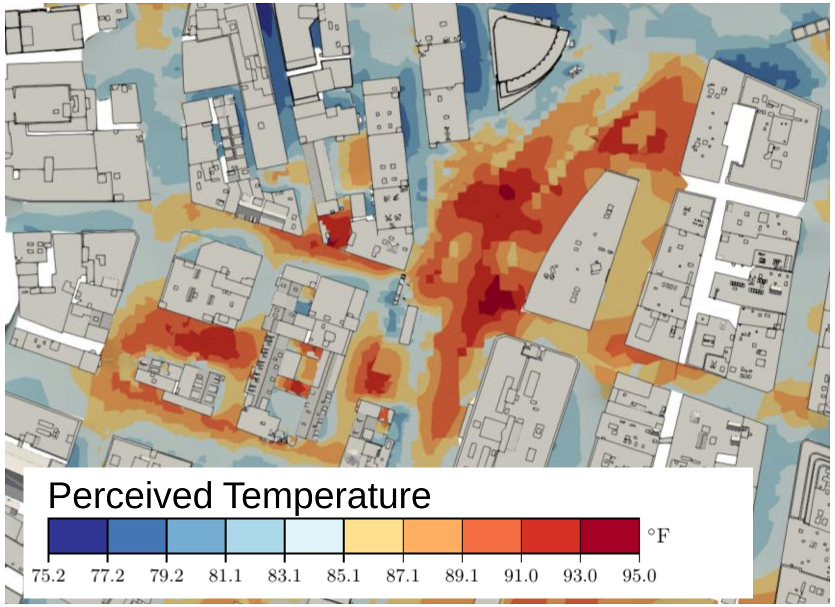
3. Trees North Side of Street

1) High albedo vs low albedo road reduces afternoon surface temperatures from 105ºF to 90ºF.
2) Effect of lower surface temperatures reduces perceived temperatures from 90ºF to 85ºF.

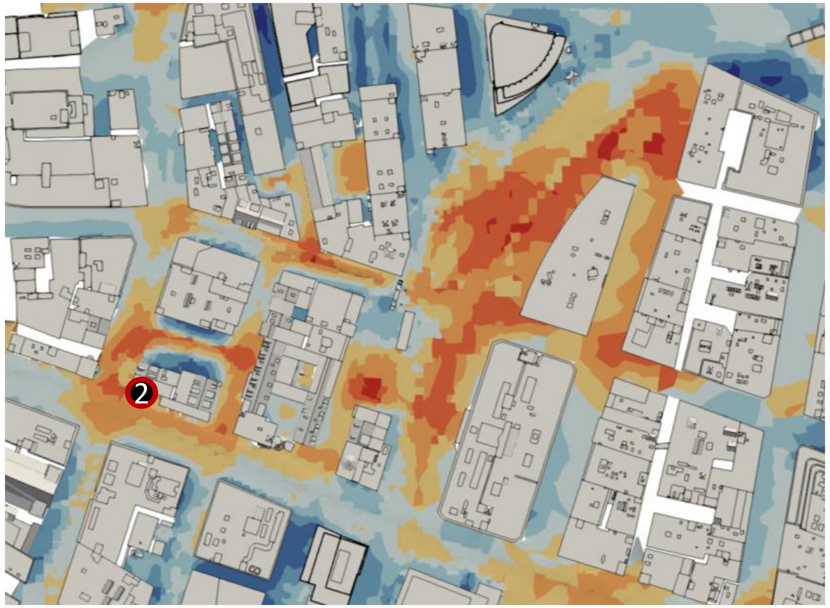


Baseline





Concept

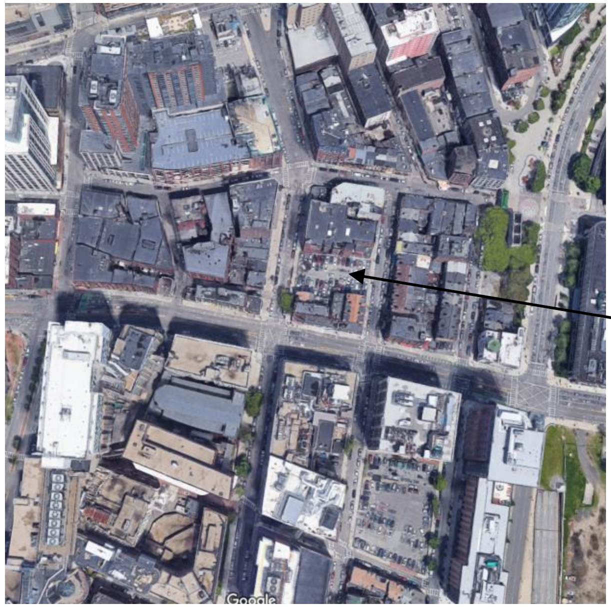


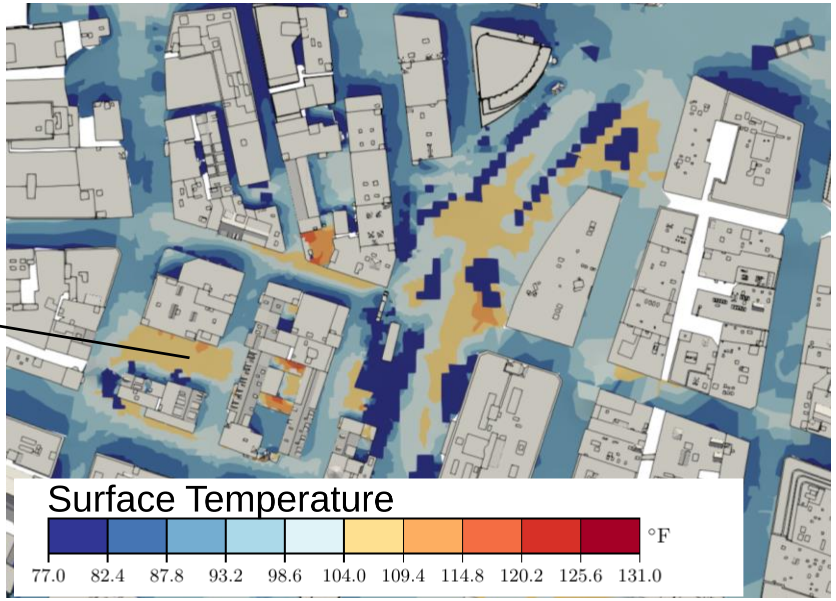
4. Effect of full shade solar canopy (solar)

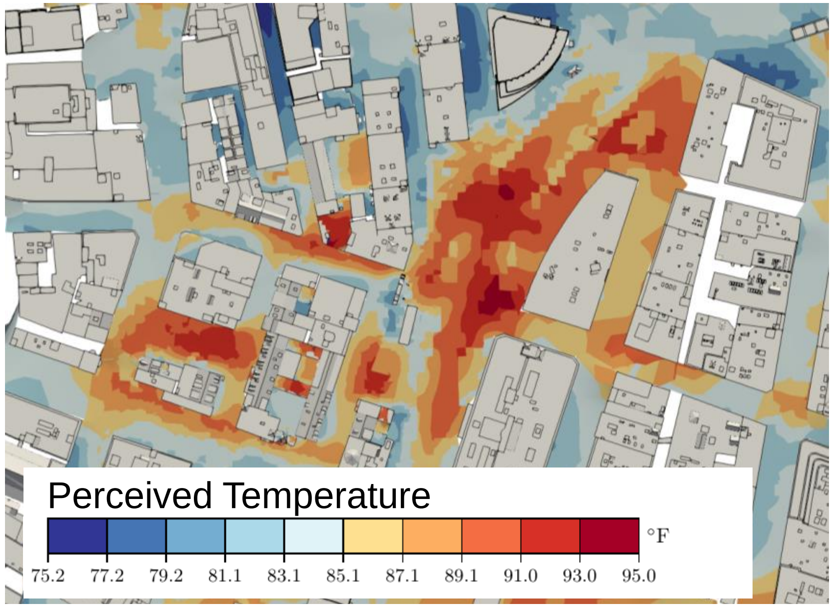
1) Solar canopy reduces afternoon surface temperatures from 109ºF to 76ºF.
2) Full shade solar canopy reduces perceived temperatures from 92ºF to 80ºF by limiting solar exposure and reducing surface temperatures.

