PREPARING FOR

HEAT WAVES IN BOSTON

A COOL WAY TO ATTACK GLOBAL WARMING

Michael Adler
Samantha Harris
Megan Krey
Loni Plocinski
Jeanette Rebecchi

Preparing for Heat Waves in Boston: A Cool Way to Attack Global Warming

Prepared for
City of Boston Environment Department
&
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Prepared by
Michael Adler
Samantha Harris
Megan Krey
Loni Plocinski
Jeanette Rebecchi

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Abstract

Under the leadership of Mayor Thomas M. Menino, the city of Boston has recently committed to developing an integrated plan that outlines the necessary actions to reduce the risks from the predicted effects of climate change. As part of that commitment, Boston's Environment Department partnered with a team of graduate students from the Tufts University Urban and Environmental Policy and Planning Program to examine the city's heat wave plan and cooling center system. This report presents the best available global, regional and local climate change and heat wave data; an analysis of Boston's heat wave response; and short and long-term solutions for mitigating the stresses of heat waves. Given the increased public health risk caused by climate change, it is essential that Boston be prepared for heat waves in the form of a comprehensive, detailed heat wave action plan and accessible, public programs. By partnering with other public, private, non-profit and volunteer entities and implementing long-term green strategies including cool roofs, green roofs and cool pavements, Boston can ensure the best possible public health and environmental outcomes during a heat wave.

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Executive Summary

Heat waves cause more fatalities in the United Sates than the total of all other meteorological events combined (Klinenberg 2002). In Boston, over 50 people die each year due to heat-related illnesses (Davis et al. 2003; Kalkstein 1997). This number will certainly increase, given that global climate change is predicted to trigger more frequent and intense heat waves. Fortunately, by the institution of proper policies, these deaths are preventable. Boston already implemented some effective measures to respond to extreme heat events, but the city can do more to ensure its preparedness. Boston has yet to experience a severe heat wave like the 1995 Chicago heat wave, which killed 500 people, or the 2003 Paris heat wave, which killed an estimated 15,000 people (United States Environmental Protection Agency 2006). City officials must immediately act to ensure that Boston does not encounter a similar catastrophe.

Boston's average temperature has steadily increased and scientists predict the continuation of this rising trend. Analyzed historical weather data for the city show that since 1950, summer temperatures and the frequency of days with temperatures exceeding 90°F, have significantly increased (National Oceanic and Atmospheric Administration 2009). Relative humidity, the other key determinant of a heat wave, has also significantly increased (National Oceanic and Atmospheric Administration 2009). Over the past 50 years, the Intergovernmental Panel on Climate Change (IPCC) and the Northeast Climate Impacts Assessment (NECIA) confirm that temperatures have considerably risen and project that over the next 50 years, temperatures will continue to rise at an escalating rate (Intergovernmental Panel on Climate Change 2007; Union of Concerned Scientists 2007).

Boston is particularly susceptible to the stresses of heat waves for two reasons. First, the city has a large population of residents considered to be vulnerable during extreme heat. Although many people are at risk during a heat wave, Boston's elderly, low-income residents and those with pre-existing illnesses are especially vulnerable. In addition, the city's dark colored infrastructure in combination with the lack of vegetation creates the urban heat island effect. The urban heat island effect acts like a bubble trapping heat within the city and elevating temperatures by as much as 8°F more than the surrounding city limits. Prolonged high temperatures lead to serious health problems like heat exhaustion, heat stroke and heart disease. Furthermore, cases of asthma rise because increased

temperatures worsen levels of air pollution.

Because heat waves can be especially dangerous for cities, the U.S. Environmental Protection Agency (EPA) and the World Health Organization (WHO) created guidelines for cities in developing heat wave policies. The EPA guidelines are based on successful strategies implemented in other North American cities like Philadelphia and Toronto. Determined by the EPA, the most necessary and effective elements of a heat wave plan include: establishing cooling centers, providing media alerts and real-time access to alerts, implementing communication systems to alert public officials to high risk individuals and directly assisting those at greatest risk (United States Environmental Protection Agency 2006). The WHO guidelines are similar to the EPA's, but also stress the importance of monitoring and evaluating the current plan and the organization of long-term, urban planning to lessen the impact of heat waves (Matthies et al. 2008). Boston currently institutes some of these measures; however, it needs to do more to ensure that the most vulnerable residents are protected in the event of a heat wave.

One of the key elements of Boston's heat wave plan includes the implementation of cooling centers. Cooling centers are public air conditioned buildings or pools throughout the city for people to go to during the day to escape the heat. Using demographic data from the 2000 Census, seven areas in the city were identified as having the greatest demand for cooling centers. These areas are located in Boston's Roxbury, Fenway, Downtown, Allston/Brighton and East Boston neighborhoods. Further analysis indicates that the city's cooling centers do not completely meet the needs of the residents in these areas. Fortunately, there are other public resources in close proximity to the areas that could provide alternative sources of relief for the city's most vulnerable residents.

Boston's current heat wave plan is employed citywide; however, it is relatively unspecific and consists of many agencies with separate, disjointed procedures. Creating and publicizing a detailed, comprehensive plan ensures that all agencies are aware of their responsibilities and the public knows where to go during a heat wave. Additional recommendations include:

- Working with non-profit agencies to provide regular assessment of vulnerable residents;
- Establishing emergency response teams in all neighborhoods to alert residents about heat issues and check on vulnerable residents;

- Creating an on-call, medical advice hotline;
- Providing air conditioning for physically homebound people unable to leave their homes without assistance;
- Purchasing backup generators for all cooling centers;
- Establishing relationships with other entities that can serve as alternative cooling centers; and
- Creating a committee of public and private citizens to monitor and annually review the current heat wave plan.

City residents can keep cool by using personal air conditioners or utilizing cooling centers, but these are only short-term strategies for combating heat waves. Air conditioning actually exacerbates temperature conditions and degrades air quality by generating warm exhaust air. Additionally, not every resident can afford to purchase an air conditioner, or pay the higher electricity bills. The city should instead focus on long-term, energy neutral cooling methods that reduce the urban heat island effect. By implementing strategies such as cool roofs, green roofs, cool pavements, and increasing the amount of trees and vegetation, the city of Boston can secure residents' safety and comfort during a heat wave without negatively impacting the environment

Boston has the potential to have all the right elements in place to ensure that future heat waves will have a minimal impact on the city's residents. With proper planning, delegation and cooperation, these elements can be used to create an effective and comprehensive heat wave plan that will certainly save lives.

1 HEAT WAVES

1.1. Past Heat Waves and Lessons Learned

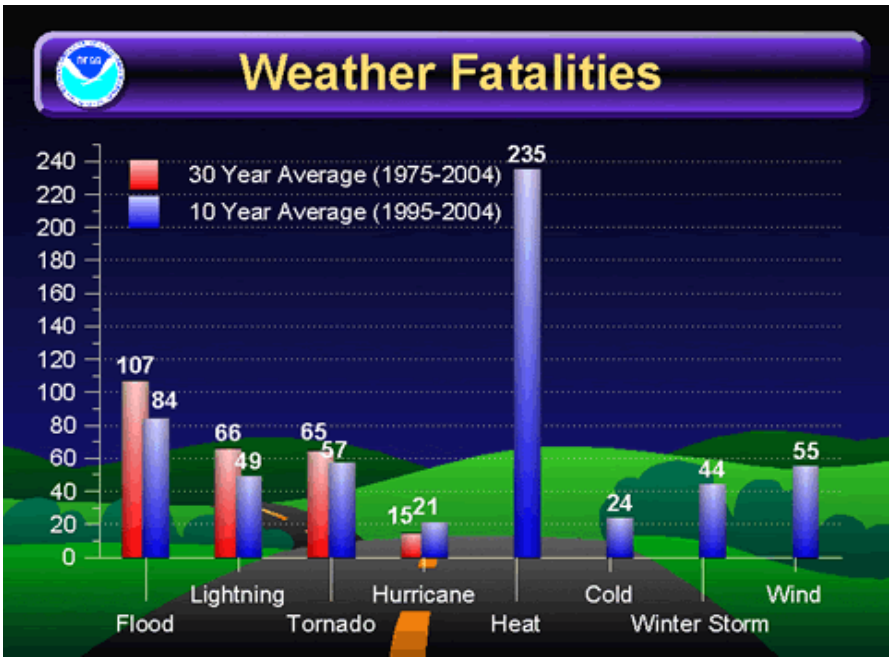
Heat waves may seem trivial in comparison to other meteorological events; however, in reality, heat waves cause more fatalities in the United States (U.S.) than all other combined meteorological events. (See Figure 1)

Heat waves cause an estimated 1,000 deaths per year in the U.S. (Kalkstein 1997; Davis et al. 2003). In 2003, Europe experienced the worst heat wave in 500 years, claiming approximately 40,000 lives (WBUR 2009). In recent years, many U.S. cities also have experienced extreme heat events with associated loss of life (United States Environmental Protection Agency 2006). Climate change is expected to increase more occurrences of extreme summer heat. As a result, the number of heat-related deaths will definitely rise. Consequently, it is necessary that every city develop a comprehensive heat wave action plan to ensure that the past heat wave tragedies are not repeated in the future.

Heat waves cause more fatalities in the United States than all other meteorological events combined

Philadelphia, a city with a similar climate to Boston, has experienced numerous heat waves in recent years. To combat this increasing trend, Philadelphia has developed a heat wave plan that goes into effect if temperatures rise to dangerous levels. Philadelphia garnered national media attention in July of 1993 with its most notable heat wave and was known as the "Heat Death Capital of the World" because of the 105 heat-related deaths (United States Environmental Protection Agency 2006). Before this event, heat waves were rarely blamed for deaths due to stringent criterion; the core body temperature had to be greater than 105°F for a death to be classified as "heat-related." In 1993, the Philadelphia medical examiner expanded the heat-related death criterion to include any body "found in an enclosed environment with a high ambient

Figure 1: Weather Fatalities



Source: National Oceanic and Atmospheric Administration

temperature without adequate cooling devices" in which "the individual was known to be alive at the onset of the heat wave" (Donoghue et al. 1997). The U.S. Centers for Disease Control and Prevention reviewed and adopted this expanded definition and it has been an important factor in demonstrating the danger of heat waves (United States Environmental Protection Agency 2006).

Severe heat waves have also had tragic consequences in Chicago. In 1995, a severe heat wave claimed the lives of 521 people solely in the month of July. Many factors contributed to this large loss of life, including a heat index above 100°F for three days, cloudless skies and the infrastructure of Chicago's urban environment. Despite the fact the entire city experienced the same weather conditions, some people suffered more than others due to their particular social situations. Those most vulnerable were people over 65 years old, people living alone and people in low-income neighborhoods. Eric Klinenberg posits in his book, Heat Wave: A Social Autopsy of Disaster in Chicago, that these segments of the population suffered primarily because of an absence of social ties, an inability (physical or environmental) to get to a cool location and a lack of essential information about the dangers of heat.

Chicago's lack of preparation and inaction exacerbated these social factors. The city failed to broadcast information about the dangers of heat, did not provide assistance in a timely manner, lacked

a plan to assist vulnerable people during the heat wave and neglected to declare an emergency until the fourth day of the heat wave; government officials refused to acknowledge the seriousness of the issue. In addition, many of the department heads were on vacation and/or unwilling to return early to address the situation (Klinenberg 2002). As a result, residents had no information about what to do or where to go to find relief. Although the National Weather Service accurately predicted the severity of the heat wave, the city failed to account for the urban heat island effect, which significantly increased the temperature of Chicago.

The city procrastinated too long to acknowledge the heat as a major problem. As a result, sufficient medical and emergency responders were not mobilized in a timely manner and many people did not receive the assistance they needed (Chagnon et al. 1995). In the wake of this tragedy, Chicago created a comprehensive "Heat Wave Warning Plan" that includes phone hotlines, transportation to cooling centers and widespread information about the dangers of heat waves. When a similar heat wave occurred in Chicago in 1999, the mortality rate was subsequently reduced to 110 people (Klinenberg 2002).

The most recent and catastrophic heat wave occurred in Europe in August of 2003. Spanning Europe entirely, approximately 40,000 people died. The largest death toll occurred in Paris where 15,000 perished from the severe heat. Residents of Paris were three times more likely to die than the rest of France because of the the city's infrastructure, demographics and lack of preparedness. Furthermore, air conditioning is rare in France, so most residents could not easily escape the heat (Bretin 2006). The built environment intensified the situation because few of the city's buildings had shutters to retain cooler air and block the sun, with urban congestion adding to the heat. In addition, the city had a large elderly population, many of them women living alone in more affordable, top floor apartments, which retain even more heat. Thus, while the majority of the country took a vacation to escape the heat, France's "mothers and grandmothers essentially baked to death" (WBUR 2009). Since Paris had not developed a heat wave plan, there was no established system to warn residents about heat wave dangers or to assist those most vulnerable (Matthies 2008).

"Heat waves are the silent and invisible killer of silenced and invisible people"

Klinenberg states that "heat waves are the silent and invisible killer of silenced and invisible people," (Klinenberg 2002) due to severe medical consequences suffered by certain vulnerable segments of the population. Unlike most meteorological events, heat waves

rarely cause property damage; instead, heat waves are extremely harmful to the health of many people. In order to ensure that the damage to human health is minimal, cities must prepare for heat waves.

1.2 Health Effects of Heat Waves

As discussed earlier, heat waves will undoubtedly increase the number and severity of heat-related illnesses, including fatalities. Other illnesses can also be exacerbated by the prolonged exposure to extreme heat, and can be just as lethal. Health problems directly attributable to heat waves include:

- Heat syncope: Heat syncope is characterized by dizziness, nausea and even fainting. It is caused by long periods of standing or a sudden change of position in a hot climate. It can be treated with fluids and rest in a cool area (National Institute for Occupational Safety and Health 2010).
- Heat cramps: Heat cramps stem from strenuous work in hot temperatures, and affect a wide range of individuals, including construction workers and athletes. Heat cramps consist of severely painful cramps, usually in the muscles of the legs and abdomen. The cramps are caused by the loss of necessary electrolytes in the body and profuse sweating. Resting and applying pressure to the cramped areas and increasing fluid intake (generally a sports drink to replace the lost electrolytes) can usually resolve the symptoms (National Institute for Occupational Safety and Health 2010).
- Heat exhaustion: Heat exhaustion is characterized by excessive sweating, resulting in a loss of essential electrolytes and water in the body. Symptoms include dizziness, fatigue, nausea, fast or shallow breathing, a slight increase in body temperature, and pale, clammy skin. Those most vulnerable to heat exhaustion include the elderly, due to existing heart conditions, those suffering from high blood pressure and workers and athletes who spend most of their time outdoors. Drinking plenty of water, taking cool baths or showers and resting in a cool place is often the best way to relieve heat exhaustion (National Institute for Occupational Safety and Health 2010).

- Heat stroke: Heat stroke is the most serious and dangerous heat-related illness. Heat stroke occurs when the body becomes excessively hot, loses the ability to sweat and fails to cool down. As a result, body temperatures can increase to 106°F in a very short time and can be fatal. Symptoms can include dry, hot skin, or limited sweating, accompanied by chills, hallucinations, headache, dizziness, slurred speech and confusion. People suffering from heat stroke must immediately seek medical attention and try to cool down as quickly as possible. People suffering from heat stoke often lose the cognitive capacity to seek help for themselves and if they are alone, their risk of death greatly increases (National Institute for Occupational Safety and Health 2010).

Other important health issues aggravated, but not initially caused by heat include:

- Heart disease: High temperatures and extreme heat can be very dangerous for people with pre-existing heart diseases like high blood pressure, poor circulation and those taking certain medications. Hot weather increases the individual's circulatory rate and raises blood pressure, which can be fatal to those already sensitive to such increases (Centers for Disease Control and Prevention (a) n.d.).
- Allergies: High temperatures and high humidity increase people's susceptibility to allergies. High temperatures increase the particle count in the air, such as smog and pollen. Since temperatures are predicted to increase in Boston (see Table 3 below) so the number of people suffering from allergies will also increase. Therefore, the heat may cause people without allergies to develop them. For people with severe allergies, the heat may intensify their symptoms to a life-threatening degree (Centers for Disease Control and Prevention (c) n.d.).
- Asthma: Pollution particles are a known asthma trigger, and an increase in temperature causes an increase of the number of these particles in the air. As a result of higher temperatures, the number of people with asthma will increase and people with asthma will experience more severe, and possibly fatal, symptoms

(Centers for Disease Control and Prevention (b) n.d).

» Exacerbation of chronic illnesses: People with cardiovascular disease, renal disease and diabetes are at increased risk during heat waves. For people with cardiovascular disease, increased temperatures cause the heart to beat faster, which then results in additional stress on the cardiovascular system. For people with diabetes and renal disease, dehydration and excessive sweating, which often occur during heat waves, result in increased stress on the kidneys (Flanders et al. 1999). People suffering this additional stress will often need medical treatment or hospitalization.

1.3 Vulnerable Populations

While many people are negatively affected by the increase in temperatures during a heat wave, increased heat and the associated health impacts are particularly dangerous for some segments of the population. The most vulnerable populations include the elderly, children, chronically ill, low-income, homebound and linguistically and socially isolated populations. The risk to these populations increases significantly for those people that live alone because they are often forgotten. The following populations experienced the greatest loss of life during the severe heat waves of the past.

The elderly are at great risk during heat waves, especially those who have pre-existing conditions or take heat-sensitive medications. With age, elderly people lose the ability to naturally cool their bodies, which can result in heat stroke. The elderly may also lose the ability to realize they are too hot, which keeps them from either utilizing a cooling center or even keeping cool at home. Many older people also suffer from cardiovascular conditions and are more sensitive to an increase in heart rate, which is a side effect of exposure to

Keystone

An elderly woman drinks after she was brought by firefighters to the Saint Antoine hospital in Paris, Monday, 11 August 2003

XINHUA/AFP

Several children cool off with the water from a fire hydrant in New York. Temperatures soared to over 100 degrees as a heat wave swept the East Coast of America in August, 2006

high temperatures. Since the elderly often live alone and need more assistance during a heat wave, their vulnerability is significantly increased (Inkley 2009).

Children are also particularly sensitive to high temperatures because of their ratio of small body mass to surface area. As temperatures increase, the amount of air pollution also increases; children are very sensitive to pollution levels and to the impacts of respiratory diseases. Children are prone to developing asthma at a young age when their lungs are still developing. Exposure to high amounts of pollution at a young age can cause permanent damage and lifelong asthma problems (Karl et al. 2009).

Heat waves also pose a great risk to chronically ill people. Increased temperatures often exacerbate symptoms such as dehydration. When combined with pre-existing conditions like heart disease and diabetes, extreme heat can put too much stress on the body. The high incidence of diabetes among the elderly only adds to their vulnerability. (Karl et al. 2009). Furthermore, the International Diabetes Federation stated that as of 2006, diabetes had increased from 30 million to 230 million cases in the prior two decades (Santora 2006). This is an indicator that the number of people that are chronically ill is rapidly increasing, resulting in an ever-increasing number of people at risk during a heat wave.

Low-income populations are another group that is extremely susceptible to health issues caused by heat waves. People with low-incomes often live in densely populated areas which may have poor air quality, lack of air conditioning and limited access to healthcare (Inkley 2009). Low-income populations may not be able to purchase air conditioners or afford the increased electricity bills that typically accompany air conditioners. Additionally, they might not be able to afford a television or have access to the Internet. Therefore, they will miss the heat wave warnings and cooling center information, or have no means of transportation to these cooling centers.

Linguistically isolated populations include people whose language is uncommon in the area in which they are living. These people are at great risk due to the fact that they might not speak or understand English and thus could fail to comprehend the issued heat wave warnings. Additionally, these people might be difficult to assist because their language and social situation makes them difficult to find.

People living alone who do not have strong social ties are especially vulnerable during a heat emergency. Socially-isolated populations lack important relationships with the neighboring community. For example, people often provide support and help by checking in on their neighbors. People can be isolated for a number of reasons, including health, mental illnesses, language barriers or choice; however, this population has a higher probability of remaining unnoticed during a heat wave (Bretin 2006; Klinenberg 2002).

Homebound populations are yet another susceptible population, especially if they have no a way to cool their homes. Their inability to leave home as a result of mobility issues makes it impossible for them to go to cooling centers. Moreover, many cities do not have the procedures in place to physically help people from their houses to a transportation vehicle that would take them to a cool location (Bretin 2006; Klinenberg 2002).

People also can be vulnerable as a result of the location of their residence, or, for the homeless, the lack of a residence. Due to the urban heat island effect, which will be further discussed in Chapter 1.4, residents living in an urban area are subjected to higher temperatures than the surrounding rural areas. Additionally, heat in residences on the top floors tends to be higher than lower floors because of direct sun exposure on the roof as well as rising heat from below (Bretin 2006).

Finally, there are many people who remain uncounted by the Census and do not register to vote, which could make them hard to find and assist during a heat emergency. (Klinenberg 2002). This also includes the large homeless population. Overall, there are many vulnerable populations that are susceptible to the effects of heat waves. However, the most important fact is that many people are even more vulnerable if they are characterized by more than one of these vulnerabilities including age, prior illnesses, demographics, social situations and housing location in the city. For these vulnerable populations, heat waves pose a serious threat to their health and wellbeing. Therefore, it is essential that cities make preparations to assist these people when temperatures rise to dangerous levels.

