CLIMATE RESILIENCE HUBS

Leveraging social infrastructure for neighborhood resilience in Boston

September 2020

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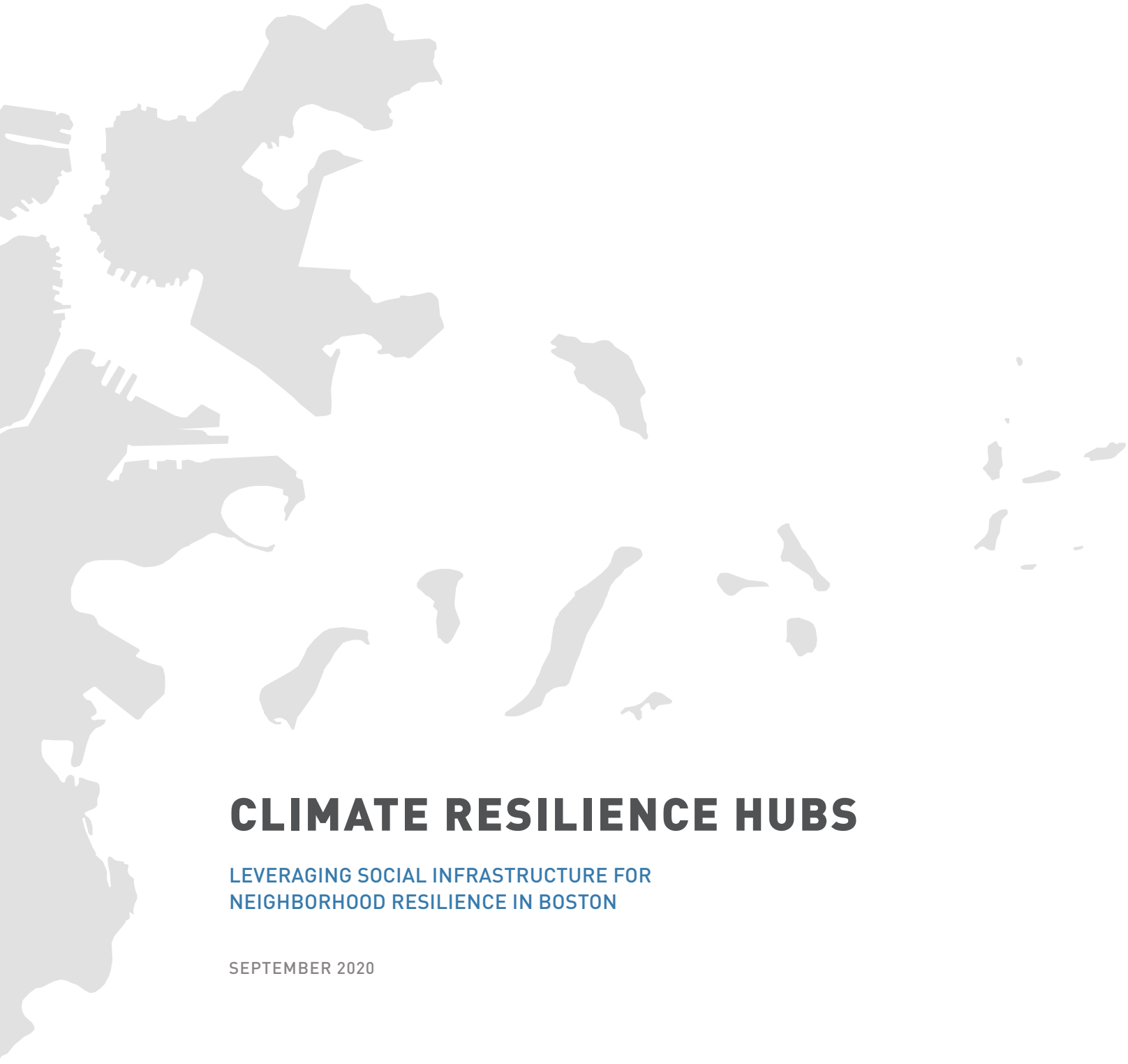

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LEVERAGING SOCIAL INFRASTRUCTURE FOR NEIGHBORHOOD RESILIENCE IN BOSTON

SEPTEMBER 2020

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COMMUNITIES RESPONDING TO EXTREME WEATHER is a network of local leaders building grassroots climate resilience through inclusive and hands-on education, service and planning. Together, CREW works to equip families and communities with the resources and capacity to prepare for and respond to local climate changes equitably, sustainably, and collaboratively. to learn more, visit www.climatecrew.org.

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EXECUTIVE SUMMARY

Climate change impacts like extreme heat and increased flooding threaten Boston's neighborhoods. The magnitude of these impacts is only expected to grow in the coming decades. By 2070, Boston is expected to experience at least three feet of sea level rise and nearly twice the number of summer days above 90 degrees.

These impacts will not be felt evenly across the city. Some neighborhoods, like Roxbury and East Boston, face a disproportionate risk of coastal flooding and/or extreme heat. Within these communities, certain populations, like low-income residents, people of color, and seniors, will be more vulnerable to the fallout from these climate risks.

To date, the City of Boston's effort to address climate change threats have focused primarily on physical infrastructure – elevating roads and structures, building berms, and retrofitting green spaces to absorb flood waters. These efforts are critical to creating a climate-resilient city, but so, too, is social resilience. Social resilience is the ability of *people*, not just structures, to adapt to and rebound from disruptions, including extreme weather.

Achieving social resilience means looking closely at a city's social infrastructure – schools, places of worship, libraries, community centers. These community institutions can tap into and leverage existing community capital and networks to provide a greater ability for residents to both respond to and bounce back from shocks at a highly local level.

As such, they can serve as "climate resilience hubs" in high-risk neighborhoods. Climate resilience hubs are institutions that are physically centered in the neighborhood; they are often places people know and trust. Resilience hubs work by aiding residents before, during, and after extreme weather events. This assistance can take many forms including dissemination of information and educational materials, providing shelter in extreme heat or cold, or offering a place to charge your phone during a power outage. Resilience hubs do not just operate during a catastrophe – they are merely mobilized during and after extreme weather events to provide the necessary resources to the community to

survive and recover. In fact, resilience hubs are most effective when they provide an everyday function in the community outside of emergency events.

This study identifies 1) 22 areas within the City of Boston that would benefit from creation or activation of a climate resilience hub and 2) where efforts to establish, support, and fund these institutions should be prioritized.

We also looked at several factors related to climate resilience and disaster preparedness that can help inform initiatives to establish climate resilience hubs, including:

- Population size within a high-priority area;
- Areas that are at risk both from heat and flooding;
- Areas that face not only climate hazards, but also disparities in the built environment such as higher amounts of impervious surfaces; reduced affordability of housing; and demographic change that is weakening social cohesion; and
- Areas with capacity to leverage existing social infrastructure for climate resilience purposes.

Based on the findings of this study, we recommend the following:

- **ESTABLISH CLIMATE RESILIENCE HUBS IN HIGH-PRIORITY AREAS.** The City should prioritize establishing, supporting, and funding resilience hubs in high-priority tracts, particularly in East Boston and Roxbury, where residents will face disproportionate impacts. The approach to this should be based on the existing conditions of each area. For example, in East Boston, the City should consider whether new facilities will be needed to serve the population. In Roxbury, the City should focus on whether existing facilities can be activated as climate resilience hubs and whether they are accessible to all residents.
- **SUPPORT CREW'S CLIMATE RESILIENCE HUB INITIATIVE.** The City should work with CREW to support a city-certification process for climate resilience hubs that can nest within a broader, cross-municipal resilience hub framework.
- **INTEGRATE CLIMATE RESILIENCE HUBS INTO CITY PLANS AND INITIATIVES.** Consistent with the City's Climate Action Plan, efforts to retrofit existing municipal buildings should prioritize institutions with the ability to serve as climate resilience hubs in high-priority areas. The City should also integrate resilience hubs into planning and policy documents, including climate adaptation, mitigation, and emergency response plans. In particular, the City should consider the role of climate resilience hubs in Climate Ready Boston neighborhood plans.
- **PRIORITIZE COMMUNITY INSTITUTIONS IN THE FACE OF BUDGET CUTS.** Many of the institutions that offer near-term opportunities to establish resilience hubs are publicly owned or operated facilities like schools, libraries, and community centers. In the face of potentially deep budget cuts in the midst and aftermath of COVID-19, the City should prioritize and invest in existing neighborhood institutions that have the ability to provide critical information, services, and respite before, during, and after extreme weather and other catastrophes. The City should also consider how the operation of these facilities may need to adapt their operations as a result of the COVID-19 crisis and support them in doing so.

- **EARMARK FUNDING TO SUPPORT CLIMATE RESILIENCE HUBS AND SOCIAL RESILIENCE.** The City should earmark capital funds to support existing and new neighborhood institutions interested in being climate resilience hubs. Funding can help ensure that these facilities are able to adapt their infrastructure and operations to withstand future climate impacts and provide necessary resources during and after an extreme weather event. In addition, a grant program should provide funds for climate resilience hubs that are not owned or operated by the city.
- **PRIORITIZE PUBLIC REALM IMPROVEMENTS AND TRANSIT ACCESS NEAR CLIMATE RESILIENCE HUBS.** The City should assess the accessibility of existing facilities, particularly publicly owned facilities, to ensure that they are accessible to all residents including seniors and children, disabled individuals, and individuals without vehicles. Street and other public realm improvements should be designed to better accommodate bicycle and pedestrian travel to facilities.
- **ENCOURAGE COMMUNITY CO-CREATION AND/OR CO-OWNERSHIP OF CLIMATE RESILIENCE HUBS.** The City should encourage and support community members and other stakeholders in co-creating and co-owning climate resilience hubs. For example, in activating existing city facilities like libraries and schools for climate resilience hubs, the City should invite residents and trusted community leaders to help design and implement hub operations and programming. In communities undergoing neighborhood change, including East Boston and Roxbury, the City should consider ways to support community land banking efforts, which could help secure space for new, community-owned facilities to serve as climate resilience hubs.
- **CONTINUE TO REDUCE VULNERABILITY TO CLIMATE IMPACTS.** In addition to investing in social infrastructure in high-priority areas, the City and other stakeholders should undertake efforts to reduce physical vulnerabilities in high-priority tracts by addressing issues like high impervious surface coverage, flood exposure, and low-quality building stock.

Looking only at physical infrastructure will never be enough to ensure that our communities and our neighbors can not only withstand climate impacts, but also bounce back quickly when catastrophe strikes. It is imperative that we consider social resilience and the social infrastructure needed to achieve it. The neighborhoods highlighted in this study are currently the highest risk in terms of both the social and physical risks of climate impacts in the City of Boston. The City can and must support and develop climate resilience hubs to ensure that our communities have the resources they need now and into the future.

INTRODUCTION

Conservation Law Foundation (CLF) partnered with Communities Responding to Extreme Weather (CREW) to conduct this analysis of the physical and social vulnerability of Boston's neighborhoods. The goal of this analysis is to identify areas within the City of Boston that could benefit from the activation of a "climate resilience hub" and where efforts should be prioritized to establish, support, and fund institutions to serve this purpose.

Climate resilience hubs are community institutions – including local businesses, nonprofits, community centers, libraries, places of worship, and schools – that have committed to aiding the community before, during, and after extreme weather events. This assistance can be in the form of educational events and information, or material items and services, like phone charging during a power outage.

PEW TRUSTS defines a resilience hub as "neighborhood centers that are designed to coordinate culturally sensitive, multilingual services to better meet the needs of diverse groups of community members. In addition to the day-to-day benefits, hubs can provide a safe place for temporary shelter and relief during days of extreme heat or operate as centers for distributing necessities such as food and multilingual information after disaster events such as floods. Year-round, they can offer space and programming for community-building efforts that increase resilience when emergencies occur."[1]

As climate change makes extreme weather events more frequent and severe, emergency services are increasingly overburdened. Climate resilience hubs provide relief by empowering local institutions to share the load and work on behalf of their communities. Resilience hubs can thus simultaneously shift power to communities and increase community capacity.[2] CREW's climate resilience hub initiative seeks to leverage community institutions to help residents respond to extreme weather events.

Climate resilience hubs play an important role throughout the year – not just in the event of extreme weather or other events. Resilience Hubs should be able to function in three situations: (1) normal/ everyday, (2) disruption, and (3) recovery.[3]

- In their **normal operations**, resilience hubs can provide basic programming and services to the community, including dissemination of information and educational materials about preparedness.
- During **disruption mode**, resilience hubs can serve as a central point of gathering and share the workload of local and government organizations in providing relief.
- In **recovery mode**, resilience hubs continue to play a critical role in communications by disseminating information and providing community support.

1 Rogerson, B., & Narayan, M. N. (2020, June 22). Resilience Hubs Can Help Communities Thrive—and Better Weather Disasters. PEW. https://www.pewtrusts.org/en/research-and-analysis/articles/2020/06/22/resilience-hubs-can-help-communities-thrive-and-better-weather-disasters

2 Baja, K. (2018, March 28). Resilience Hubs Shifting Power to Communities and Increasing Community Capacity. Urban Sustainability Directors Network. https://www.usdn.org/uploads/cms/documents/usdn_resiliencehubs_2018.pdf

3 Baja, K. (2019, October). USDN Guide to Developing Resilience Hubs. Urban Sustainability Directors Network. http://resilience-hub.org/wp-content/uploads/2019/10/USDN_ResilienceHubsGuidance-1.pdf

In Boston, and elsewhere in Massachusetts, CREW has been working to recruit trusted anchor community institutions to embrace their role as climate resilience hubs. Currently, CREW has recruited 15 such hubs across Massachusetts, as well as three outside of the state. Thanks to a close partnership with the Mass Library System, most of these hubs are libraries, though commited hubs also include houses of worship and a community center. As the program is still in its first year (one substantially disrupted by the pandemic, no less), the benefits of this program have yet to be fully realized. But as more hubs are recruited and as their community engagement and programming becomes more sophisticated and best practices are shared across hubs, Massachusetts residents should be more resilient in the face of the many challenges that climate change will bring.

CREW's Climate Resilience Hub Initiative

CREW recruits and supports local institutions to become climate resilience hubs with the goal of having every Bostonian within 20 minutes of a hub by 2030.

Community institutions can participate by displaying a climate resilience hub window decal and having brochures about extreme weather preparedness available to their patrons. All hubs are also required to organize at least one yearly educational event about climate preparedness. Beyond that, hubs are encouraged to think independently (and work with CREW) to determine what additional services they might be able to provide to the community.

CREW assists hubs by providing educational materials on emergency preparedness, sample workshops, presentations, and role-playing activities related to extreme weather preparedness; maintaining an online database with information about the services that each hub provides; facilitating inter-hub coordination and sharing of best practices; and alerting hubs to impending extreme weather events and helping them connect to emergency managers before, during, and after these events.

There are three different levels of action: Hub, Center, or Shelter.

LEVEL ONE

Hub

Serve as outreach, education, and engagement hub for your community

LEVEL TWO

Center

Serve as outreach, education, and engagement hub for your community

Serve as electricity/internet/cooling provider during extreme weather events

LEVEL THREE

Shelter

Serve as outreach, education, and engagement hub for your community

Serve as electricity/internet/cooling provider during extreme weather events

Serve as overnight, powered, supply-equipped emergency shelter during extreme weather events

For more information, visit www.climatecrew.org/resilience_hubs

THE ROLE OF SOCIAL RESILIENCE IN MANAGING CLIMATE RISKS

Climate adaptation and resilience in the City of Boston and elsewhere is often discussed in the context of gray and green infrastructure to protect against risks like flooding and heat. Gray infrastructure strategies may include sea walls and levees, whereas green infrastructure strategies may include wetlands, berms, and living shorelines. Of course, hybrid gray-green infrastructure strategies are also common. But these are not the only types of infrastructure that are important for addressing climate risks. Social resilience is a key, and often underutilized, strategy for ensuring that a community can endure and bounce back from more extreme weather. Social infrastructure, like schools, community centers, and libraries, is often referred to as "soft" infrastructure.

Social infrastructure provides communities with the ability to "respond, reorganize, and adapt at a highly local level to cope with shocks" by tapping into existing community capital, institutions, and networks.[4] Resilience strategies that leverage social infrastructure are sometimes more simplistic than engineered solutions, but extremely impactful.[5] For Boston to successfully confront climate risks, it must broaden its approach beyond modifying physical infrastructure and embrace the role of social infrastructure as well.

COMMUNITY INSTITUTIONS & RESILIENCE

Leveraging social infrastructure – including existing community institutions, like schools, libraries, and community centers – to serve emergency response functions is not a new concept. In Boston and many other cities across the United States, "cooling centers" are commonly used during extreme heat events. The concept of cooling centers should be expanded on to serve residents during all extreme weather events and catastrophes – not just heat. Cooling centers can provide a roadmap for how to leverage existing community institutions to provide residents with critical resources and services during an emergency.