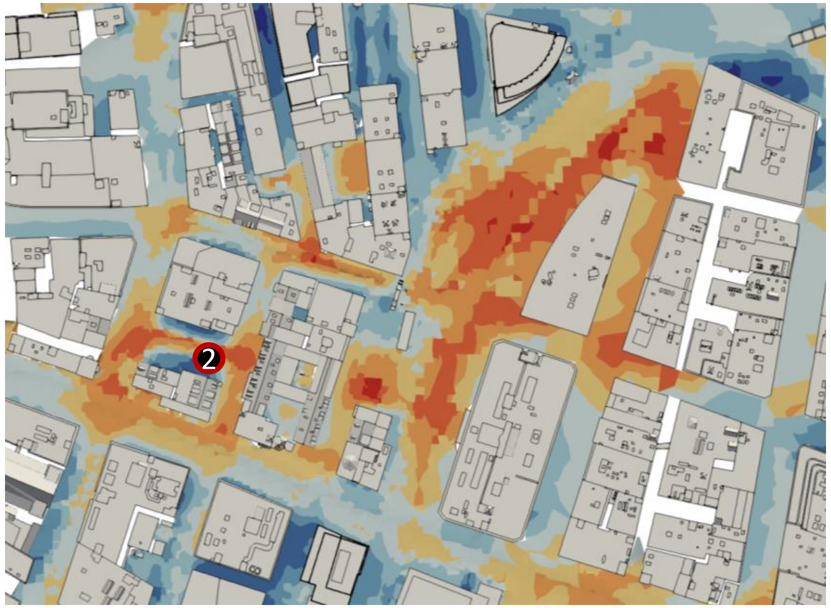
Baseline

Concept



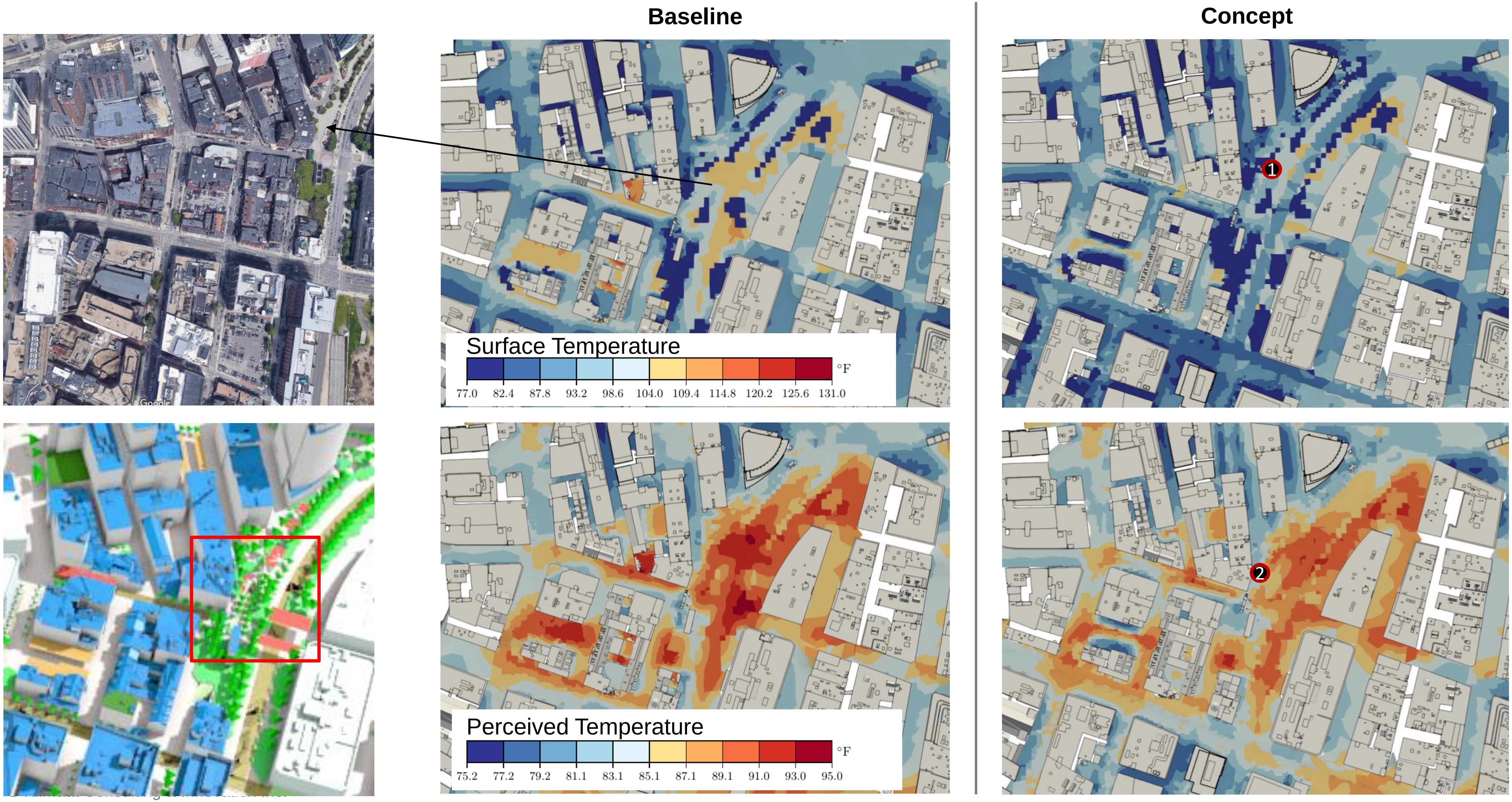






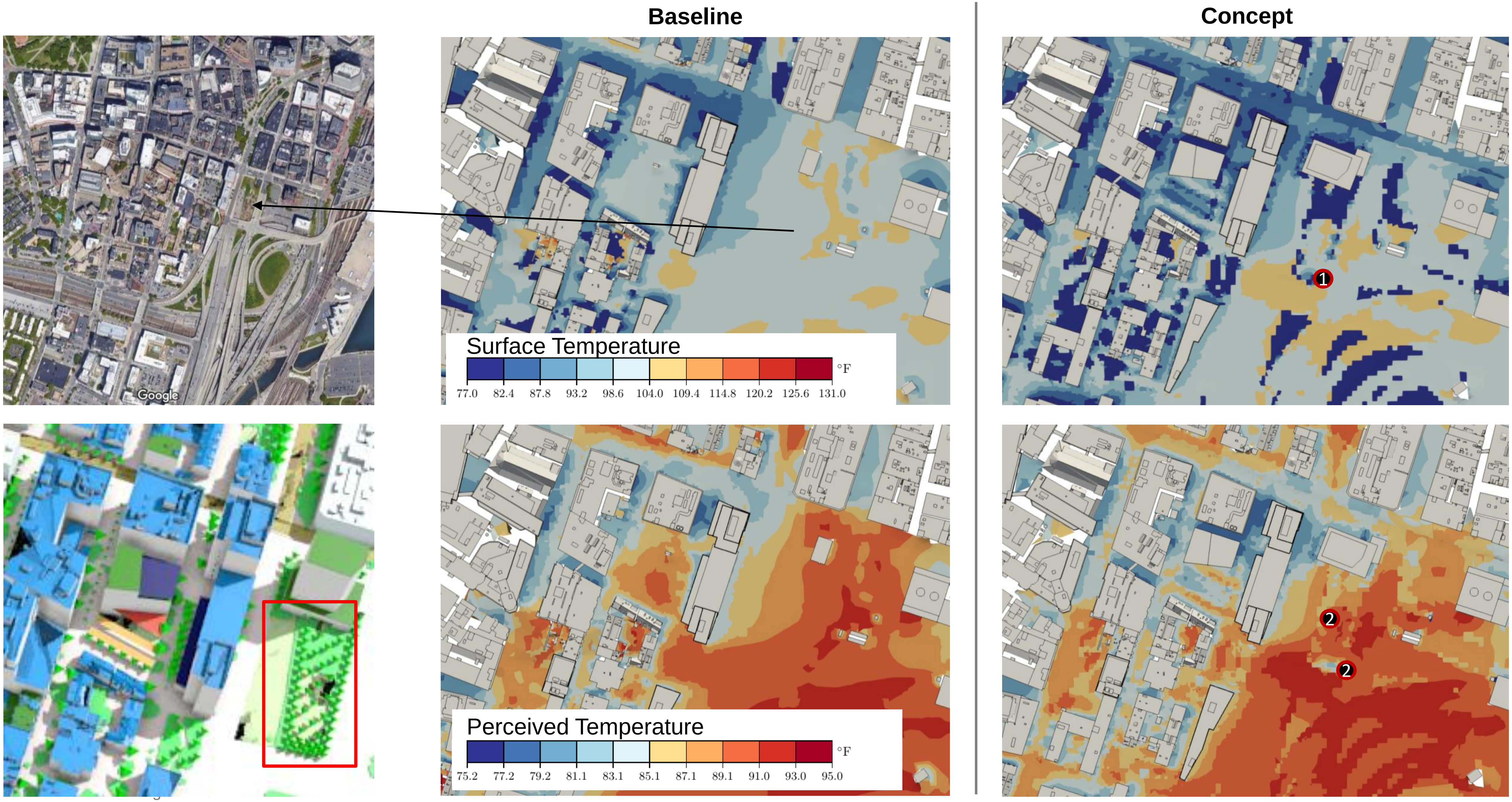
5. Effect of medium tree cluster or shading canopies at sun exposed areas

1) Tree canopy reduces afternoon surface temperatures from 100ºF to 90ºF.
2) Tree canopy reduces perceived temperatures from 88ºF to 84ºF by reducing solar exposure and surface temperatures.



6. Effect of medium tree canopy cluster with grass open space in solar and wind exposed area

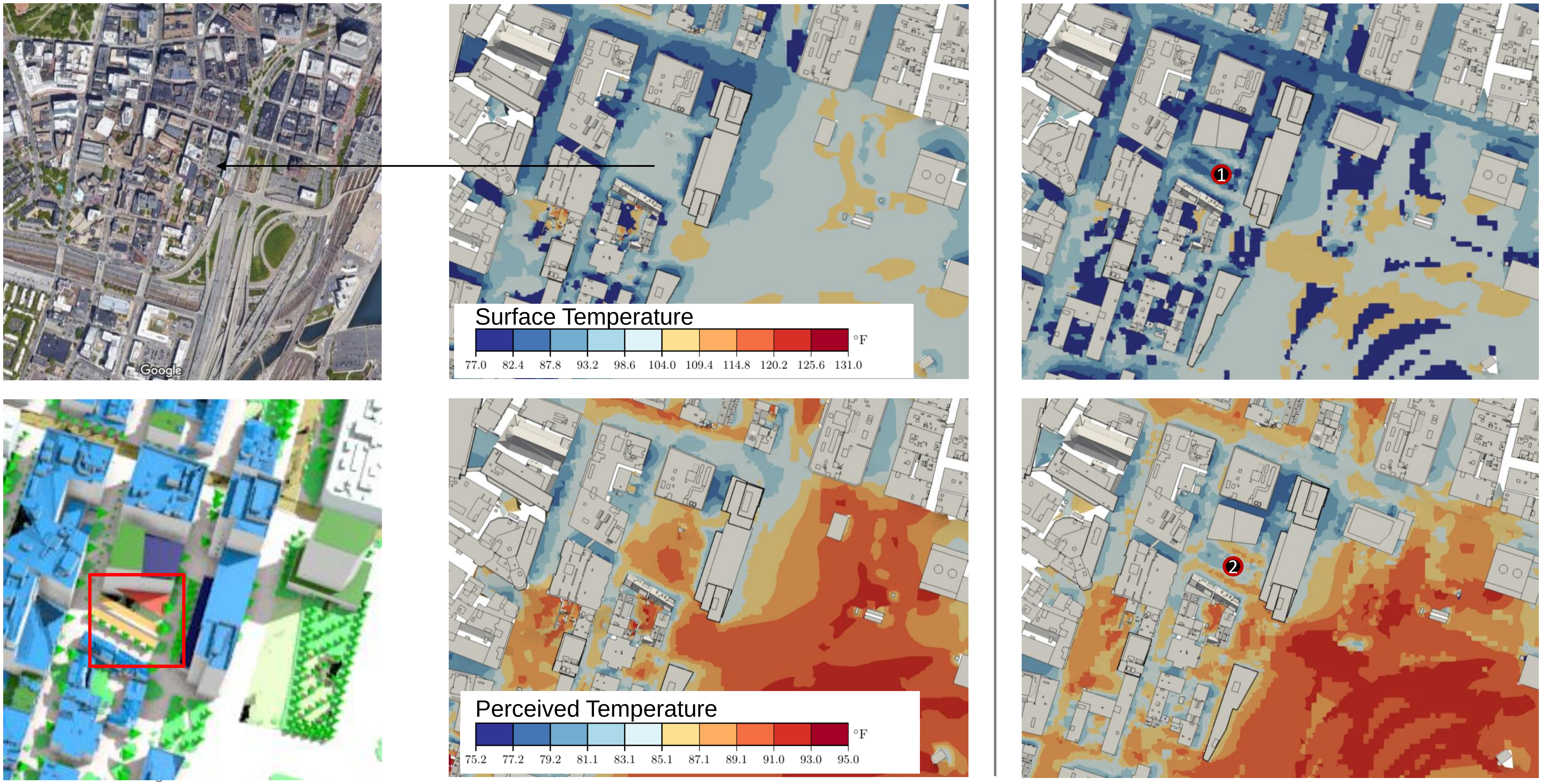
1) Medium tree canopy and grass surfaces reduces surface temperatures from 103ºF to 73ºF.
2) Densely arranged medium tree canopy and grass surfaces reduces perceived temperatures from 90ºF to 81ºF. More exposed areas between trees are ~88ºF.



7. Effect of full shade solar canopy

1) Solar canopy reduces afternoon surface temperatures from 103ºF to 85ºF.
2) Full shade solar canopy reduces perceived temperatures from 90F to 82ºF by limiting solar exposure and reducing surface temperatures

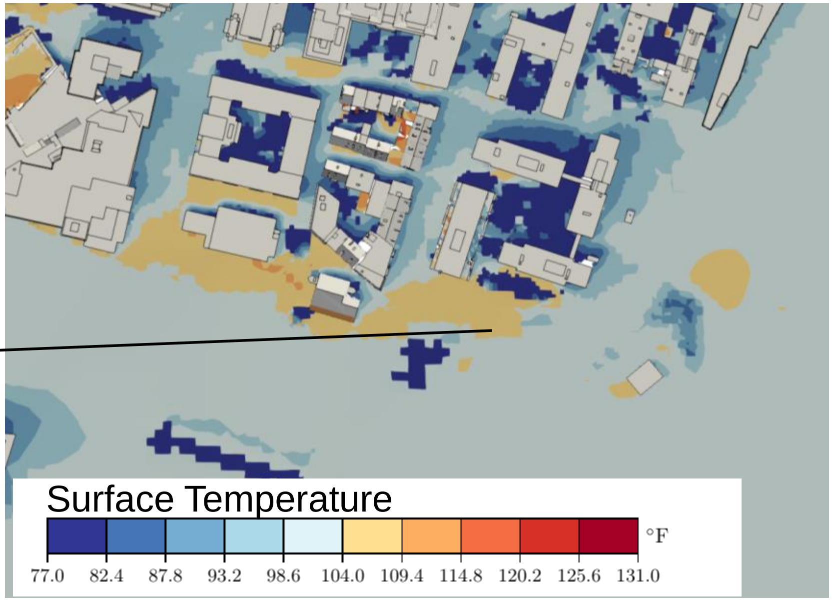
Baseline | **Concept**



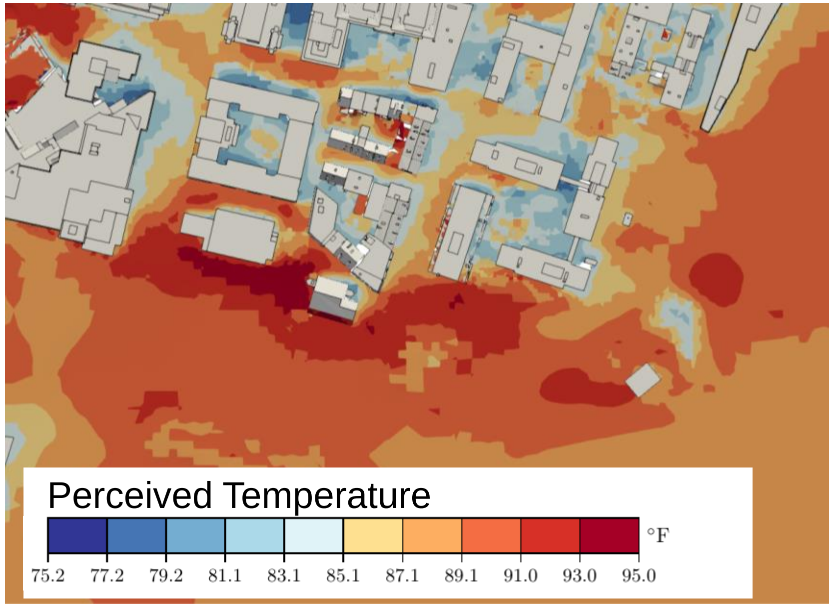
8. Effect of full shade solar canopy in exposed areas