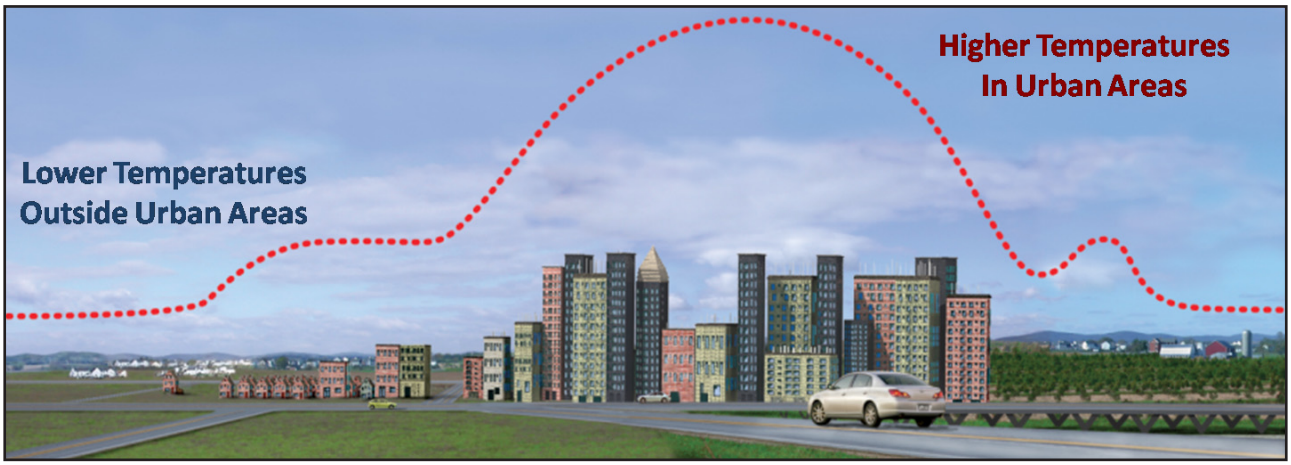
For these vulnerable populations, heat waves pose a serious threat to their health and wellbeing.

1.4. Urban Heat Island Effect

Heat waves are especially dangerous for vulnerable populations living in metropolitan areas as a result of the urban heat island effect. During a heat wave, urban areas become much hotter, as much as 8°F, than non-urban or rural areas. Cities, due to their infrastructure and design, create an effect that traps heat and increases the temperature as can be seen in Figure 2. The urban heat island effect occurs because of lack of vegetation, dark colored infrastructure and impermeable surfaces, design of tall infrastructure that blocks wind and create urban canyons that trap heat as well as other anthropogenic heat sources (Environmental Protection Agency (a) 2010). For example, cities contain mostly dark colored or black concrete buildings with black rooftops. All of these tend to directly absorb the heat from the sun's rays as well as block air currents, thus heating the city.

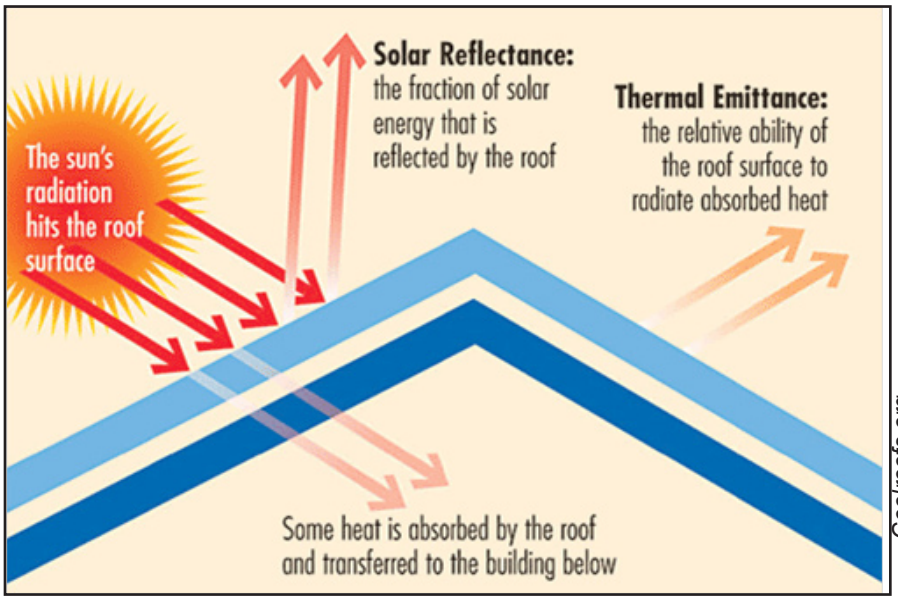
The urban heat island effect is directly related to the basic thermal properties of different materials used in construction. The cool temperature of a building, sidewalk, or street is determined by its solar reflectance and thermal emittance. Solar reflectance, or albedo, is the percentage of solar energy reflected by a surface. The greater the solar reflectance, the less energy is absorbed by the material and less heat is transferred to the building below. Thermal emittance is measured as a percentage of solar energy absorbed and instantly released. A high thermal emittance is desirable because energy that is not instantly re-radiated is absorbed and raises a material's internal temperature. Over the course of the day and night, this absorbed energy is slowly transferred as heat to the building below and to the air above. This contributes to the urban heat island

Figure 2: Urban Heat island Effect



Source: National Aeronautics and Space Administration

FIGURE 3: THERMAL EMITTANCE



Coolroofs.org

effect making temperatures even hotter during a heat wave (Gartland 2006). This process can be seen in Figure 3, which shows an example of cool roofs, a long-term mitigation strategy that is discussed in Chapter 5.

In addition, air conditioning use rises as temperatures increase and peaks when temperatures are the hottest. While air conditioning cools a building inside, it emits heat into the city air and thus adds to the already hot temperature. Extensive parks and tree-shaded areas can sometimes reduce the effect of the urban heat island. However, the effect of vegetation is often too weak to decrease temperatures because of pervasiveness of dark-colored infrastructure found in most urban areas. The expansion of cities, both upward and outward, combined with ominous predictions of climate change prove that heat waves should be a particular concern for all cities (United States Environmental Protection Agency (a) 2010).

2 CLIMATE CHANGE

2.1. Observed Climate Change Data

In 2009, the Commonwealth of Massachusetts's Executive Office of Energy and Environmental Affairs organized the Climate Change Adaptation Advisory Committee. The Committee is composed of stakeholders from local governments, transportation, energy generation and distribution, water supply and quality, recreation, public health, insurance, and forestry sectors as well as low-income consumers. The Advisory Committee's mission is to meet the goals set by the Global Warming Solutions Act including reducing CO2 emissions to below 1990 levels by 2020 (Executive Office of Energy and Environmental Affairs, 2009). The committee is also tasked with defining, assessing and evaluating strategies for adapting to potential vulnerabilities Massachusetts may face due to the predicted impacts of climate change (Executive Office of Energy and Environmental Affairs, 2009). Extreme temperatures are among the most dangerous impacts associated with climate change. Likewise, additional impacts pose serious threats to the safety of urban areas, including droughts, rising sea level, and decreased biodiversity, but extreme heat is among the most deleterious to public health and safety (Klinenberg 2002). For a summary of the observed climatic changes detailed in the Intergovernmental Panel on Climate Change (IPCC) 2007 summary report, see Table 1.

Table 1: Observed Global Climate Impacts (1960 – 1990)

Parameter	Observed Changes
Temperatures	Increased by 1.8 to 4 Degrees Celsius
Water	10-40% more availability in high latitudes; 10-30% less availability in dry regions; vast desertification of African continent
Sea Level	Increase by 7-14 inches; coastal inundation
Biodiversity	20-30% of assessed plant and animal species face elevated risk of extinction
Public Health	Longer transmission seasons and range of vector bone diseases; malnutrition expected to increase
Snow	Reduced snow cover in Northern Hemisphere

Source: IPCC Climate Change 2007: Synthesis Report Summary for Policy Makers.

To better understand the risk extreme heat poses for Boston, an evaluation was conducted of Boston's historical weather trends. To perform this analysis, 60 years of hourly temperature and relative humidity data for the Logan Airport Weather Station were acquired from the National Oceanic and Atmospheric Administration (NOAA 2009). A temperature baseline was created using the period 1950-1975, which was then compared to the following 25 year period, 1976-2001. The data shows that the average daily maximum temperature has increased by more than 2°F in the summer months over the baseline (NOAA, 2009). This confirms the IPCC's observations shown in Table 2. For additional tables and charts based on these data, please see Appendix A.

By every metric, it is clear that temperatures have increased by more than 2°F or 3% from the baseline to the recent period. Relative humidity, or dew point, which contributes to how hot it feels, is also increasing at a similar rate of nearly 2% over the baseline. Heat and relative humidity are the two determinants of a heat wave and this increasing trend translates into an increased probability of more extreme heat events in Boston.

Table 2: Average Daily Maximum Temperatures and Humidity for Boston

Month	Period 1: 1950-1975 (Baseline)		Period 2: 1976-2001	
	Avg Daily Max Temp	Avg Max Daily Dewpoint	Avg Daily Max Temp	Avg Max Daily Dewpoint
May	66.5	49.7	69.0	51.4
June	76.7	59.9	79.1	60.9
July	81.9	64.7	84.1	65.9
August	79.9	64.1	82.0	65.8
September	72.4	58.8	75.0	59.9

Month	Period 1 to Period 2 Increases			
	Increase in Avg Daily Max Temp	% Increase in Max Temp	Avg Max Daily Dewpoint	% Increase in Max Dewpoint
May	2.5	3.8%	1.8	2.6%
June	2.4	3.2%	1	1.3%
July	2.2	2.7%	1.2	1.4%
August	2.1	2.6%	1.7	2.0%
September	2.6	3.6%	1.1	1.5%

Source: NOAA KBOS Weather Station Data 1950-2008.

2.2. Predicted Increase in Extreme Heat

It is expected that climate change will cause temperatures to increase in Boston, but it is difficult to predict by how much or at what rate. A conservative approach would be to accept the highest projections and prepare for the worst. The Northeast Climate Impact Assessment provides both a low CO2 emissions scenario and a high CO2 emissions scenario, and the effect these scenarios will have on temperatures in the region. This can be seen in Tables 3 and 4. These data are presented as the number of days per year exceeding 90 and 100 degress, temperatures extremely dangerous to both vulnerable populations and the general public.

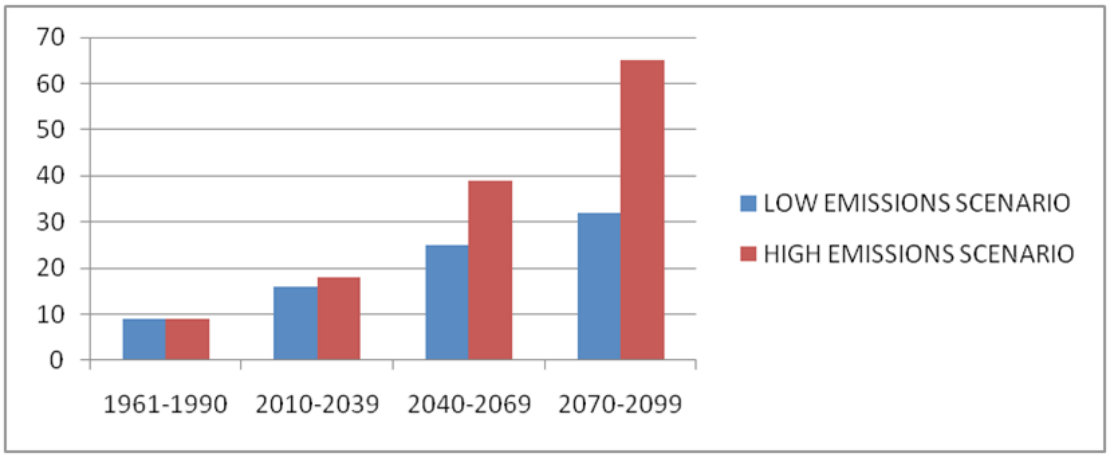
As seen in Table 4, under the high emissions scenario, over 62 days a year will experience temperatures in excess of 90°F. By comparison, there were only 15 days per year with temperatures exceeding 90°F in the period of 1950-2008 (NOAA, 2009). This is a more than 400% increase in the number of days with temperatures exceeding 90°F. As days exceeding 90°F become more common, consecutive days of extreme heat, or heat waves, are more likely to occur.

Table 3: Days per Time Period Exceeding 100°F

Period	Low Emissions Scenario	High Emissions Scenario
1961-1990	1	1
2070-2099	6	25

Source: Northeast Climate Impact Assessment.

Figure 4: Days per Time Period Exceeding 90°F



Source: Northeast Climate Impact Assessment.

2.3. Heat Waves and Heat Emergencies in Boston

Undisputed evidence shows that extreme heat events in Boston have become more common and more severe over the past 50 years. Boston needs to be prepared because this trend is expected to continue at an increasing rate over the next 50 to 100 years. However, before the city can develop a comprehensive plan for the response to heat waves, the different departments and agencies must first agree on, specifically, what defines a heat emergency and when it should be declared.

In Boston, a prolonged number of days with high temperature, or a heat wave, triggers the city to declare a "heat emergency". Yet city agencies have different definitions of what constitutes a heat wave and heat emergency, making it challenging to conduct an evaluation of the city's heat wave history and heat emergency plan. For example, Boston's Commission on Affairs of the Elderly (Elderly Commission) defines a heat emergency as three consecutive days with temperatures exceeding 86°F and relative humidity exceeding 68% (Heat Wave Alert Plan 2008). The Elderly Commission also declares a "heat advisory" if these conditions are in effect for one to two days (City of Boston EMS 2008). The Mayor's Office, on the other hand,

defines a heat wave to be three consecutive days with maximum temperature exceeding 90°F (City of Boston (f) 2009). However, the Mayor also has the authority to declare a heat emergency at his discretion, should he determine the conditions are acceptable. Another definition, used by the National Oceanic and Atmospheric Administration and the City's Comprehensive Emergency Management Plan (CEMP), is derived from the NOAA heat wave index in Table 4 below. This definition is used for this report because it provides the most comprehensive integration of temperature and relative humidity. The index does not necessarily account for heat wave duration, as it can apply to daily occurrences. The NOAA index applies to daily temperatures and relative humidity, and does not track the number of days, consecutive or non-consecutive, for which caution and warning levels have occured. This is a significant problem because the index fails to account for heat wave duration. Therefore, we recommend that the city integrate the NOAA index into its current definitions for heat emergencies and heat advisories. For a further description of the various city agencies' heat emergency

Table 4: NOAA Heat Wave Index

Temperature (°F)

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

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution Extreme Caution Danger Extreme Danger

Source: NOAA-ESRL Physical Sciences Division, Boulder Colorado

and heat advisory definitions, please see chapter 3.3.

It is critical that the city develop a standard definition for both heat emergencies and heat advisories. The NOAA index is recommended for both heat advisories and heat emergencies because it provides the most detailed information. However, it is not necessarily significant which definition the city uses, as long as it is a standard definition used by all of the involved agencies.

Using the NOAA index above, the historical occurrences of each warning level, the peak period of vulnerability and the length and severity of a given heat wave were determined for Boston. Any occurrence of any warning level is significant; however, for the purpose of this report, heat emergencies were classified as three or more consecutive level three or level four warning days also characterized by "danger" and "extreme danger" in Table 4. The three-day period was used because it is in line with both the city's definition and common definitions of a heat emergency used by other cities in the U.S.

Using the parameters set by the NOAA index, historical daily occurrences of each warning level were analyzed to determine the distribution of heat emergency days over the past 50 years. The number of heat warning days occurring outside the period May 1st to September 30th is extremely limited. The week that is the most likely

Table 5: Trends in Heat Warning Days

Parameter	Baseline Period (1950-1975)	Recent Period (1976-2001)	% Increase
Total Heat Warning Days	1483	1859	25.4%
Avg. Number of Heat Warning Days/Year	57	72	26.3%
Total Number of Level 3 and 4 Heat Warning Days	197	362	83.8%

Source: NOAA Historical Hourly Temperature for KBOS Station.

Table 6: Trends in Heat Wave Days

Parameter	Baseline Period (1950-1975)	Recent Period (1976-2001)	% Increase
Total Heat Wave Days	59	218	269.5%
Avg. Number of Heat Wave Days/Year	5	10	100%

Source: NOAA Historical Hourly Temperature for KBOS Station.

to trigger a day with a level four warning is July 17th to July 23rd. It is clear that the peak "heat emergency season" occurs between the beginning of July and the end of August. See Figure 2 below for occurrences by week and warning level for the period 1950-2001. In addition, the number of heat warning and heat emergency days are clearly increasing from the baseline period to the recent period. See Tables 5 and 6 above for a summary of these trends.

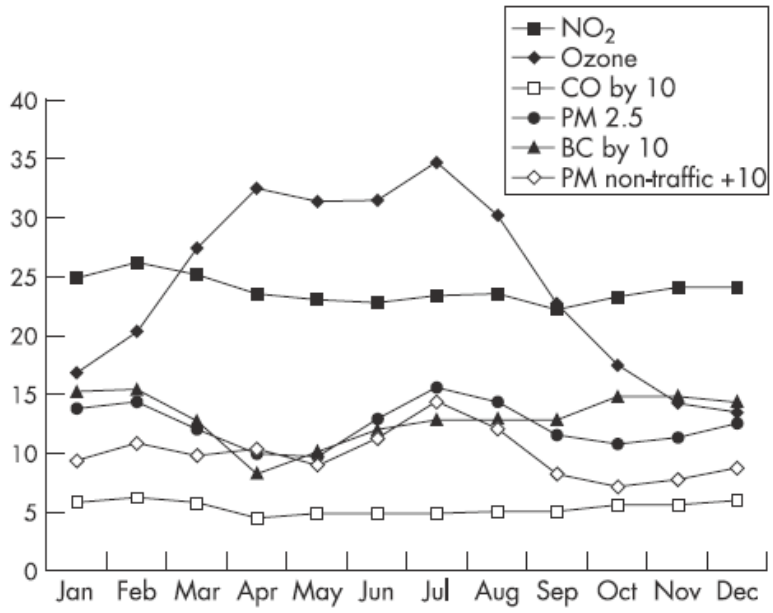
The likelihood of heat waves occurring in Boston is increasing. The historical data show that the City of Boston is twice as likely to experience a heat wave today as in 1950 and thus the number of declared heat emergency declarations will certainly increase. As such, it behooves City officials to take the threat of heat waves extremely seriously.

For additional analysis of these data, please see Appendix B.

2.4. Air Pollution

The increase in heat waves due to climate change will also almost certainly increase the amount of pollution in the air, which includes ground-level ozone, one of the main ingredients of smog. Currently, approximately 158 million Americans live in areas that exceed air pollution standards which negatively impacts human health (Karl et al. 2009). "A warmer climate is projected to increase the natural emissions of VOCs, accelerate ozone formation, and

Figure 5: Boston's Air Pollution Levels in the Summer Months



Source: Air Pollution and Emergency Admissions in Boston, MA. Schwartz and Zanobetti.

increase the frequency and duration of stagnant air masses that allow pollution to accumulate, which will exacerbate health symptoms" (Karl et al. 2009). As the temperature increases, so does the smog, which can increase and induce the affects of asthma, allergies and other respiratory diseases, proving especially dangerous to elderly people and children with pre-existing illnesses. However, everyone is affected because breathing ozone damages the cell lining of both healthy and vulnerable lungs. Those that spend a large amount of their time outdoors for work and/or leisure, including construction workers and athletes, are especially at risk (Karl et al. 2009).

Undoubtedly, Boston will be affected by increased pollution due to the warmer weather trends described above. Air pollutants, especially ozone, have been proven to increase in the City of Boston when temperatures rise (Schwartz 2006). Pollution levels are highest during the summer months as shown in the Figure 5 above which also lists several different types of pollutants in the key; however, for the purpose of health effects, this report focuses on ozone. Therefore, as the number of days over 90°F increase, smog will increase and the health of Boston residents will decline.

2.5. Blackouts

In addition to the negative impact that increasing temperatures have on quality of life, air quality and human health, there is a clear correlation between hot temperatures and stresses on the electricity grid. The New England region's electricity grid is overseen by the non-profit Independent System Operator New England (ISO-NE 2010). In Massachusetts, this grid is divided into three parts, or load zones, including Western Central Massachusetts (WMCA), South Eastern Massachusetts (SEMA), and North Eastern Massachusetts-Boston (NEMA-BOS). Boston and its surrounding suburbs are included in the NEMA-BOS load zone.

In the NEMA-BOS load zone, and the rest of New England, peak annual demand for electricity occurs exclusively in the summer (see Table 7 below). From 2004 to 2009, peak system demand has always occurred within a summer month (ISO-NE, 2010). One of the primary reasons for this spike in demand is increased air conditioning use (ISO-NE, 2010). Air conditioners use more electricity than nearly any other household appliance. When the electricity grid is under extreme stress, the Independent System Operator declares an "OP 4 Action," which means that either a blackout or brownout, described as some incidence of lost power, has occurred, will occur, or is very likely to occur. Of the nine summer

OP 4 Action events declared since 2004, more than 60% of them coincide with a heat wave (National Oceanic and Atmospheric Administration 2009; ISO-NE 2010).