Cooling centers are facilities – usually a school or community center – that provide access to air conditioning for people who do not otherwise have easy access to a safe, cool environment. This often includes low-income individuals, seniors, children, persons experiencing homelessness, and others.[6] Cooling centers commonly have amenities like a generator, drinking water, medical supplies, heat-health education materials, and trained staff who can recognize the signs of heat illness.[7] Studies have shown cooling centers help reduce illness and death related to extreme heat.[8]

4 Marini, M. (2013, August 12). Resilient cities need social infrastructure too. Get Resilient. http://getresilient.com/2013/08/12/resilient-cities-need-social-infrastructure-too/.
5 Marini, 2013.
6 Widerynski, S., Schramm, P., Conlon, K., Noe, R., Grossman, E., Hawkins, M., Nayak, S., Roach, M., & Shipp Hilts, A. (2017). The Use of Cooling Centers to Prevent Heat-Related Illness: Summary of Evidence and Strategies for Implementation (p. 22). Centers for Disease Control and Prevention. https://www.cdc.gov/climateandhealth/docs/UseOfCoolingCenters.pdf.
7 Widerynski et al., 2017, p. 17.
8 Widerynski et al., 2017, p. 5.

Over the past few years, cities across the country have been exploring ways to expand on the concept of cooling centers to provide respite during all types of extreme weather events, not just heat. Baltimore pioneered the concept of resilience hubs in 2014 and, since then, the idea has spread across the U.S., including to Minneapolis, Miami, Washington, D.C., San Francisco, Vancouver, and now Boston.[9]

In addition to providing a roadmap for leveraging existing institutions for emergency response, cooling centers may also shed light on how climate resilience hubs can be more effective. An evaluation of current cooling center practices may be useful for designing and implementing climate resilience hubs. For example, a review of the literature on their effectiveness shows that common barriers to use of cooling centers include limited access to transportation, fear of or inability to leave home, not wanting to leave pets behind, populations not self-identifying as vulnerable, and a stigma that cooling centers are meant for seniors.[10] While this study focuses on the location of climate resilience hubs based on physical and social vulnerability, these barriers to access should also be considered.

GOING BEYOND THE INSTITUTION

CREW's model of climate resilience hubs encourages each hub to consider their role in advancing social infrastructure to extend beyond their physical infrastructure and into their surrounding community. For instance, while providing cooling shelters during heatwaves is a critical public service, there will always be a population of individuals unable or unwilling to relocate to a cooling shelter. And as extreme heat worsens, evenings will in many cases continue to maintain excessively high temperatures. As a result, CREW believes that a key part of the role of resilience hubs is to educate the community around best practices such as keeping cool in your residence, as well as to create systems and practices for welfare checks on vulnerable residents, so that those who are unable or unwilling to relocate still receive the support of the community to weather the coming storms.

IMPLICATIONS OF COVID-19

It is worth noting that localities have recently faced barriers in opening certain community institutions, including cooling centers, due to COVID-19. Some of the populations most vulnerable to extreme weather events like heat are also most vulnerable to the virus.[11] To adapt to the new reality, facilities have had to limit the number of people who can be inside at one time, implement fever checks, and, in some cases, close facilities altogether.[12]

Going forward, cities should consider strategies to increase the adaptability of climate resilience hubs to respond to and function in the face of public health threats like COVID-19. That could mean having more locations, using some locations as distribution centers for supplies like food and clothing, or supplementing services by delivering people the resources they need to safely stay in their own homes.[13]

9 Rogerson, & Narayan, 2020.
10 Widerynski et al., 2017, p. 17.
11 Sauro, S. (2020, July 22). Pandemic, heat wave could be deadly combination, especially for elderly. LNP. https://lancasteronline.com/news/local/pandemic-heat-wave-could-be-deadly-combination-especially-for-elderly/article_c16c24de-cb8f-11ea-ac25-bb150ae1d7a9.html
12 Simon, S. (2020, June 13). COVID-19 Pandemic Keeps Cooling Center Closed Despite Rising Temperatures. [Radio broadcast transcript]. NPR. https://www.npr.org/2020/06/13/876522024/covid-19-pandemic-keeps-cooling-center-closed-despite-rising-temperatures
13 Muse, Q. (2020, July 8). How Can the City Protect Residents From Extreme Heat Amid COVID? Philly Health Experts Have Ideas. Philadelphia. https://www.phillymag.com/healthcare-news/2020/07/08/extreme-heat-covid19-pandemic/

Resilience Hubs in Action

BALTIMORE RESILIENCE HUBS[14]

The City of Baltimore is credited with pioneering the concept of resilience hubs in 2014.[15] Baltimore's Health Department and Office of Sustainability have since collaborated with hub leaders to expand and improve services at the city's six existing hubs and select locations for three new ones.[16] To help identify gaps in hub locations and inform future site selection, city staff mapped climate, health, and demographic data. The analysis identified three neighborhoods where hubs could provide essential services.[17]

One important function of resilience hubs is providing residents power during extreme weather events and other emergencies. At the state level, the Maryland Energy Administration administers a grant program to help fund resilience hubs serving low-to-moderate income residents. Specifically, the grants support solar-plus-energy storage systems so that resilience hubs can provide no-cost energy to surrounding residents during periods of grid outage. This allows residents to keep safe from severe temperatures, preserve medications, and stay connected with family and friends with a fully charged cell phone.[18]

SEATTLE COMMUNITY EMERGENCY HUBS[19]

The City of Seattle has expanded on the concept of cooling centers to provide "community emergency hubs."

The Seattle Office of Emergency Management has advised residents that "after a major disaster, first responders may not be able to help you for 7 to 10 days" and that hubs are "natural gathering places in the community where people meet to help each other until City systems are restored." Seattle currently has 135 designated hubs throughout the city. An interactive map is available on the city website so that residents can locate the nearest hub.

Some examples of hubs include small business locations and faith-based centers. Notably, under the Seattle model, city-owned facilities are not eligible to become hubs.

14 Nelson, L. (n.d.). Emergency Management. Seattle.gov. https://www.seattle.gov/emergency-management/prepare/prepare-your-neighborhood/community-emergency-hubs.
15 Curran, C., & Pottiger, M. (n.d.). City government reaches out to community leaders to create 'hub' network that helps Baltimoreans cope with emergencies — but some say scope is too narrow. Capital News Service. https://cnsmaryland.org/interactives/fall-2019/hubs/index.html.
16 Rogerson, & Narayan, 2020.
17 Rogerson, & Narayan, 2020.
18 Maryland.gov (n.d.). Grant application deadline extended to April 15, 2019 on a first come, first served basis. https://energy.maryland.gov/Pages/Resiliency-Hub.aspx.
19 Nelson, n.d..

PART II

IDENTIFYING HIGH-PRIORITY AREAS

The City of Boston has a unique mix of geographic and demographic characteristics across neighborhoods. Some areas of the city are more susceptible to harm caused by climate risks based on neighborhood characteristics, making them "climate-sensitive." These areas of the city should be prioritized for investment in climate resilience hubs.

CLIMATE HAZARDS IN BOSTON

The City of Boston is already experiencing the effects of climate change with more extreme heat and flooding. These impacts are expected to become more severe over the next few decades, including more hot days, increased extreme precipitation, and greater amounts of sea level rise. The City's Climate Ready Boston report projects that by 2070, the city will see at least three feet of sea level rise and nearly twice the amount of hot days (above 90 degrees Fahrenheit).

We know that these effects will not be felt evenly throughout the city. Some neighborhoods, like Roxbury, already suffer from hotter summer days and worse urban heat island effect. East Boston and South Boston are expected to have the most land affected by coastal flooding and sea level rise. Within these communities, certain populations will be more vulnerable to climate impacts, including older adults, children, people of color, people with limited-English proficiency, low-income individuals, people with disabilities, and people with medical illnesses.

These communities are climate-sensitive because residents are less likely to have the physical or financial capability or flexibility to evacuate during an extreme weather event. They also are less likely to have the resources and supplies to shelter in place. Some of these neighborhoods may also face circumstances that exacerbate their risk to impacts like extreme heat and flooding, such as low-quality building stock, poor access to transportation, and poor internet quality.

METHODS

This analysis aims to identify high-priority areas within the City of Boston to help inform efforts to create and support Climate Resilience Hubs. High-priority areas were identified based on three components: social vulnerability, built environment factors, and climate hazards, including heat and flooding. To consider both heat and flooding hazards, we employed the following methodology:

- **Climate-sensitive census tracts for extreme heat:** A composite indicator was developed based on data for social vulnerability, built environment characteristics, and land surface temperature. We identified the top ten highest scoring tracts. The details of these data are included in Figure 1 below.
- **Climate-sensitive census tracts for flooding:** A second composite indicator was developed based on data for social vulnerability, built environment characteristics, and the one percent annual storm event ("100-year storm") for the years 2030, 2050, and 2070. The flood data was incorporated by overlaying it with the combined social vulnerability and built environment data. For each of the three floodplains, we identified the top ten highest scoring tracts. The details of these data are included in Figure 1 below.

- **Why are heat and flooding separated out?** Census tracts were selected individually for heat and flood risk, instead of combining all of the data into one indicator, to account for the fact that some areas of the city are at risk for extreme heat but not flooding and vice versa. By identifying the tracts individually based on each risk, we can identify the highest scoring tracts that are at risk for heat, flooding, and both.

- **The final high-priority tracts:** A list was generated based on the two data analyses described above, which included the highest scoring tract lists (top ten) for both flood and heat. The result was 22 high-priority census tracts.[20]

To be clear, all of Boston's neighborhoods are expected to experience impacts from climate change. Some neighborhoods may even face greater risks for heat or flooding than the areas identified in this report. But the ability of Boston's neighborhoods to withstand and recover from climate risks is not equal. The goal of this report is to acknowledge that some neighborhoods face both physical and social risks, making them more vulnerable to climate change. The City can leverage social infrastructure in these communities to help address the ability of *people*, not just structures, to adapt to and rebound from disruptions, including extreme weather.

FIGURE 1: DATA POINTS FOR HIGH-PRIORITY TRACTS

Component	Data points	Why these data points?	Data Source
Social vulnerability	The indicator is composed of four data points, each with their own component variables, including the following categories: - Socioeconomic status (this includes poverty and employment statuses, income, and education) - Household composition & disability - Minority status & language - Housing type & transportation	These demographic factors are related to historic and current racial disparities. Individuals with fewer resources are also less likely to have alternative places to go in the event of extreme weather. Children, elderly, and disabled individuals are especially vulnerable from a public health perspective. Crowded housing and poor access to transportation are also risk factors.	Center for Disease Control (CDC) Social Vulnerability Index - 2018

20 The final total accounts for tracts that were identified in both the heat and flooding analyses. The "top ten" tracts for the composite flood indicator combines the top ten tracts from each time horizon (2030, 2050, and 2070). However, many of these tracts overlapped, which resulted in a total of 12 tracts.

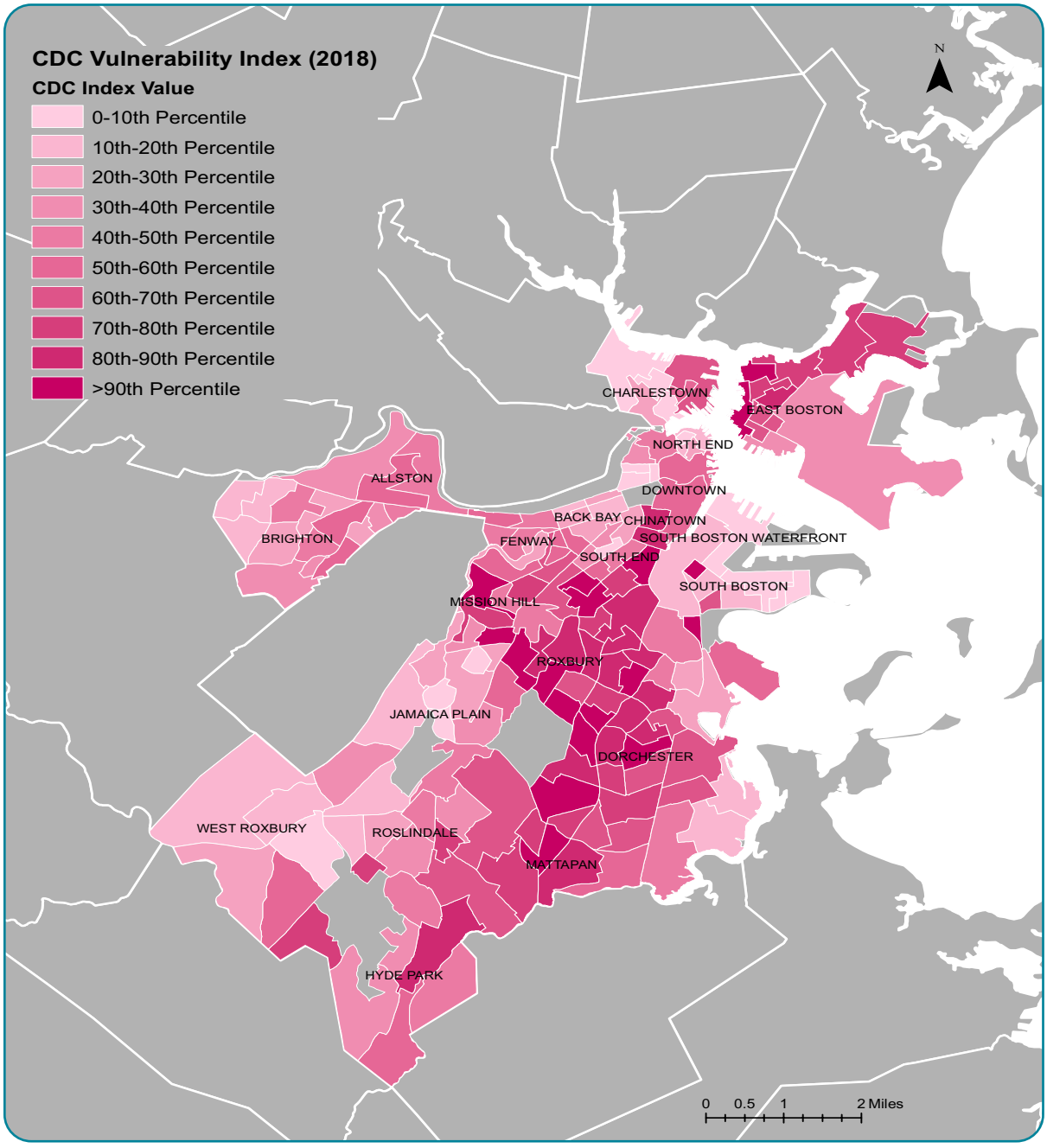
Built environment	Internet speed	Access to high-quality internet is important for keeping residents connected, making sure they can access their networks, and get critical information during emergencies	Federal Communications Commission Fixed Broadband Deployment Data from FCC Form 477 – Data current from June 2019
	Building code violations	Building code violations are used here as a proxy for the safety and quality of building stock. The total number of violations are divided by the total number of lots within each census tract.	City of Boston Inspectional Services – Provided via Analyze Boston – 2009- July 2020
	Renovations	Renovation data is used here as a proxy for investment in building stock and is a counterbalance to data on building code violations. The total value of renovations is divided by the total number of lots within each census tract.	City of Boston Inspectional Services – Provided via Analyze Boston - 2009-July 2020
	Impervious surface	Impervious surfaces, particularly roads and parking lots, generally absorb heat, which can contribute to urban heat island effect. Impervious surface also increases stormwater runoff and can exacerbate flooding.	Metropolitan Area Planning Council Parcel Data
Climate hazards	Flooding from 1 percent annual chance storm event 2030, 2050, 2070	Sea level rise over the next 50 years is expected to increase the extent of flooding during an extreme storm event. In some cases, this means that neighborhoods that never or rarely flood today will experience flooding in the future.	City of Boston Climate Ready Boston
	Land surface temperature/ urban heat island	Similar to impervious surface, land surface temperature is an indicator of where heat absorption is greatest. It is used as a proxy for urban heat island.	Metropolitan Area Planning Council LandSat Analysis of Land surface temperature

INDICATOR MAPS

Map 1: Social Vulnerability

The indicators used here for social vulnerability are defined by the Center for Disease Control (CDC) and include socioeconomic status, household composition, disabilities, minority status and language, housing type and transportation.

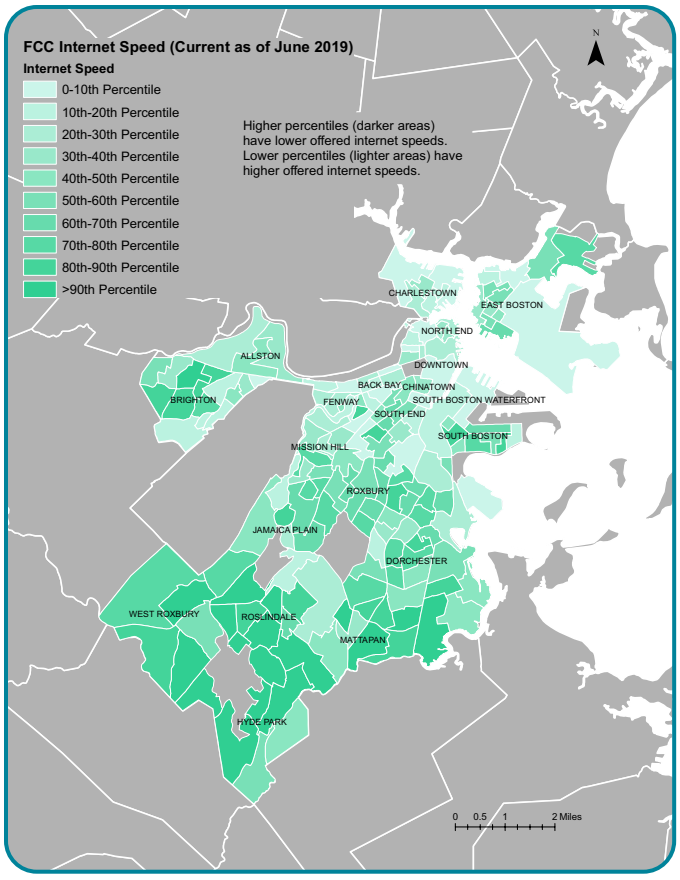
Social vulnerability is highest in Roxbury, Mission Hill, Dorchester, and East Boston. Parts of Hyde Park, Roslindale, and South Boston also have pockets of high social vulnerability.