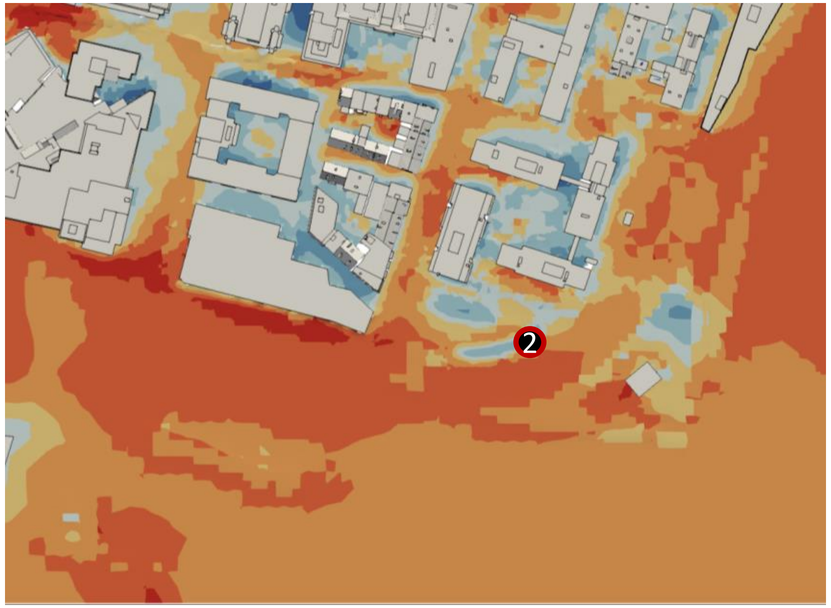
1) Solar canopy reduces afternoon surface temperatures from 106ºF to 82ºF.
2) Full shade solar canopy reduces perceived temperatures from 93ºF to 81ºF by limiting solar exposure and reducing surface temperatures

Baseline



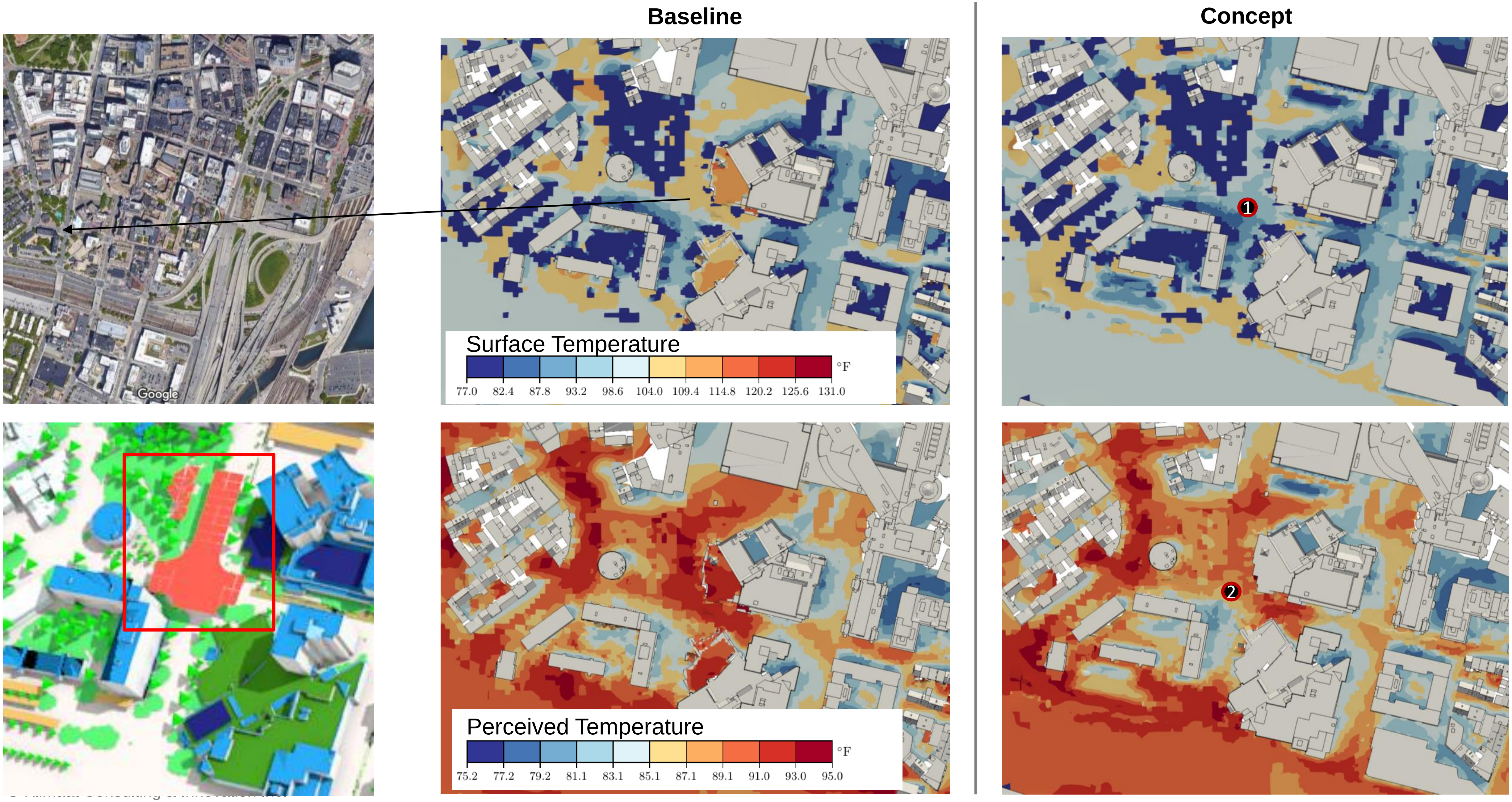
Concept





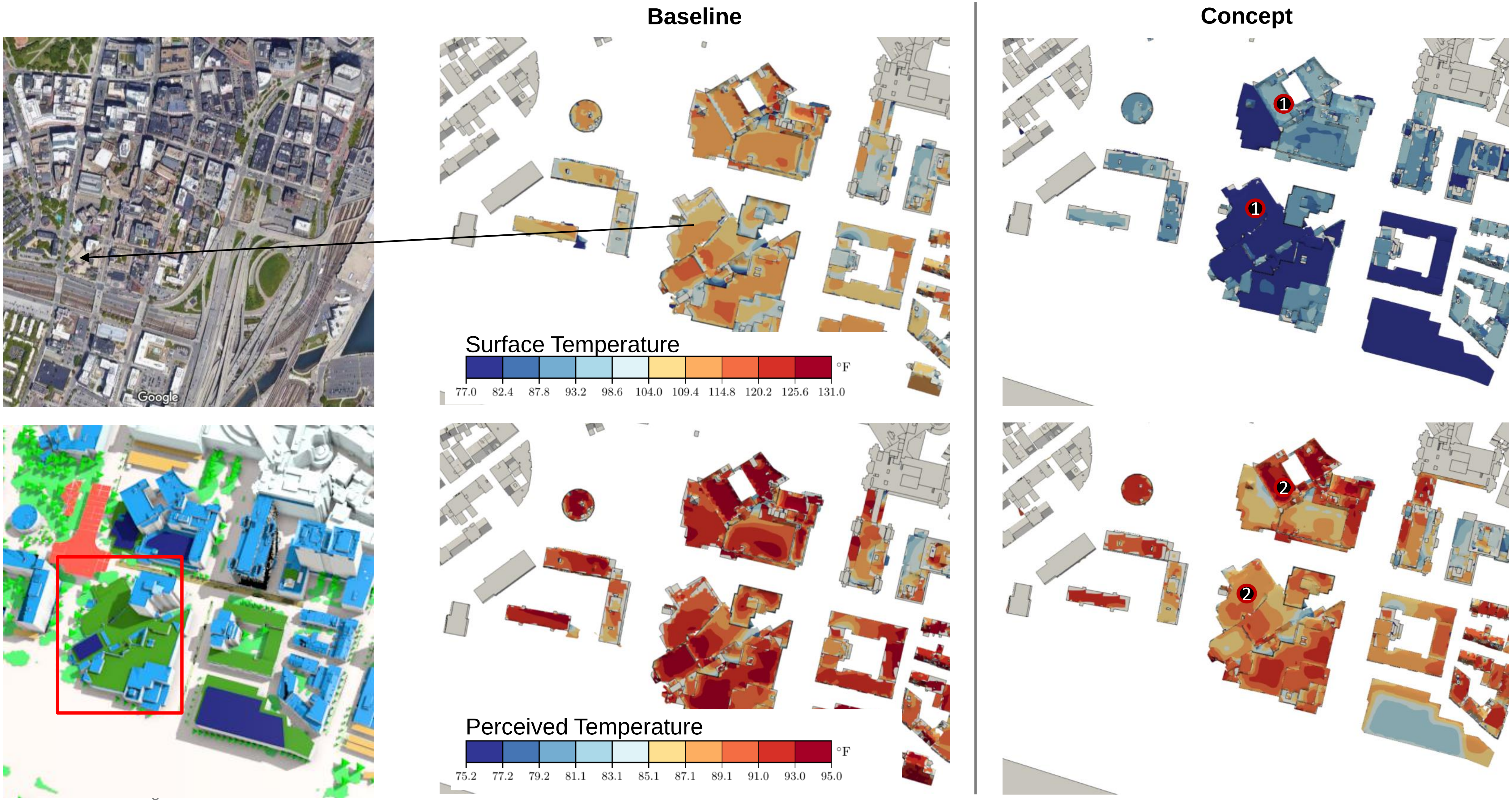
9. Effect of canopy (50%) over street intersection

1) Canopy reduces afternoon surface temperatures from 107ºF to 96ºF.
2) Canopy reduces perceived temperatures from 93ºF to 88ºF by reducing solar exposure and surface temperatures.