This increased likelihood of blackouts during heat waves is an extreme problem for Boston. If a blackout occurs during a heat wave, Boston's cooling centers will no longer be effective because most of them do not have a back up power source (McDonough 2010) 2010). People that may not have air conditioning in their homes or lose power in a blackout will often use public cooling centers to escape the heat. However, in the event of a blackout or brownout, cooling centers without back-up generators lose the ability to provide a public air-conditioned place and people will have to find a cool location elsewhere. As a result, more people will have prolonged exposure to the heat which will further exacerbate health issues and, in the worst-case scenario, mortality rates.

Table 7. Peak Electric Demand

Maximum Electricity Demand by Year by Month (MW)												
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2004	4414	3760	3638	3541	3521	4576	4472	4715	4097	4022	3569	4189
2005	4193	3731	3808	3328	3249	4964	5391	4959	4450	4307	3576	4060
2006	3815	3934	3702	3290	3679	4908	5379	5582	3872	4229	3629	3959
2007	4148	4206	4173	3492	4139	5309	4906	5199	4737	3925	4311	4080
2008	4260	4003	3581	3380	3758	5302	5096	4380	4603	3436	4290	4071
2009	4098	3990	3804	3883	3805	3888	4654	5134	3801	4382	4262	4478
AVERAGES	4155	3937	3784	3486	3692	4825	4983	4995	4260	4050	3940	4140

Source: Independent System Operator-New England, 2010

3 HEAT WAVE PREPERATION MEASURES

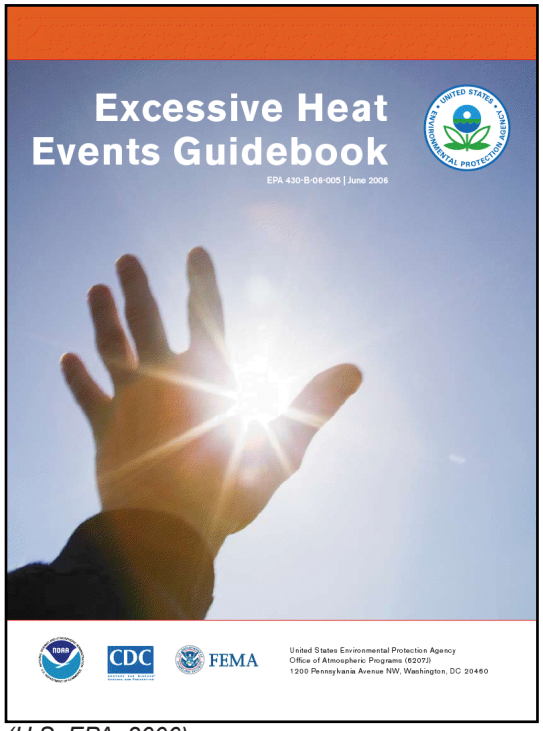
3.1. Heat Wave Plan Guidance

The abovementioned evidence illustrates that climate change will increase the frequency and severity of heat waves. Local, regional, and national governments need to develop action plans to prepare for future heat waves, and ensure that the tragic consequences of past heat waves do not reoccur. Both the United States Environmental Protection Agency (EPA) and the World Health Organization's Regional Office for Europe (WHO) have developed comprehensive guidance manuals to help governments devise essential strategies for mitigating the negative effects of heat on human health. These recommendations are based on cities and countries that have experienced the most success in implementing effective heat wave plans. Most importantly, these guides acknowledge that each city has unique circumstances, and suggest that cities tailor the recommendations so that are best suited for their populations and local conditions.

EPA Guidance

In 2006, the EPA published an "Excessive Heat Events Guidebook," summarizing the importance of having a written heat wave plan (referred to as an Extreme Heat Event Program). It outlines the necessary items to include in a comprehensive heat wave plan while also critiquing the heat wave plans from Philadelphia, Toronto and Phoenix. The EPA guidelines lists four critical elements that heat wave action plans must include: 1) prediction of extreme heat events one to five days in advance, 2) risk assessment, 3) notification and response and 4) mitigation. There are many aspects

to these elements, summarized in Table 8, but within these elements, the critical actions that must be taken in order to minimize negative health impacts include:



(U.S. EPA, 2006)

- Immediately activating heat wave response plans when an excessive heat emergency has been forecasted;
- Identifying vulnerable groups and their locations so to focus efforts on these areas;
- Establishing and facilitating access to air conditioned public shelters;
- Ensuring real-time public access information about the risks of extreme heat and the appropriate responses through broadcast media, web sites, toll-free phone lines and other means;
- Establishing systems to alert public health officials about high-risk individuals or those in distress during an extreme heat event; for example, using phone hotlines and high-risk lists;
- Directly assessing and, if needed, intervening on behalf of vulnerable populations.

The EPA encourages governments to utilize all available resources and collaborate with program partners when planning and implementing heat wave plans. This helps to ensure that plans are cost effective, efforts are not duplicated, and that plans can be executed without creating additional, organizational bodies. For example, places that are used for emergency shelters can also be used as cooling centers if they have adequate air conditioning. In addition, organizations that already serve elderly clients should be utilized to help check in on vulnerable people. Public employees can also be requested to briefly alter their job duties to help with the relief effort. Furthermore, the EPA's guidelines stress the importance of active and regular review of heat wave plans so that varying needs, opportunities for new partnerships, and new potential vulnerabilities can be addressed.

World Health Organization Guidance

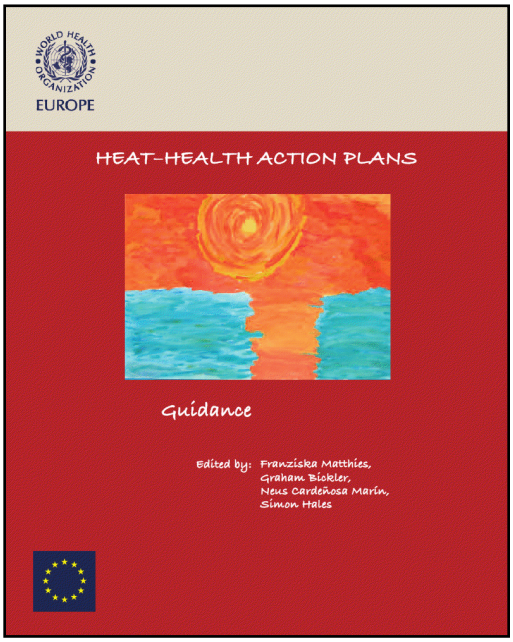
In 2008, the WHO's Regional Office for Europe published, "Heat Health Action Plans Guidance," summarizing the result of EuroHEAT, a two-year project focused on improving public health responses during heat waves. The WHO designed the document

Table 8: EPA Recommendations for Heat Wave Plan Elements

EPA Guidance: Critical Elements of a Heat Wave Policy (EHE = Extreme Heat Event)
Prediction • Ensure access to weather forecasts capable of predicting EHE conditions 1-5 days in advance
Risk Assessment • Coordinate and transfer evaluation of weather forecasts by EHE program personnel • Develop quantitative estimates of EHE's potential health impact • Use broader criteria to identify heat-attributable deaths • Develop information on high-risk individuals • Develop an accessible record on facilities and locations with concentrations of high-risk individuals
Notification and Response • Coordinate public broadcasts of information about the anticipated timing, severity and duration of EHE conditions and availability and hours of all public cooling centers • Coordinate the publication and broadcast of heat exposure symptoms and tips on how to stay cool during an EHE • Operate informational phone lines that can be used to report heat-related health concerns • Designate public buildings or specific, private buildings with air conditioning as public cooling shelters and provide transportation • Extend the hours of operation at community centers with air conditioning • Arrange for extra staffing of emergency support services • Directly contact and evaluate the environmental conditions and health status of known individuals and locations likely to have concentrations of these individuals • Increase outreach efforts to the homeless and establish provisions for their protective transfer to cooling shelters • Suspend public shutoffs • Reschedule public events to avoid large outdoor gatherings when possible
Mitigation • Develop and promote action to reduce urban heat island effects

Source: United States Environmental Protection Agency. 2006. Excessive Heat Events Guidebook

to provide policy makers and medical professionals with guidance and suggestions for constructing national and regional heat wave plans. In creating heat wave plans, the WHO stresses the importance of using existing emergency response plans and focuses on a collaborative, multi-agency approach. According to the WHO, the eight core elements necessary for an effective heat wave plan and successful implementation are:



(Matthies, 2008)

- Agreement for a lead body to coordinate response efforts among and between different agencies;
- An accurate and timely alert system;
- A heat-related health information plan detailing what is communicated to whom and when;
- Short, medium and long-term strategies to reduce indoor heat exposure;
- Particular care and strategies for assisting vulnerable populations;
- Preparedness of the health and social care systems;
- Long-term urban planning to reduce the urban heat island effect;
- Real time surveillance and evaluation.

The EPA and WHO recommendations are similar; however, the WHO recommendations emphasize the need to mitigate the effects of heat with long-term solutions. In addition, the WHO highlights the importance of creating plans that do not intensify climate change. For example, the WHO does not advise increased dependence on air conditioners and the construction of new cooling centers. Instead, the report recommends incorporating a variety of urban design strategies that include external shading and insulation to reduce indoor temperatures (Matthies 2008). Therefore, the principles outlined in the WHO manual are most beneficial for urban planners developing heat wave prevention strategies, whereas policy makers might find the EPA's recommendations more useful due to the specific, reactive strategies.

3.2 Efficacy and Criticisms of Heat Wave Plans

Several cities developed comprehensive heat wave plans after experiencing severe heat waves. Many of these plans follow the recommendations in the EPA and WHO manuals. Unfortunately, due

to variations in heat wave conditions, population differences and lack of control groups, measuring the efficacy of heat wave plans is complicated. Yet, evidence from Philadelphia, Chicago and France has indicated that the number of heat-related deaths appears to decrease dramatically when a city institutes a heat wave plan.

Slate

Did we learn anything from Chicago?

In the 1995 Chicago heat wave, over 700 people are estimated to have died (Klinenberg 2002). Following this disaster, Chicago enacted a more comprehensive heat wave plan. Four years later in 1999 when the city experienced yet another heat wave, only approximately 100 people died from heat-related causes (United States Environmental Protection Agency 2006). Similarly, a study of heat wave mortality rates in Philadelphia from 1995 to 1998 found that due to the efficacy of the city's heat wave plan, a total of 117 lives were saved over this three year period (Ebi 2004). When activated, Philadelphia's heat wave emergency plan costs the city approximately $10,000 per day. However, when the statistical value of a human life is valued at $6 million, the plan not only saves lives, it is also extremely cost effective (United States Environmental Protection Agency 2006).

In the 1995 Chicago heat wave, over 700 people are estimated to have died

Additionally, a French study following a 2006 heat wave found a two-thirds reduction in the number of deaths after the implementation of a heat wave plan. The study attributed the reduction in deaths to "a decrease in the population's vulnerability to heat, together with, since 2003, increased awareness of the risk related to extreme temperatures, preventive measures and the set-up of the warning system" (Fouillet 2008). Despite the limited research on the efficacy of heat waves plans, study results suggest that cities that adequately prepare for extreme heat events reduce the number of heat-related deaths.

Criticisms of Heat Wave Plans

Even though there is lack of concrete evidence to prove that heat wave plans and procedures are effective, there appears to be general acceptance and support for such plans. Very little information has been published critiquing governments'

implementation of heat wave plans, perhaps because they are relatively recent. The only severe criticism occurred after the second heat wave in Chicago in 1999. Media outlets decried the government's use of taxpayer money to enact heat wave measures including paying city employees to call vulnerable residents. The media posited that volunteers or non-profit organizations should be performing these services. As a result of this condemnation, the government partnered with non-profit organizations to consolidate resources and save funds (Klinenberg 2002).

3.3. Boston's Heat Wave Plan

Boston has not yet experienced a severe heat wave, but as the levels of CO2 in the atmosphere increase, the city is at an increasingly greater risk of experiencing an extreme heat emergency. Researchers have estimated that during an average summer, 56 to 96 Boston residents die as a result of heat-related causes. This broad estimate reveals the differences in measuring and classifying excessive and attributed heat wave deaths (Kalkstein 1997; Davis et al. 2003) and this number will, without a doubt, increase as temperatures become more extreme. Despite this fact, Boston has not yet fully addressed the dangers of heat waves and has failed to develop a comprehensive heat wave plan. This can be attributed to the infrequency of extreme heat in Boston and the apparent effectiveness and public acceptance of the current heat wave procedures. Although Boston's lack of a comprehensive heat wave plan is unacceptable, it is not unusual. A 2002 study of 18 cities with a history or risk of frequent heat waves found that only six cities had detailed, written heat wave plans, six cities had absolutely no written plans, and six cities had very cursory plans, similar to Boston (Bernard 2004).

Boston has instituted policies to help residents during extreme heat events, but its only all-inclusive heat wave plan, the draft of the Natural Hazard Annex L for Extreme Heat and Humidity, is extremely general. This annex cannot be publicly distributed because it is part of Boston's Comprehensive Emergency Management Plan (CEMP), currently under revision with National Incident Management System. The plan is developed and maintained by the Mayor's Office of Emergency Preparedness (MOEP) and the Boston Public Health Commission (BPHC). The MOEP is responsible for coordinating response efforts.

The annex clearly defines the dangers of a heat wave in Boston through the acknowledgement of previous, severe heat waves in other cities and the impact of the urban heat island effect. Also

included is a description of the most vulnerable populations, and possible, successful interventions to prevent deaths within these populations. The annex lists the large network of agencies responsible for providing services during a heat wave and briefly describes each agency's tasks. However, it lacks critical and specific details of each agency's role during a heat emergency. The annex fails to list some of the vital agencies involved in heat wave responses, like the Boston Center for Youth and Families (BCYF), who operates the city's cooling centers. There is also no mention of any plan evaluation or subsequent revisions regarding its effectiveness during a heat wave. The WHO previously determined this post-event analysis and revision to be a critical component of any effective heat wave plan.

Fortunately, some of the essential missing information in the annex is included in the City of Boston Emergency Medical Services (EMS) documents, "Heat Alert Plan 2008" and "Draft Heat Alert Plan Procedure." The activation of these plans is based on the expected temperature, duration and humidity forecasted for a heat wave and a "citywide survey of heat related disorders." Boston divides its actions into three levels: heat advisory, heat alert and heat emergency. The level is determined by the number of days the heat wave has lasted or is expected to last. Table 9 outlines the procedures taken at each level.

Both the city's Heat Wave Annex and Heat Alert Plans enlist the support of a large network of agencies. The network of agencies include: Mayor's Office, Boston Public Health Commission, Emergency Medical Services, Emergency Preparedness, Elderly Commission, Emergency Shelter Commission, Boston Centers for Youth and Family, Boston Redevelopment Authority, Boston Police Department, Boston Health Care for the Homeless, City of Boston Homeless Services, Boston Senior Home Care, ETHOS, Central Boston Elder Services and Boston Housing Authority. The roles of agencies and, if applicable, their specific plans are described below. The majority of this information was compiled through comprehensive research and interviews with the directors of these particular agencies. These interviews provided essential information and exposed discrepancies between the written plan and what is actually accomplished. Unfortunately, some departments failed to respond to repeated requests for information. As a result, some the following descriptions are based on limited information.

Table 9: City of Boston EMS: Heat Alert Plan (2008)

Alert Level	Agencies in charge	Action Taken
Heat Advisory Declared during the initial 1-2 days when the temperature is over 86°F and humidity is greater than 68%	BPHC, EMS, and the Elderly Commission	• Mayor's Office contacts the media to issue warnings, describe emergency conditions and broadcast phone numbers • Public Service announcement given and every Boston resident over the age of 65 receives a recorded phone call explaining the dangers of heat waves and how to seek help
Heat Alert Declared after 3 days of high temperatures.	BPHC, BPH, Boston EMS, Mayor's press office, Elderly Commission	• EMS staffs extra ambulances and issues warnings to all public safety agencies • Commission staff and medical support staff assist in opening various neighborhood cooling centers staffed by BCYF • The hours of the city's swimming pools are extended • Elderly Commission contacts nutrition vendors, home care agencies and visiting nurses associations for telephone and in-person checks on bed-ridden, homebound and chronically ill elders. • Home care agencies are advised to set up telephone trees for clients at risk. • Senior Shuttle fleet is mobilized for transportation to cooling centers
Heat Emergency Declared when high temperatures last more than 3 days.	Mayor Menino. Mayor's Office of Emergency Preparedness	• Continue the above action • Department heads meet to plan future actions • Additional will be evaluated on a case by case basis

Source: "Heat Wave Alert Plan 2008," City of Boston EMS, City of Boston "Draft Heat Alert Plan Procedure" and Melissa Carlson, Commission on Elderly Affairs, Interview February 2, 2010.

Mayor's Office

At the beginning of the summer, the Mayor's Office issues a press release to all media outlets, in all major languages, regarding the dangers of heat, and provides important phone numbers to call, including the Mayor's 24-hour hotline, the Elderly Commission and EMS. (See Appendix C.) The media outlets in Boston include local newspapers, television stations, and local radio stations. There are over 20 different local newspapers in Boston reaching a diverse audience; eight newspapers are in different languages (Armenian, Portuguese, Cantonese, Mandarin, Haitian, Korean, Polish, Spanish and Vietnamese) (O'Brien 2010).

When the temperatures in Boston reach 86ºF with a relative humidity of 68%, and are predicted to remain at this level for at least two days, the Heat Alert Plan is activated. Once this plan is engaged, the main role of the Mayor's Office is to provide information to the public. A press release is issued and the media is contacted to issue warnings, describe emergency conditions, broadcast helpful phone numbers, and provide information about public cooling centers. (See Appendix D for an example of a press release.) Heat wave information is widely distributed in hopes of reaching all segments of the population. The last time a heat alert was declared was in 2006; however, no information could be collected about the number of times the city has activated its Heat Alert Plan (Sudanowicz 2010).

Mayor's Office of Emergency Preparedness (MOEP)

The MOEP coordinates the actions of all departments during a heat emergency. When this occurs, all department heads are brought together to determine the next best course of action (Sudanowicz 2010).

Elderly Commission

The Boston Public Health Commission (BPHC) notifies the Elderly Commission to enact heat wave procedures when the temperature is forecasted to be over 86°F with a relative humidity of 68% or greater. The current actions of Elderly Commission include the following:

- *Communication*: After a heat advisory is declared, the Elderly Commission sends a blast phone call to all Boston residents over the age of 65. This list created by the Elderly Commission, consists of over 48,000 phone numbers gathered from all public databases including voter registration lists (Greenberg 2010). The Boston

Management & Information Services (MIS) sends out the phone message (O'Leary 2010), which explains the signs of heat-related illness, how to keep cool, and prompts seniors to call the Elderly Commission or the Mayor's 24-hour hotline for help or questions.

» *Transportation*: During a declared heat wave, the Elderly Commission mobilizes five to seven Senior Shuttle vans (each holding up to 12 passengers) to provide elders transportation to cooling centers. If needed, the commission will arrange for the use of more vans. To make use of the vans, seniors call to request transportation and are picked up the same day the call is placed. Information about this service is broadcasted in conjunction with cooling center information (Carlson 2010).

» Cooling Centers: The Elderly Commission staff helps BCYF staff to open cooling centers. In the written plan, the commission is responsible for securing food and beverages for distribution to these sites; however, this has not happened to date (Carlson 2010).

» Heat wave education seminars: The Elderly Commission holds community seminars to teach residents about heat wave dangers and tips for staying cool (City of Boston (b) 2009).

» Partnership: The Elderly Commission instructs Aging Service Access Point, Visiting Nurse Associations and home helivered heal providers to check in on their clients at greatest risk (see below).

Aging Service Access Points (ASAP): Boston Senior Home Care, ETHOS, Central Boston Elder Services and Title III Programs

State and federal government has hired Aging Service Access Points (ASAP) to provide case management and in-home services for Boston residents who are low-income, over 60 years of age and in need of assistance to live independently. Agencies become aware of these elderly residents that need services through referrals by friends, family or medical professionals as long as they are open to receiving help. However, the people who do not meet these guidelines or lack a referral technically would not have access to this support.

During the summer, all new clients are given heat wave informational fliers published by the city (See Appendix E). In the

event of a declared heat wave, ASAP case managers are directed to call all at-risk clients identified by medical, mobility, social or environmental factors (as assessed by nurses or case managers). If they become concerned about an elder's safety, case managers will also conduct home visits. The severity of the heat wave and the condition of the client, dictate the frequency of calls and visits by a case manager. These agencies may also purchase and install, through discretionary funds or grant monies, window unit air conditioners for elders who are homebound, have limited income, and are at risk for heat-related illnesses (Ridolfi 2010).

Elderly residents over the age of 60 considered homebound and in need of assistance with meal preparation are eligible to receive home delivered meals through the federally funded Title III grant. During heat waves, a flier with tips for staying cool and a listing of important phone numbers is attached to each meal (Stanley 2010). In addition, the delivery staff is supposed to check in on each person as they deliver the food. However, meals are often left at clients' doors.