Map 2: Internet Speed

Internet speed can be important before, during, and after an emergency. It helps residents stay connected to their social networks and get critical information.

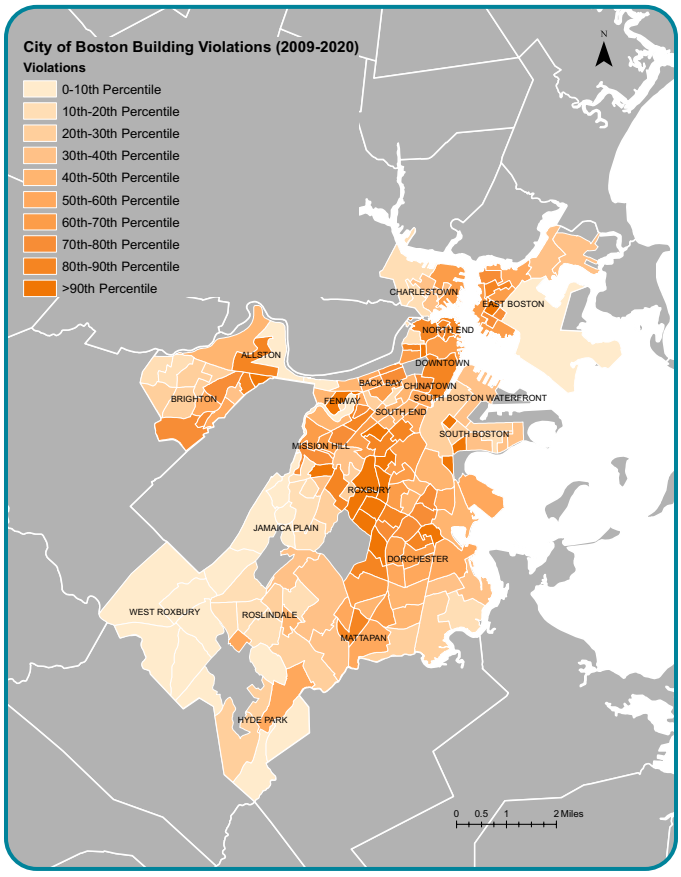
The slowest offered broadband speeds are in Hyde Park, West Roxbury, and Roslindale. Pockets of Brighton, Dorchester, Mattapan, South Boston, and Mission Hill also have low speeds.



Map 3: Building Code Violations

Building code violations can be used as a proxy for the safety and quality of building stock. This map shows the total number of building code violations divided by the total number of lots within each census tract.

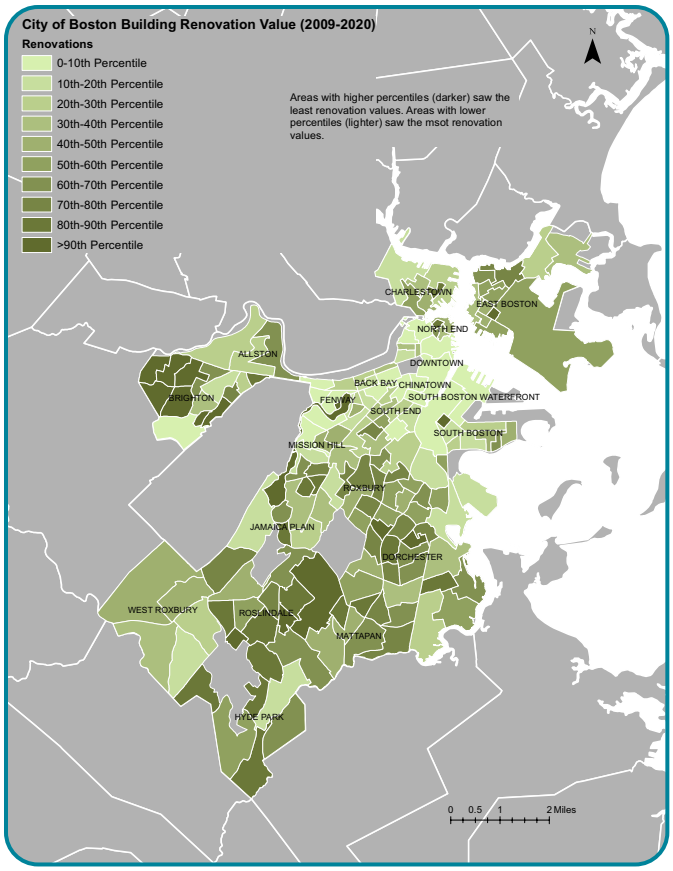
High building code violations are observed in Roxbury, Dorchester, South Boston, and Brighton.



Map 4: Renovations

Renovation data indicates where investment in building stock is taking place. This map shows the total value of renovations divided by the total number of lots within each census tract.

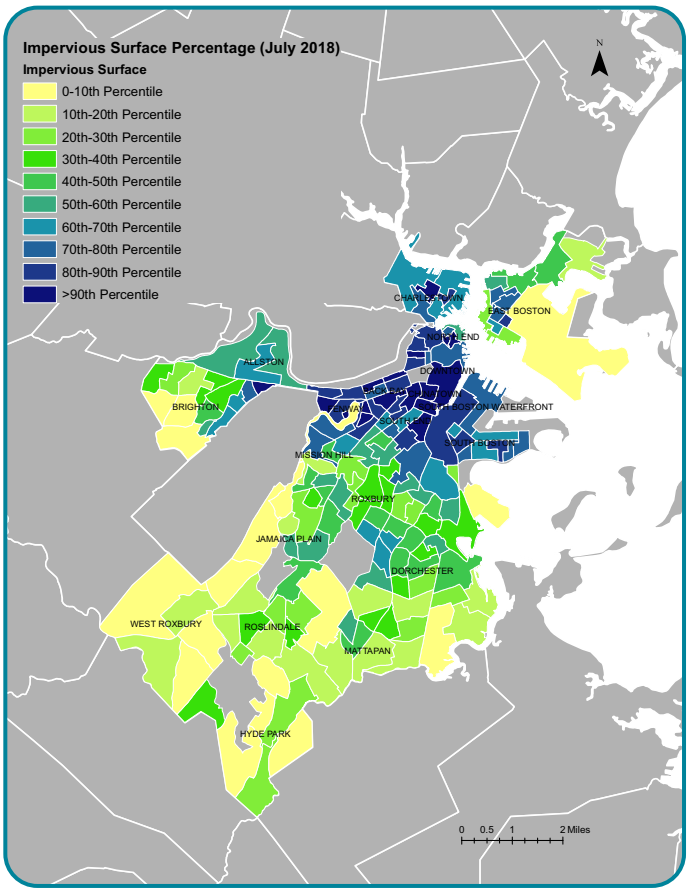
The lowest renovation values are observed in Roxbury, Dorchester, Hyde Park, Roslindale, and Brighton.



Map 5: Impervious Surface

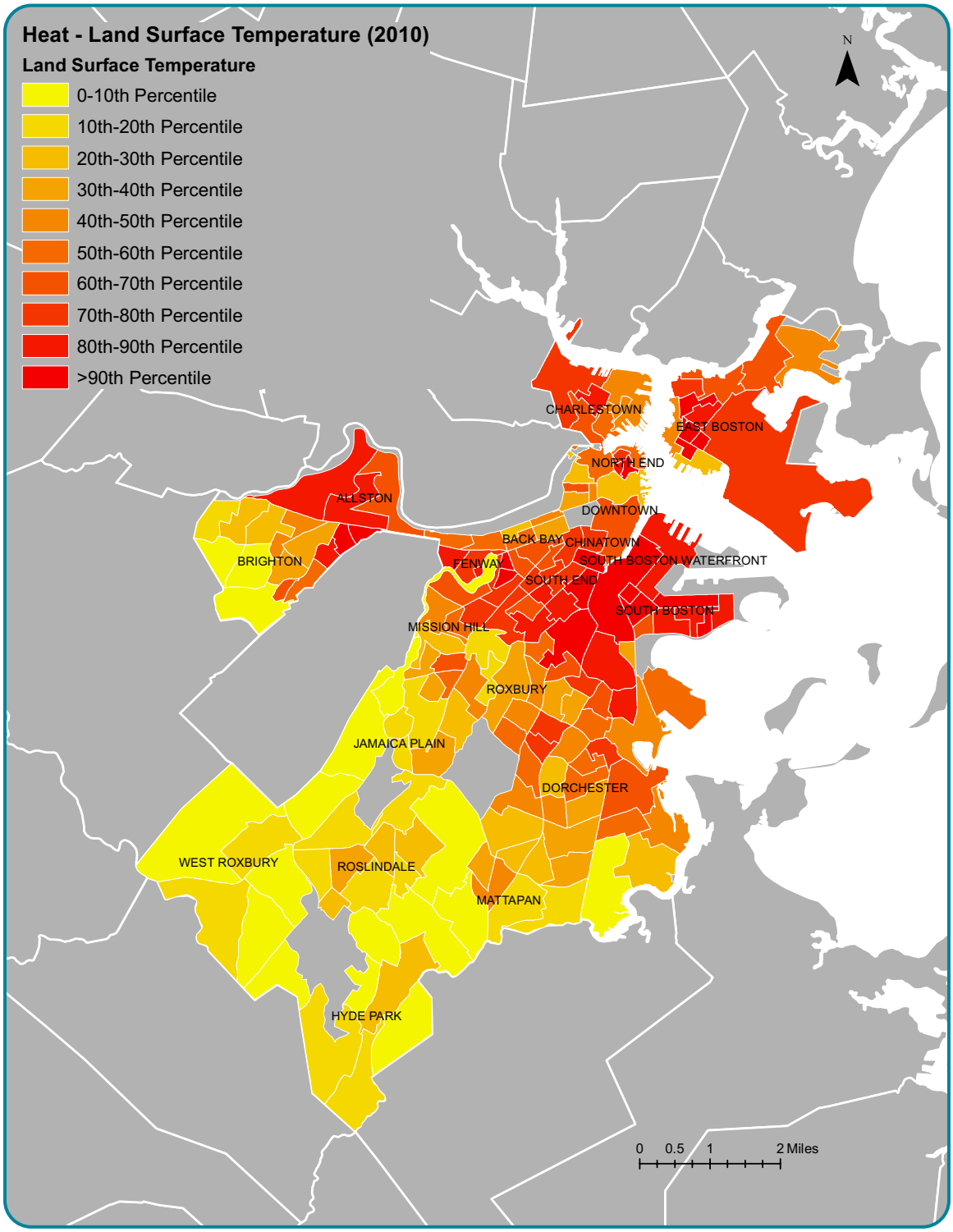
High impervious surface coverage is an indicator of higher heat absorption and increased stormwater runoff.

The areas with the most impervious surface coverage include Downtown, East Boston, and Allston. In general, there is less impervious surface coverage farther out from the Downtown core.



Map 6: Land Surface Temperature

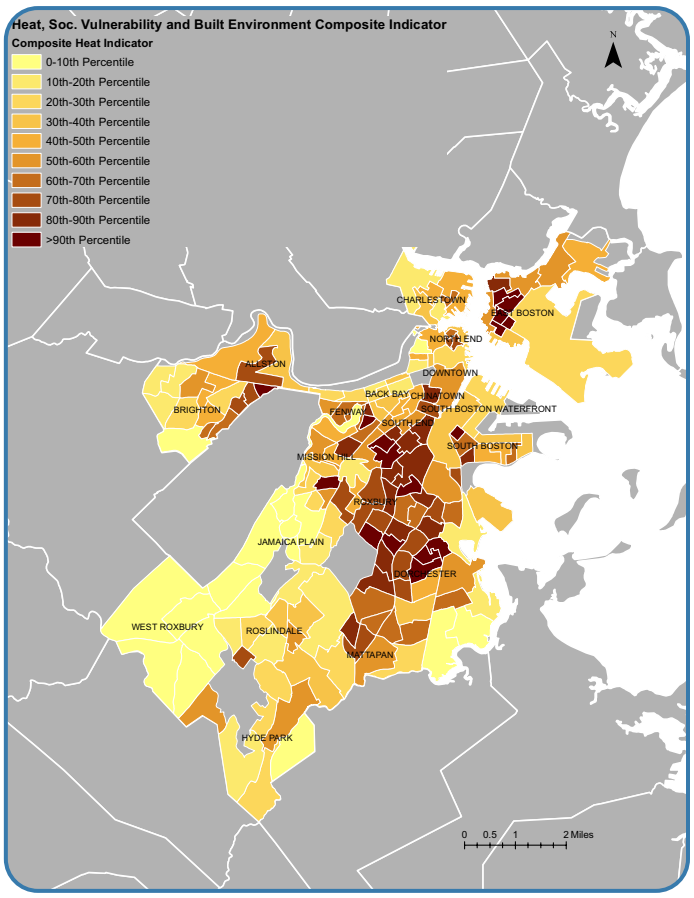
Land surface temperature is an indicator of where heat absorption is the greatest and can serve as a proxy for urban heat island effect. The highest land surface temperatures are in East Boston, Downtown, Roxbury, Dorchester, and Allston. It relatively mirrors the areas with high impervious surface coverage in Map 5.



Map 7: Composite Indicator for Heat, Social Vulnerability, and Built Environment

The composite indicator for this map was developed based on combined census data for social vulnerability and built environment characteristics as well as data on land surface temperature.

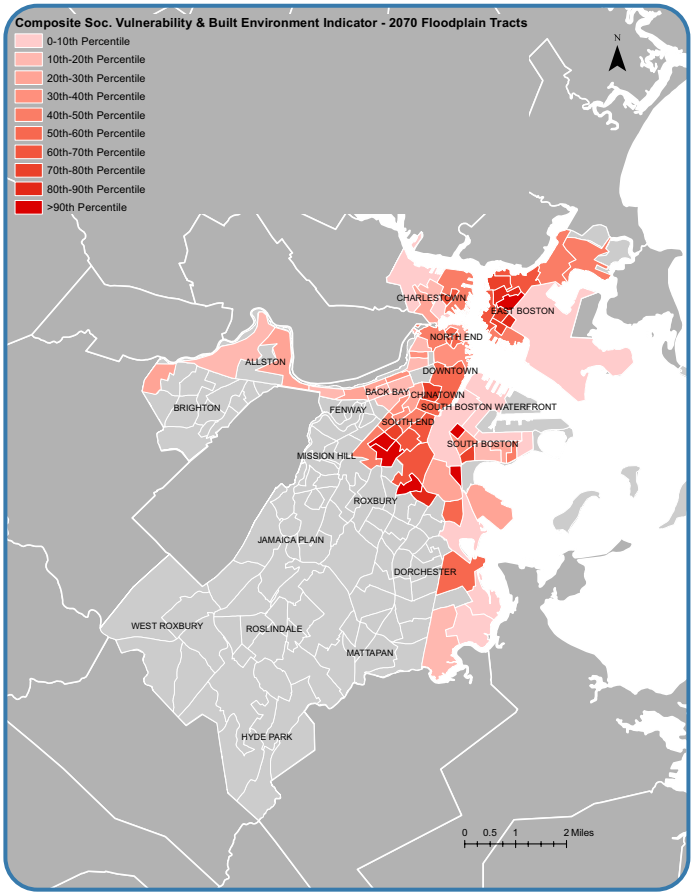
The map shows the areas where these indicators come together to create high-risk.