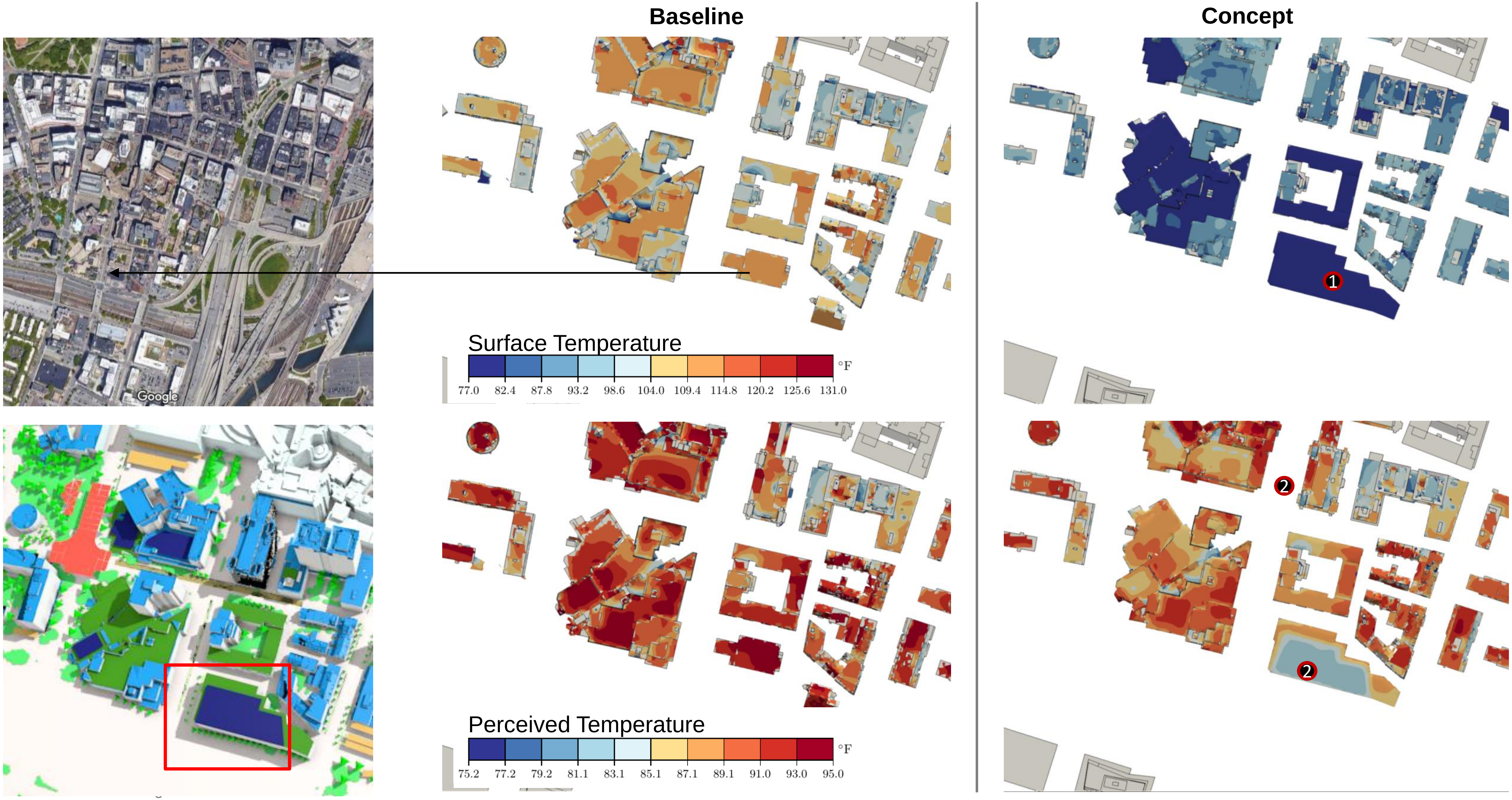
10. Effect of green and cool roofs

1) Green roof reduces afternoon surface temperatures from 110ºF to 81ºF. Cool roof reduces afternoon surface temperatures from 111ºF to 95ºF
2) Green roof reduces afternoon perceived temperatures from 93ºF to 89ºF. Cool roof reduces afternoon perceived temperatures from 94ºF to 93ºF



11. Effect of shade canopy (50%) over green roof

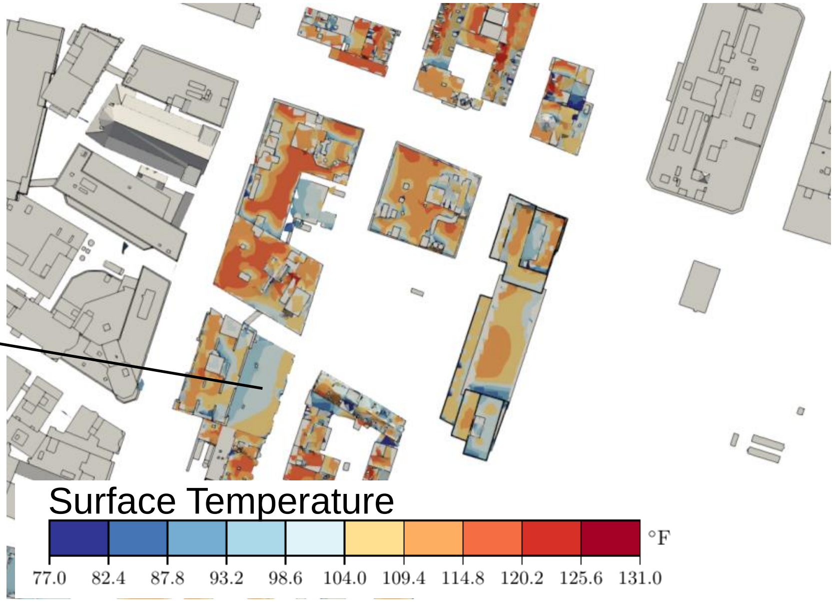
1) Canopy over green roof reduces afternoon surface temperatures from 112ºF to 75ºF
2) Canopy over green roof reduces afternoon perceived temperatures from 93ºF to 82ºF

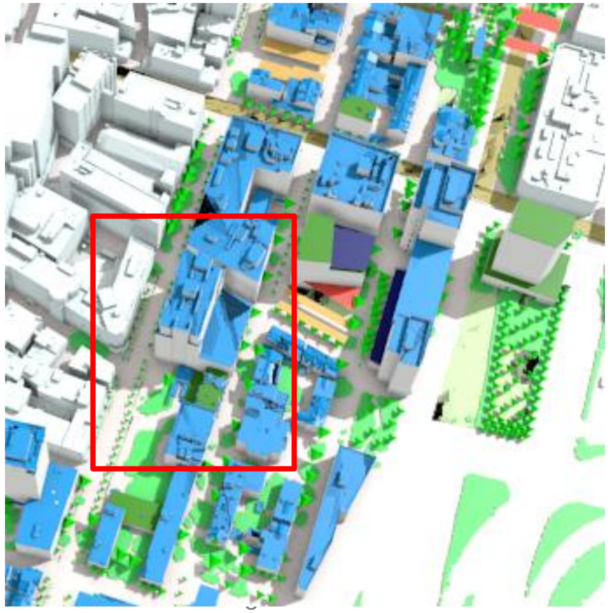


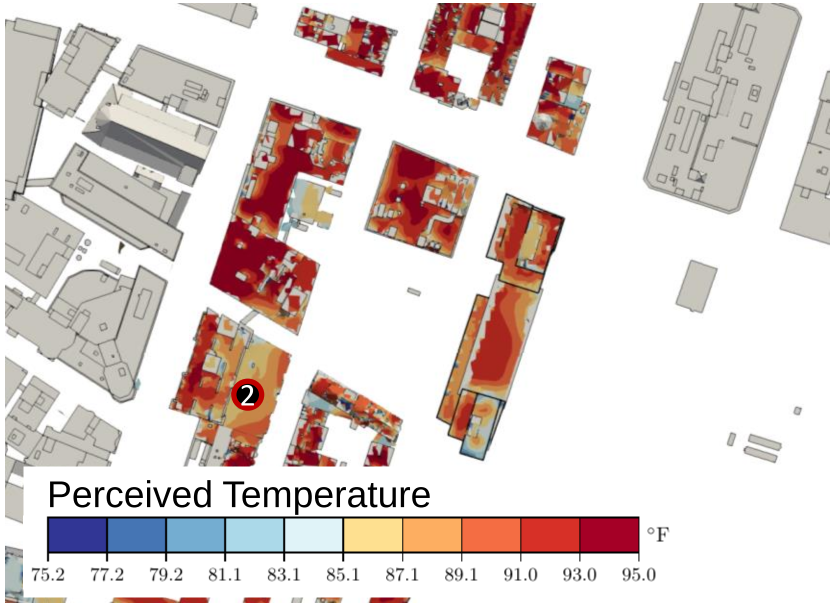
12. Effect of roof step

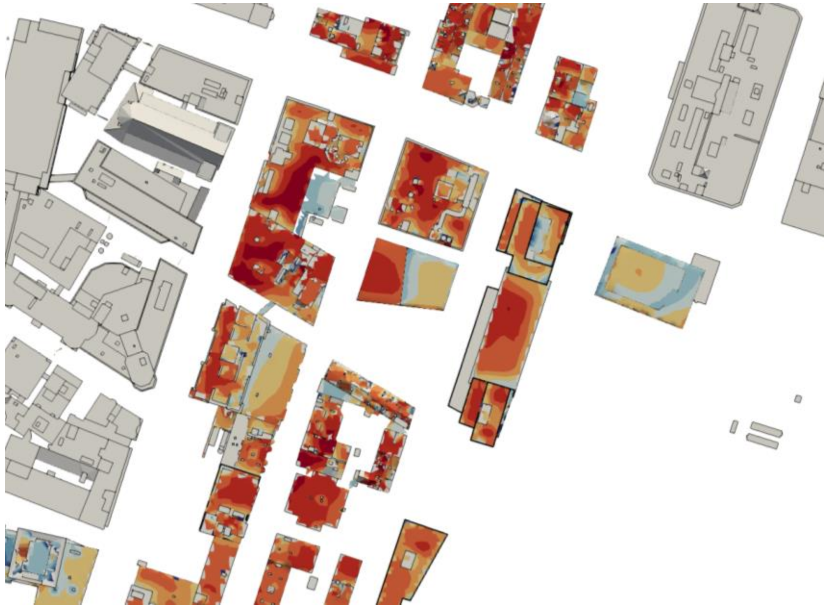
1) Building height steps that create shade reduces the surface temperatures from 114ºF to 81ºF compared to fully solar exposed roof areas.
2) Building height steps reduces afternoon perceived temperatures from 95ºF to 87ºF compared to fully solar exposure roof areas.

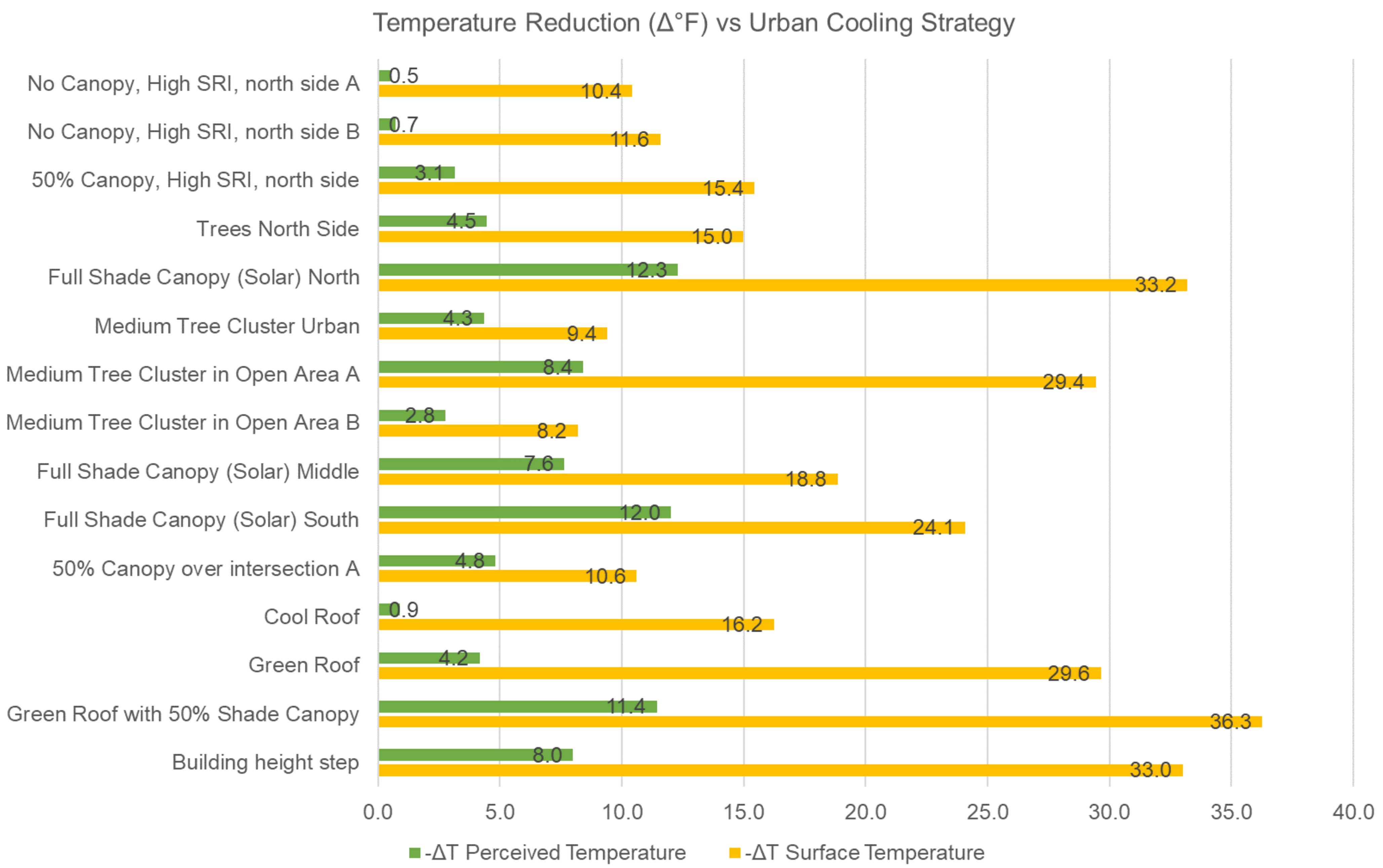
Baseline | **Concept**










Temperature Reduction (Δ°F) vs Urban Cooling Strategy
No Canopy, High SRI, north side A
No Canopy, High SRI, north side B
50% Canopy, High SRI, north side
Trees North Side
Full Shade Canopy (Solar) North
Medium Tree Cluster Urban
Medium Tree Cluster in Open Area A
Medium Tree Cluster in Open Area B
Full Shade Canopy (Solar) Middle
Full Shade Canopy (Solar) South
50% Canopy over intersection A
Cool Roof
Green Roof
Green Roof with 50% Shade Canopy
Building height step
0.5
10.4
0.7
11.6
3.1
15.4
4.5
15.0
12.3
33.2
4.3
9.4
8.4
29.4
2.8
8.2
7.6
18.8
12.0
24.1
4.8
10.6
0.9
16.2
4.2
29.6
11.4
36.3
8.0
33.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
-ΔT Perceived Temperature
-ΔT Surface Temperature