Boston Housing Authority's Elderly and Disabled Services

During heat waves, the Elderly and Disabled Services division of the Boston Housing Authority (BHA) is considered a partner of the Elderly Commission because they serve some of the most vulnerable Boston residents. Building managers and resident service coordinators in charge of the 37 designated elderly/disabled housing developments attend annual heat stress training classes and conduct seasonal presentations to residents about the dangers of heat (Boston Housing Authority n.d.). In addition, flyers containing information about heat dangers and staying cool are posted in common areas and distributed to residents (See appendix F).

During a heat wave, each facility opens its air conditioned "cooling site" or community room, and cool drinking water is provided. Approximately 10 out of the 37 facilities also have food services to provide snacks to people using the cooling sites. If the BHA expects a large turnout at any facility, the providers try to provide extra food and games.

These cooling sites are not open to the public unless, due to extreme circumstances, people living nearby are also in need of relief. During an emergency, managers and resident services coordinators of these developments consult an in-house "frail list" to perform door-to-door checks on vulnerable residents. Residents found without air conditioning are encouraged to use the facilities' cooling sites. In the past, the BHA has also purchased air conditioners for

its most vulnerable residents. Fortunately, in the last 12 years, only one of the BHA's cooling sites lost power; when this happened, the Senior Shuttle transported residents to the closest BHA facility with a functional cooling site (Davis 2010).

Emergency Shelter Commission

The Emergency Shelter Commission is responsible for providing information and support to Boston's homeless population. The current measures taken during extreme heat include:

- Heat wave alerts in the media and public announcements requesting the public to offer homeless people water and sunscreen, and to notify EMS if they see anyone in need (See Appendix G).
- Homeless shelters and service providers offer homeless people at greatest risk of heat-related illnesses the option to stay in the shelter during the day. Eight shelters are instructed to remain open for this purpose.
- Nurses at Massachusetts General Hospital and Boston Medical Center are encouraged to refer any homeless people at their facilities to Boston Health Care for the Homeless.
- Boston EMS is alerted twice per shift to identify people at risk of heat-related illnesses and make arrangements to have the person transported to a cooling center or shelter if hospitalization is not necessary.
- Boston Police Department is given hourly directives on all channels to seek out the homeless and encourage them to go to a shelter. They are also instructed to provide transportation to the shelter.
- Boston Park Rangers patrol the Emerald Necklace from the Boston Common to Franklin Park from 10:00am to 6:00pm. They are advised of shelter options for the homeless and are encouraged to work with the Boston Police, EMS and outreach organizations to help homeless individuals.
  (City of Boston (c) 2009)

Boston Police Department

The Police Department is put on alert during a heat emergency. Police are instructed to seek out homeless individuals and encourage them to seek shelter (City of Boston (c) 2009). Additionally, often

during blackouts, police will provide surveillance and security to areas that might be vulnerable to crime (City of Boston (c) 2009).

Boston Center for Youth and Families

The BCYF manages the public cooling centers for the city. The cooling centers are primarily air conditioned buildings, such as schools and community centers, with or without pools. A few cooling centers are outdoor pools that may or may not have an associated air conditioned building. The location and hours of operation of the cooling centers are publicly distributed by the BCYF through the city of Boston's website. During a declared heat wave, the BCYF, as instructed by the mayor, will keep the doors of the cooling centers open until 9:00pm, which is called the "9 at 90 Program" (McDonough 2010).

City residents can get to the cooling centers in a variety of ways including public transportation, taxicabs, personal cars, the Senior Shuttles, or on foot Appendix H, show a list of the cooling centers, locations and building capacities. Figure 4, on the following page, also displays the location and capacity as well as the type of each cooling center.

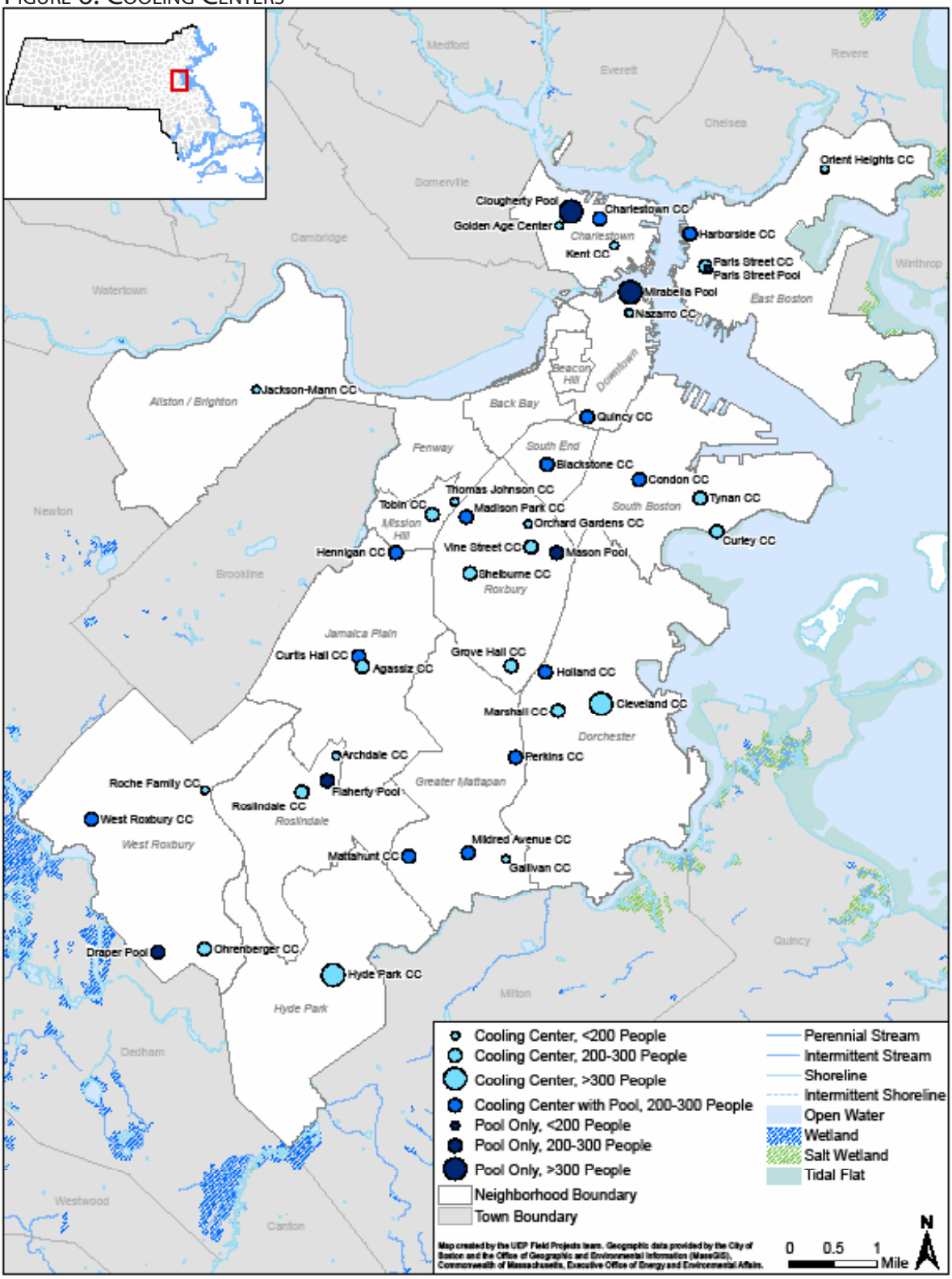
3.4 Critique of Boston's Heat Wave Plan

The city's lack of a comprehensive heat wave plan is a major flaw

Information about Boston's heat wave plan was collected from both government documents and a number of informational interviews, because there is no existing comprehensive plan describing the critical information. The city's lack of a comprehensive heat wave plan is a major flaw. The city's only two plans, the Extreme Heat and Humidity Annex L and the Boston EMS Heat Alert Plan 2008, lack necessary details and contain outdated information. The 2008 version of the Heat Alert Plan is exactly the same as the 1998 version, proving that this plan has not been modified in at least ten years. If there is a 2010 version of this plan, it was not made available for use in this report, despite numerous requests. Also, many discrepancies were found, through interviews, between the written plans and what is actually done. This further proves that the plan is outdated and incomplete. Without a current document, it is impossible to accurately assess and evaluate the scope of the plan, understand what agencies are involved, and what each agency's role is. It is also impossible for the government and public to hold these agencies accountable.

In addition, many of the policies in Boston's plan do not completely fulfill the EPA recommendations. The first EPA guideline,

Figure 6: Cooling Centers



outlined in Chapter 3.1, declares that the immediate activation of a heat wave plan is vital to saving lives. According to Boston's EMS Heat Alert Plan 2008, outreach to vulnerable clients and the establishment of cooling centers is not done until the third day of a heat wave. This delay is significantly late, because heat-related deaths can and do occur within the first two days of a heat wave (National Health Service 2009).

The EPA guidelines also emphasize the need to ensure everyone has access to information about the dangers of heat waves. Boston notifies its residents of the dangers of heat and the location of cooling centers via newspapers, media outlets and phone calls, but there is still the potential to miss many people. First, the "blast" phone calls sent out to people over 65 are only in English (Carlson 2010). Nearly 30,000 Boston households do not speak English, so this portion of the population would miss critical information (United States Census Bureau 2010). In addition, many people no longer have landlines and rely solely on cellular phones. These phone lists may also be out of date. Lastly, many elderly people suffer from hearing loss which prohibits them from clearly hearing or understanding the message. Therefore, there is the potential for many people to miss this important message (Greenberg 2010; O'Leary 2010).

"Blast" phone calls sent out to people over 65 are only in English

Evidently, the blast phone calls have created confusion among residents who did not clearly understand the message resulting in a "flood" of inquiries to the Mayor's 24-hotline service. As a result, questions have been raised regarding the necessity and usefulness of the blast phone call service. Television, radio and newspaper outlets have been proposed as alternative ways to broadcast the heat alert message. This service may be equally or more effective than the current system and potentially less confusing (O'Shea 2010). However, the Elderly Commission does not support the idea of stopping the blast phone call service (Greenberg 2010). Despite the fact this program reaches only a small segment of the population, stopping this program would be detrimentawl to vulnerable people. Relying solely on the media to broadcast heat information would be inappropriate because information would fail to reach those people who do utilize the television or radio, and media outlets may subjectively broadcast the information neglecting urgency or frequency.

Fortunately, ASAP's outreach efforts through case mangers and the distribution of fliers on home delivered meals (as described above) have helped to provide heat emergency information to people who may not reached by other mainstream methods. Case managers

in these programs provide information in different languages, essential to helping non-English speaking residents. However, these agencies only serve referred, eligible individuals over 60 years old who agree to accepting assistance. As such, the people who do not meet these requirements, or who have no family, friends or medical professionals to refer them would be unknown to these agencies.

People who speak English, have registered phone numbers and are already connected to other agencies are likely to be alerted during a heat wave. For people not included in these categories, Boston's communication methods are lacking. Thus, identifying people who need services the most and alerting them to available resources is an essential part of an effective heat wave plan, and one that Boston is missing.

Cooling centers are shown to be extremely successful in reducing heat wave mortality

Although Boston's heat wave plan meets the EPA guidelines of establishing and facilitating access to cooling centers, there some significant issues with the current system. Cooling centers are shown to be extremely successful in reducing heat wave mortality; however, Boston's cooling centers have an extremely dangerous vulnerability: no backup power supply. Peak demand for energy occurs on the hottest days of the year, so in the event that the energy grid fails to meet demand, there is the possibility for blackouts and brownouts. Regardless of their location, capacity, air conditioning capability and type, a cooling center without power is no longer a cooling center. In addition, refreshments might be served at the cooling centers, but most often food and beverages are not provided because of the lack of staff and funding. Also, the centers that are classified as pools are not ideal for the elderly, ill, or small children. Finally, there is no kept record of the historical use data for Boston's cooling centers so it is impossible to measure their effectiveness (McDonough 2010). Even if cooling centers are functional, convincing people to use them is another potential issue. During the 1995 heat wave in Chicago, many vulnerable residents did not leave their homes for fear of being burglarized if they went to a cooling center (Klinenberg 2002). Therefore, residents should be surveyed to see if this is also an issue in Boston.

Transportation to cooling centers presents another significant vulnerability. When cooling centers are opened, Boston's fleet of Senior Shuttles is mobilized to provide some elderly residents free transportation. Directions on how to us this free service are broadcast in conjunction with information about cooling centers. However, the Senior Shuttles only perform "curb to curb" transportation and are not equipped to accommodate wheelchairs.

Due to liability reasons, drivers cannot provide assistance to anyone through navigating stairs, helping riders in and out of vans, or providing any type of physical support. This presents a significant issue because the elderly often have mobility issues and are likely to be the most in need of assistance during a heat wave. Any elder who requires mobility help is unable to use to the Senior Shuttle and may not be able to get to the cooling centers. Since over 3,200[1] elders in Boston are considered to need assistance exiting their homes, a large portion of this vulnerable population will not be able to access the cooling centers.

In the event of an emergency, Boston has a relationship with the MBTA. If a blackout or brownout occurs and cooling centers lose power, buses can be made available to transport people to another cool location or, alternatively, an air conditioned, stationary bus could at least provide respite from the heat (Carlson 2010). Additionally, people who previously signed up for the MBTA's "The RIDE" program can use this service for cooling center transportation. Although RIDE does accommodate wheelchairs, people must apply for this service prior to use, which may take up to 30 days. For those people who have prior approval, a reservation for travel must be made one day in advance, which is problematic during a heat crisis (Massachusetts Bay Transit Authority 2010).

Boston has recently devoted more attention to climate change and heat waves and there is reason to believe that the shortcomings of the current heat wave plan will soon be addressed. The city has recently created a Climate Action Leadership Committee to analyze and prepare for climate change in Boston (City of Boston (a) 2010). Moreover, Boston's Environment Department has taken a particular interest in Boston's heat wave preparedness plan. The city should examine how other cities prepare for heat waves and use this information to develop a more comprehensive plan for Boston.

3.5 Evaluation of Heat Wave Plans in Other Cities

Many of the issues with Boston's current plan have relatively easy to implement solutions that have proven effective in other

1. This is an estimate based on evaluating the number of elders known to Aging Service Access Points (Boston Senior Home Care, ETHOS and Central Boston Elder Service) who have been identified as needing assistance with at least bathing, dressing and going outside as of March 2010. The number of total clients with this need is 3,227. Since this only includes elders that are clients of these agencies, the total number of homebound individuals is likely greater, especially because no one under the age of 60 or with an income above 300% of the poverty level would be included (Faucher 2010).

cities. Unlike Boston, many cities have a comprehensive heat wave plan, which the EPA and WHO used as a model to create their recommendations. Philadelphia and Toronto's plans are considered to be exceptional models for future heat wave plans because of their broad scope and attention to detail. Other cities, like Fresno and New York City have used these plans as benchmarks to create similar plans (United States Environmental Protection Agency 2006). It is recommended that Boston do the same.

Boston's current plan contains some of the same basic elements found in the plans of other cities, like issuing a blast telephone call and establishing cooling centers. However, other cities' plans incorporate more creative and broader strategies to respond to the particular vulnerable needs of their communities to ensure everyone has access to help. Some of these unique elements, with proper adaptation, can be beneficial to Boston given that its plan is particularly lacking in outreach, communication and evaluation. The strategies that have the highest potential to work well in Boston are discussed below.

Methods of Risk Assessment

In order to estimate the potential impact of each unique heat wave, both Toronto and Philadelphia use health impact models with corresponding current meteorological data to estimate the potential number of heat-attributable deaths. This enables the city to plan, prepare and adjust how it will enact its heat wave plan (United States Environmental Protection Agency 2006). In order to monitor vulnerable populations, many cities have compiled databases with information regarding high-risk individuals, for example where they live and any organizations that can reach out to them. In addition, Chicago created a system by allowing individuals to proactively register for extra support and regular check-ins. (Klinenberg 2002).

Outreach

Philadelphia created a "Heat Line," which is staffed by a nurse who can provide advice about heat-related medical issues in addition to providing 24-hour telephone information resources. The Department of Public Health staff subsequently visits individuals who call and seem to be at great risk. The city also has 5,000 "block captains" covering every neighborhood. When an emergency happens, they are asked to check-in on vulnerable neighbors and distribute heat information. The block captains are volunteers elected by residents in their area to lead neighborhood improvements

and safety. The media often broadcasts footage of block captains performing check-ins, which helps to remind all residents to do the same. Lastly, the city has sponsored a "buddy system" outreach effort, which encourages all citizens to check in on their vulnerable neighbors (Natural Capitalism Solutions 2007; National Resources Defense Council 2008.). In England, social workers are responsible for arranging daily visits to at-risk individuals by coordinating the efforts of formal (social workers, nurses or doctors) or informal (family or friends) supports ensuring every individual receives daily attention (National Health Service 2009). These policies help increase the chances that people without access to phones or unaware of the current resources are being contacted.

Cooling Centers and Transportation

In Chicago, cooling centers are open 24-hours a day and Toronto allows residents to visit parks late at night (Natural Capitalism Solutions 2007). Toronto also distributes free transit tokens to people who appear to be at risk in order to help them get to a cooling center (United States Environmental Protection Agency 2006). Alternatively, Fresno, California offers free taxi vouchers for people to use as transportation to cooling centers (Health & Medicine Week 2007).

Evaluation

Every fall, Toronto's "Hot Weather Response Committee" meets to evaluate and improve the city's heat wave plan based on the performance that year. The committee consists of representatives from different city departments and agencies that serve vulnerable populations. England and Philadelphia conduct similar annual reviews (United States Environmental Protection Agency 2006; National Health Service 2009). Fresno collects data on heat-related deaths and illnesses, cooling center attendance, the distribution of educational materials, number of contacts with vulnerable persons, effectiveness of internal and external communications and the activation of the plan after each heat wave. This information is compiled in a "post event report," which is immediately reviewed after the heat wave to urgently adjust any programs or procedures. After every summer, reports of all heat wave data are reviewed to help amend the heat wave plan for the following year (Fresno County Department of Public Health 2007).

These strategies and their applicability to properly function in Boston will be discussed further in Chapter 5.

4 CITY OF BOSTON POPULATION & VULNERABILITY ANALYSIS

4.1 City of Boston Population and Population Growth

In order to write the most effective heat wave plan, Boston must address the needs of its most vulnerable residents. Through evaluating historical, current and projected population data, the city can determine both the location of these residents and the amount of resources it needs to ensure their health and safety today and in the future. Between 1900 and today, Boston's population has fluctuated between 500,000 and 800,000 people (United States Census Bureau n.d.) as shown in Table 10. In 2000, the U.S. Census reported the population for the city to be 574,283 people (United States Census Bureau 2010). It is difficult to project total population growth for a city, particularly by age group, because of a variety of other factors including social, economic and cultural tendencies. However, the Metropolitan Area Planning Council (MAPC) provides population projections, by age group, through 2030. Using the MAPC estimates, Boston's total population growth per decade is approximately two percent (Metropolitan Area Planning Council 2010). However, the expected growth for those over 65 years of age is far greater at approximately 15% per decade, as shown in Table 11. This information is extremely important because heat waves pose increased risks for the elderly population. The dramatic increase in this segment of the population again proves the necessity for Boston to develop a comprehensive heat wave plan that can adequately respond to increased demands for assistance.

Table 10: City of Boston Annual Population, 1900-1990

Year	Population	Year	Population
1900	560,892	1950	801,444
1910	670,585	1960	697,197
1920	748,060	1970	641,071
1930	781,188	1980	562,994
1940	770,816	1990	574,823

Table 11: City of Boston Population Growth, by Age, 1990-2030

Age Range	1990	2000	2010	2020	2030
00-19	137,095	142,723	141,746	134,564	131,646
20-39	251,362	242,923	232,543	230,486	221,971
40-44	33,853	39,874	41,845	36,185	37,544
45-49	25,371	34,002	38,948	34,764	31,815
50-54	20,909	29,898	32,811	32,864	29,277
55-59	19,668	22,870	28,799	34,295	31,280
60-64	20,873	18,388	24,333	29,983	30,947
65-69	19,691	15,937	18,689	25,564	30,979
70-74	15,818	15,386	15,359	23,183	29,390
75-79	12,816	12,963	12,206	15,161	21,373
80-85	8,856	8,830	9,911	9,774	15,110
85+	7,971	8,553	10,448	10,814	13,063
Over 60	86,025	80,057	90,946	114,479	140,862
Percent over 60	15%	14%	15%	19%	23%
Total Population	574,283	592,347	607,638	617,636	624,395
60+ Pop. Increase (%)		-7%	14%	26%	23%
Total Increase (%)		3%	3%	2%	1%

4.2 Cooling Center Location Analysis

Boston's cooling centers are a critical component of the city's overall heat wave response because they have the potential to help large numbers of vulnerable residents. In order to provide life-saving relief to the most vulnerable residents, cooling centers must be strategically located within each neighborhood of the city. By identifying the neighborhoods that are likely to have the greatest

demand for cooling centers, the city can make an informed decision as to how it should allocate its resources. The first goal of this analysis is to determine whether Boston's cooling cewnters are optimally located, in terms of meeting the needs of the most vulnerable populations. To the extent that the cooling centers are not well located, the second goal is to recommend alternative cooling center locations or other general relief options, such as public parks, that can be used in the event of a heat wave.