Map 8: Composite Indicator for Flooding, Social Vulnerability, and Built Environment

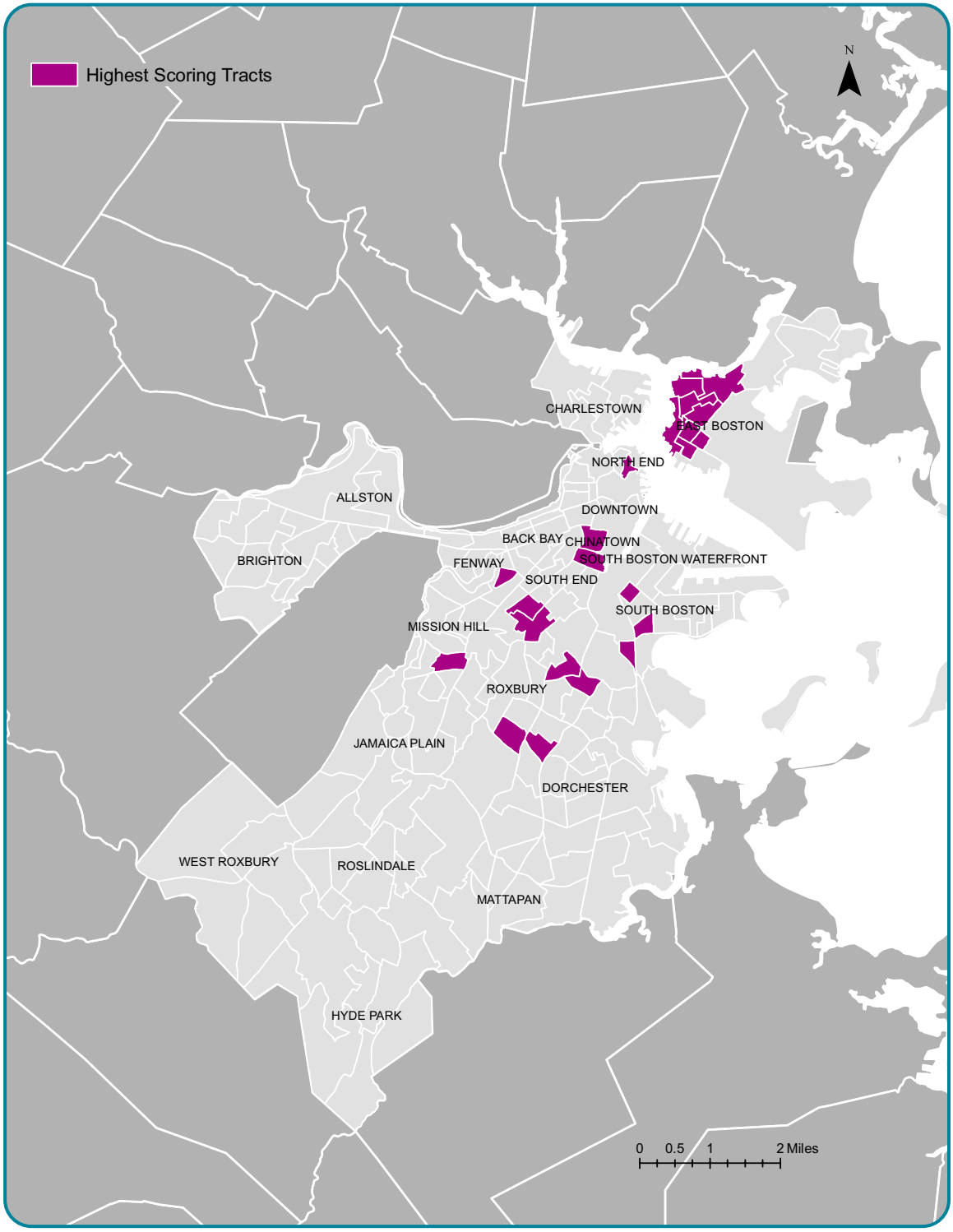
The composite indicator for this map was developed based on combined data for social vulnerability, built environment characteristics as well as the one percent annual storm event ("100-year storm") for the years 2030, 2050, and 2070.

The map shows the areas where these indicators come together to create high-risk.



Map 9: High-Priority Tracts – Heat & Floodplain

The final list of high-priority census tracts was generated based on the two composite indicators shown in Maps 7 and 8, which included the highest scoring tracts (top ten) for both flood and heat. The result is 22 high-priority tracts.



Of the 22 high-priority tracts, eight are in East Boston, four are in Roxbury, three are in South Boston, and two are in Dorchester. One high-priority tract each is in Chinatown, Fenway, Jamaica Plain, the North End, and the South End.

Notably, six tracts are identified for both heat and flooding vulnerability. Of these, three are in East Boston and lie within the floodplain for all time periods. The remaining three – two in Roxbury and one in South Boston – are within the floodplain for the 2070 time horizon only.

FIGURE 2: TRACTS BY NEIGHBORHOOD - POPULATION OF HIGH-PRIORITY TRACTS

Neighborhood	Total Tracts	Total High-Priority Tracts	Total Population in High-Priority Tracts[21]	Share of Neighborhood Population in High-Priority Areas	Hazards Present in High-Priority Tracts
Chinatown	1	1	5,622	100%	2050 Floodplain
East Boston	15	8	31,241	59%	Heat; 2030, 2050 and 2070 Floodplains
North End	4	1	2,715	29%	2030 Floodplain
Roxbury	17	4	14,826	27%	Heat; 2070 Floodplain
South Boston	12	3	8,142	22%	Heat; 2070 Floodplain
Fenway	8	1	5,223	15%	Heat
South End	6	1	2,398	11%	2030 Floodplain
Jamaica Plain	15	1	3,664	7%	Heat
Dorchester	29	2	5,148	4%	Heat

East Boston and Roxbury have the highest number of individual residents living within these high-priority tracts. Chinatown and East Boston have the highest shares of neighborhood population living within these high-priority tracts.

21 Note that in identifying population totals and assigning these to neighborhoods, we created centroids for each census tract, which are located in the center of each tract. Though some tracts overlap over neighborhood boundaries, we assigned population counts by whether a tract centroid fell within neighborhood boundaries. We did not attempt to proportionally assign populations to neighborhoods by land area or any other method.

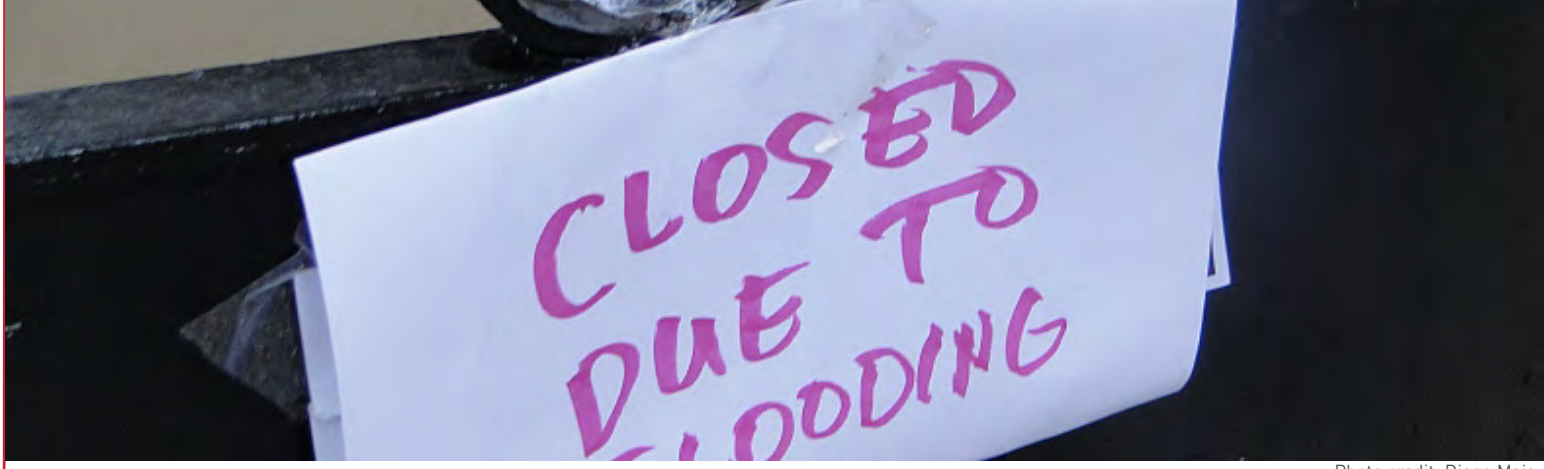


Photo credit: Diego Maia

PART III

MAPPING EXISTING COMMUNITY INSTITUTIONS IN HIGH-PRIORITY AREAS

New resilience hubs may be needed in climate-sensitive areas where there are currently gaps and either no existing community institutions or existing community institutions are unable to serve as resilience hubs.

The Urban Sustainability Directors Network (USDN) describes "existing well-used or well-trusted buildings" as the core of resilience hubs. According to USDN, buildings should be in fairly good condition and able to support critical elements like solar and energy storage systems.[22] Other key components include community support, energy systems, community uses, and resources to meet community needs during extreme events.[23] In the near-term, existing, trusted, and well-known community institutions can successfully serve as climate resilience hubs.

The facilities included in this analysis are schools, places of worship, libraries, and community centers. Numerous other sources of social infrastructure in Boston's neighborhoods could be considered for climate resilience hubs as well. This study prioritizes these four facility types because they are likely to be: 1) well-positioned to take on the functions of a climate resilience hub without much outfitting, 2) well-known and trusted in the community, and 3) in good condition.

The majority of these existing community institutions are publicly owned and funded. This makes them more secure in their neighborhoods than privately owned businesses or facilities that may be prone to displacement from rent increases and other dynamics. (Neighborhood stability is discussed in Part IV). In particular, the community centers – Boston Centers for Youth and Families – may be well-positioned to serve as resilience hubs as the City already utilizes many of them as cooling centers during the summer months.[24]

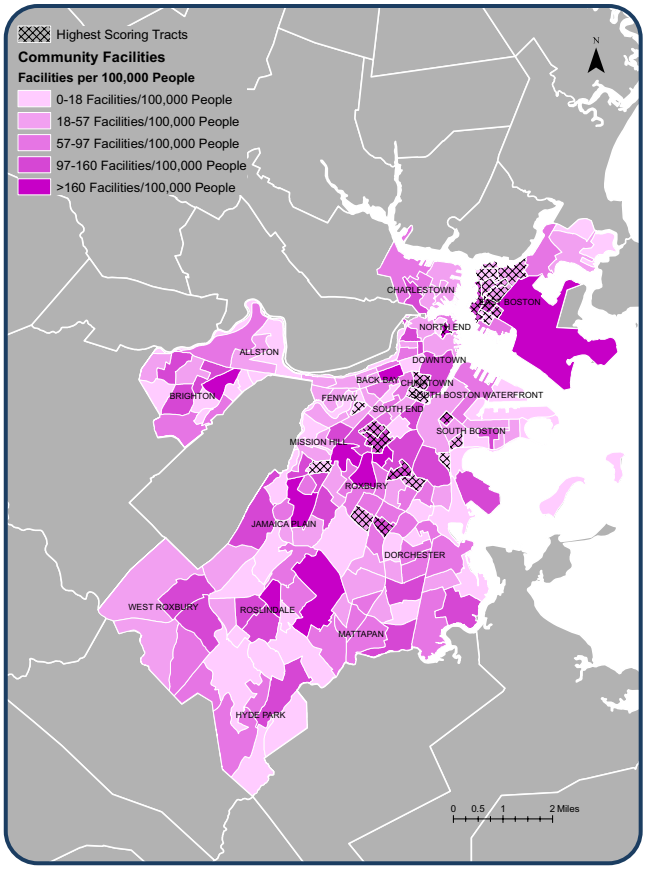
Further studies should investigate the potential for other types of facilities to serve as climate resilience hubs including small businesses, neighborhood association and nonprofit spaces, and others, particularly in areas where there are gaps in capacity. Future data gathering is also needed to understand the current capabilities of individual facilities including energy systems and sheltering capacity.

22 Baja, 2018.
23 Baja, 2018.
24 Boston Centers for Youth and Families (BCYF) serve as cooling centers during the summer months. Of the City's 36 BCYF facilities, 21 served as cooling centers this past summer.

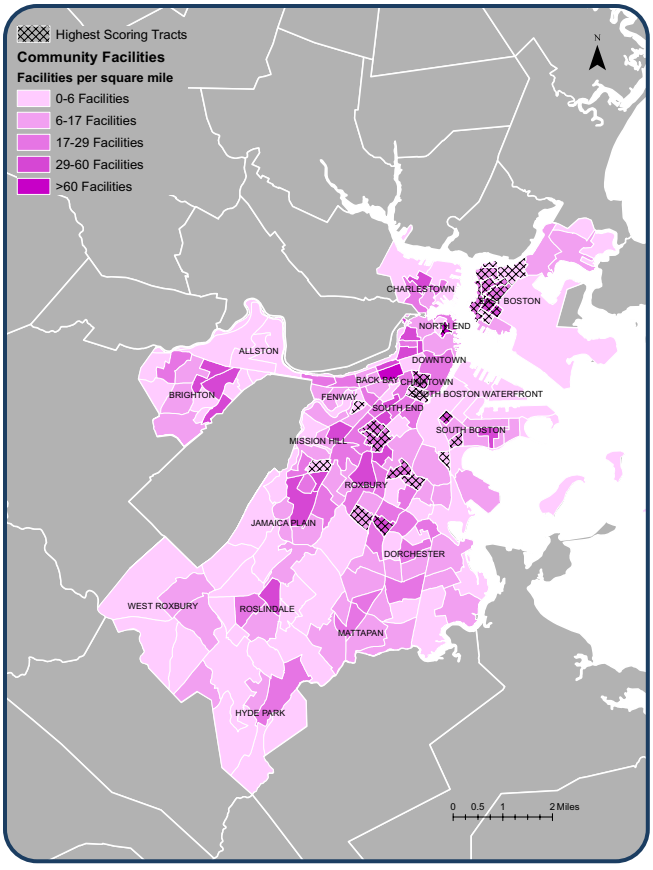
Across the 22 high-priority areas we identified, there are a total of 44 facilities, including 20 schools, 14 places of worship, 3 libraries, and 7 community centers, that could be used as climate resilience hubs. 6 of the 7 community centers were used this past summer as cooling centers, but the remaining facilities have not been activated as cooling centers or climate resilience hubs.

The City of Boston currently owns and operates the majority of the mapped facilities including all of the libraries and community centers. The 14 places of worship are privately owned and operated as well as 4 of the 20 mapped schools. Map 10 below shows the total number of Facilities per Square Mile, while Map 11 shows the total facilities per 100,000 People in the city."

Map 10: Facilities per Square Mile



Map 11: Facilities per 100,000 people



The chart below shows the total number of facilities in each of Boston's neighborhoods as well as facilities per square mile and facilities per 100,000 people. The latter statistic depicts facilities as a function of population because the facilities per square mile statistic may be misleading in neighborhoods that are smaller and denser.

FIGURE 3: NEIGHBORHOODS BY TOTAL FACILITIES, FACILITIES PER SQUARE MILE, AND FACILITIES PER 100,000 PEOPLE

Neighborhood	Total Facilities	Facilities Per Square Mile	Facilities per 100,000 People
Leather District	0	0	0.00
Fenway*	9	10.23	25.31
Charlestown	12	8.82	25.68
Longwood	3	10.34	27.32
Brighton	25	8.68	30.78
West End	5	16.67	33.05
Hyde Park	20	4.38	33.17
West Roxbury	25	4.55	39.53
Mission Hill	9	16.36	42.32
Bay Village	2	50	44.83
East Boston*	25	5.31	47.24
Mattapan	19	9	51.42
Chinatown*	3	25	53.36
Seaport	2	2.06	55.23
South Boston*	20	8.89	55.25
South End*	13	17.57	60.47
Dorchester*	79	10.84	62.47
Allston	17	10.9	65.69
Roslindale	23	9.16	77.75
Jamaica Plain*	39	9.9	79.16
North End*	8	40	85.55
Roxbury*	52	15.81	94.69
Back Bay	20	32.26	96.35
Beacon Hill	6	19.35	104.69
Downtown	10	16.13	180.02

The neighborhoods denoted with an asterisk are ones where one or more high-priority tracts are located. The highlighted neighborhoods are ones that have a community center in a high-priority tract that currently functions as a cooling center.

These figures help us identify where there may be existing capacity to support climate resilience hubs versus where there may be gaps. By neighborhood, Fenway, Charlestown, Longwood, and Brighton have the fewest facilities per 100,000 people. By geographic accessibility, the Seaport, Hyde Park, and West Roxbury have the fewest facilities per square mile. This demonstrates that the needs of individual neighborhoods will vary based on geographic size and population.

For instance, East Boston has one of the highest counts of existing facilities per neighborhood, but one of the lowest counts per square mile and per 100,000 people. Roxbury, on the other hand, has one of the highest counts per neighborhood and per 100,000 people. Different strategies may be needed depending on the current saturation and distribution of facilities in each neighborhood. For instance, in East Boston, there may be a need to look beyond existing schools, libraries, community centers, and places of worship for climate resilience hubs. Whereas, in Roxbury the focus may need to be on activating and ensuring accessibility to existing facilities.

INDICATORS OF NEIGHBORHOOD CHANGE AND STABILITY

In addition to climate hazards, urban neighborhoods are simultaneously facing a housing crisis, where rents and the costs of ownership are unaffordable to large shares of the population. In the City of Boston, just under half of all renters are cost burdened, meaning that they spend at least 30% of their income on rent; around 30% of homeowners are similarly cost burdened.[25]

It is well documented that Massachusetts has some of the highest housing costs in the nation.[26] A study by the National Community Reinvestment Coalition documents that Boston is one of the country's most "intensely gentrified" cities.[27] Rapid rent and housing cost increases can lead to displacement and housing instability. The legacy of housing discrimination, redlining, and other exclusionary policies means that neighborhoods of color are particularly affected.

Unstable housing situations and increased transience reduces the overall social resilience of neighborhoods. It is therefore relevant to climate resiliency, disaster response, and recovery. To summarize, "housing stability is also integral to community resilience, helping to enhance social cohesion, build community ties, and enable residents to stay better connected — particularly during extreme weather or other emergencies when neighbors often become each other's first responders."[28]

Given this connection, we reviewed the high-priority tracts for changes in affordability and demographic change. Neighborhood change is complicated, and there are many explanations as to why households may relocate. In addition, cities and researchers use multiple methods and indicators to measure displacement and gentrification. While no standard methodologies exist,[29] we consider the following indicators to measure neighborhood change and changes in affordability.