Appendix A: Layer surface specifications for urban climate simulation

Layer specifications

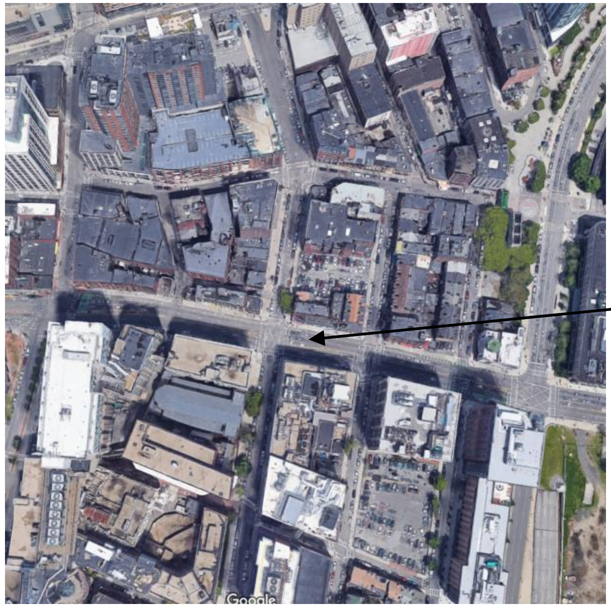
Layer	Material	Thermal Conductivity	Specific Heat Capacity MJ	Albedo	Solar Transmission	LAI
Base layer	Asphalt over concrete	1.2	1.9	0.12	-	0.0
Open Space	Concrete	0.8	1.33	0.25	-	0.0
Light road	High SRI on asphalt/concrete	1.2	1.9	0.45	-	0.0
Grass	Low Vegetation	1.2	1.8	0.25	-	2.88
Green Roof	Low Vegetation	1.2	1.8	0.25	-	2.88
Blue Roof	Light coloured roof	0.6	1.4	0.50	-	-
Dark Roof	Dark coloured roof	0.6	1.4	0.08	-	-
Solar Canopy	PV Modules	-	-	0.1	0.0	0.0
Shade Canopy	Shade cloth	-	-	0.25	0.5	0.0
Water Feature	Water	0.6	4.2	0.08	-	2.88

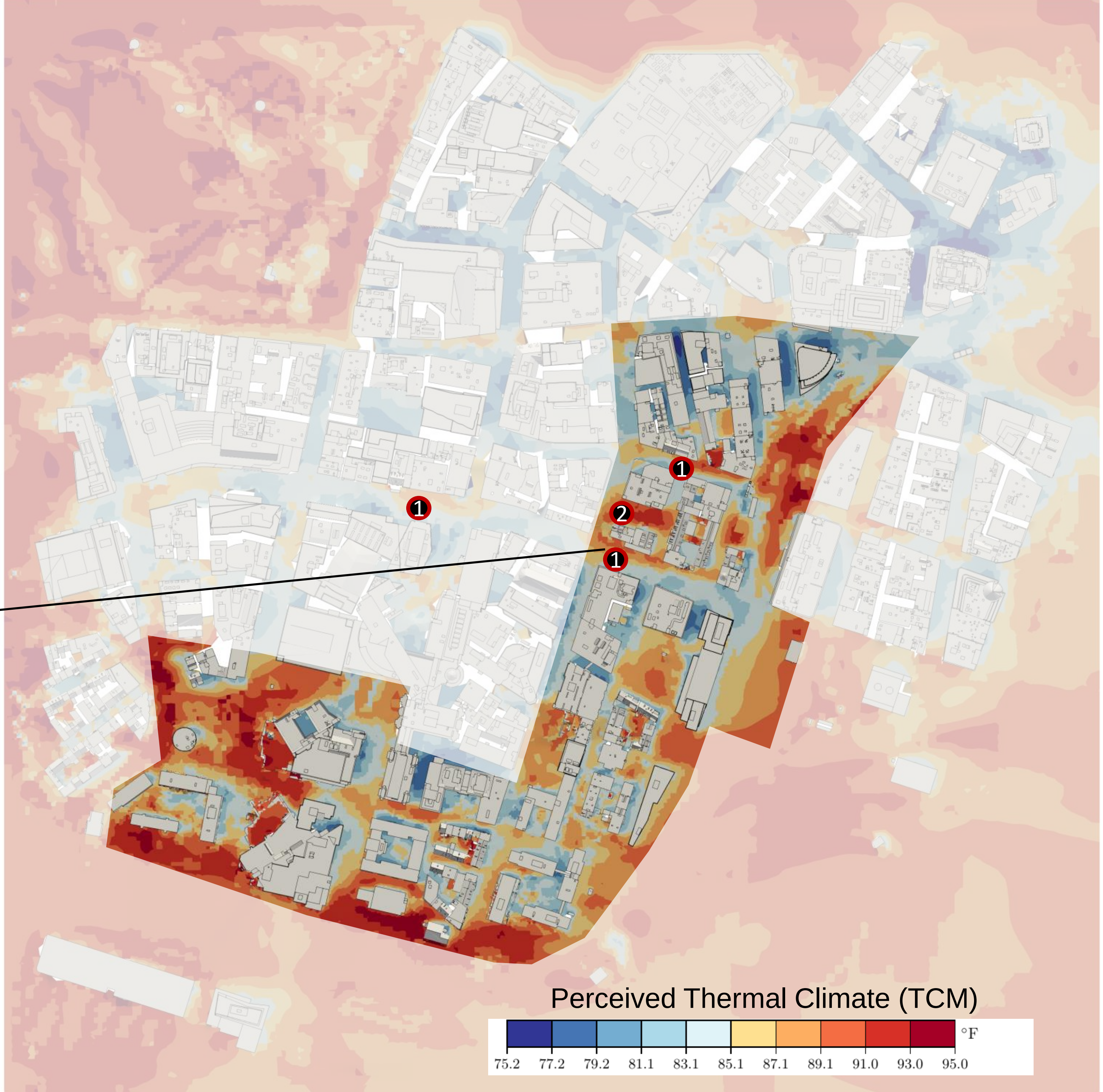
Trees	Diameter (m)	Height	LAI	Solar transmission
Trees - Existing	5		5	0.08
Trees – Medium	5		5	0.08
Trees - Small	3		5	0.08

Appendix B: Initial Observations for Baseline Simulations

Summary observations

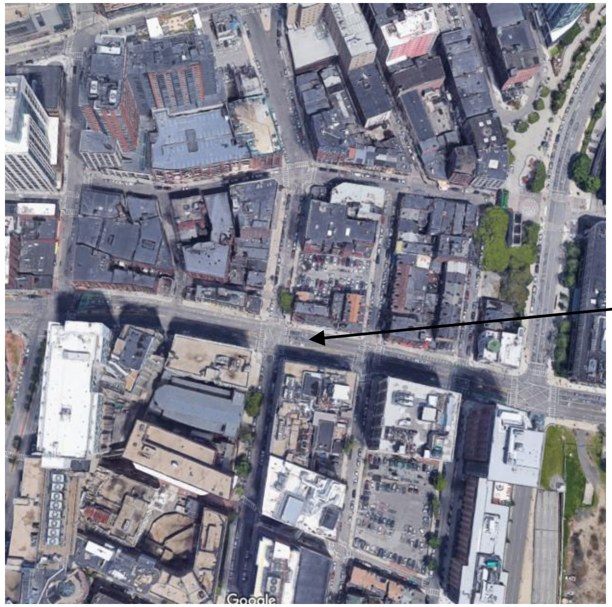
1) Hot conditions on north side of streets due to high solar exposure and low vegetation cover
2) Hot conditions due to high solar exposure, low vegetation and limited wind ventilation