The U.S. Census Bureau is a great source of information in terms of estimating the size and location of vulnerable populations. The Census Bureau uses three standard geographic units to present and analyze Census data every 10 years. The largest geographic unit is the Tract and it generally contains between 1,500 and 8,000 people (United States Census Bureau 2000). The second geographic unit is referred to as the Block Group and it generally contains between 600 and 3,000 people (United States Census Bureau 2000). The final geographic unit is the Block; it is the smallest of the three geographic units.

Geographic Information System (GIS) software was used to analyze the following five vulnerable population categories within the Census Bureau's 2000 Block Group data: 1) population 65 years and over, 2) one-person households, 3) linguistically isolated households or households in which no one over the age of 14 speaks English at least very well, 4) low income households or households that earn less than $25,000 per year and 5) occupied housing units, age 65 years and over, without a vehicle. This last category is worthy of some additional explanation. In a metropolitan area with a well-established public transportation system, it is likely that a majority of the population will not have a vehicle. However, for a vulnerable segment of the population, the lack of a vehicle may actually increase their susceptibility during a heat wave because of their dependence on public transportation. In other words, these individuals may not have the means to quickly and independently find relief and instead may be forced to wait for the next train, bus or Senior Shuttle. Additionally, should the public transportation system be compromised due to a blackout or brownout, these individuals will be in even greater need of assistance. Figures 7 through 11 on the following pages display the distribution of each vulnerable population category listed above.

Figure 7: Population 65 Years and Over

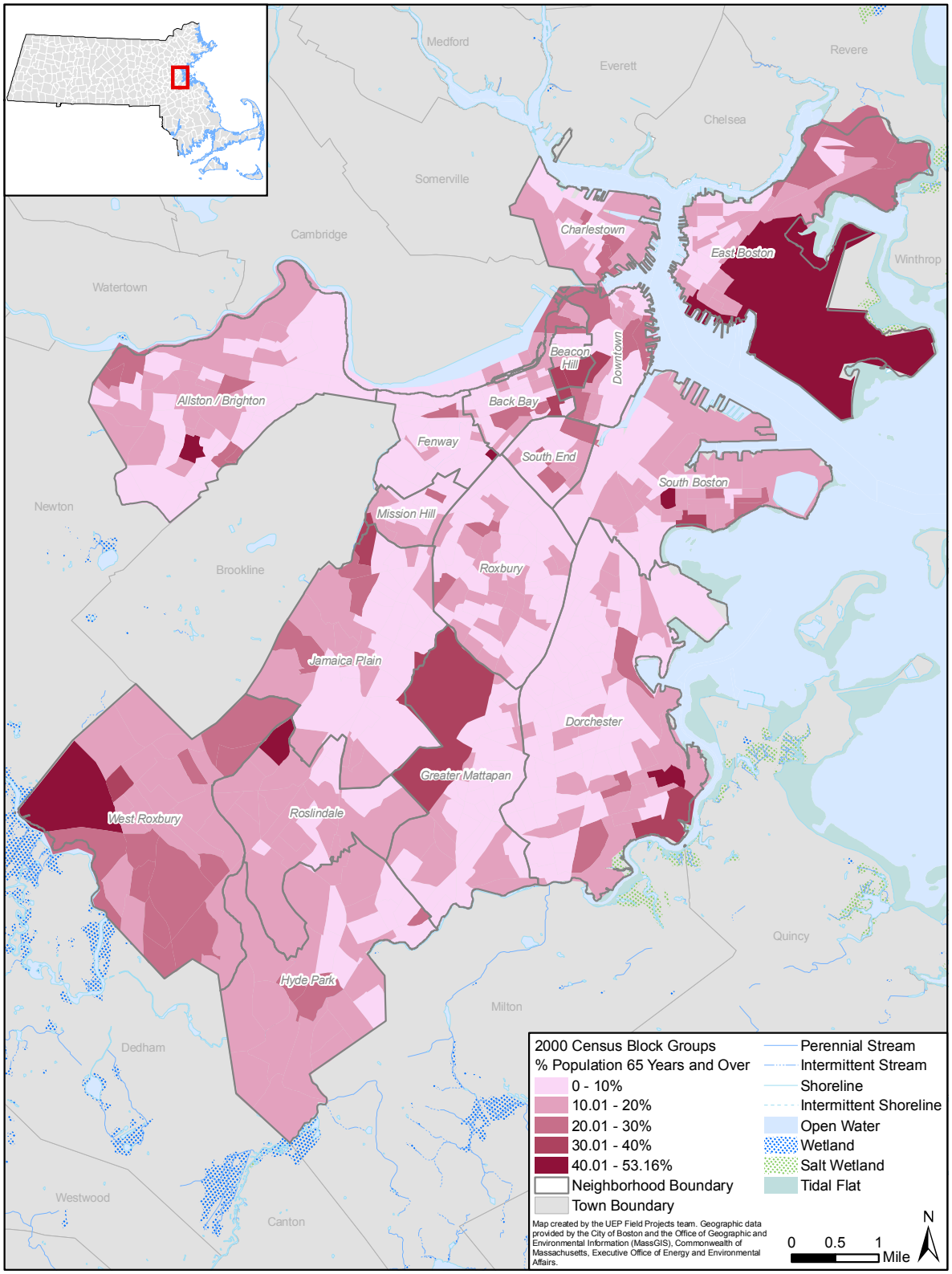


Figure 8: One-Person Households

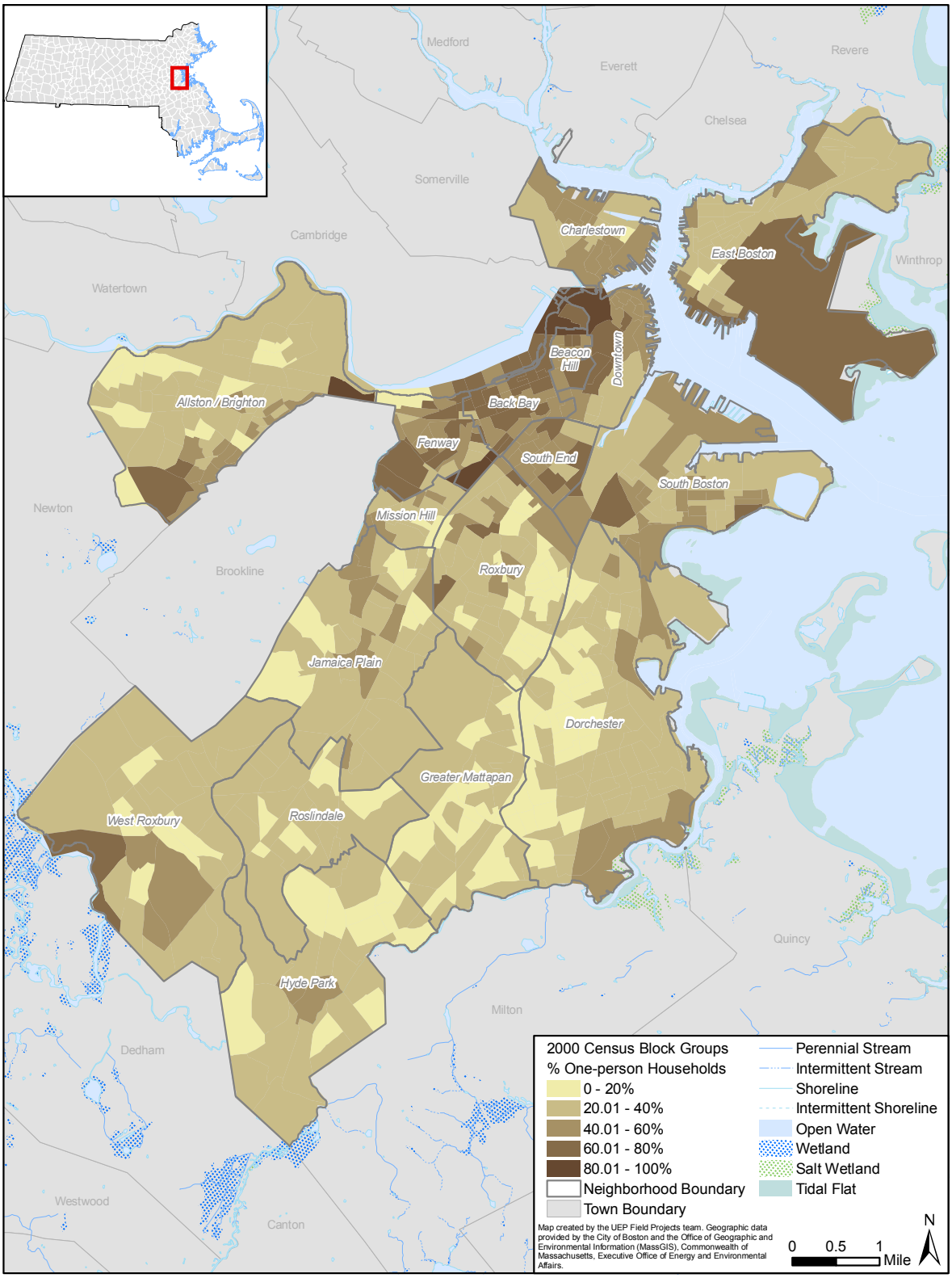


Figure 9: Linguistically Isolated Households

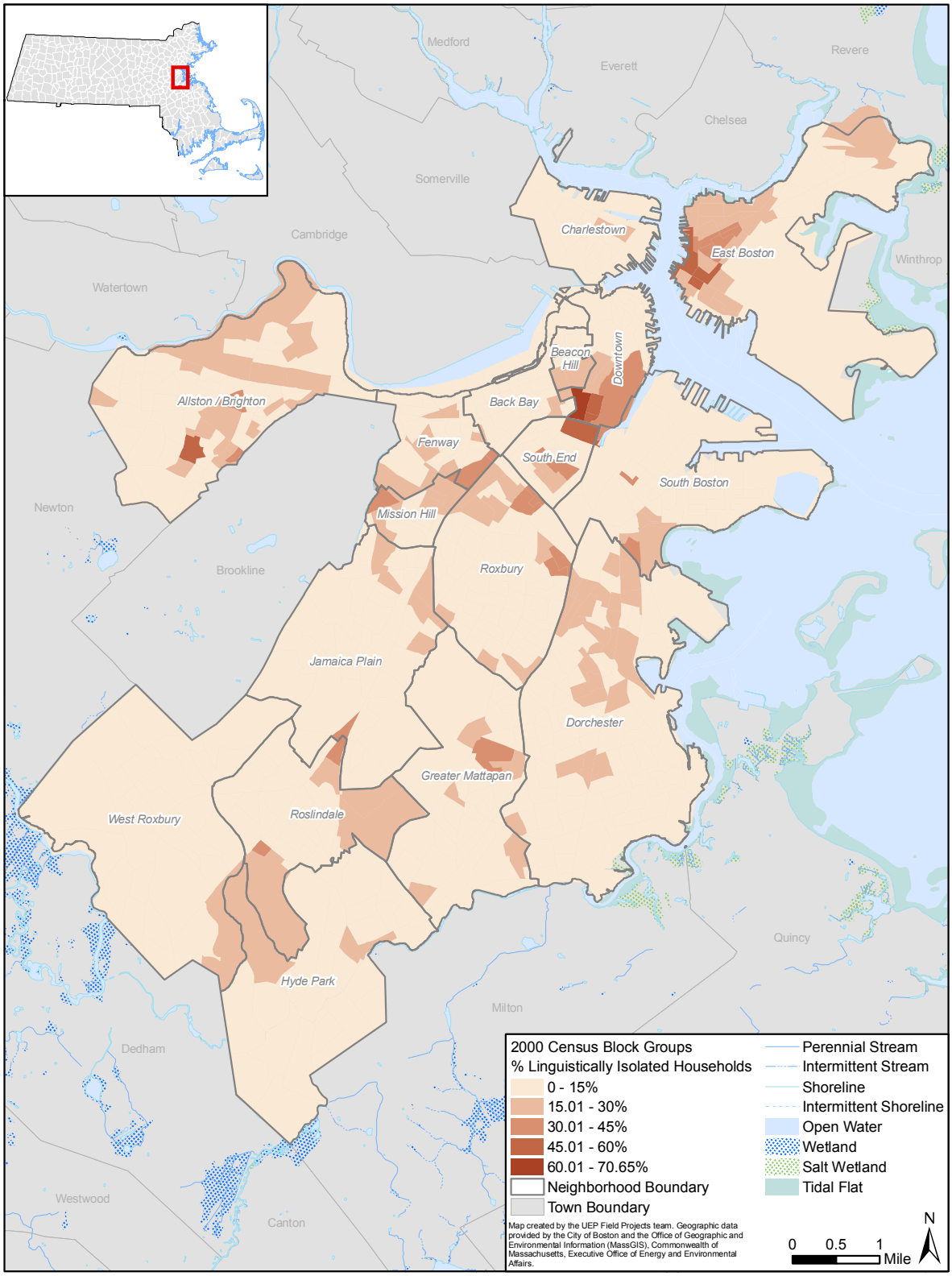


Figure 10: Low-income Households

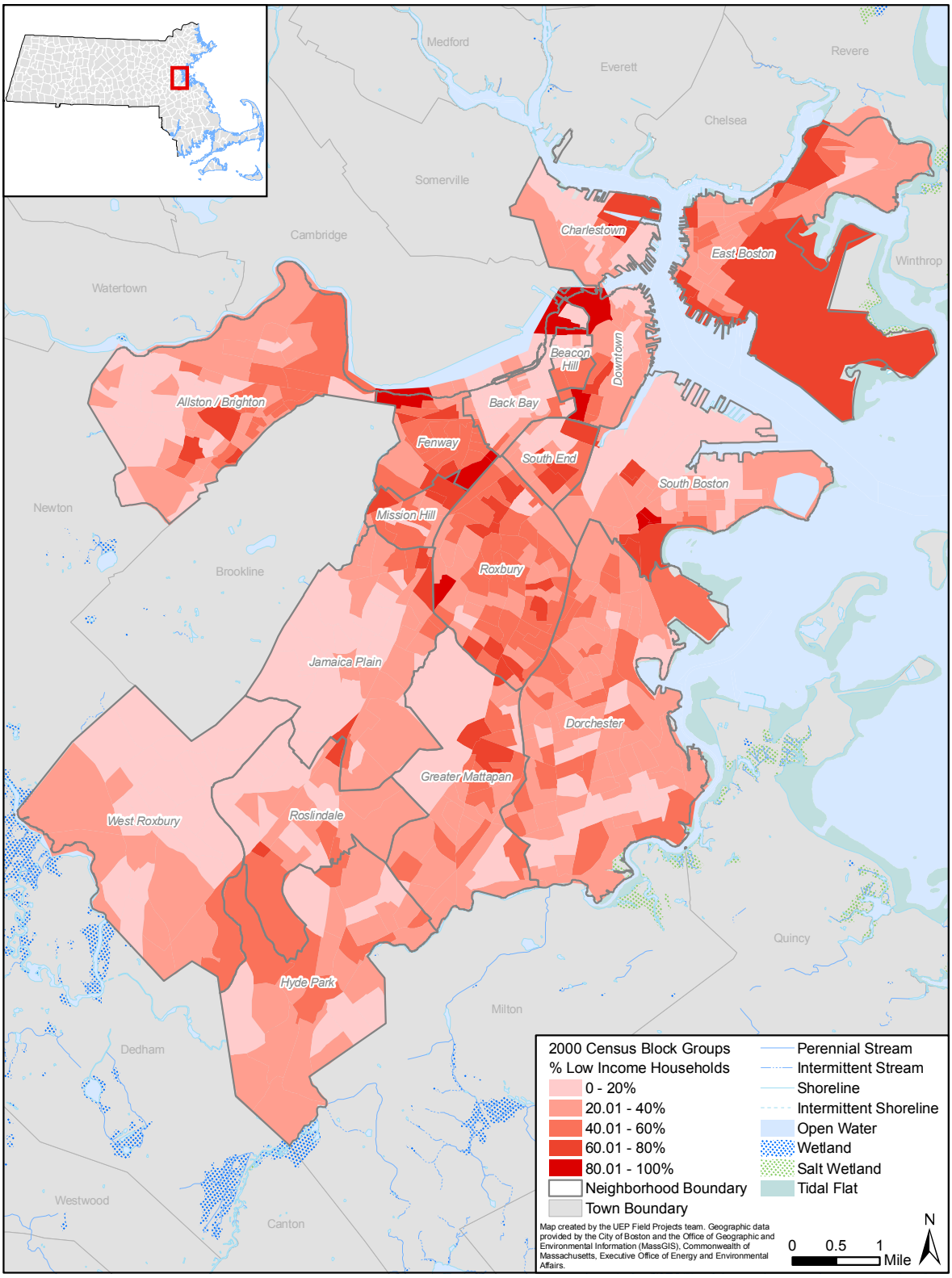
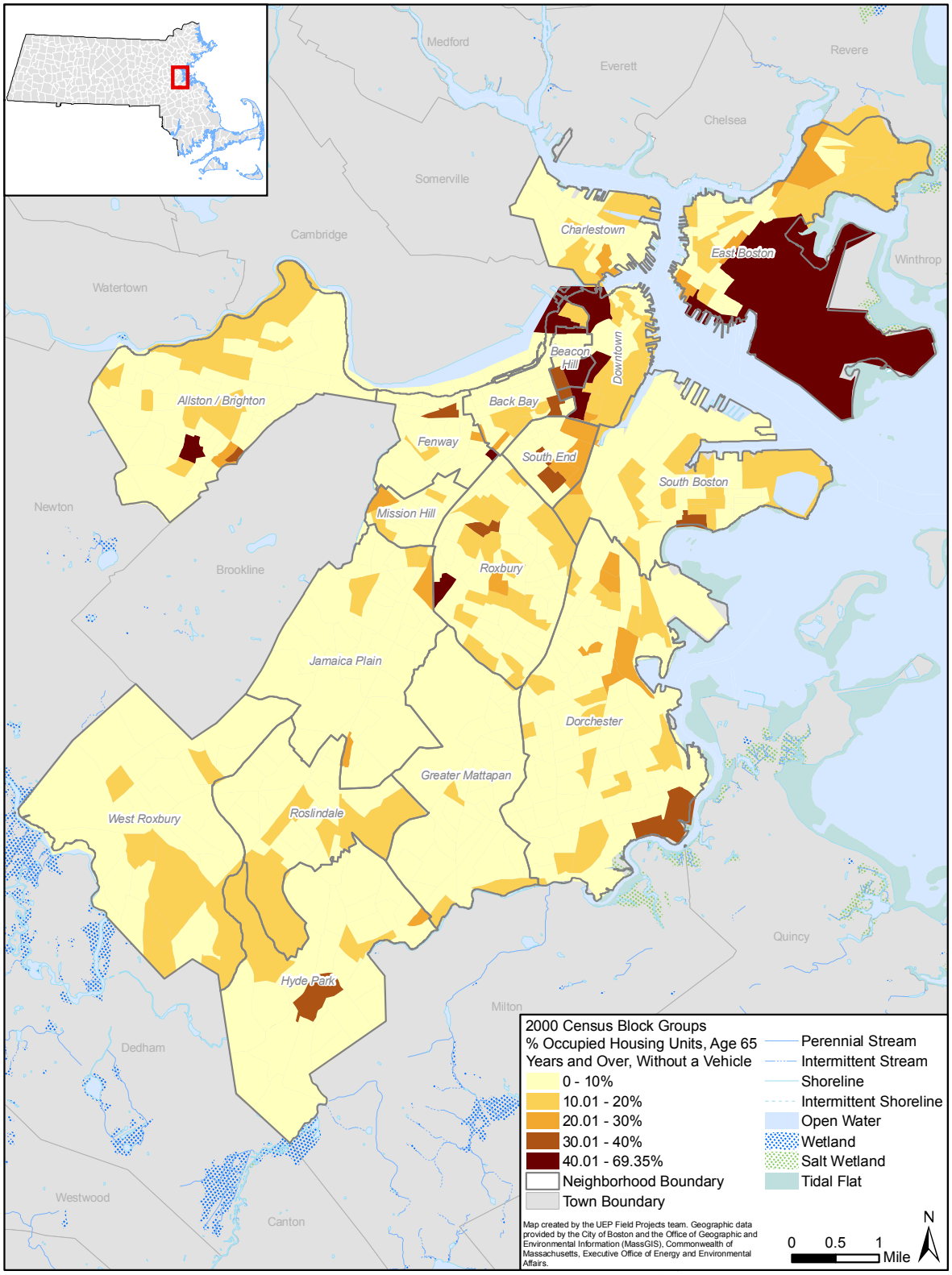


Figure 11: Occupied Housing Units, Age 65 Years and Over, Without a Vehicle



While each map is helpful in terms of identifying the overall distribution of one vulnerable population category, a more useful product is a map identifying the specific areas within the city where a high concentration of one vulnerable population category overlaps with another or more. Subsequently, Boston's 544 total Block Groups, not including the Harbor Island Block Groups, were narrowed to 169 by selecting only those where the percentage of any one of the five vulnerable population categories was equal to or greater than 50%. Table 12, below, provides an example of this step in the narrowing process.