Our analysis shows that neighborhood change and stability compound climate risk in these neighborhoods.

25 United States Census Bureau (2019, December 19). American Community Survey 5-Year Data (2009-2018). https://www.census.gov/data/developers/data-sets/acs-5year.html
26 Lisinski, C. (2019, June 19). Rental Price Burden In Mass. Surpasses New York And D.C., Report Finds. WBUR. ttps://www.wbur.org/bostonomix/2019/06/19/rent-affordable-housing-crisis-income-ranking
27 Pan, D. (2020, July 10). Boston is the third most 'intensely gentrified' city in the United States, study says. Boston Globe. https://www.bostonglobe.com/2020/07/10/metro/boston-is-third-most-intensely-gentrified-city-united-states-study-says/
28 Georgetown Climate Center (n.d.). Resilient Affordable Housing, Anti-Displacement & Gentrification. https://www.georgetownclimate.org/adaptation/toolkits/equitable-adaptation-toolkit/resilient-affordable-housing-anti-displacement-gentrification.html
29 Preis, B., Janakiraman, A., Bob, A., & Steil, J. (2020). Mapping gentrification and displacement pressure: An exploration of four distinct methodologies. Urban Studies, 0042098020903011.

- **INCREASED RENTS AND MEDIAN HOME VALUE FOR OWNER-OCCUPANTS** in high-priority tracts are higher than the City's average rate of change.
- **CHANGES IN NEIGHBORHOOD DEMOGRAPHICS** were also observed in several of the high-priority areas at higher than average rates.
    - In East Boston there were notable average rent increases as well as demographic changes.
    - In Roxbury, home ownership costs have increased in addition to demographic changes.

Ultimately, resilience measures should be prioritized in high-priority tracts that are also subject to changes in affordability and neighborhood change because these neighborhoods may be facing greater barriers to social resilience.

FIGURE 4: DATA POINTS FOR NEIGHBORHOOD CHANGE/STABILITY

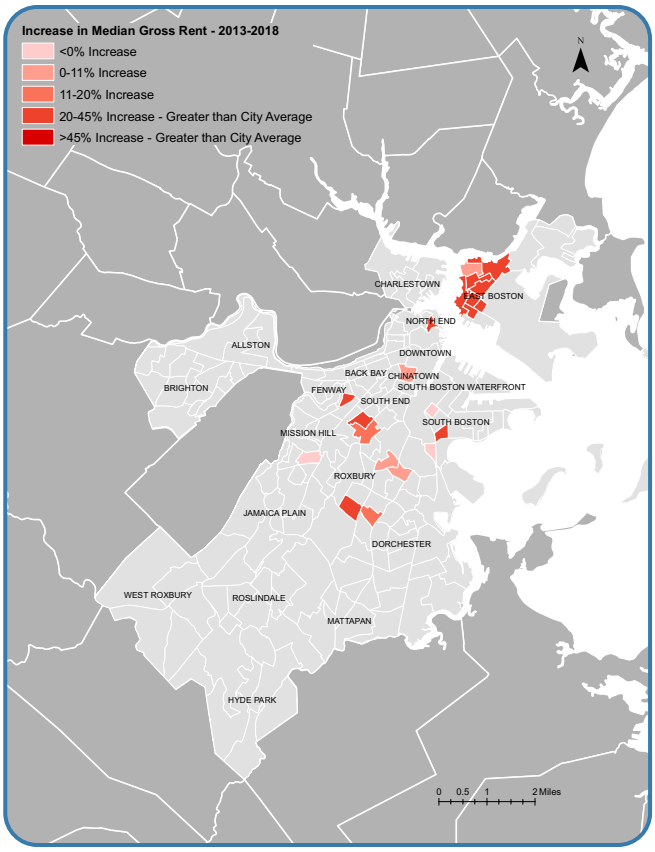
Data Points	Why these data points?	Source
Median Rent Prices	Changes in median rent over time indicates decreased affordability for existing renters.	ACS 2018, 2013 5-Year Estimates
Median Owner-occupied Home Value[30]	Changes in median owner-occupied home value may serve as a proxy for higher property taxes and indicate decreased affordability of new homeownership opportunities for low- and moderate-income residents.	ACS 2018, 2013 5-Year Estimates
Share of People of Color	Changes in the share of people of color indicates whether neighborhood composition is changing, potentially as a result of the following dynamics: • Households of color are more likely to experience housing instability compared to white households. • Neighborhoods of color have also seen new investment at price points that may be unaffordable to existing residents.	ACS 2018, 2013 5-Year Estimates
Share of Bachelor's Degree Holders	Changes in the share of people with bachelor's degrees is an indicator of neighborhood composition. People with more formal education are typically higher earners and have greater access to employment opportunities.	ACS 2018, 2013 5-Year Estimates

30 Owner-occupied homes are ones where the person who owns the home resides there as a primary residence. This is distinct from situations where a homeowner rents out their home and lives elsewhere. Owner-occupants include homeowners who live in a multi-family property and rent a portion of the house but also reside there as their primary residence.

Map 12: Rent Increases

Over the five-year period from 2013 to 2018, the median increase in gross rent for 13 out of the 22 high-priority tracts was greater than the city's median increase of 20%.

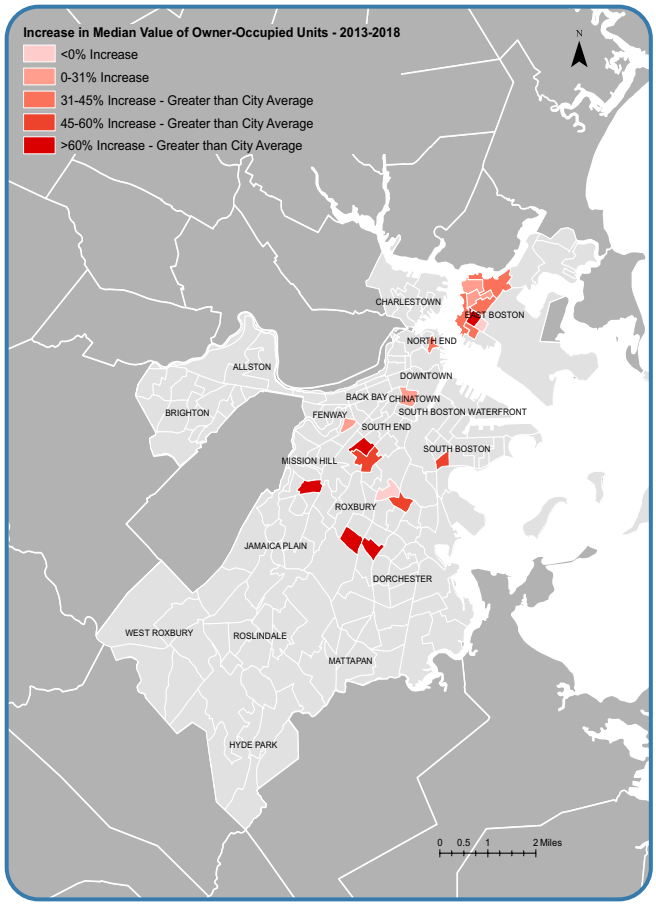
Rent increases were highest in East Boston, South Boston, and the North End.



Map 13: Owner-Occupied Home Values

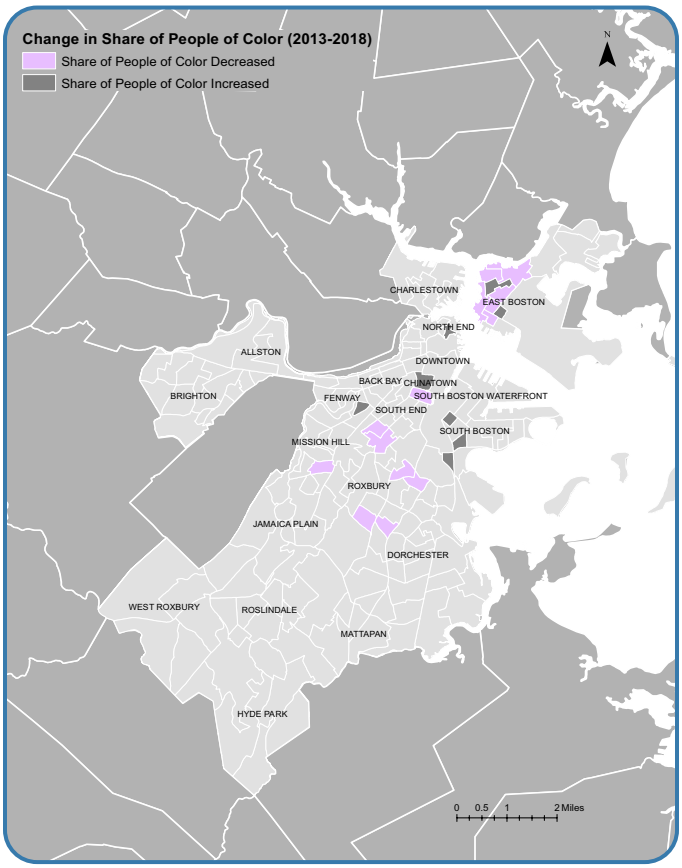
Over the five-year period from 2013 to 2018, the median increase in home value for owner-occupied homes was 31%. The median increase in home values in 12 out of the 23 high-priority tracts exceeded the city-wide median.

Home value increases were highest in Roxbury, Jamaica Plain, and Dorchester. This increase is particularly noteworthy in parts of Roxbury, Jamaica Plain, and Dorchester where there are already a higher number of cost-burdened homeowners as compared to the city-wide average.



Map 14: Share of People of Color

13 tracts became whiter between 2013–2018. This trend is especially apparent in Roxbury, Dorchester, and East Boston.



Map 15: Share of Bachelor's Degree Holders

16 tracts saw an increased share of bachelor's-degree holders between 2013–2018. This trend is especially apparent in Roxbury and East Boston.

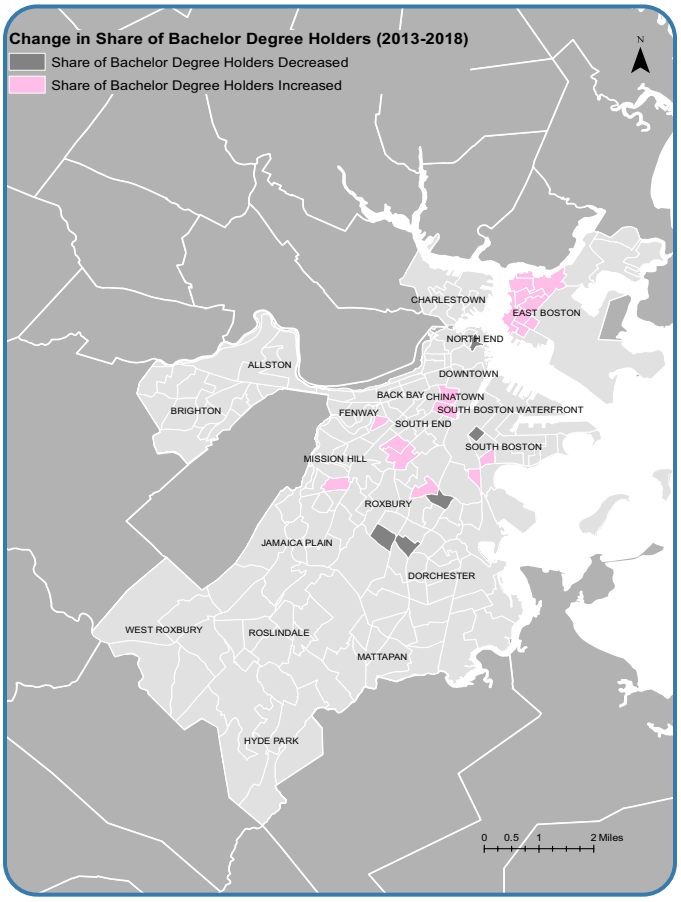


Photo credit: Rkcr

KEY FINDINGS

This report identifies a number of factors related to climate resilience, social resilience, and disaster preparedness. Boston's neighborhoods are unique and not all neighborhoods will require the same level of attention or investment. In the near-term, the City should focus on neighborhoods that face both physical and social risks that increase their vulnerability to climate change impacts. Within these neighborhoods, the City should prioritize areas facing changes in neighborhood composition and stability, as they may face additional barriers to achieving social resilience.

HIGH-PRIORITY AREAS:

- There are **22 "high-priority" census tracts in Fenway, East Boston, South Boston, Dorchester, Roxbury, Chinatown, Jamaica Plain, the North End, and the South End.** These areas are more physically and socially vulnerable to the impacts of climate change than other Boston neighborhoods.
    - Six of the 22 high-priority tracts are at risk for **both heat and flooding.** Of these six, three are in **East Boston,** two are in **Roxbury,** and one is in **South Boston.** This combination of risks makes these neighborhoods more vulnerable to climate change impacts.
    - **East Boston** and **Roxbury** have the greatest number of residents living within high-priority tracts.
    - **Chinatown** and **East Boston** have the greatest share of total neighborhood population living within high-priority tracts.
- **Chinatown's** entire neighborhood population is within one census tract. This means the entire neighborhood is high-risk, not just parts of it.

- **East Boston** and **Roxbury** face the most significant climate hazards, disparities in the condition of the built environment, housing affordability challenges, and changes in demographics as compared to other Boston neighborhoods. The combination of these factors makes these neighborhoods both physically and socially vulnerable to climate impacts.
    - **Physical risks**: Much of East Boston is located within the floodplain for all time horizons (2030, 2050, and 2070). It also has a relatively high share of impervious surface and high land surface temperature. Roxbury has high land surface temperatures and a high share of impervious surface. It also has a high number of building code violations and low value of renovations.
    - **Social risks:** Both East Boston and Roxbury are socially vulnerability as defined by the CDC's social vulnerability index, which includes indicators like socioeconomic status, disability, race, language, and housing type. Roxbury, in particular, has a high share of low-income people of color. Both neighborhoods have seen changes in housing affordability. East Boston has experienced a relatively high increase in rents and Roxbury has experienced a relatively high increase in the cost of homeownership. Both neighborhoods are also experiencing changes in composition, including a relative increase in white residents and a relative increase in bachelor's-degree holders.

EXISTING COMMUNITY INSTITUTIONS:

- Schools, libraries, places of worship, and community centers vary by neighborhoods. Facilities per square mile and facilities per 100,000 people are two ways of measuring the existing capacity.
    - **Fenway** and **East Boston** are the neighborhoods with the biggest gaps in existing capacity. Each neighborhood has a relatively low number of facilities per 100,000 people. This indicates that even if all of the existing institutions are activated as climate resilience hubs, more capacity may still be needed. However, Fenway has a lower share of its population living within a high-priority tract (15%) as compared to East Boston (59%) where capacity issues may be more apparent.
    - **East Boston** also has a relatively low number of facilities per square mile, which indicates that community institutions may be concentrated in one or more areas of the neighborhood and geographically inaccessible for some residents.
    - **Roxbury** has a relatively high number of facilities per 100,000 people, which indicates that there is existing capacity to support climate resilience hubs. Roxbury's number of facilities per square mile is average.
    - **Other neighborhoods** that have a low number of facilities per square mile or per 100,000 people are less socially vulnerable areas that do not have any high-priority tracts including Charlestown, Longwood, Brighton, Hyde Park, West Roxbury, and the Seaport.

RECOMMENDATIONS

ESTABLISH CLIMATE RESILIENCE HUBS IN HIGH-PRIORITY AREAS.

The City should prioritize establishing, supporting, and funding resilience hubs in high-priority tracts, particularly in East Boston and Roxbury, where residents will face disproportionate impacts. The approach to this should be based on the existing conditions of each area. For example, in East Boston, the City should consider whether new facilities will be needed to serve the population. In Roxbury, the City should focus on whether existing facilities can be activated as climate resilience hubs and whether they are accessible to all residents.

SUPPORT CREW'S CLIMATE RESILIENCE HUB INITIATIVE.

The City should work with CREW to support a city-certification process for climate resilience hubs that can nest within a broader, cross-municipal resilience hub framework.

INTEGRATE CLIMATE RESILIENCE HUBS INTO CITY PLANS AND INITIATIVES.

Consistent with the City's Climate Action Plan, efforts to retrofit existing municipal buildings should prioritize institutions with the ability to serve as climate resilience hubs in high-priority areas. The City should also integrate resilience hubs into planning and policy documents, including climate adaptation, mitigation, and emergency response plans. In particular, the City should consider the role of climate resilience hubs in Climate Ready Boston neighborhood plans.

PRIORITIZE COMMUNITY INSTITUTIONS IN THE FACE OF BUDGET CUTS.

Many of the institutions that offer near-term opportunities to establish resilience hubs are publicly owned or operated facilities like schools, libraries, and community centers. In the face of potentially deep budget cuts in the midst and aftermath of COVID-19, the City should prioritize and invest in existing neighborhood institutions that have the ability to provide critical information, services, and respite before, during, and after extreme weather and other catastrophes. The City should also consider how the operation of these facilities may need to adapt their operations as a result of the COVID-19 crisis and support them in doing so.