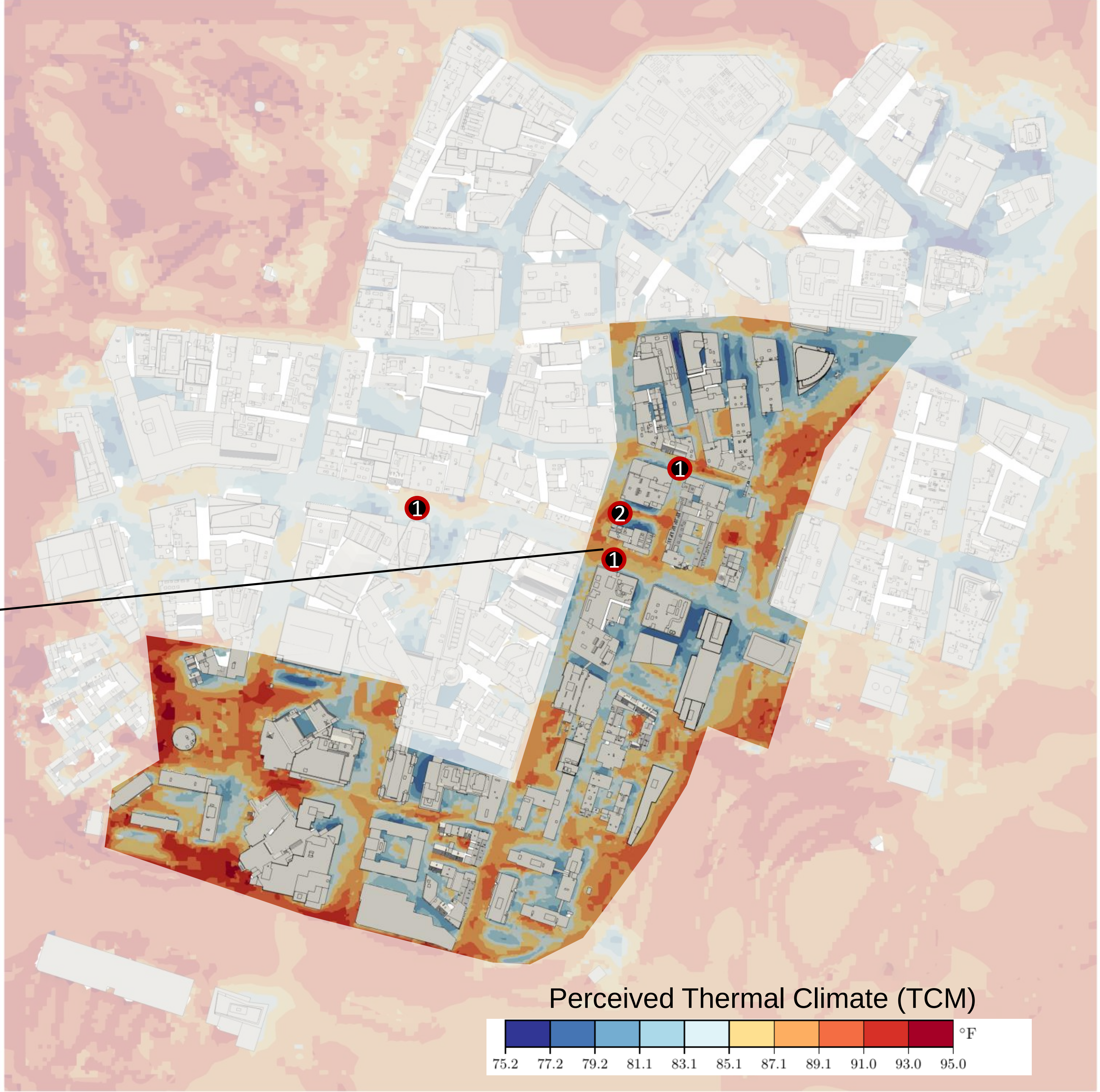




Summary observations

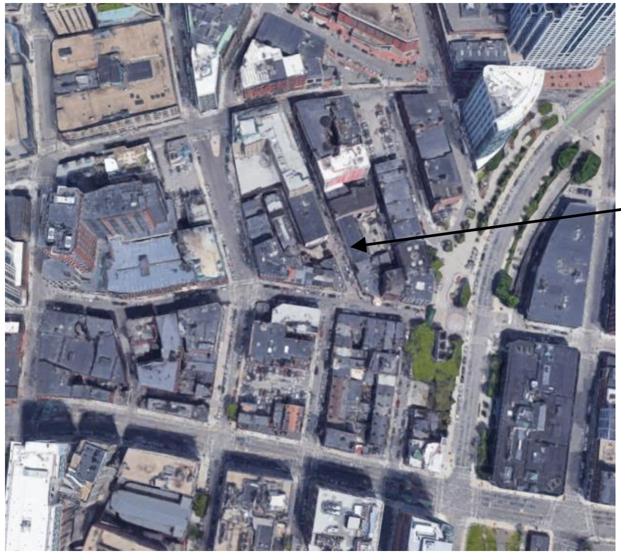
1) Hot conditions on north side of streets due to high solar exposure and low vegetation cover
2) Hot conditions due to high solar exposure, low vegetation and limited wind ventilation

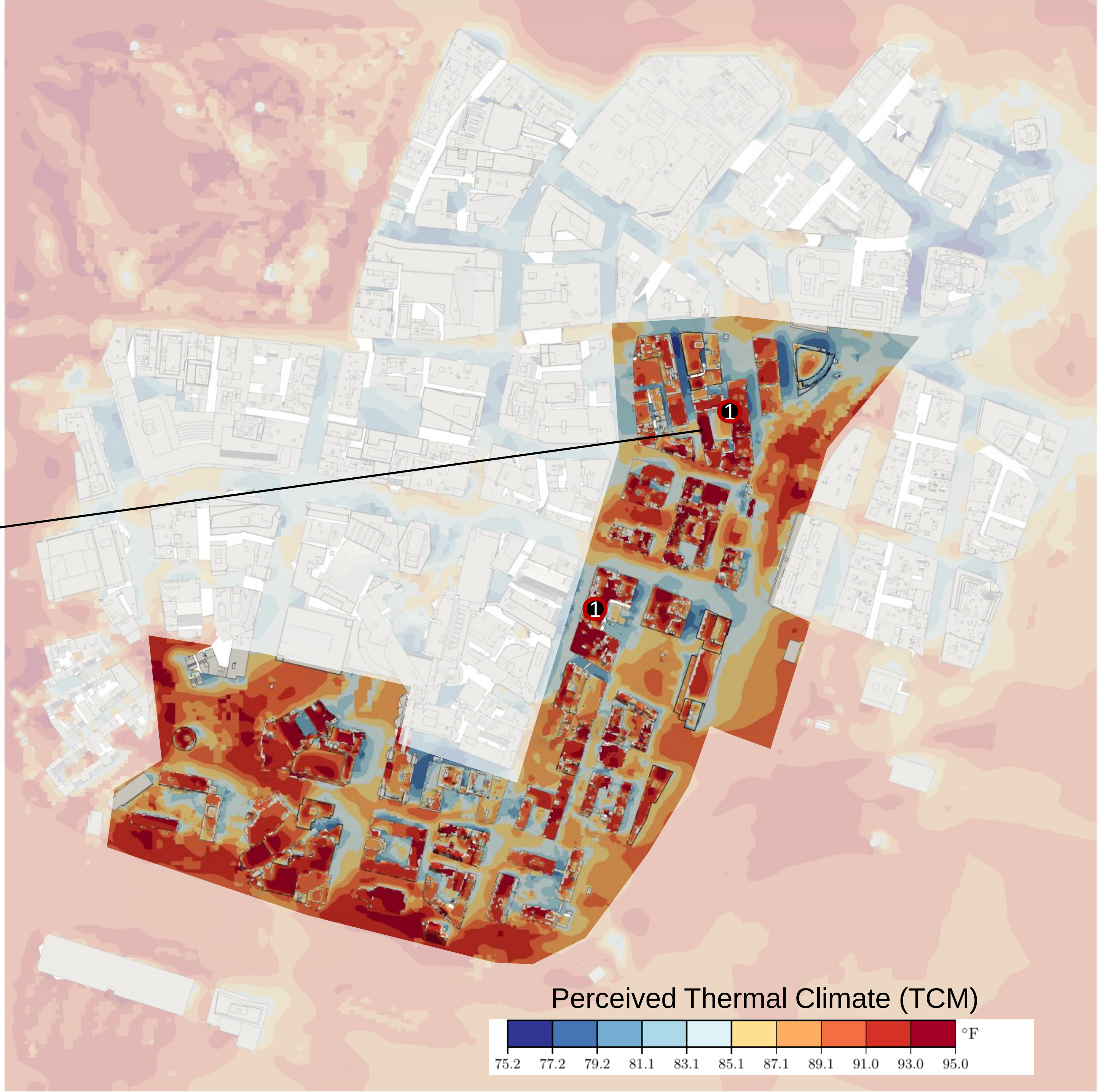




Summary observations

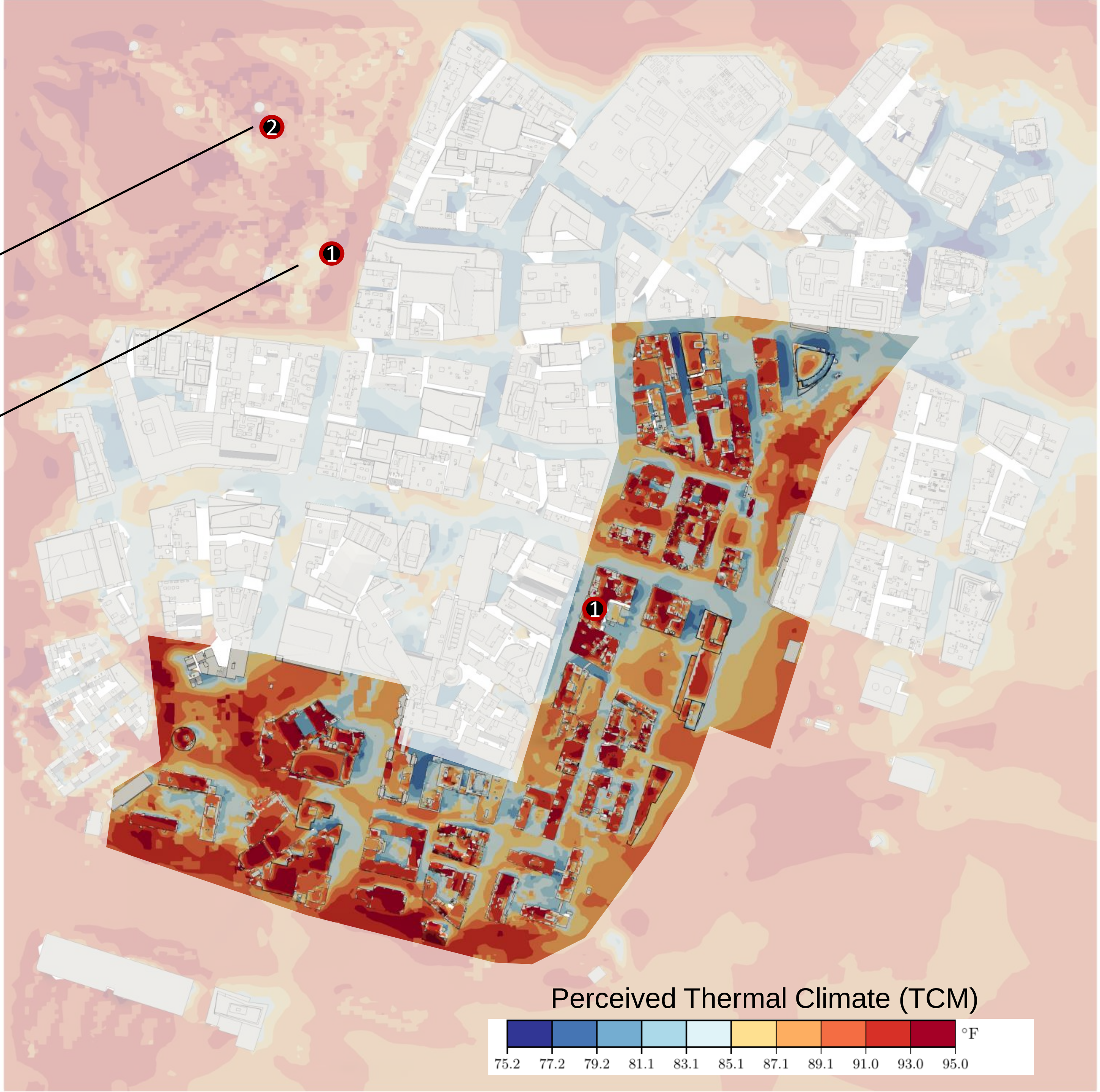
1) Very hot perceived thermal conditions on most roofs due to high surface temperatures and high solar exposure.