Table 12: Narrowing Block Groups by Vulnerable Population Category, Equal to or Greater Than 50%

Block Group	Category 1	Category 2	Category 3	Category 4	Category 5	Action
250250512009	50.74	80.00	9.23	76.92	51.60	Selected
250250702001	10.72	22.12	47.35	53.58	18.85	Selected
250251301006	50.89	39.42	8.03	35.04	5.22	Selected
250251304012	20.07	38.08	4.42	21.13	12.50	Not Selected

Category 1 = % population 65 years and over; Category 2 = % one-person households; Category 3 = % linguistically isolated households; Category 4 = % low-income households; Category 5 = % occupied housing units, age 65 ears and over, without a vehicle.

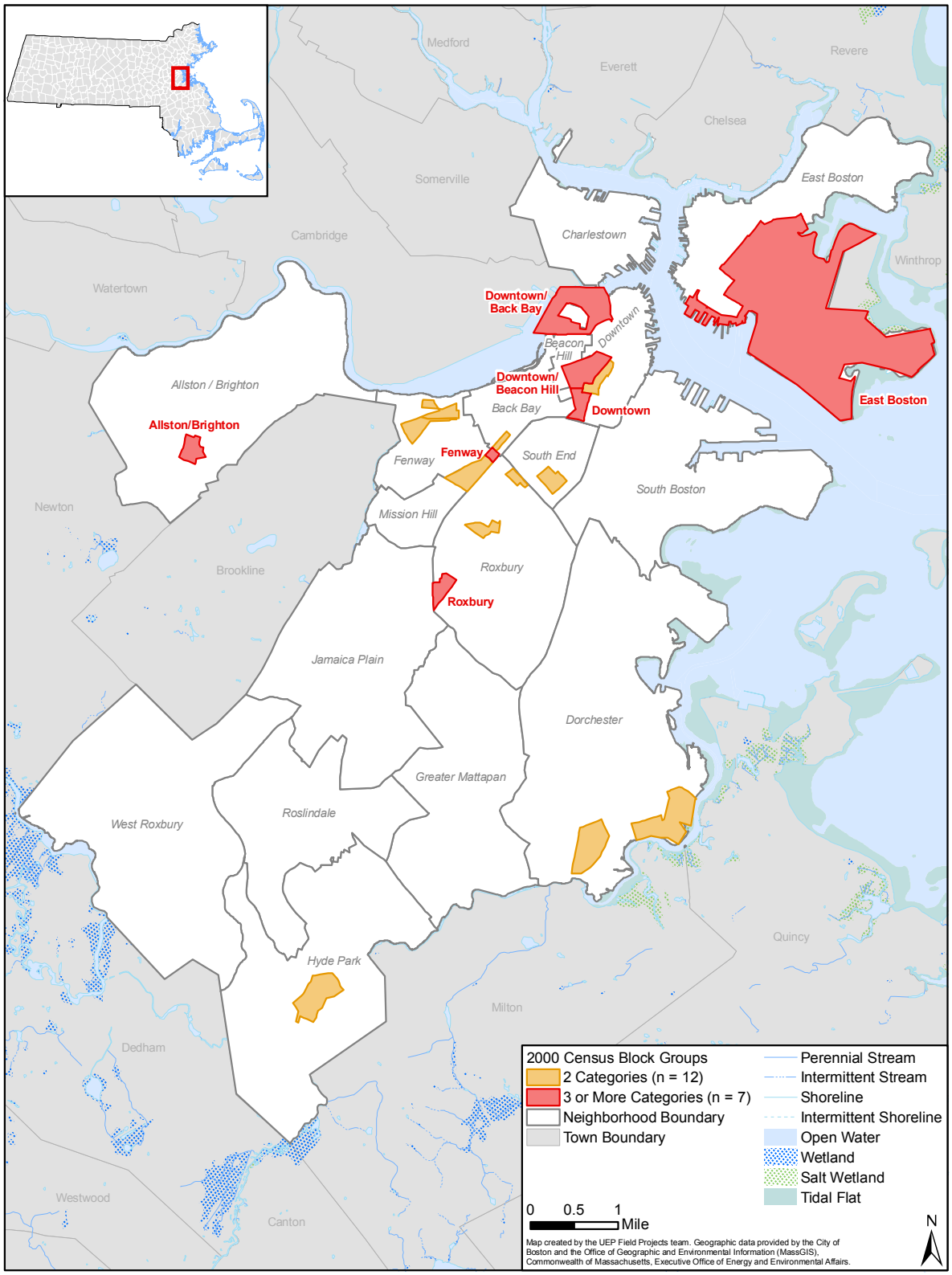
Next, the Block Groups were further narrowed to 19, by selecting only those where the percentage of two or more of the five vulnerable population categories were equal to or greater than 50%. Table 13, below, provides an example of this step in the narrowing process and Figure 12 on the next page displays the location of these 19 Block Groups by the number of vulnerable population categories equal to or greater than 50%.

Table 13: Narrowing Block Groups by Vulnerable Population Category, Two or More Categories Equal to or Greater Than 50%

Block Group	Category 1	Category 2	Category 3	Category 4	Category 5	Action
250250203001	23.25	85.20	5.10	93.37	69.35	Selected
250250512009	50.74	80.00	9.23	76.92	51.60	Selected
250250701002	13.21	77.97	29.16	76.67	16.27	Selected
250251106021	53.16	28.13	4.69	2.73	3.35	Not Selected

Category 1 = % population 65 years and over; Category 2 = % one-person households; Category 3 = % linguistically isolated households; Category 4 = % low income households; Category 5 = % occupied housing units, age 65 ears and over, without a vehicle.

Figure 12: Seven Block Groups Selected for Further Analysis



Finally, for the purpose of this project, only the seven Block Groups where the percentage of three or more of the five vulnerable population categories were equal to or greater than 50% were selected for further analysis. Five of these Block Groups have a high concentration of three vulnerable population categories and are located in the Roxbury, Fenway and Downtown neighborhoods of Boston. The two remaining Block Groups have a high concentration of four vulnerable population categories and are located in the Allston/Brighton and East Boston neighborhoods of the city. However, none of Boston's 544 total Block Groups were characterized by a high concentration of all five vulnerable population categories. Table 14, below, summarizes the characteristics of the seven Block Groups selected for further analysis.

Table 14: Characteristics of the Seven Block Groups Selected for Further Analysis

Block Group Location	Bordering Streets	Total Population of Block Group	Vulnerable Population Categories
Roxbury	Columbus Ave., Washington St., Marcella St. and Ritchie St.	376	Low income, one-person and no vehicle
Fenway	Huntington Ave., Gainsborough St., Saint Botolph St. and Massachusetts Ave.	660	Low income, one-person and no vehicle
Downtown	Charles St. South, Marginal Rd., Washington St. and Boylston St.	2010	Low income, linguistically isolated and no vehicle
Downtown/Beacon Hill	Park St., Tremont St., Avery St., Washington St., School St. and Beacon St.	1449	Low income, one-person and no vehicle
Downtown/Back Bay	3 clusters: 1) Canal St. and Causeway St., 2) Blossom St. and 3) Cambridge St. and Charles St. Cir.	1279	Low income, one-person and no vehicle
Allston/Brighton	Chestnut Hill Ave., Chiswick Rd., Commonwealth Ave. and both sides of Leamington Rd., Wallingford Rd. and Melton Rd.	1977	Low income, one-person, linguistically isolated and no vehicle
East Boston	4 clusters: 1) Jeffries St., 2) Maverick St. between Tomahawk Dr. and Geneva St., 3) Porter St. and 4) Cowper St.	266	65 years and over, low income, one-person and no vehicle

Since Block Groups encompass many different types of land uses – from open space to commercial lots – an attempt was made to isolate the residential areas within each of the seven Block Groups listed in Table 14. This effort, while tedious due to the lack of readily available, descriptive parcel or building data for the city of Boston, was valuable because it produced a more accurate estimate of the proximity of the Block Group residents to the cooling centers.

The first step in this process involved selecting the parcels associated with each Block Group. It is important to note that Boston's Block Group and parcel boundaries do not necessarily coincide. In the absence of a straightforward association between the two data sets, parcels were selected based on the best representation of each Block Group's boundaries. Next, each selected parcel was closely examined through 2008 aerial photography and pictometry or "Bird's Eye View" imagery to determine its residential status. For the Fenway and Downtown Block Groups, this proved especially challenging, as the office and residential buildings in this area are nearly undistinguishable. As a result, it is likely that a reasonable amount of error was introduced into the overall process during this step. After each selected parcel was closely examined, a total of 428 parcels were identified as potentially residential. Finally, in order to simplify the comparison of these 428 parcels, represented as polygons, to the cooling centers, represented as points, each parcel was converted to a point; the points were placed in the center of each polygon.

The distribution of last year's cooling centers was, overall, quite reasonable. Of the 42 cooling centers open for the 2009 season, 37 were located within one mile of another cooling center. Three of the five remaining cooling centers (Hyde Park Community Center (CC), Roche Family CC and West Roxbury CC) were located within one and a half miles of another cooling center. The final two cooling centers (Jackson-Mann CC and Orient Heights CC) were located over one and half miles from another cooling center. In terms of neighborhood-level distribution, at least one cooling center was located within each neighborhood, except for the Back Bay, Beacon Hill and Fenway neighborhoods. Historical use data for the cooling centers in these neighborhoods and those that only have one cooling center (Allston/Brighton and Hyde Park) would be especially useful determining whether the supply of cooling centers, or the lack thereof, meets the demand of the neighborhood residents.

The true test of the cooling centers is their accessibility, especially in terms of those who may need relief the most in the event of a

heat wave. In order to determine if last year's cooling centers could be easily utilized by the residents of the seven Block Groups listed in Table 14, the cooling centers closest to each Block Group were buffered by a quarter and half mile. This means that a line was drawn around each cooling center at a quarter mile and then a half mile away from its location; the area in between the cooling center and each of these lines is the buffer. The quarter and half mile distances were chosen because of their walkability; each can be walked, on average, in three to five or six to eight minutes, respectively. Additional time or physical exertion outside during a heat wave would arguably not be in the best interest of the most vulnerable Block Group residents. Table 15, below, summarizes the number of residential parcel points – not the number of residents or residential buildings – that were captured by the quarter and half mile cooling center buffers.

Table 15: Residential Parcel Points Captured by Cooling Center Buffers

Block Group Location	Residential Parcel Points	Residential Parcel Points within ¼ mi Buffer	Residential Parcel Points within ½ mi Buffer	Residential Parcel Points outside of ½ mi Buffer
Roxbury	69	10	55	4
Fenway	7	0	0	7
Downtown	51	28	23	0
Downtown/Beacon Hill	89	0	35	54
Downtown/Back Bay	28	3	21	4
Allston/Brighton	147	0	0	147
East Boston	37	1	17	19
Total	428	42	151	235

The results of this analysis indicate that last year's cooling centers were not completely accessible to the seven Block Groups with the highest concentration of vulnerable residents; over half of the residential parcel points were more than a half mile away from a cooling center. Of particular concern are the Fenway, Downtown/Beacon Hill and Allston/Brighton Block Groups, because the majority, if not all, of those residential parcel points fell outside of the half mile cooling center buffer.

Given these results, additional research was performed in order to determine alternative cooling center locations or general relief options for each of the seven Block Groups. The research results are presented in Table 16. For each Block Group, an indoor, shaded outdoor and water-based source of relief within a quarter or half mile was identified. It was assumed that each indoor space is equipped with air conditioning. Finally, it is important to note that the BHA's John J. Carroll development is located in the Allston/Brighton Block Group. Based on information obtained from the BHA, it is known that John J. Carroll residents would be able to utilize the development's air conditioned community room in the event of a heat wave.

Each of the seven Block Groups also has a valuable resource at its doorstep – public transportation. An MBTA subway line is adjacent to or runs through each Block Group except for Roxbury, where the closest subway line is approximately a half mile away. Additionally, an MBTA bus route is adjacent to or runs through each Block Group. If residents of the seven Block Groups were unable or unwilling to go to either the cooling centers or the relief alternatives listed in Table 16 on foot, a variety of public transportation options, including the Senior Shuttle, are within close proximity and provide relief, through air conditioning, in and of themselves.

Table 16: Selected Block Group Cooling Center Alternatives

Block Group Location	¼ mi Alternatives			½ mi Alternatives		
	Indoor	Shaded Outdoor	Water-based	Indoor	Shaded Outdoor	Water-based
Roxbury	Ellis Mendell School, Egleston Community High School, Rafael Hernandez School				Franklin Park, Southwest Corridor Park	Stony Brook Spray Deck
Fenway	Matthews Arena, Carter Development Center	Carter Playground	Christian Science Plaza			
Downtown	Various retail and entertainment venues	Boston Common	Frog Pond and Playground			
Downtown/ Beacon Hill	Various retail and entertainment venues	Boston Common	Frog Pond and Playground			
Downtown/ Back Bay	TD Bank Garden		Lee Pool	Museum of Science	Charles River Reservation	North Point Spray Deck
Allston/ Brighton	John J. Carroll community room, Alexander Hamilton School				Chestnut Hill Reservation	Reilly Memorial Pool
East Boston	Donald McKay School, Samuel Adams School				East Boston Piers Park	Constitution Beach

5 RECOMMENDATIONS

5.1 Short-term Policy Recommendations

Although some of Boston's cooling centers are suitably located, the city's current heat wave plan needs a sufficient amount of work to meet the future demands created by climate and population changes. In order to rectify the shortcomings in the current heat wave plan, further strengthen the plan and adequately prepare for extreme heat events, it is essential that the city implement the following policy recommendations:

Develop a comprehensive heat wave plan

The city currently has some effective strategies in place to respond to heat waves, as well as a network of city agencies. However, these strategies and procedures must be documented in a comprehensive heat wave plan, similar to the plans of Philadelphia and Toronto described in Chapter 3. This plan should be distributed to each agency involved and the public, so everyone knows what systems are in place, the responsibilities of each agency and where to go for assistance. (See Appendix I for an example of a detailed heat wave plan.)

Create a Heat Wave Response Committee

A committee consisting of members from the MOEP, Elderly Commission, EMS, BHA, the Emergency Shelter Commission, representatives from partner agencies and non-profit groups and concerned citizens should be created to cooperatively meet prior to May 1st, the start of the heat emergency season defined in Chapter 2. The committee's mission is to assess the current heat emergency plan, develop new and necessary actions and designate responsibilities. The team should also need to meet at the end of each summer to

evaluate the effectiveness of the heat wave plan and examine data on mortality rates and cooling center use. This team approach and regular review has proven to be very effective in Philadelphia and Toronto; it ensures all heat wave plans are current and all agencies are aware of their responsibilities (United States Environmental Protection Agency 2006).

Expand the role of the city's Commnity Emergency Response Teams

Community Emergency Response Teams (CERT) are part of the National Citizen Corps program, which "aims to make communities, safer, stronger and better prepared through education, training and volunteer service" (City of Boston (e) n.d.). The teams are comprised of volunteers, grouped by neighborhood, who provide assistance to residents in an emergency. There are currently three Boston teams, each with 20-24 volunteer members serving the neighborhoods of Charlestown, Dorchester and Jamaica Plain. Currently, CERT volunteers respond to shelter and commodity distribution needs in an emergency and serve as "preparedness ambassadors;" they do not provide any assistance during heat waves. These volunteers should be utilized to distribute heat wave information and perform daily check ins on vulnerable residents. Boston needs to provide support, through increased funding and publicity, to expand the current teams into all Boston neighborhoods and raise neighborhood awareness of the CERT teams in their areas. With increased community and government support, this program has the potential to be as successful as Philadelphia's "block captain" program, which plays an essential role in helping vulnerable people during heat waves.

Coordinate with non-profits to mobilize volunteers to check on high-risk populations, distribute information and fans

Both the EPA and WHO guidelines emphasize the importance of program partnerships during heat waves. Boston residents would benefit from the volunteers that could check in on residents and distribute heat-related information. There are many agencies that can and do provide volunteers to check on vulnerable residents as described below. In order to ensure that the partnerships are successful, the city will need to provide all necessary, heat-related information in different languages:

Little Brother's Friends of the Elderly serves 680 elders over the age of 75 and coordinates 160 volunteer home visits per week. During the summer, volunteers distribute heat-related information to elders and make daily phone calls to the most vulnerable people (Guerin 2010).

Boston Cares is a non-profit organization with over 16,000 participants that coordinates volunteer opportunities around greater Boston (Boston Cares 2010). During the 2010 flooding in Massachusetts, Boston Cares emailed its volunteers requesting immediate assistance with the disaster relief. In a heat wave, the city should partner with Boston Cares by requesting volunteer assistance to perform outreach in underserved areas, distribute water and heat-related information to homeless individuals and provide activities at cooling centers.

MATCH-UP Interfaith Volunteers is an organization that pairs elderly and disabled persons in Boston with volunteers who provide friendly visits and medical escorts. During a heat wave, MATCH-UP's volunteers should conduct daily telephone calls to their elderly and disabled participants. Additionally, volunteers could be requested to provide transportation to cooling centers for people who do not feel comfortable using the city's vans.

Churches and cultural groups are often aware of who in their communities may need assistance and how to best contact them. The city should partner with these groups to help translate the its heat-related information into different languages and disseminate this information to the group members and other residents at-large. Additionally, the city should work with the group leaders to encourage members to check in on each other during heat emergencies. Boston houses approximately 51 churches (Boston City Links 2007) and many churches have volunteers who could be enlisted to assist. Lastly, air conditioned churches and cultural centers could be used as alternatives to the city's cooling centers.

Continue and improve the heat wave alert telephone calls

Although the blast heat wave phone calls have caused confusion in the past, this strategy is essential to spreading the word about the severity of heat waves. Thus, the program should be improved to include all residents of Boston with a message emphasizing that everyone is at risk of heat-related illnesses and encouraging all residents to check on their vulnerable neighbors. This message should be available in more languages, with an option to choose the language at the onset of the call. To garner people's attention, the message should mention past heat wave tragedies. Although some people may not pay attention to this alert, by reminding people to consider the vulnerability of their neighbors and homeless individuals, there can be a great potential to save lives.

Provide additional transportation methods

Following the examples of Toronto and Fresno, Boston could offer residents free Charlie Cards to use for transportation to a cooling center. This may be helpful in transporting homeless individuals to a cool location because they likely cannot pay the fare. Boston should also explore the option of offering taxi vouchers to at-risk individuals. Currently, seniors are able to purchase taxi rides at a 50% discount, but during emergencies, the city could attempt to contract with a taxi company to offer free transportation for individuals identified by caseworkers, nurses or building managers. This would be especially helpful if the city could utilize taxis with the ability to transport wheelchairs (chair cars). The Aging Access Service Points would be an excellent source to help coordinate the effort because they already have contracts with these taxi companies.

On-call medical advice

Similar to Philadelphia's system, the Mayor's 24-hour hotline should be staffed with a nurse to answer questions about heat-related medical issues. The city might consider partnering with community health centers that already have "advice nurse" telephone lines to establish a call forwarding system. Alternatively, during business hours, the city might consider partnering with the three Aging Service Access Points by forwarding the hotline's phone calls from people with health concerns. Upon consent of the caller, a nurse could share concerns about vulnerable individuals to the Department of Public Health and arrange for a wellness check on the individual.

An increased public awareness campaign of the dangers of heat waves

Boston needs to increase and improve its heat wave outreach efforts

To ensure public understanding about the dangers of heat waves and encourage concern within neighborhoods to assist vulnerable residents, the city needs to increase and improve its heat wave outreach efforts by doing the following:

» Updating heat wave fliers: The current fliers (seen in Appendix E) lack graphics and have small fonts, possibly making it difficult for the elderly to comprehend and read. More effectively designed brochures and posters should display the information through pictures and large fonts. In addition, this information should be posted in public places including doctor's offices, community centers and on public transportation.

» Creating a heat wave website: Boston should develop

a website specifically designed for heat waves with information about heath issues, how to seek assistance, lists and a map of cooling centers, a map of cooling center alternatives, the city's hospitals and appropriate links to all relevant information. This website would not only be useful for those living in Boston, but also non-residents trying to help family or friends in the city who need assistance. Boston would be the first city to develop a website of this nature.

Boston should develop a website specifically designed for heat waves

Perform a second analysis on vulnerable population and cooling center locations upon the conclusion of the 2010 Census

By following the steps described in this report's cooling center location analysis and utilizing the most recent demographic data, the city can confirm and identify new areas that are likely to have high risk populations and a greater need of cooling centers. With this information, Boston can make an informed decision as to where it should direct outreach efforts and how to allocate resources. This meets two of the four critical recommendations outlined by the EPA and is similar to the risk assessment methods of other cities, as previously stated.

Partner with public, private and non-profit entities to ensure that cooling center alternatives are open and available to residents in the event of a heat wave

As the results of this report's cooling center location analysis demonstrated, the city's cooling centers cannot be the only source of relief for Boston residents. In forming a relationship with other entities like the Boston Parks and Recreation Department, the Department of Conservation and Recreation, local colleges or universities and entertainment or shopping venues, the city can potentially provide the greatest number of life-saving sources of relief to the most residents. The city should especially try to focus on forming partnerships with locations that already equipped with back-up generators.