EARMARK FUNDING TO SUPPORT CLIMATE RESILIENCE HUBS AND SOCIAL RESILIENCE.

The City should earmark capital funds to support existing and new neighborhood institutions interested in being climate resilience hubs. Funding can help ensure that these facilities are able to adapt their infrastructure and operations to withstand future climate impacts and provide necessary resources during and after an extreme weather event. In addition, a grant program should provide funds for climate resilience hubs that are not owned or operated by the city.

PRIORITIZE PUBLIC REALM IMPROVEMENTS AND TRANSIT ACCESS NEAR CLIMATE RESILIENCE HUBS.

The City should assess the accessibility of existing facilities, particularly publicly owned facilities, to ensure that they are accessible to all residents including seniors and children, disabled individuals, and individuals without vehicles. Street and other public realm improvements should be designed to better accommodate bicycle and pedestrian travel to facilities.

ENCOURAGE COMMUNITY CO-CREATION AND/OR CO-OWNERSHIP OF CLIMATE RESILIENCE HUBS.

The City should encourage and support community members and other stakeholders in co-creating and co-owning climate resilience hubs. For example, in activating existing city facilities like libraries and schools for climate resilience hubs, the City should invite residents and trusted community leaders to help design and implement hub operations and programming. In communities undergoing neighborhood change, including East Boston and Roxbury, the City should consider ways to support community land banking efforts, which could help secure space for new, community-owned facilities to serve as climate resilience hubs.

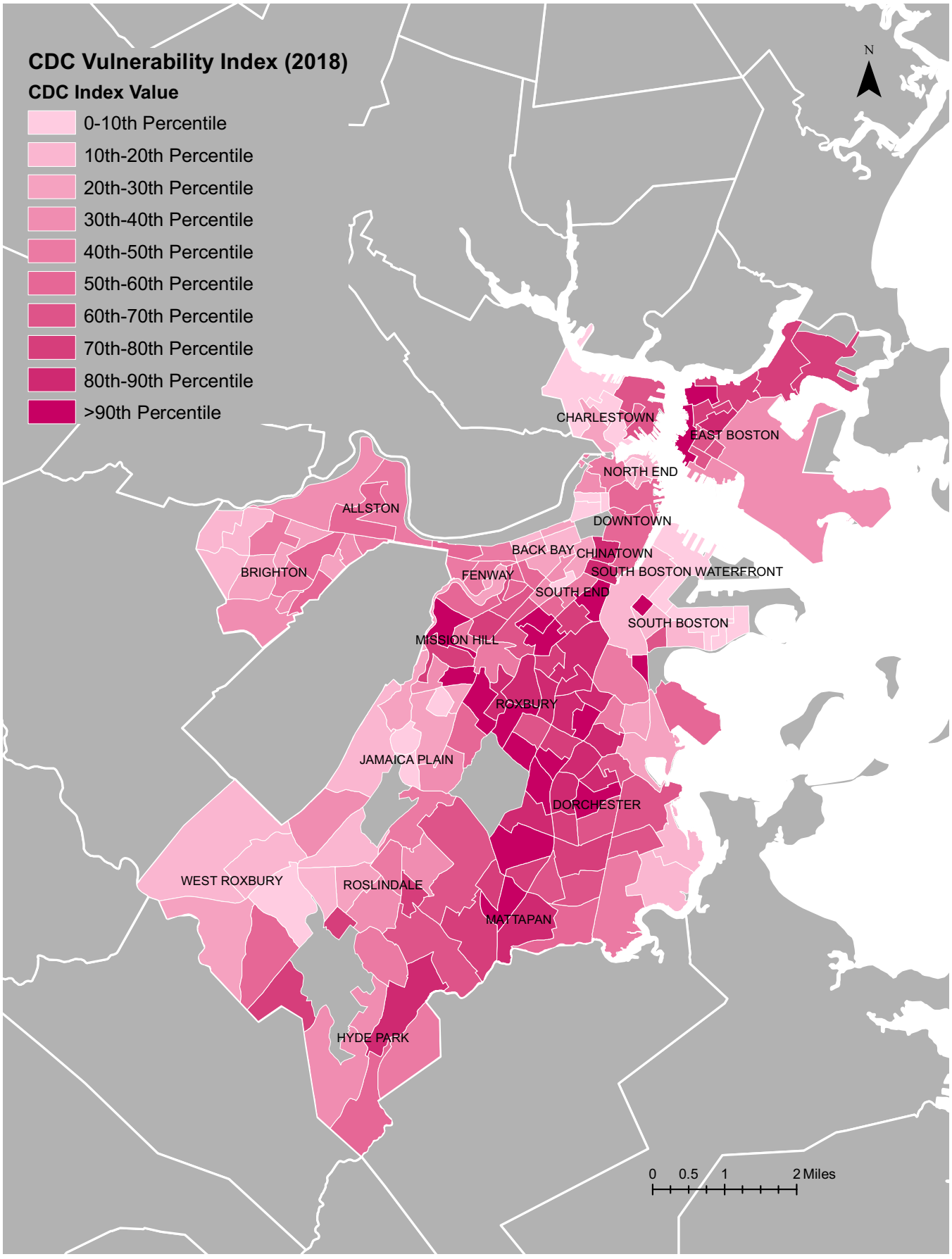
CONTINUE TO REDUCE VULNERABILITY TO CLIMATE IMPACTS.

In addition to investing in social infrastructure in high-priority areas, the City and other stakeholders should undertake efforts to reduce physical vulnerabilities in high-priority tracts by addressing issues like high impervious surface coverage, flood exposure, and low-quality building stock.