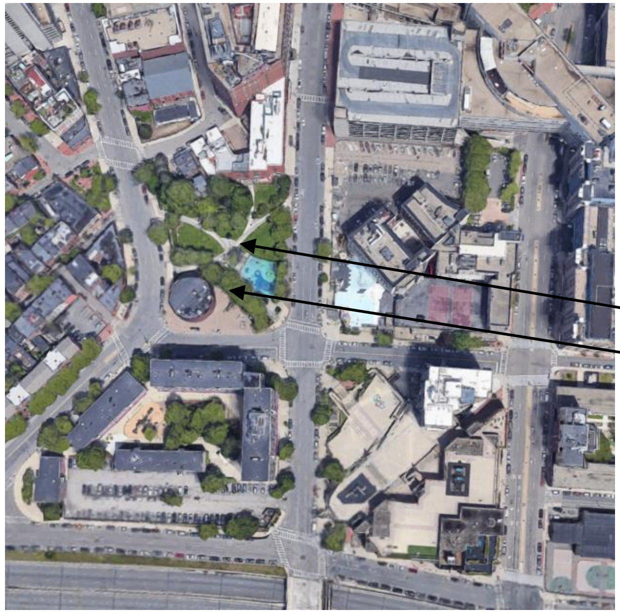
Summary observations

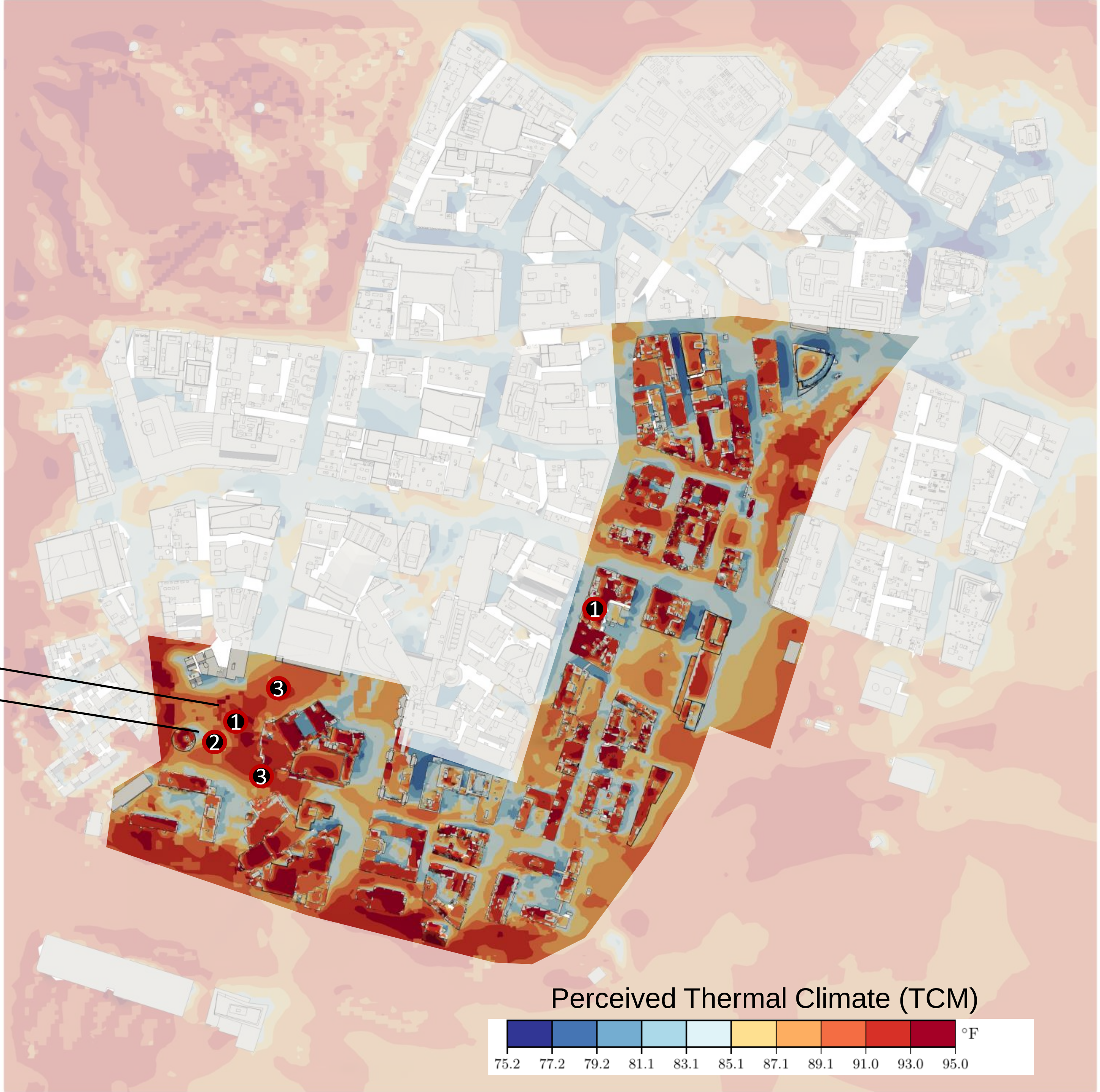
1) Relatively cool conditions (comfortable to moderate heat stress) across areas with higher density tree cover within park.
2) More exposed park areas (grass or hardscape) perceived thermal climate is warm with moderate to high heat stress on average



Summary observations

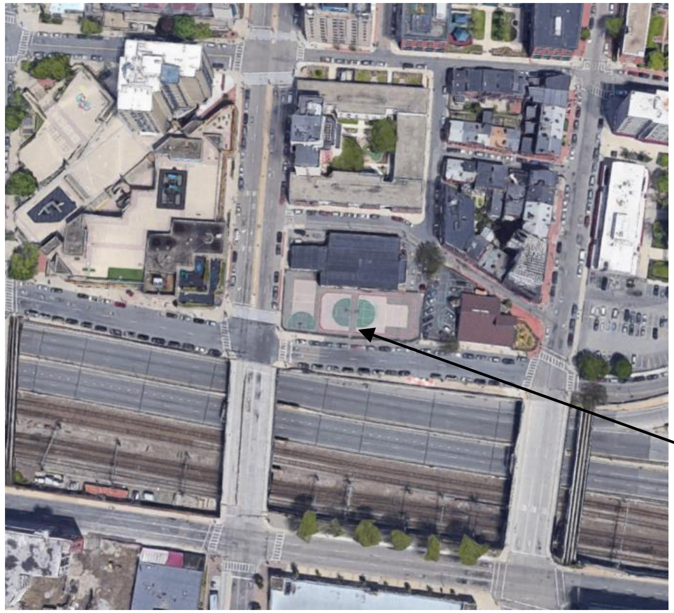
1) Exposed park areas with limited tree cover remains warm to hot on average.
2) Tree cover and or building shade provides more solar shelter and creates conditions that are comfortable to warm with moderate heat stress on average.
3) Very hot conditions due to limited shading from buildings and low vegetation cover.

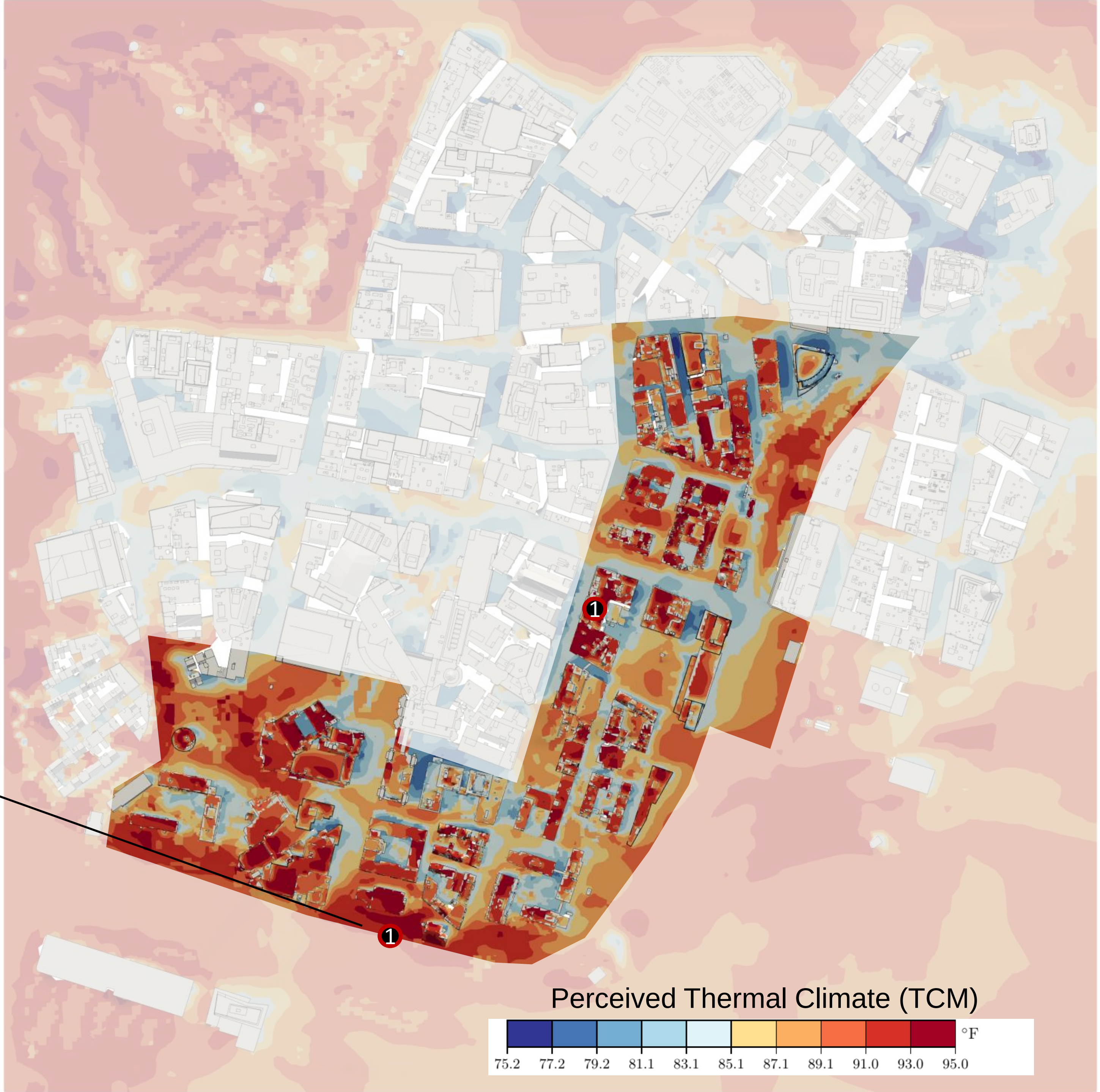




Summary observations

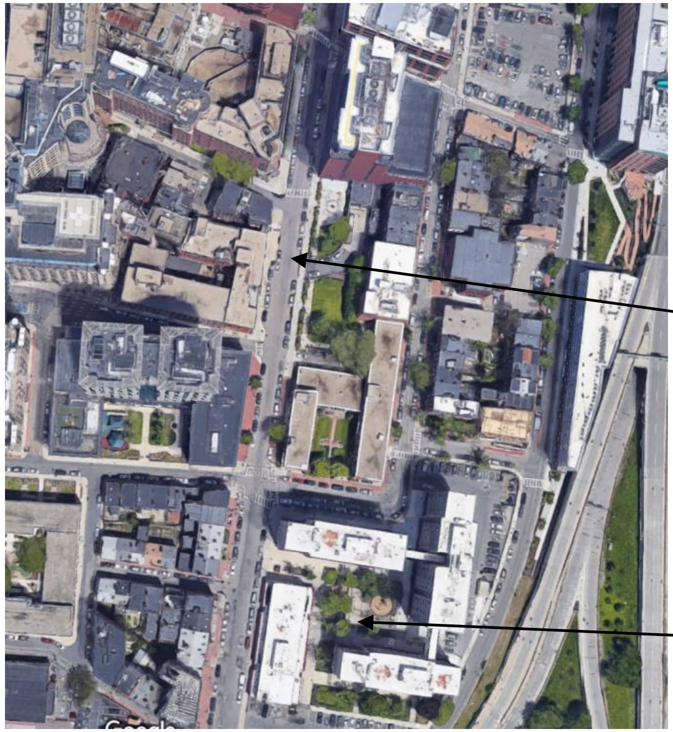
1) Very hot conditions, especially on South side of buildings, due to high solar exposure, limited shade from buildings or landscape, and negligible vegetation

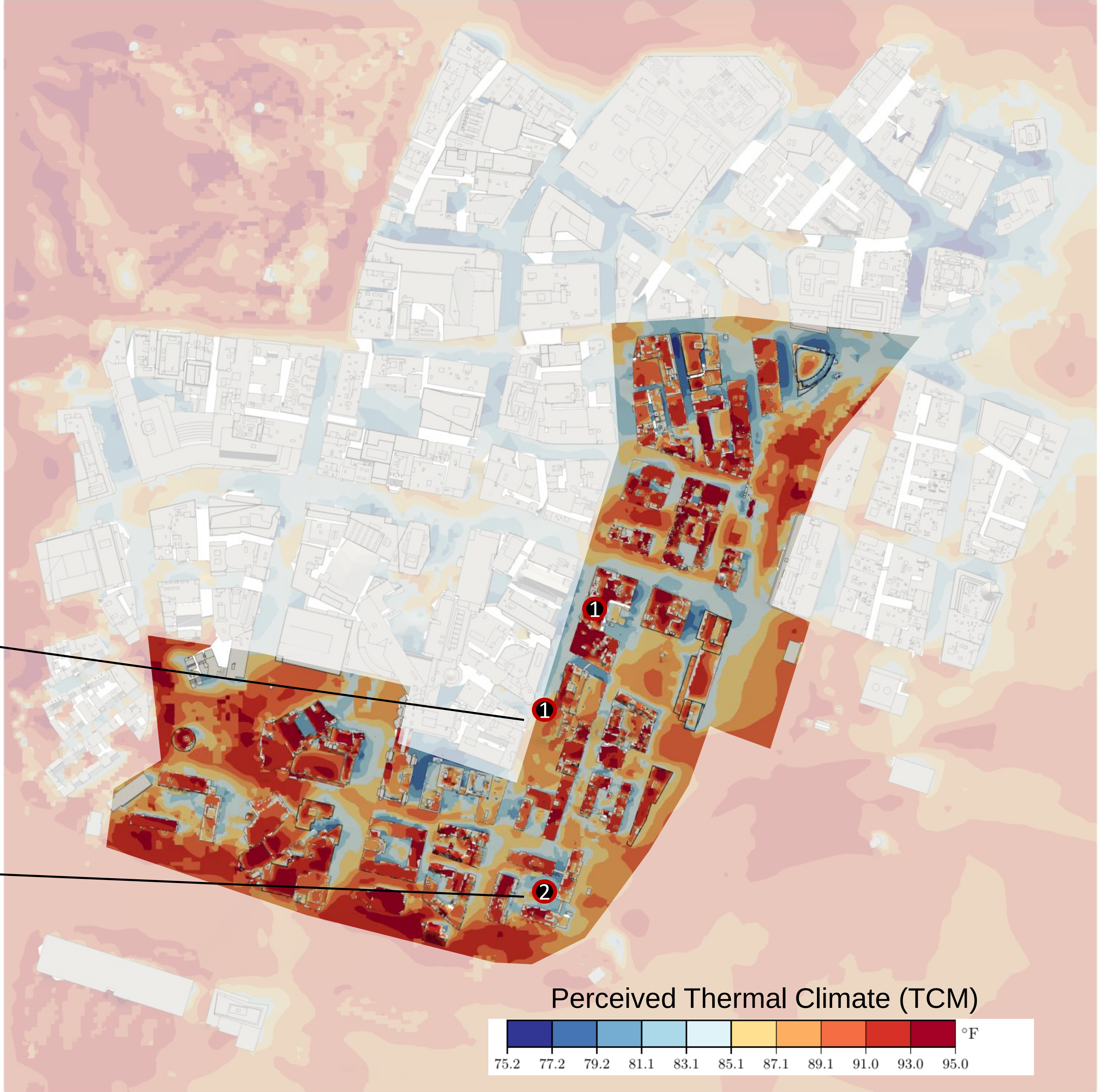




Summary observations

1) Relatively warm conditions (moderate heat stress) due to high solar exposure (limited shading from adjacent buildings, and limited wind ventilation
2) Comfortable and relatively cool conditions due to high solar shading, good vegetation cover