5.2. Short-term Cooling Recommendations

Air Conditioning

In addition to creating and developing a comprehensive heat wave plan, Boston can implement some short-term cooling efforts to help those people with the greatest needs. The 2007 American Housing Survey for the Boston metropolitan area provides an estimate of the number of households in the area with or without air conditioning, central or window-mounted (Housing Survey for the Boston Metropolitan Area 2007). The survey shows that approximately 18% of households are without any type of air conditioning (Housing Survey for the Boston Metropolitan Area 2007). Using this figure, it can be determined that approximately 43,000 of the 239,000 households in Boston are without air conditioning (United States Census Bureau n.d.).

NSTAR, the incumbent electric distribution company for the city of Boston, offers rebates on air conditioners for up to $500 (NSTAR n.d.). A typical energy efficient, window-mounted air conditioning unit has an energy capacity rating of approximately 1,000 watts or one kilowatt (KW). As such, every 1,000 new air conditioning units adds 1,000 KW or one Megawatt (MW) of instantaneous demand to the NEMA-BOS load zone (ISO-NE 2010). The average peak summer demand for the NEMA-BOS load zone is 4,624 MW (ISO-NE, 2010). As a result, every 1,000 new air conditioners adds 0.022% to peak system demand during the summer period when the grid is already under stress.

It is not recommended that the city purchase air conditioners for all of its residents

If each of the 43,000 households without air conditioning purchased a new window-mounted air conditioning unit and operated it during the summer months, they would add 43 MW (43,000 KW) or about 1%, to the total system electricity load. In addition, if each air conditioner operated for 75 hours a year, they would contribute 7.4 million pounds of CO2 emissions. It is important to note that air conditioners contribute to the urban heat island effect and exacerbate climate change. As this is not a sustainable outcome, it is not recommended that the city purchase air conditioners for all of its residents that do not currently have one.

However, it is estimated that there are approximately 3,000 homebound elders in Boston, some of which do not have air conditioning. Unfortunately, there is not enough data to project how many of these people do not have air conditioning (Faucher 2010). But, even if all of these individuals were provided with new air conditioners, this would not create a significant increase in electricity

demand, CO2 emissions or the urban heat island effect. Perhaps the city could create an additional incentive or rebate to assist these homebound elders and other people vulnerable to heat illnesses, in acquiring new air conditioners. Although this is not an ideal solution, it could significantly reduce the number of deaths during a heat wave.

Open Air Misting Systems

Another temporary short-term cooling recommendation is the installation of open-air misting sites. These have been used in Boston in the past and are frequently used in Las Vegas and other hot cities and claim to reduce temperatures by up to 30°F. By placing misters in large public spaces, like the Boston Common, and bus stops individuals could find some relief from the heat (FogCo Systems Incorporated n.d.).

François Nonnenmacher

The mist generator was the most visited attraction during the 2003 Paris heat wave

5.3 Long Term Cooling Recommendations

In the short term, city residents can keep cool by using personal air conditioners or utilizing the cooling centers, but this is neither an ideal nor sustainable solution. Air conditioners require a significant amount of energy to operate and actually exacerbate heat wave conditions by generating additional heat. In the event of a blackout, residents who were not considered vulnerable due to the fact that they had access to an air conditioned location would suddenly be left in the heat, unprotected. This is why cities need to concentrate on long-term planning strategies that rely on using energy neutral cooling methods to reduce the urban heat island effect and naturally mitigate the hot temperatures. Several approaches can be taken to accomplish this goal such as using cool roofs, green roofs, cool pavements and increasing the amount of trees and vegetation. In the future, if the city of Boston implements some or all of the following recommendations, residents can be kept safer and more comfortable during a heat wave without negatively impacting the environment.

Cool Roofs

Traditional roofs can heat up to temperatures ranging from 150°F to 190°F

Traditional black or metal roofs with low solar reflectance and thermal emittance values (as described in Chapter 1.4) can heat up to temperatures ranging from 150°F to 190°F. This heat is then transferred into the building below and to the outside air above (Gartland 2008). During a heat wave, these types of roofing materials can cause indoor air temperatures to reach dangerously high levels if there is no cooling system. If there is a cooling system, it uses additional energy to cool the building. This increases the amount of air pollution, places additional pressure on the already stressed electric grid and generates further heat (Gartland 2008).

Cool roofs, on the other hand, keep buildings naturally cooler by using light colored, reflective materials that have high solar reflectance and high thermal emittance values. In the past, white coatings have frequently been applied to large commercial buildings. However, new products are continually being developed and consumers have a choice of many different colored metal, shingle or tile roofs that can be used on virtually any type of roof, sloped or flat.

This new technology does deflect some desired heat gain during the winter by keeping the roof within 10-20°F of the background temperature, but during the summer months, homes and offices are kept cooler by several degrees (United States Environmental Protection Agency (b) n.d.). Despite initial increased costs, cool

roofs actually save money in the long run due to the increased durability of the roof and the reduced cooling load for the building (Gartland 2008). Since a periodic application of cool roof coatings could potentially preserve the underlying roof indefinitely, these roofs will not have to be completely torn-off and replaced every several years, thus saving even more money and resources (Gartland 2008).

To offset some of these initial costs and to encourage more residential installation of cool roofs, the federal government currently offers an Energy Star tax credit that covers 30% of the cost for a cool roof up to $1,500. Massachusetts does not currently offer any additional incentives, but Boston can do many things to encourage a switch to cool roofing. For example, the California Energy Commission's Title 24 Building Energy Efficiency Standards now requires cool roofs on both residential and non-residential buildings. In Philadelphia, the Energy Coordinating Agency (ECA) has been promoting cool roofs particularly for low-income elders, one of the most vulnerable populations affected by hot summer temperatures. The city's Cool Homes program aims to provide affordable cooling measures that reduce indoor temperatures without increasing electricity use. Funded through Philadelphia's weatherization program, Cool Homes supplies a white, elastomeric top coating to the roof which costs on average $1,500 per home and is mostly funded by the city weatherization programs (Blasnik 2004). The program has been successful in eliminating nearly all the solar heat gain and in reducing the indoor air temperature by several degrees on warm days (Blasnik 2004). Recently, the city of Philadelphia has teamed up with the ECA and Dow Building and Construction to host a "coolest block" contest. Residents team up with their neighbors to enlist the highest number of homes on their block interested in participating. The block with the highest number of participants wins free cool roof applications, home energy audits and home weatherization services.

Currently, there are many free tools that can be used by individuals that showcase how cool roofs can be effective in reducing temperatures, saving energy and saving money. A product comparison can be found at the Cool Roof Rating Council website, an independent, non-profit organization that maintains a third-party rating system. The Department of Energy Cool Roof Calculator also provides information on the amount of energy saved for any proposed non-black roof when compared to traditional black roofing. Whereas, the Energy Star Roofing Calculator compares a

conventional roof with any Energy Star roofing products. The city of Boston needs to promote these information tools, form partners with cool roof builders and create similar incentive programs to encourage people to install cool roofs.

Green Roofs

Green roofs are an even better alternative to cool roofs (see Table 17 below). Green roofs can be as simple as a vegetative groundcover or as complex as a park with trees and pedestrian access. Green roofs are more commonly installed on flat roofs, but special consideration can be taken for pitched roofs by installing a retention system to keep the soil and vegetation in place on the steeper incline. Extensive green roofs require less than six inches of soil and are supported by hearty, low growing plants that require little maintenance. In contrast, intensive green roofs include shrubs and small trees and typically require greater than twelve inches of growing medium. These types of green roofs require more care, but are often designed to be accessible to building occupants. Both types of green roofs transform what would be wasted space into an aesthetically pleasing and beneficial area as well as reduce the urban heat island effect on the city.

Green roofing is a very effective heat wave adaptation strategy. Due to vegetation shading the roof's surface, a building's solar heat gain is reduced by nearly 100% (Federal Energy Management Program 2004). On hot summer days the surface temperature of a green roof is cooler than the air temperature (Gartland 2008). This is primarily because trees and vegetation lower the surrounding air temperature through evapotranspiration, a process in which water is absorbed via the roots and emitted as water vapor by the leaves. By keeping the roof cool in the summer and acting as insulation during the winter months, green roofs provide a more comfortable living environment throughout the year.

Green roofs also provide many other benefits. Due to the lower demand placed on external heating and cooling systems, they have been shown to reduce average daily energy demand by up to 75% (Federal Energy Management Program 2004). Vegetation also has the ability to reduce local air pollution by absorbing airborne particulate, pollutants and greenhouse gas emissions that are particularly elevated on days of extreme heat (Gartland 2008). In a highly urbanized city such as Boston, where roofs make up a large percentage of the city's impervious surfaces, green roofs are very effective in reducing storm water runoff. By actually utilizing the rain as part of its miniature

ecosystem, this eases the burden on costly water treatment facilities and reduces local water pollution levels (Clark 2008).

There are already several green roofs installed throughout the Boston area, including the City Hall's roof. Many other North American cities have been offering green roof incentives, but Boston still seems to lag behind. In 2009, City Councilor Sam Yoon proposed a one-time green roof tax incentive of $5 per sq/ft up to $100,000 for commercial and residential green roofs, yet nothing appears to have been implemented since that proposal (Toness 2009).

Katrin Scholz-Barth

Chicago City Hall: Retrofitted in 2001 to demonstrate that green roofs help reduce urban air temperature

Chicago on the other hand, a city that has been greatly affected by heat waves in the past, adopted a Green Roofs Grant program in 2005 offering 20, $6,000 grants for green roof projects during its first year. Toronto has also developed an extensive urban heat island mitigation program that involves mandatory green building design elements. The Toronto Green Standard, first adopted in 2007, is a set of LEED based performance standards for sustainable site development including elements for cool roofing, on-site cool paving and minimum vegetation. While similar to Boston's new green building codes, Toronto requires these standards for all new residential, commercial and industrial builds, with financial incentives for those who meet the additional suggested performance targets. The Toronto Green Roof Bylaw complements these standards by requiring green roofs on all new builds above a certain size. Toronto also offers the Eco-roof Incentive Program that provides funding for green or cool roof retrofit projects on existing commercial, industrial and institutional buildings. During the selection process, priority is given to areas where temperature surface mapping has demonstrated the urban heat island effect is particularly high.

It is estimated that "widespread implementation of green roofs in

Table 17: Green/Vegetated Roofs vs. Reflective Cool Roofs

Building Attributes	Green/Vegetated Roof	Reflective Cool Roof
Cooling Season Energy Use	Most efficient due to shading, thermal mass, evapotranspiration, water storage	More efficient than conventional roof, depending on clean roof surface
Requires Cleaning	No cleaning necessary	Yes – reflectivity can be reduced significantly depending on pollutants and product discoloration. Expense to clean.
Heating Season Energy Use	Most efficient- growing media adds thermal mass and R value	Least efficient – reflective roof has heating season penalty
Peak Summer Energy Load	Most efficient – peak temperature is lower than cool roof, and peak temperature is delayed due to roof's thermal mass	More efficient than conventional roof, depending on clean roof surface
Roof Longevity	Most efficient – waterproofing membrane is protected from direct sunlight (heat & UV), foot traffic, hail, etc.	Least efficient – dependent on formulation and ability to withstand climate, foot traffic, hailstorms, etc.
Urban Heat Island	Most efficient – vegetation keeps itself cool via transpiration and shade	More efficient that conventional roof, although reflection of sunlight to other building surfaces can be detrimental
Aesthetics	Can be used as an amenity	Reflective roof can be obtrusive, especially if viewed from above, can be a hazard in low altitude aircraft approaches
Water Needs	Needs supplemental moisture	None needed, except for during dry periods periodic membrane cleaning
Initial Cost	Green roofs more costly	Less costly
Life Cycle Cost	Long-term performance of waterproofing membrane helps reduce life cycle costs, although more costly to maintain vegetation	Roof membrane life expectancy is less than protected green roof membrane

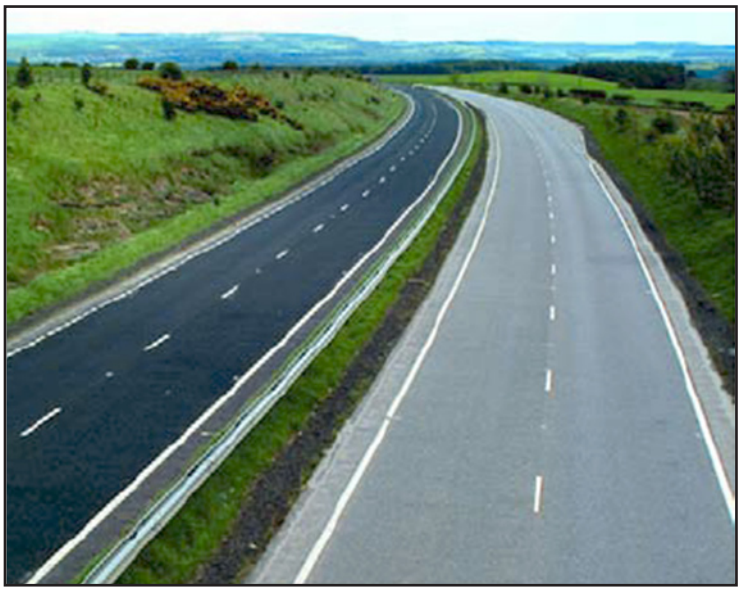
Source: Gardiner 2010

Toronto could save the city between $40 million and $120 million in storm water infrastructure costs and reduce the impacts of the urban heat island effect by lowering local ambient temperatures by up to 2°C [3.6°F]" (City of Toronto Canada 2010). By adopting similar programs, Boston will not only save money but heat wave dangers will be lessened.

Cool Pavements

Conventional paving materials made of dark colored asphalt and concrete can reach peak summertime temperatures of 120 to150°F, transferring much of this excess heat to the air above and contributing to excessive heat during a heat wave (United States Environmental Protection Agency (a) n.d.). Cool pavements, however, have increased solar reflectance or permeability keeping them much cooler than traditional types of paving materials. Considering 56% of Boston's land area is paved, cooler pavement options are an important element to reducing the urban heat island effect (Daly 2010).

To create a cooler pavement that absorbs less solar radiation, manufacturers have increased the solar reflectance by using lighter colored materials. Asphalt, typically near black in color when new, is brightened by adding light colored pigments to the dry mix. For existing pavement, a reflective emulsion seal coating can be applied on top of the existing surface during routine maintenance. Concrete is already a lighter color and can be lightened to achieve a solar reflectance as high as 80% (Levinson 2001).



David Hitchcock, HARC

Conventional asphalt vs. asphalt lightened with color additives

Permeable cool pavement while originally designed for stormwater control is frequently being used in urban heat island mitigation strategies. In order to increase the permeability of conventional pavement, large particulate such as rocks, sand or shredded rubber are added to the pavement mixture. This more porous medium allows water to drain during rainstorms and filter through to the soil below. When heated, the water evaporates and naturally draws heat from the pavement reducing the overall temperature.

Elmich Australia

Grass Pavers

David Hitchcock, HARC

A Houston stadium parking lot uses grass pavers

Block pavers are another type of permeable pavement that consists of plastic, metal or concrete lattice blocks laid on top of a graded and prepared base. These pavers can be filled with gravel or turned into grass pavers by filling them with soil and seeding with grass or other low vegetation. The blocks provide structural support for the weight of vehicles and, at the same time, allow water to drain, which cools the surface area. These pavers are most often used in low traffic areas such as parking lots and alleys to minimize damage to the vegetation.

Currently, there are no official standards or labeling programs that designate cool paving materials. It is also challenging to compare the costs of cool pavements with those of conventional pavements since paving costs vary widely depending on local conditions (United States Environmental Protection Agency (a) n.d.). This should not deter the city from the fact that there are many benefits to installing cool pavement. Permeable pavement due to its open pores reduces tire noise and improves roadway safety by allowing better water drainage (Gartland 2008). Reflective pavements increase nighttime visibility thereby potentially reducing lighting requirements and saving energy (Gartland 2008). Most importantly, cool pavements provide a more comfortable urban environment by reducing the temperatures on a hot summer day. Even if cool pavements replaced just 10 to 35% of traditional paved areas in Boston, they have the potential to reduce the city's summer air temperature by at least one degree (Pomerantz 2000).

Alternatively, another way to reduce pavement generated heat is by reducing the amount of paved surface area throughout the city. This can be accomplished by a variety of planning measures such as:

- Allowing for narrower street widths
- Requiring a percentage of every parcel be devoted to landscaping or other pervious surfaces
- Reducing minimum parking requirements
- Setting individual or area-wide parking caps
- Reducing parking stall dimensions
- Encouraging the construction of multi-level parking lots rather than expansive surface lots

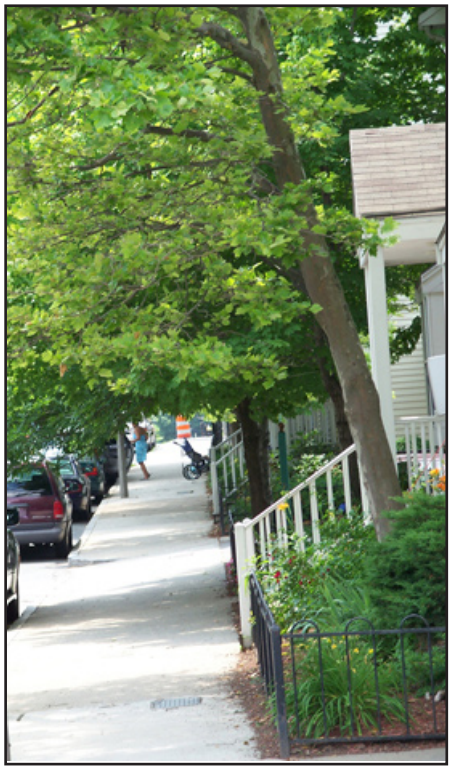
» Allowing developers to pay in-lieu of fees or institute transportation demand management programs that encourage public transportation in place of meeting minimum parking requirements (United States Environmental Protection Agency 2008)

Trees & Vegetation

Increasing the amount of trees and vegetation can be one of the simplest solutions to reducing extreme summer temperatures. By physically shading surrounding surfaces and through evapotranspiration, trees are very effective at keeping buildings, pavement and people cooler during hot summer days (Gartland 2008). Increasing the amount of urban vegetation has been shown to decrease local ambient air temperatures and reduce the urban heat island effect. The U.S. Department of Agriculture Forest Services estimates that for every 1% increase in tree canopy cover, the maximum mid-day air temperature decreases by 0.007 °F to 0.36 °F (Golden et al. 2007).

The extent of cooling a tree can provide depends on the size, shape and location of the tree; however, they generally inhibit between 70% and 94% of solar energy from reaching the surface below their canopy. To achieve maximum cooling potential, trees should be planted in strategic locations, with deciduous species planted to the east and west of buildings in areas that preferably shade windows, air conditioning units or the building's roof. Consequently, this reduces indoor air temperatures and results in higher energy savings due to reduced cooling needs. A study performed by the Lawrence Berkeley National Laboratory found that several strategically placed trees provided energy savings ranging between 7 and 40% (Gartland 2008). By reducing demand on the electric grid, particularly during peak hours, the risk of having wide spread blackouts and brownouts will be decreased.

Since extreme summer heat causes increased air pollution levels, trees and vegetation are beneficial in terms of the ecosystem services they provide (Gartland 2008). Trees act as a sink for air pollutants by absorbing gases and collecting particles via their leaves. This process is called dry deposition and can remove many harmful pollutants such as nitrogen oxides, sulphur oxides, particulate matter and ozone from the air (Gartland 2008). By improving the overall air quality in Boston, the health impacts from



Cool tree- lined street

excessive heat events can be minimized.

Boston has a great advantage in using trees to reduce temperatures since most of the urban forestry infrastructure is already in place. In 2006, the Boston Urban Forest Coalition and the Urban Ecology Institute (UEI) completed the first comprehensive inventory of Boston's urban forest. Using remote sensing and aerial photography, the results showed that Boston only had 29% tree canopy cover (See Figure 13) (Urban Ecology Institute 2008). In response to these findings, in 2007, the city launched the "Growing Boston Greener" program that aims to increase Boston's tree canopy cover to 35% by planting 100,000 trees by 2020. These 100,000 trees will be planted on both public and private property under the direction of the Boston Urban Forest Coalition; however this initiative may not be enough.

The non-profit conservation organization American Forests recommends that, on average, a metropolitan area should have at least 40% tree canopy cover (American Forests n.d.). Depending on the characteristics of the neighborhood, this figure can be higher or lower. For commercial and highly developed areas they recommend 15% tree canopy cover. In urban residential locations, this figure is higher, at 25%, and in suburban neighborhoods the tree canopy cover should reach 50% (American Forests n.d.). Using these figures and comparing them to the data gathered by the UEI, it shows there are entire neighborhoods that have far below these minimum recommendations (See Figure 14) . When comparing these neighborhoods to those identified as most heat vulnerable, four out of seven are in these areas with low tree canopy cover. These areas have less than the recommended tree cover and they should be a leading priority for receiving additional trees via the Growing Boston Greener program. Although some of the vulnerable neighborhoods are dominated by large landmark buildings such as the New England Medical Center, Boston University and Logan International Airport, sight inspection will be necessary to determine which streets have the most need and perhaps to work with the private owners of these buildings to be more proactive in increasing tree canopy cover.