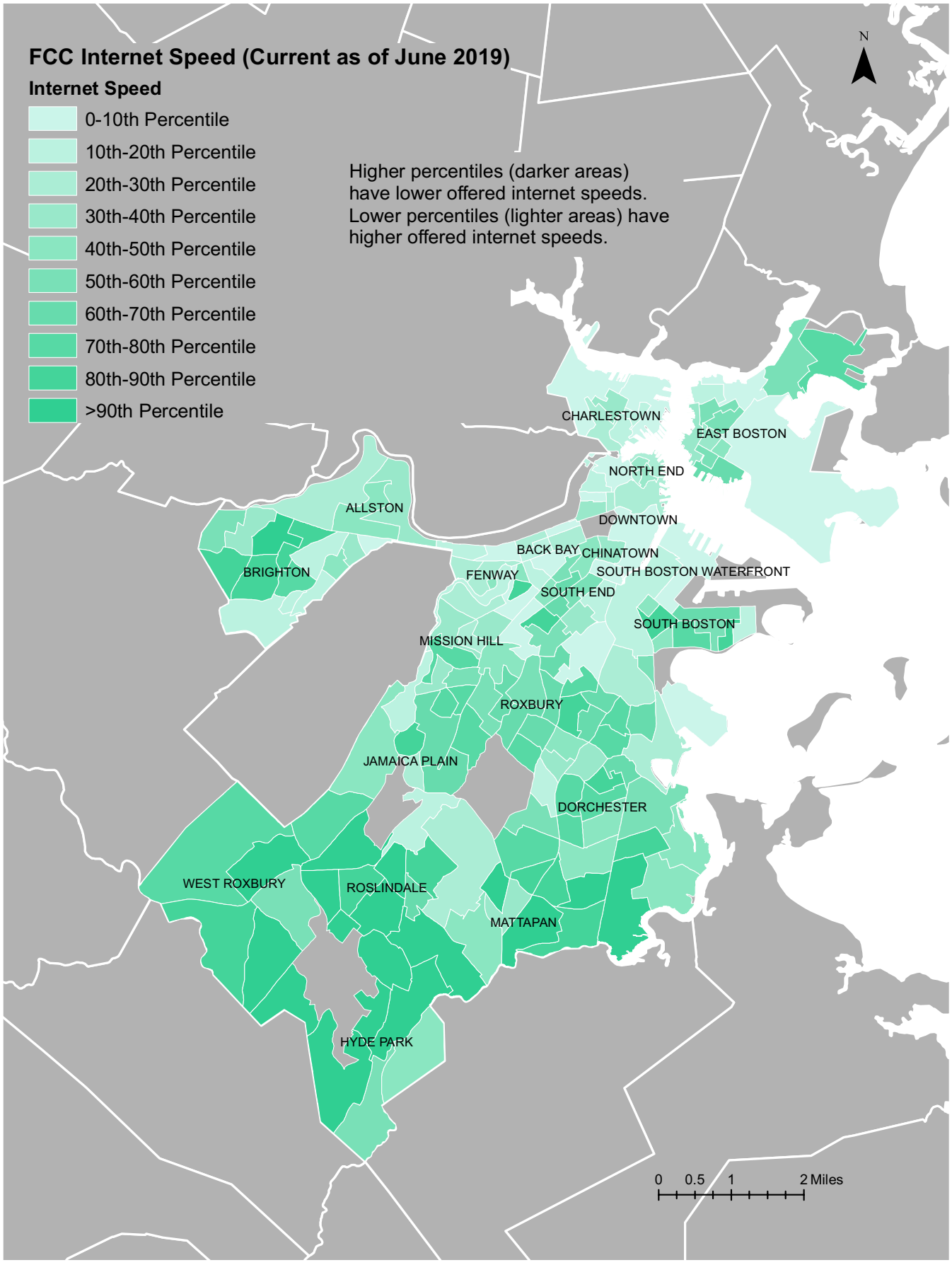
Photo credit: Kevin Fink, Shutterstock

APPENDIX OF FULL-SIZE MAPS

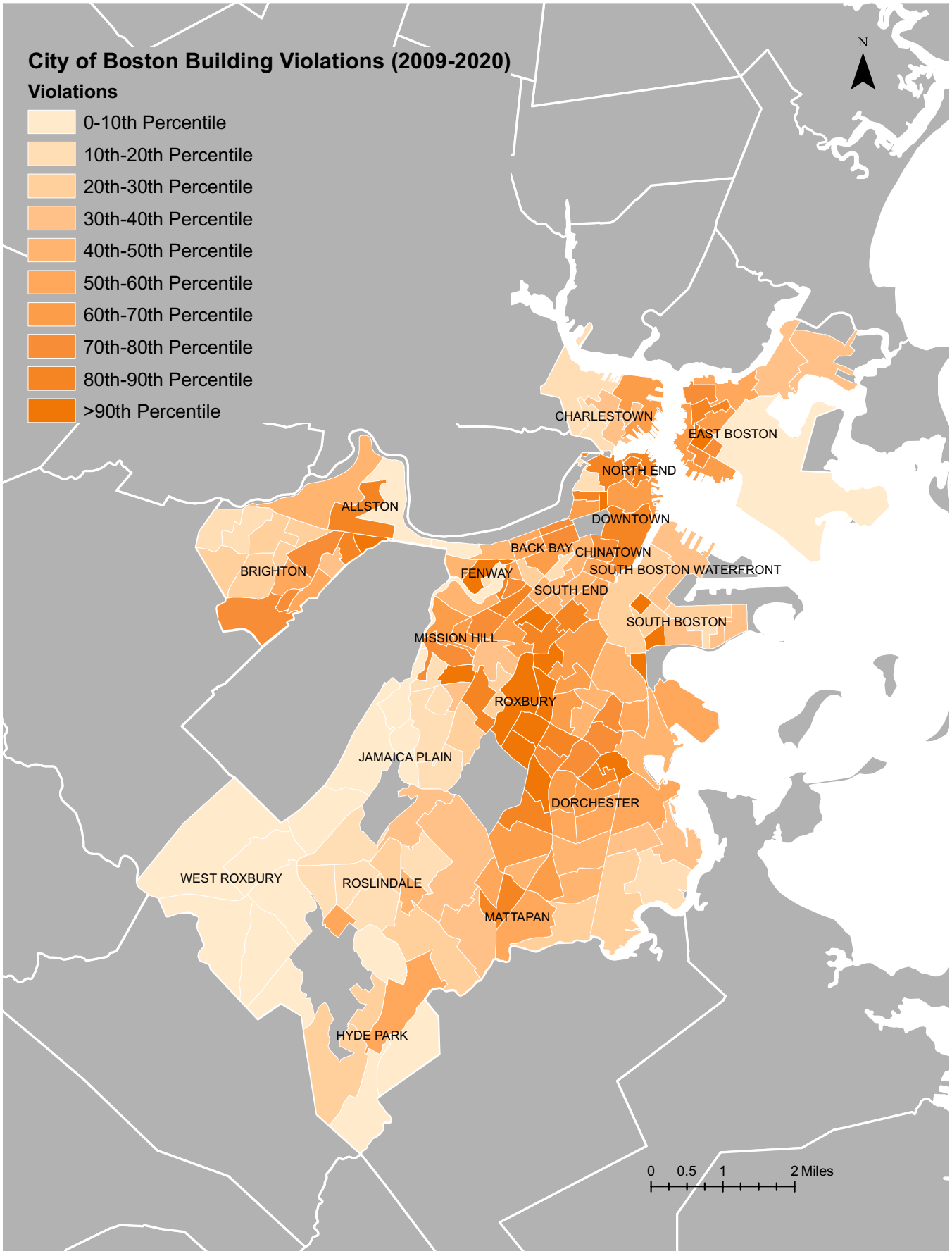
MAP 1: SOCIAL VULNERABILITY



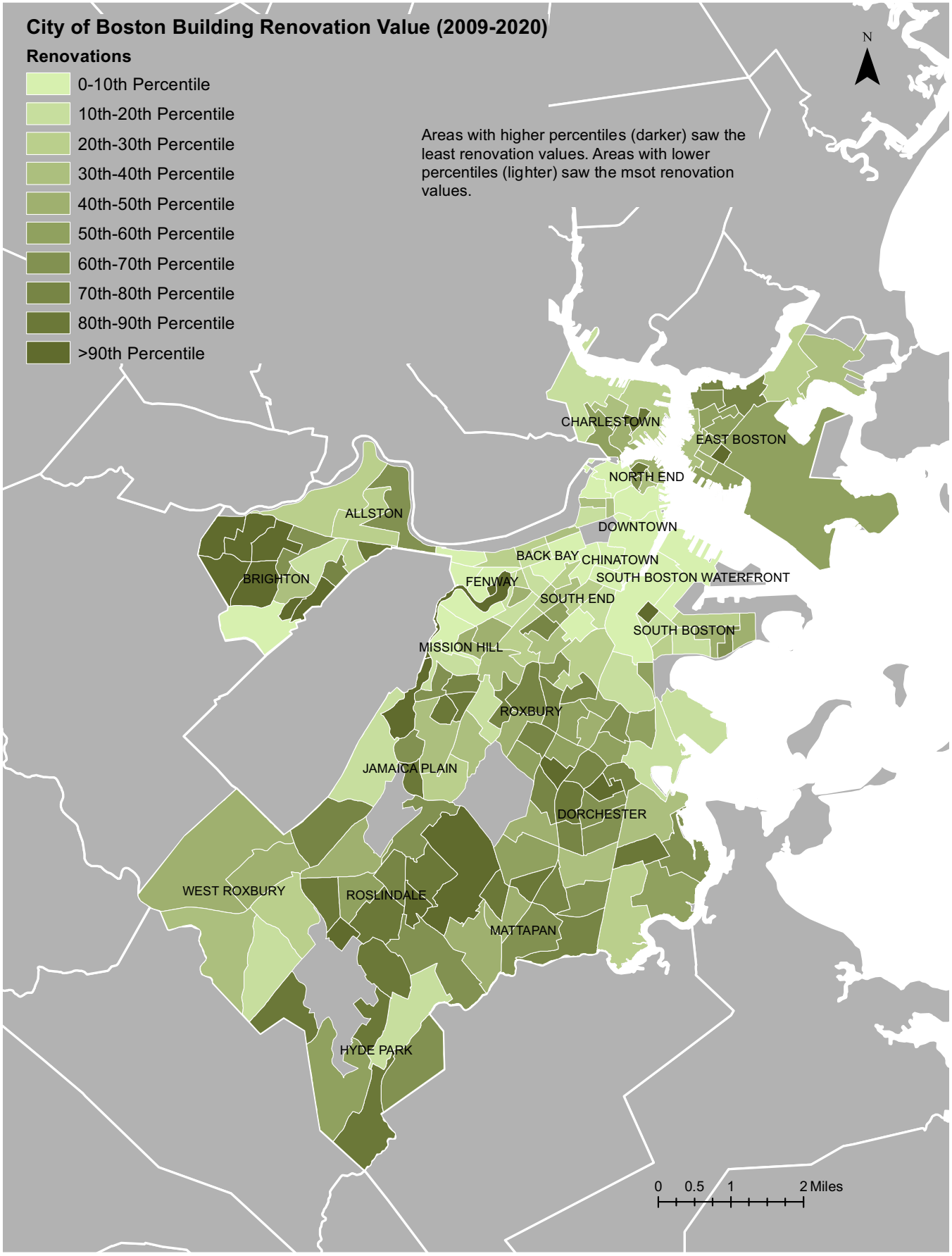
MAP 2: INTERNET SPEED



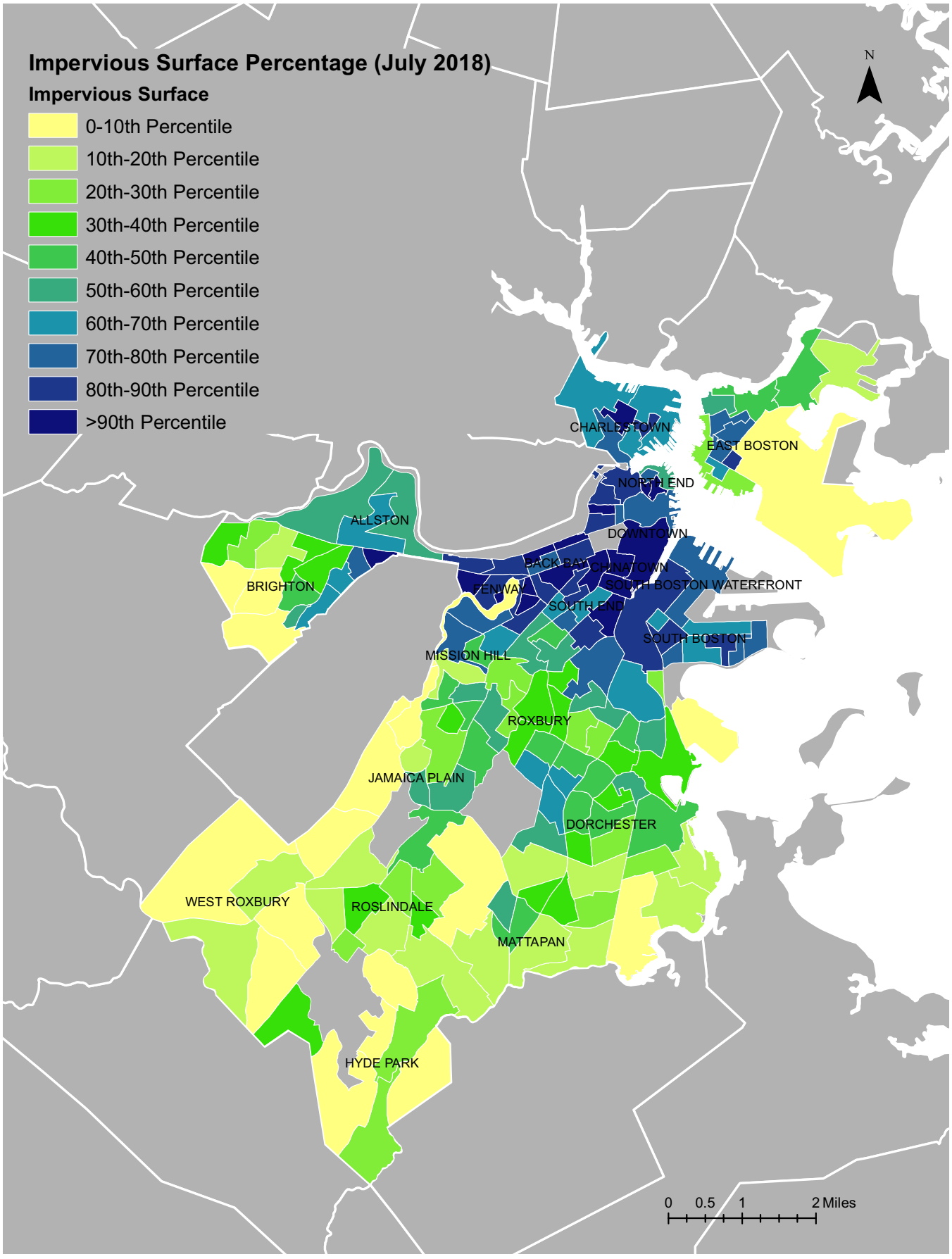
MAP 3: BUILDING CODE VIOLATIONS



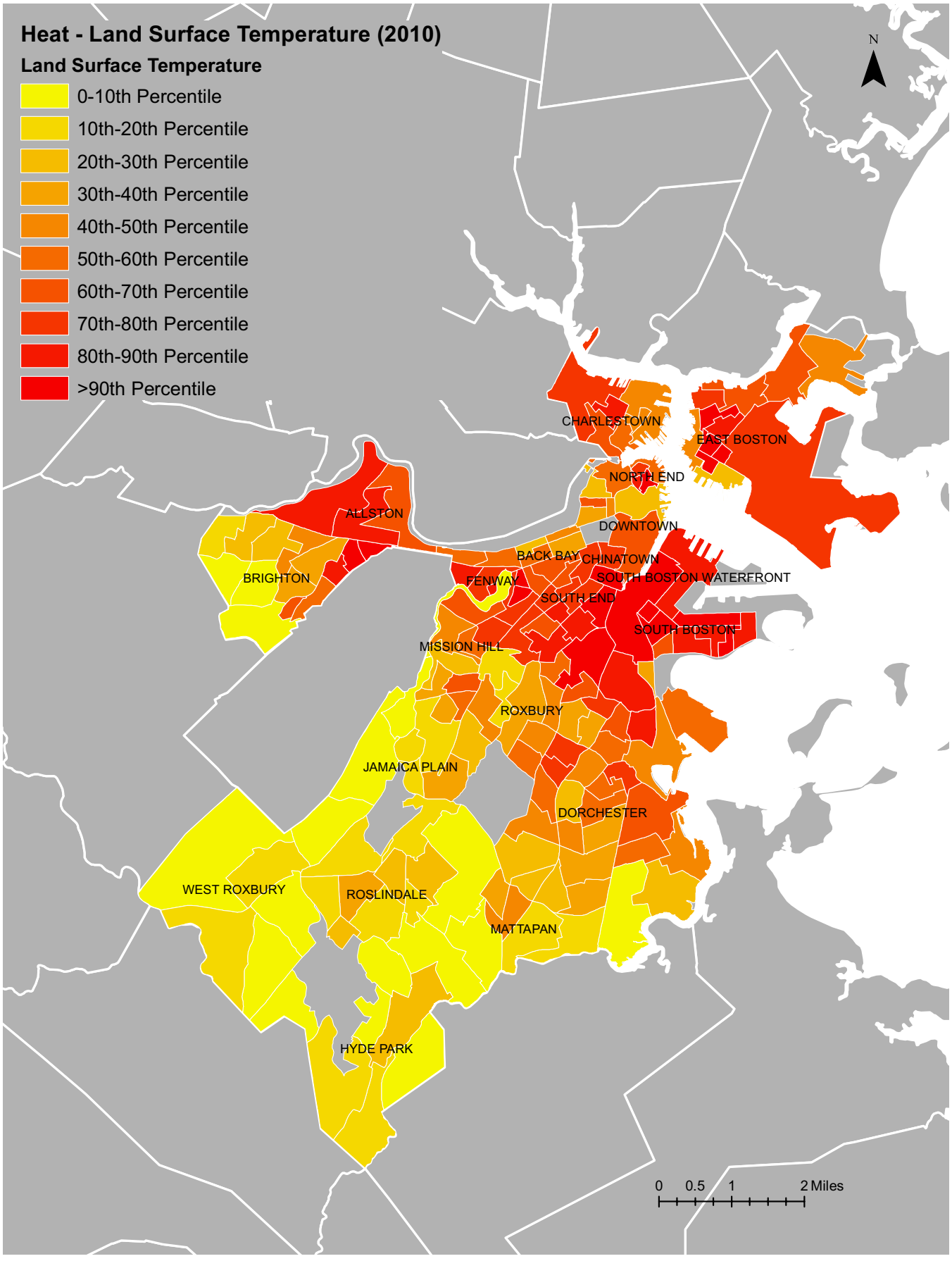
MAP 4: RENOVATIONS



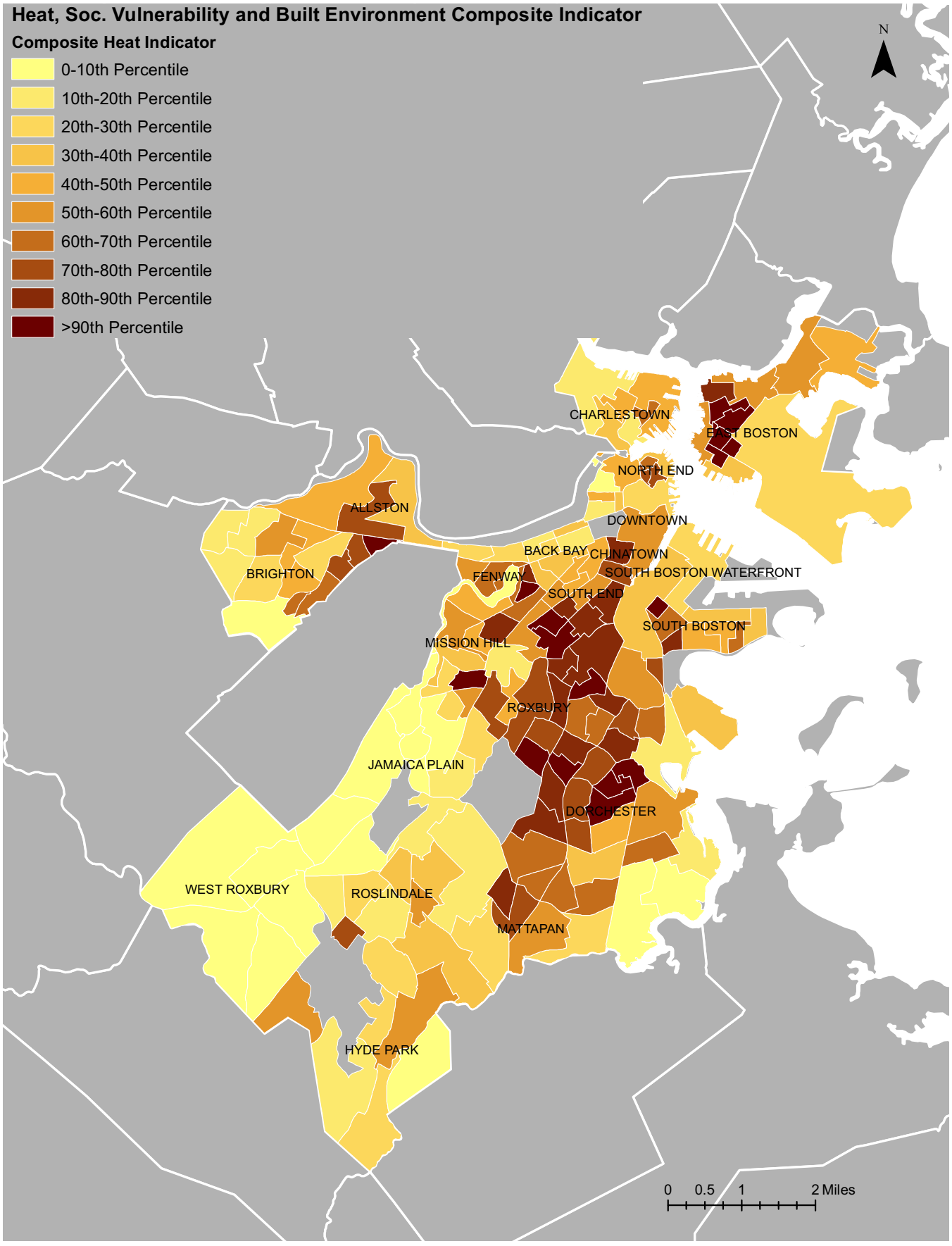
MAP 5: IMPERVIOUS SURFACE



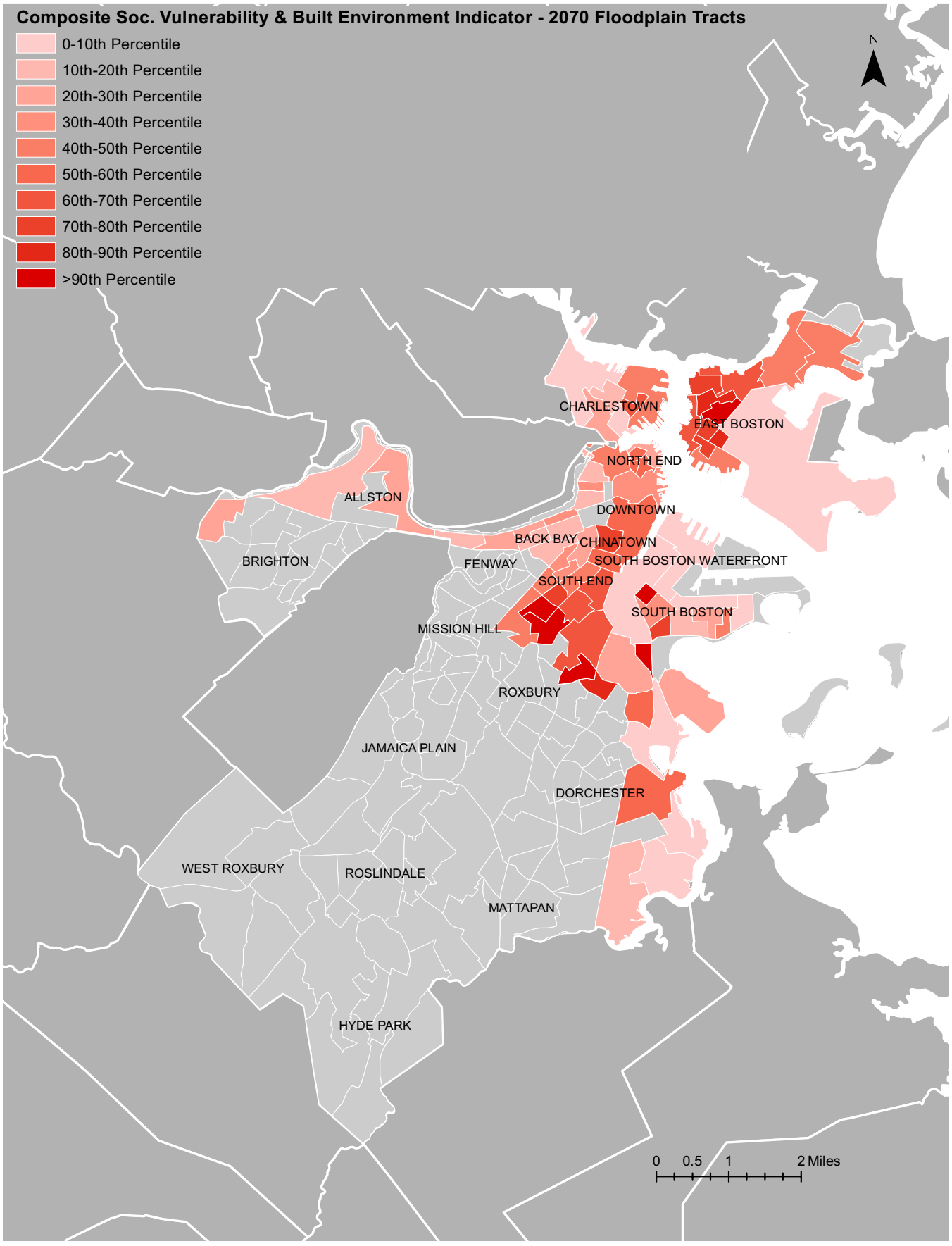
MAP 6: LAND SURFACE TEMPERATURE



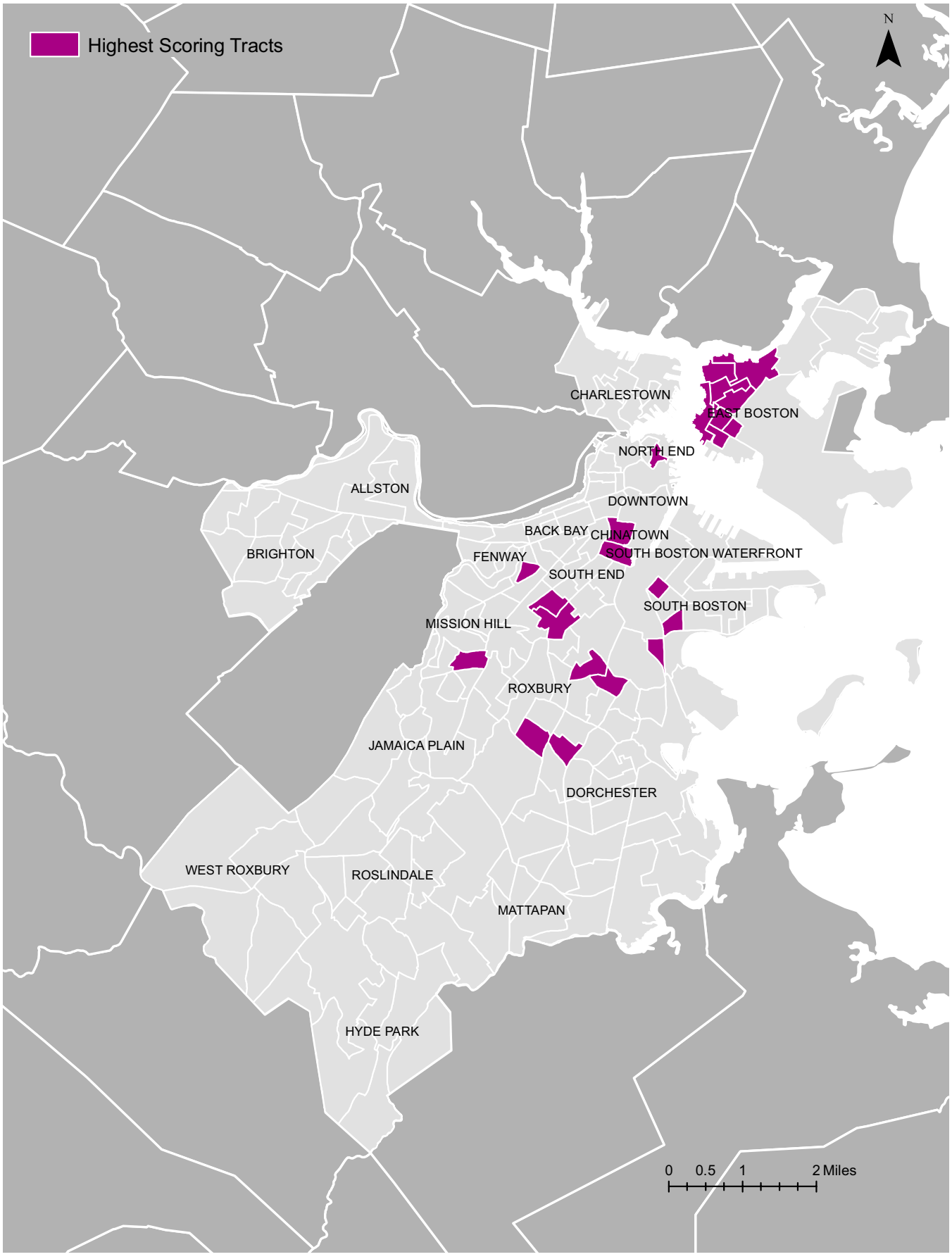
MAP 7: COMPOSITE INDICATOR FOR HEAT, SOCIAL VULNERABILITY, AND BUILT ENVIRONMENT