APPENDIX 3

UNIT COSTS

UNIT COSTS

In support of the unit costs of heat resilience elements, the *Heat Plan* process included the development of cost estimates for mitigation and adaptation. The following unit costs are provided to support strategies listed in Chapter 6.

SHADE CANOPIES AND COOL PAVEMENT

Element	Unit Cost	Notes
Prefabricated Canopy with metal roofing and fascia	$155.40/SF	*50' x 20' canopy; includes fabrication, delivery, installation; spread footing foundations and LED lighting.*
Fabric awnings with light gauge steel, per square foot	$98.00/SF	*50' x 20' canopy; includes installation, spread footings, and LED lighting.*
Steel framed awnings on buildings/ storefronts	$256.03/linear foot	*Attached to building facade; cost is based on a fixed fabric awning with lightweight steel frame, projecting 6ft from face of building; assumes 100' continuous length; includes installation.*
Cool coating for travel lanes	$190.12/linear foot	*28 foot width; includes StreetBond coating; 3 applications + friction coat layer; 3 colors allowed on final coat.* *The cool coating market is expanding material offerings. More options may be available in the future.*

SHADE TREES AND DRINKING FOUNTAINS

Element	Unit Cost	Notes
Shade Trees, no drainage box - planting	$2,023.70/tree	*3" caliper shade tree; assumes tree is not planted in a box; includes excavation and disposal; bioretention soil mix / crushed stone.*
Shade trees, with drainage box - planting	$6,687.33/tree	*Includes excavation and installation.*
Shade Trees - maintenance	$896.30/tree annually	*Includes pruning (6 to 10 year cycle), storm damage correct/clean-up (on average every 5 years), insect and disease treatment (on average every 10 years), tree and stump removal at end of life. These numbers do not include salaries, equipment, supplies, or administrative costs.*

COOL ROOFS UNIT COSTS

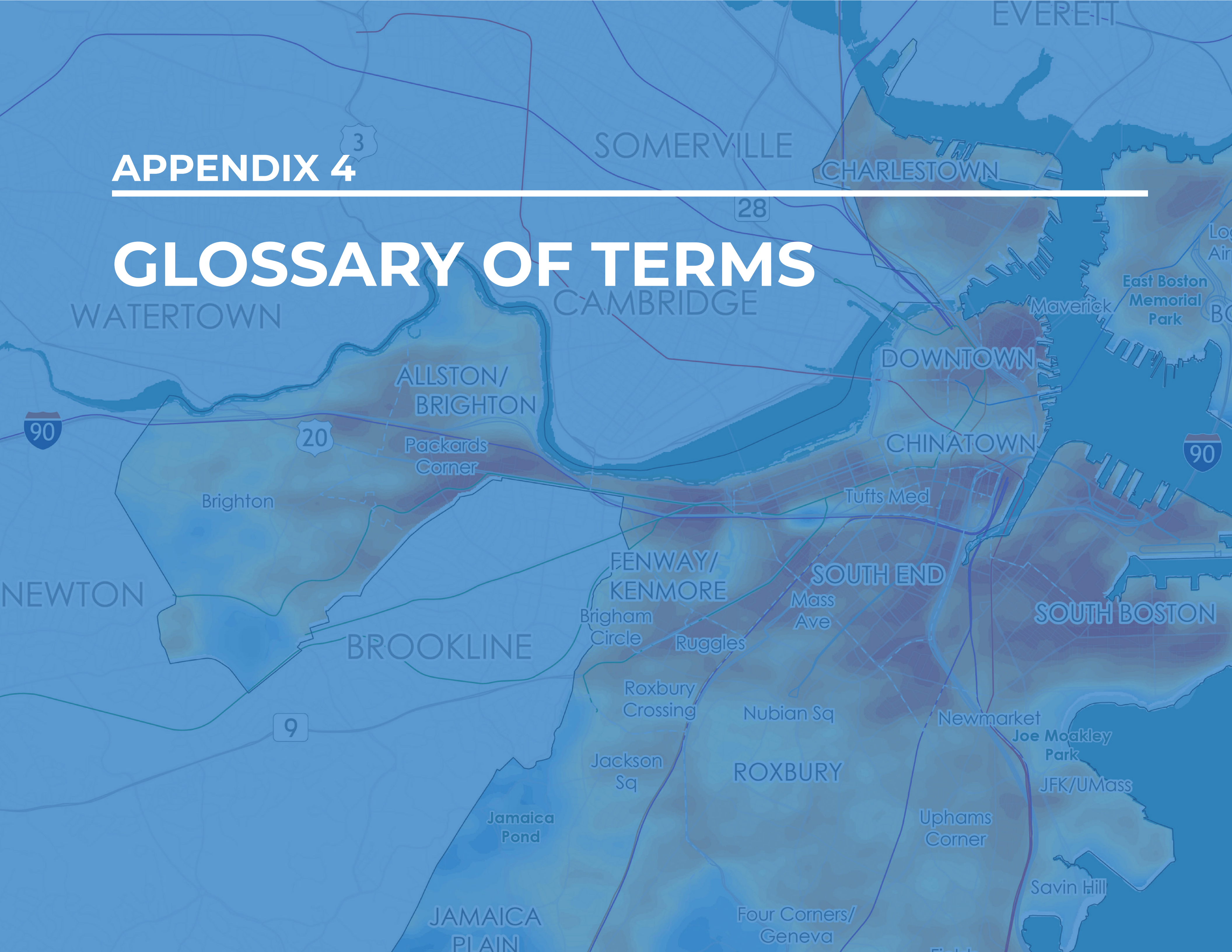
Element	Unit Cost / SF	Notes
Flat light-colored roofs + insulation (permanent)	$44.03	*Eg. white PVC membrane, includes striping and disposal of existing roofing materials, working around roof top equipment, and materials, craning, and lifting.*
Pitched light-colored roofs (white asphalt shingles) + insulation (permanent)	$13.37	*Light-colored roofs + insulation (permanent) Eg. light-colored asphalt shingles, includes strip existing shingles down to sheathing, miscellaneous flashing replacement, prepare existing sheathing and install light-colored 30 yr Asphalt shingles; lifting of materials; dumpsters; police details and permits.*
Pitched light-colored roofs (profiled metal roofing) + insulation (permanent)	$62.26	*Kynar coated metal roofing placed over existing asphalt shingles; includes removing existing flashings and providing new; lifting of materials; dumpsters; police details and permits.*
Light-colored roofs (temporary, painted)	$6.50	*Includes clean & repairing existing EPDM roofing; light-colored coating; 3 applications + friction coat layer; lifting of materials; dumpsters; police details and permits.*
Green roofs	$35.00	*Includes plant materials, soil, waterproofing membrane/system, working around roof top equipment, and materials, craning and lifting.*

COOL HOMES

Element	Unit Cost	Notes
Building wide AC system	$48.79/SF	*Cost for installation in an 80-family apartment building with a total GSf of 80,000. Includes a 2-pipe fan coil system with roof top equipment, digital thermostats, testing and commissioning, and removal of existing redundant heating system. Includes architectural , structural, electrical work associated with HVAC installation.*
Window AC unit	$4,060.00/unit	*Includes installation of a commercial grade window/wall AC unit (230 Volt, 12,000 BTU). Includes wall mounting (form opening and 230V electrical rough in). Includes electrical upgrade to unit panelboard.*
Replacement of windows for improved building performance	$1,001.00/each	*Installation of new replacement windows with caulking and sealing.*
Blinds	$74.90/each	*Installation of blinds/shades to provide passive shading, especially on South facing windows.*

APPENDIX 4

GLOSSARY OF TERMS



GLOSSARY OF TERMS

Displacement: Occurs as a result of gentrification where residents move out of their community to another. This outcome is typically involuntary and occurs when residents can no longer afford to live in their neighborhoods/communities. Displacement can also occur if the character of the neighborhood transforms and remaining residents feel a sense of dislocation despite remaining in the neighborhood. Displacement can also occur to local businesses for similar reasons.

Source: *Resilient Boston and University of Texas Entrepreneurship and Community Development Clinic (School of Law) and the Community and Regional Planning Program (School of Architecture)*

Environmental justice: "Environmental justice is based on the principle that all people have a right to be protected from environmental hazards and to live in and enjoy a clean and healthful environment regardless of race, color, national origin, income, or English language proficiency. Environmental justice is the equal protection and meaningful involvement of all people and communities with respect to the development, implementation, and enforcement of energy, climate change, and environmental laws, regulations, and policies and the equitable distribution of energy and environmental benefits and burdens."

Source: Mass.gov

Environmental justice community: In Massachusetts, a neighborhood is designated as an environmental justice community (EJC) if it meets at least one of the following:

- Annual Income <65% of the statewide median household income
- >40% of the population is comprised of minority residents
- >25% of households lack English language proficiency
- >25% of the population is comprised of minority residents and the annual median household income of the city does not exceed 150% of the statewide annual median household income.

Source: Mass.gov

Equity: Respectful treatment and fair involvement of all people in a society. It is the state in which everyone has the opportunity to reach their full potential. Additionally, the National Academy of Public Administration, which has been studying the use of equity as a means of evaluating public policy describes equity as the "fair, just, and equitable management of all institutions serving the public directly or by contract; the fair, just, and equitable distribution of public services and implementation of public policy; and the commitment to promote fairness, justice, and equity in the formation of public policy." This definition lays the groundwork for measuring equity in Resilient Boston's initiatives. *Source: Resilient Boston*

Gentrification: A change in the population and culture in a particular area as a result of higher property values driven by renovation or redevelopment in that area. This term is often used negatively because of its common effects on communities of color. *Source: Resilient Boston*

Redlining: A term used to "illustrate the geographic dimensions of housing discrimination" due to the Home Owners' Loan Corporation's grading of residential neighborhoods based on mortgage security. The grading system is highly correlated with the racial composition of neighborhoods. Communities of color, immigrant communities, and lower income areas were typically given lower grades. The lowest grading was outlined in red on maps, meaning that they were considered high-risk resulting it a reduction of opportunities for wealth-building associated with homeownership. *Source: Mapping Inequality*

Social vulnerability: "Populations or people who are more vulnerable to climate hazards because they already experience stressors, such as poverty, poor health, and limited English proficiency." *Source: Climate Ready Boston*

Urban renewal: An economic development tool used to address deterioration in underinvested areas. Urban renewal uses public investment to encourage private investment and revitalize areas. "Urban renewal dates back to the American Housing Act of 1949, when the federal government invested funds to redevelop cities that were rapidly declining after World War II. Early urban renewal efforts attempted to address widespread decline of urban infrastructure in cities across the US by assembling land to develop massive infrastructure and public facilities, usually at the expense of displacing poor and marginalized residents."

Source: Mayor's Office of Planning/BPDA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