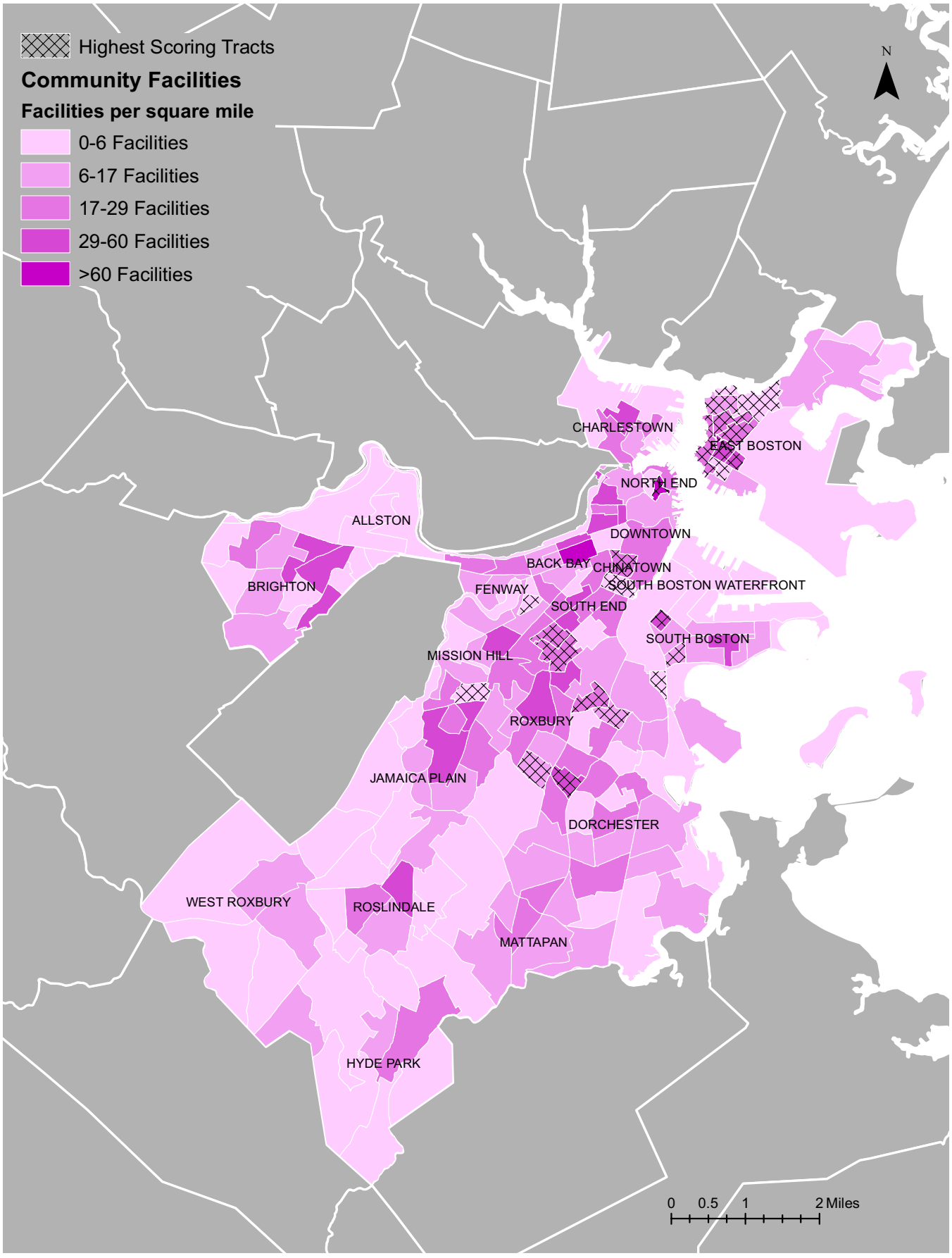
MAP 8: COMPOSITE INDICATOR FOR FLOODING, SOCIAL VULNERABILITY, AND BUILT ENVIRONMENT



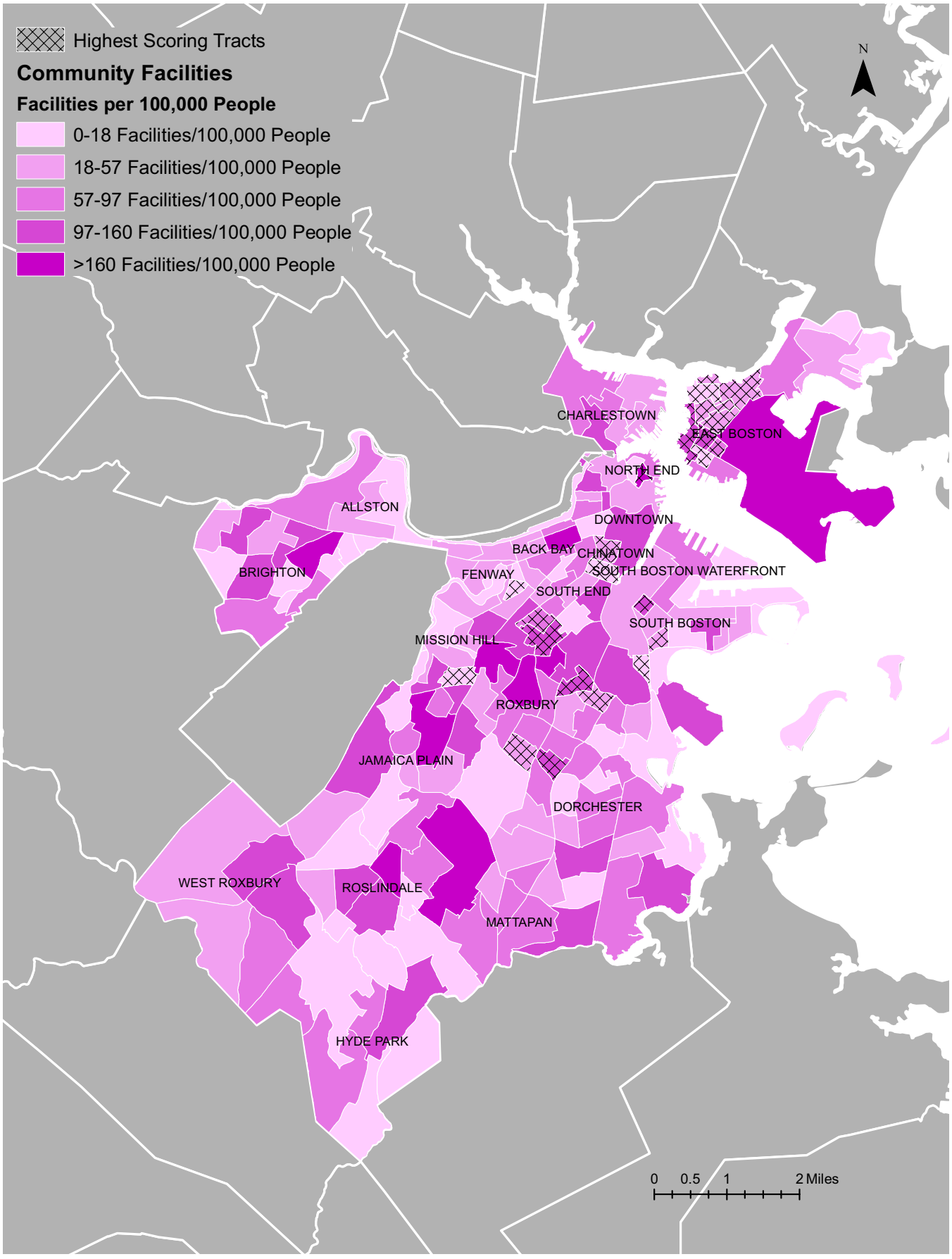
MAP 9: HIGH-PRIORITY TRACTS - HEAT AND FLOODPLAIN



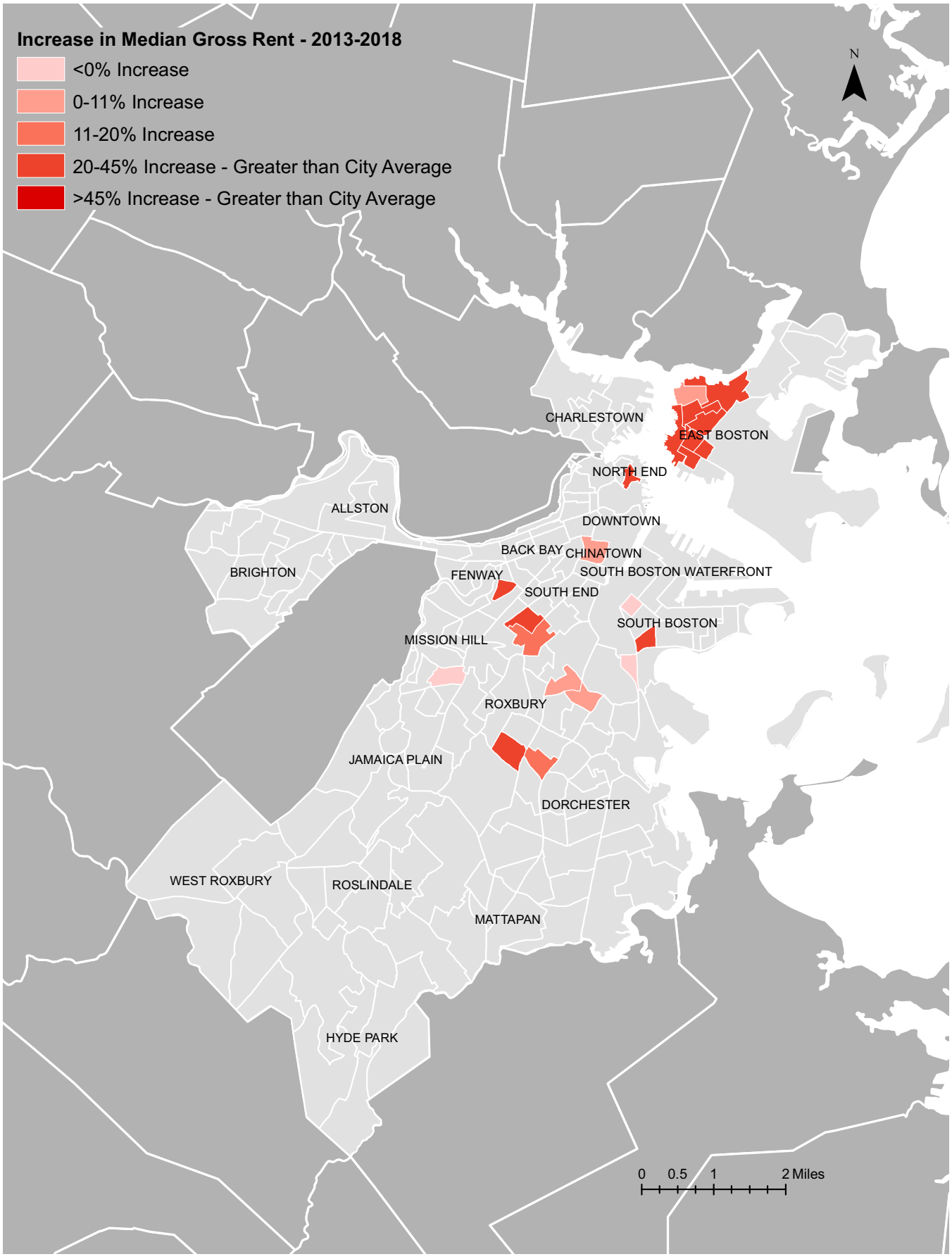
MAP 10: FACILITIES PER SQUARE MILE



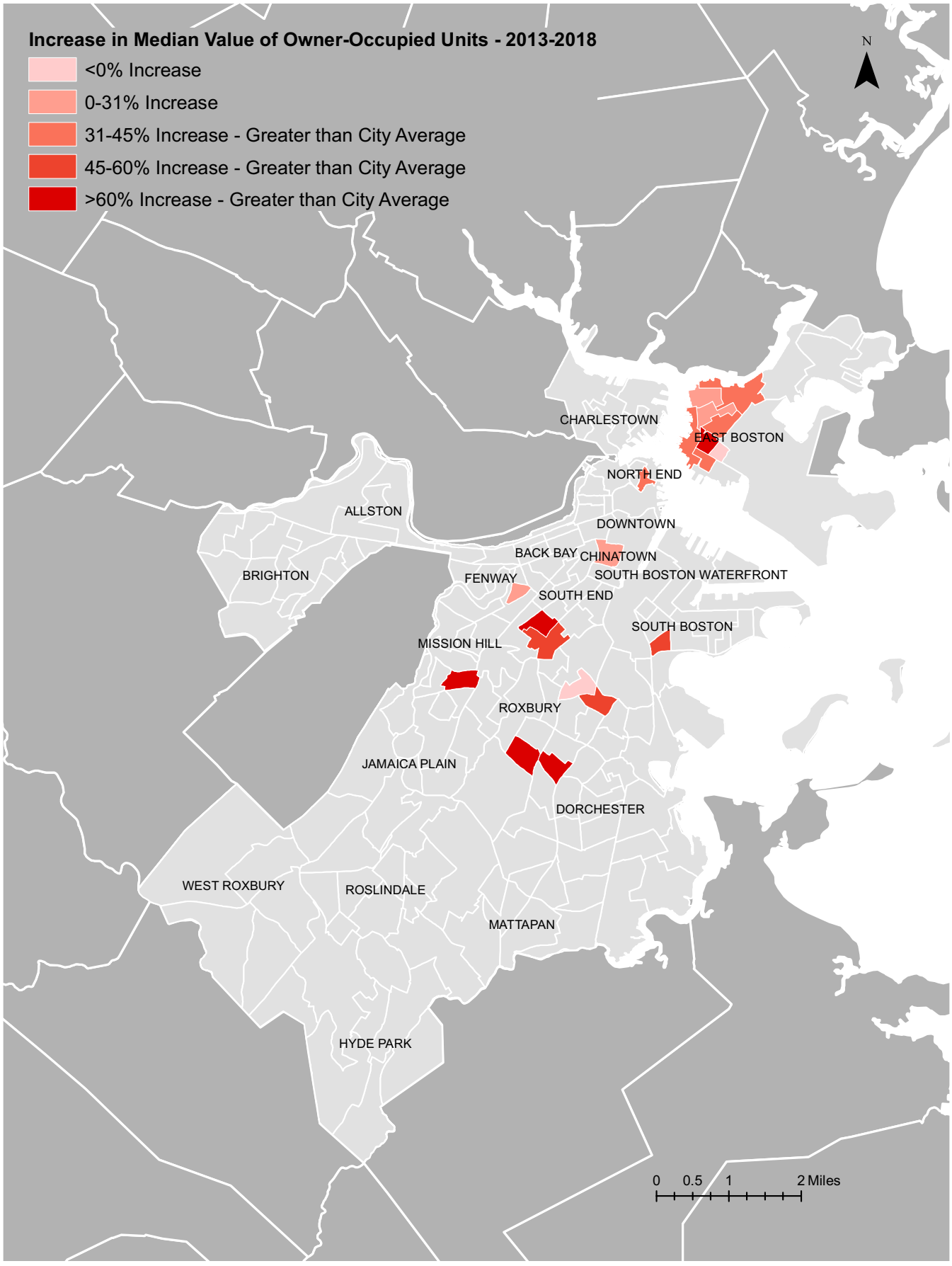
MAP 11: FACILITIES PER 100,000 PEOPLE



MAP 12: RENT INCREASES



MAP 13: OWNER-OCCUPIED HOME VALUES



MAP 14: SHARE OF PEOPLE OF COLOR

MAP 15: SHARE OF BACHELOR'S DEGREE HOLDERS

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CLIMATE RESILIENCE HUBS:

Leveraging social infrastructure for neighborhood resilience in Boston