In addition to ramping up the Growing Boston Greener program, the city of Boston should institute a mandatory minimum landscaping ordinance. Some cities such as Sacramento and Davis, California have created municipal codes that place more of the responsibility on the property developer and owner to shade their parcel appropriately. Both of these ordinances require that 50% of the paved parking lot surface of any building be shaded with tree

FIGURE 13: BOSTON LAND COVER

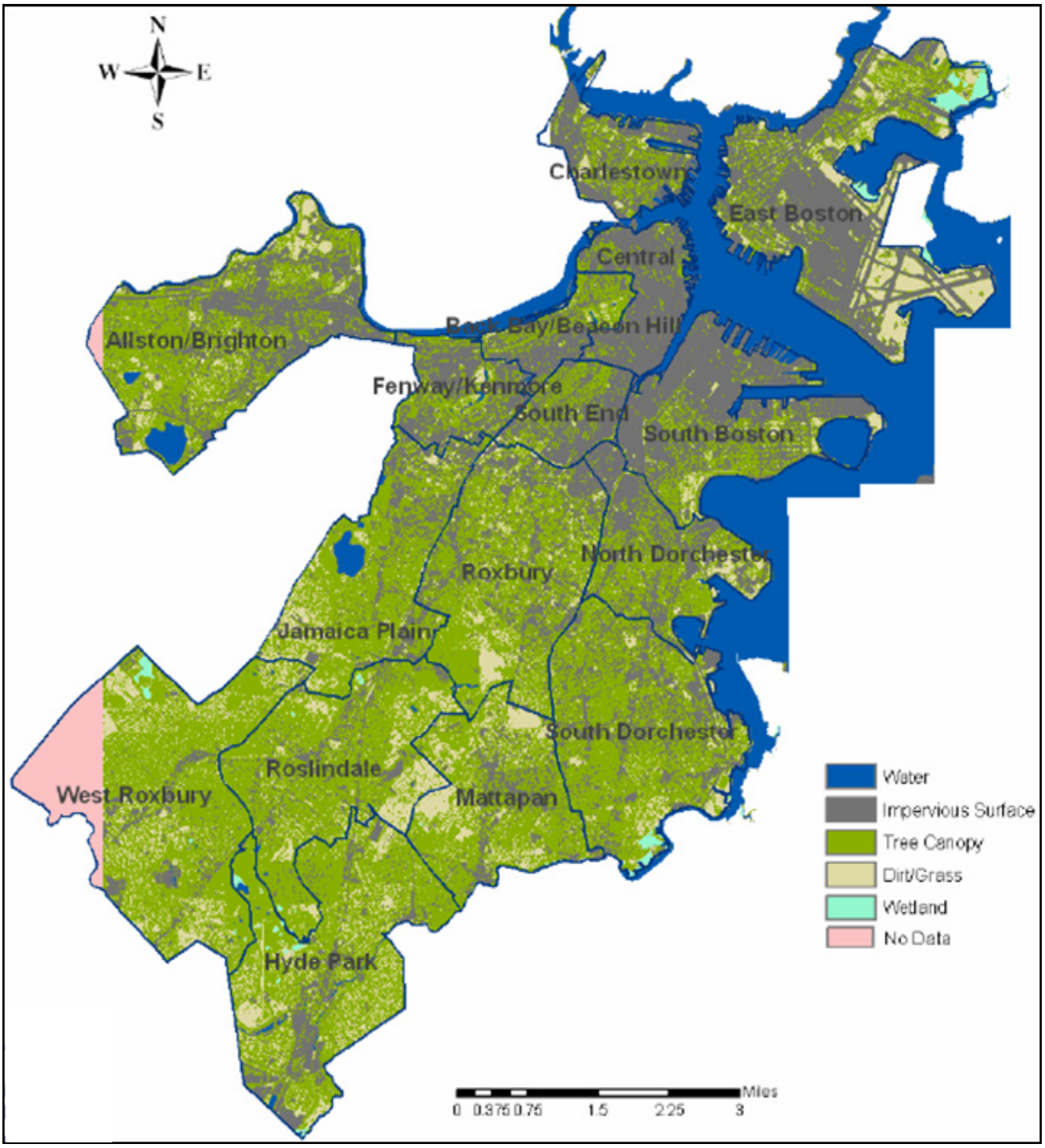
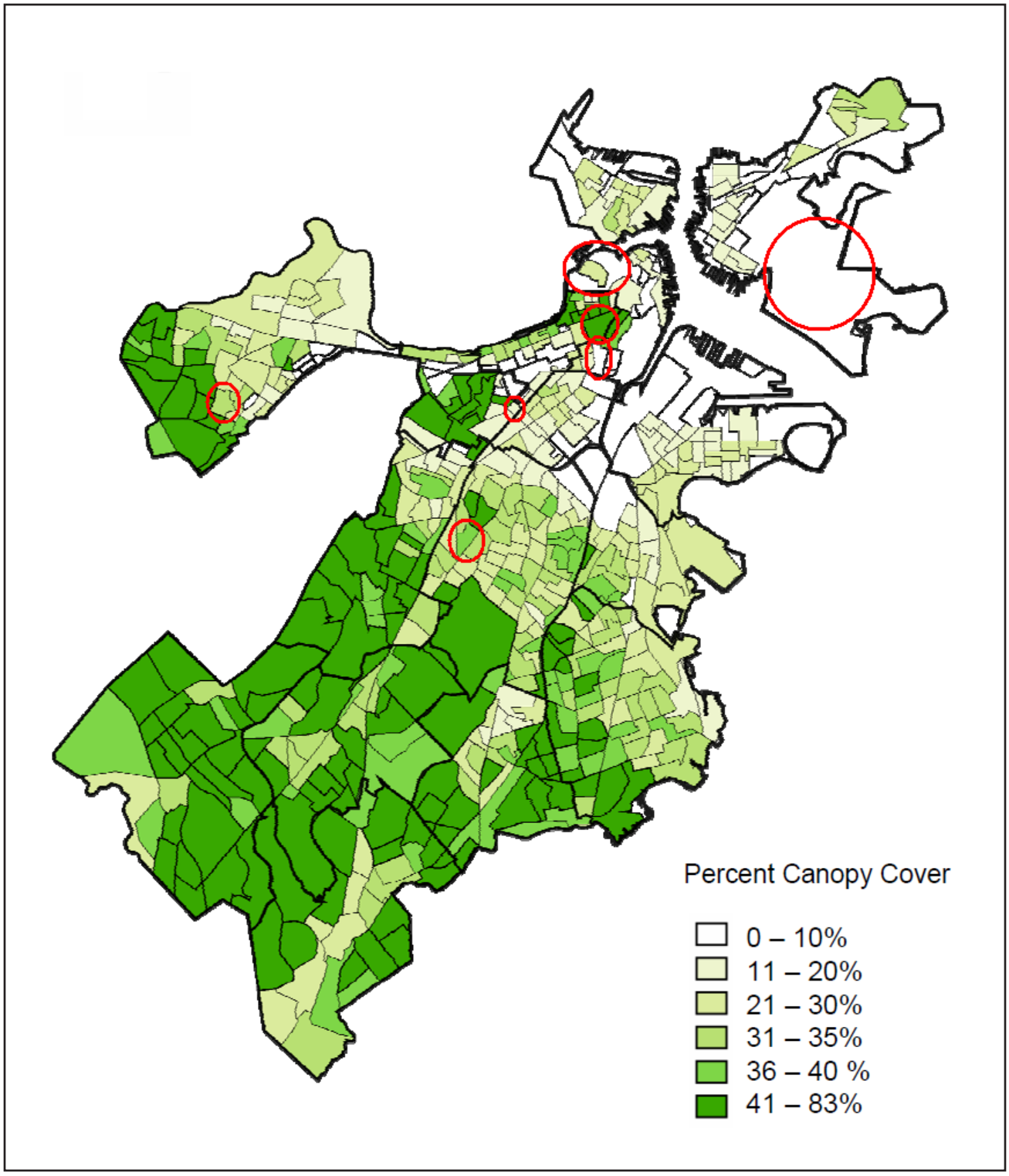


Figure 14: Boston's Existing Urban Tree Canopy by Census Block



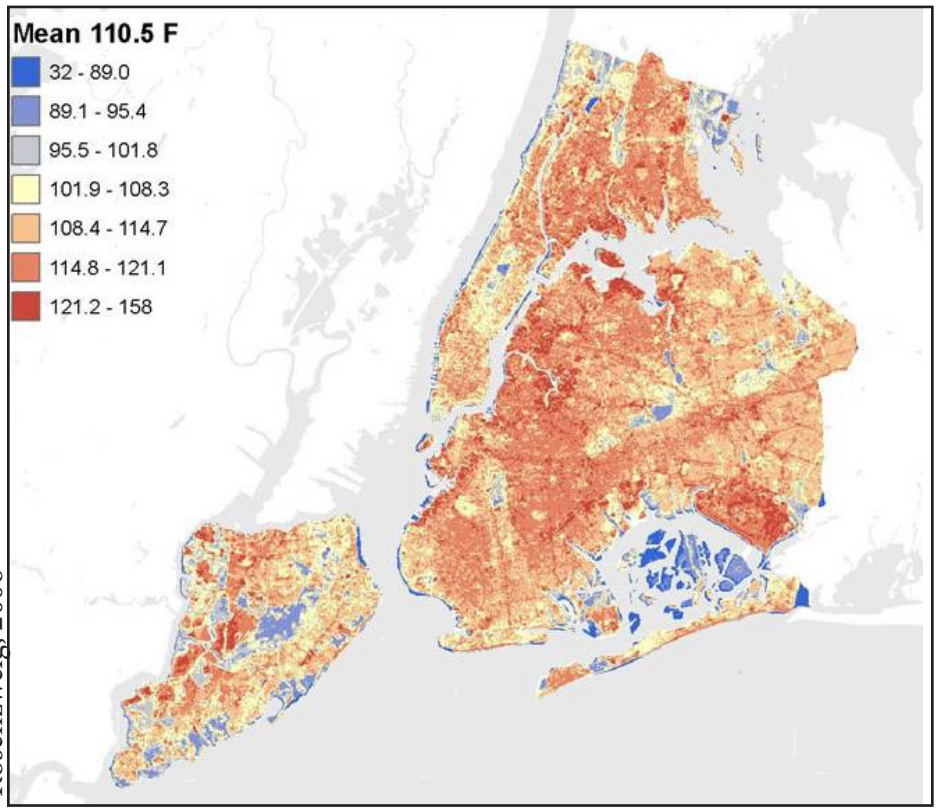
canopies within 15 years of the project's development (Sacramento, California, USA). Orlando, Florida specifies that trees must be planted along both sides of the street every 50 to 100 feet, with the selected trees having to reach a minimum height of 40 feet and a crown spreading 30 feet in diameter (United States Environmental Protection Agency (b) 2010).

Local Ecologist BlogSpot

Tree shading keeps parking lots cooler

Any of the above mentioned strategies have the capacity to reduce Boston's overall urban heat island effect and the severity of future heat waves. In order to properly implement a program using these long-term solutions, it is necessary to first measure the extent of the urban heat island effect and identify locations that would benefit most from any particular strategy. A preliminary investigative tool that can be used to measure this is the Mitigation Impact Screening Tool (MIST). This web-based software contains climate data from over 170 U.S. cities, including Boston. The user is able to input hypothetical citywide changes in surface reflectivity and vegetative cover into the program, which then estimates the projected air temperature reductions. However, the results provided by MIST contain a high degree of uncertainty and should only be used as a preliminary estimate for any proposed cooling strategy (Sailor & Dietsch 2007). The city of Boston should undertake a more detailed modeling before implementing a long-term cooling program.

This is exactly what New York City did in 2006 with the release of New York State Energy Research and Development Authority's (NYSERDA) report Mitigating New York City's Heat Island with Urban Forestry, Living Roofs, and Light Surfaces. By using a regional climate model in combination with observed meteorological, satellite and GIS data, researchers were able to identify which particular areas of the city are most affected by the heat island effect They found that on average, New York City's summertime temperature is around 7°F higher than the surrounding suburbs (Rosenzweig 2006). To try and reduce these elevated temperatures, they modeled cooling

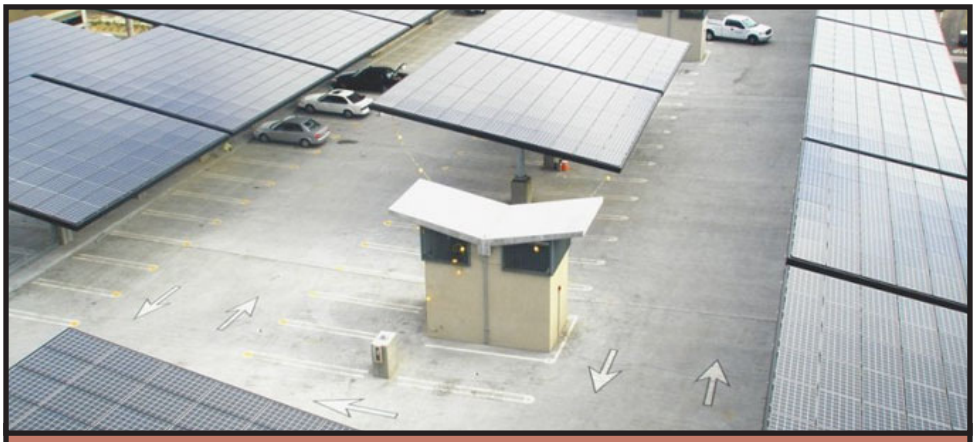


Rosenzweig, 2006

By using a regional climate model in combination with observed meteorological, satellite and GIS data, NYSERDA was able to identify which particular areas of the city are most affected by the heat island effect

strategies that included a combination of urban forestry, living roofs and light colored surfaces. Their results showed that street trees have the largest cooling potential per unit area, followed by living roofs, light-colored surfaces and open space tree planting. However, cool pavements offered the greatest total temperature reductions, because 64% of New York City's surface areas can be lightened, whereas only 17% can be planted with new trees (Rosenzweig 2006). It is important to note that when choosing a particular strategy, the characteristics of the neighborhood, cost/benefit factors and the available area for implementation are considered (Rosenzweig 2006).

Overall, the NYSERDA report was very successful in measuring the extent of New York's urban heat island effect and investigating which combination of strategies would work best to reduce extreme summer temperatures. The city of Boston should use this study as a model for conducting Boston's own urban heat island effect assessment and subsequent appropriate mitigation strategies. It is vital to the safety and welfare of the city's most heat vulnerable residents that any locations that have above normal localized heating are identified and long-term cooling strategies are promptly implemented.



Photovoltaic (PV) Shade Canopies

Some local governments and private firms have taken it a step further and are considering installing solar panel canopies to shade parking lots. These photovoltaic (PV) canopies not only would generate electricity to power nearby buildings or new plug-in electric vehicles, but will shade the surfaces beneath from the sun. One analysis even showed that PV canopy shade actually achieves a 55.8°F surface temperature reduction where as the tree canopy only reduced the surface lot temperature by 43.2°F on a fully exposed surface (Golden et al. 2007). The study further suggested that PV canopy arrays would be the most appropriate for large volume parking lots near schools, retail or commercial buildings where the generated electricity could be most easily utilized (Golden 2007).

CONCLUSION ---- NEXT STEPS

Boston has the ability to better protect its residents from the dangers of heat waves.

Boston has the ability to better protect its residents from the dangers of heat waves. Recent natural and man-made disasters prove that the city is capable of quickly assembling an effective and widespread response to an emergency. The key to ensuring an equally successful outcome in the event of a heat wave is advanced preparation. Climate change will almost certainly result in a more frequent and severe heat waves in Boston; the city needs to prepare for those circumstances now, especially since many of the long-term strategies described in this report become more effective over time. By developing a comprehensive heat wave plan, continuing to evaluate the effectiveness of its cooling centers and adopting long-term, green solutions, Boston can drastically reduce the negative impacts of heat waves without solely relying on its ability to react to emergency situations. The lives of Boston's most vulnerable residents are in imminent danger; however, with proper planning, the city can ensure lives will be saved.

Report Contributors

James Alberque, GIS Specialist
[City of Boston] Enterprise GIS
Email correspondence 2/23/10, 3/5/10 and 3/9/10
Loni Plocinski, Interviewer

Lydia Argo, Director of Communications and Public Affairs
Boston Housing Authority
Email correspondence 3/20/10, 4/1/10
Loni Plocinski, Interviewer

Melissa Carlson, Deputy Commissioner of Advocacy and Planning
[City of Boston] Commission on Affairs of the Elderly
Phone interview 2/2/10, 2/18/10 and 3/31/10
Megan Krey, Interviewer

Alfred Davis, Director of Elderly and Disabled Services
Boston Housing Authority
Phone interview 4/1/10
Loni Plocinski, Interviewer

Jean Faucher, Director of Quality Control
Boston Senior Home Care
Interviewed at Boston Senior Home Care 3/29/10
Megan Krey, Interviewer

Eliza Greenberg, Commissioner
[City of Boston] Commission on Affairs of the Elderly
Phone interview 4/28/10
Megan Krey, Interviewer

Mary Guerin, Executive Director
Little Brothers – Friends of the Elderly
Email correspondence 2/18/10
Megan Krey, Interviewer

John Hardiman, Community Emergency Response Team Coordinator
[City of Boston] Community Emergency Response Team
Phone interview 3/28/10
Loni Plocinski, Interviewer

Claire Lane, GIS Manager
[City of Boston] Enterprise GIS
Email correspondence 2/17/10
Loni Plocinski, Interviewer

Pat McDonough, Facilities Manager
Boston Centers for Youth and Families
Email correspondence 2/12/10 and 3/9/10
Samantha Harris, Interviewer

Mark Melnik, Deputy Director for Research
Boston Redevelopment Authority
Interviewed at City Hall 2/18/2010
Michael Adler, Interviewer

Nancy Norman, Chief Medical Officer
Boston Public Health Commission
Email correspondence 2/17/10
Samantha Harris, Interviewer

Kerry O'Brien, Director of Public Relations
[City of Boston] Mayor's Office
Phone interview 2/10/10, 3/1/10 and 3/10/10
Megan Krey, Interviewer

Christine O'Leary, Telecommunications Team
[City of Boston] Management & Information Services Department
Phone interview 4/20/10
Megan Krey, Interviewer

Michael Ridolfi, Director of Health Services
Boston Senior Home Care
Interviewed at Boston Senior Home Care 2/2/10
Megan Krey, Interviewer

Michael O'Shea, Web Team
[City of Boston] Management & Information Services Department
Phone interview 4/20/10
Megan Krey, Interviewer

Robert Stanley, Director of Home Delivered Meal Services
Kit Clark Senior Services
Phone interview 4/2/10
Megan Krey, Interviewer

Elaine Sudanowicz, Interagency Coordinator
[City of Boston] Mayor's Office of Emergency Management
Phone interview 3/5/10; email correspondence 3/5/10, 3/12/10 and 3/17/10
Jeanette Rebecchi, Interviewer

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Appendix A: Weather Data Charts

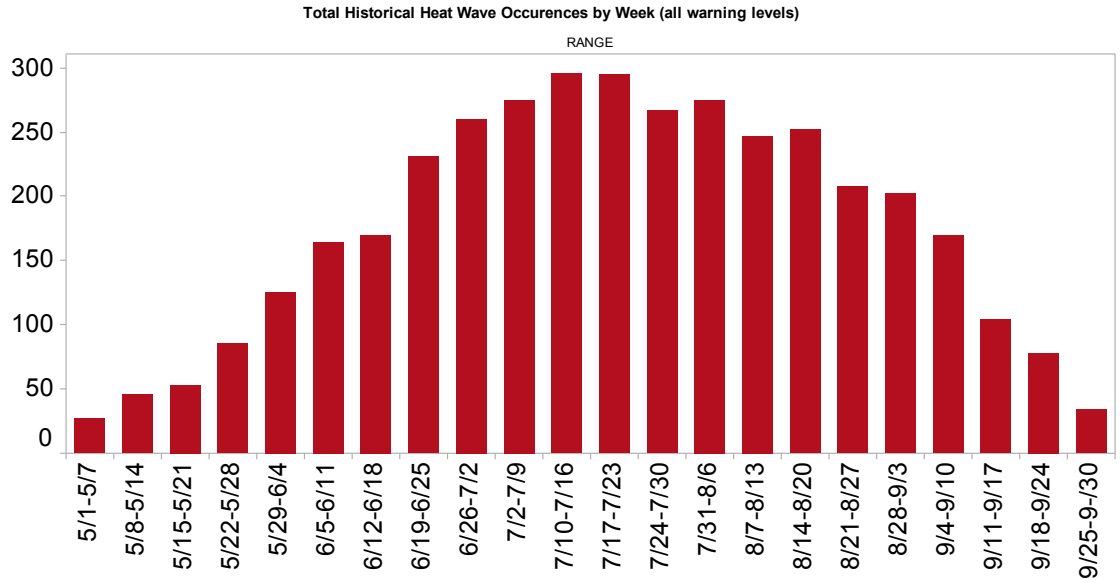
Maximum Daily Temperature (Summer 1950-2008)			
Average of Max Temp (F)	StdDev of Max Temp (F)	Average of Max Dewpoint (%)	StdDev of Max Dewpoint (%)
77	10.05	61	8.13

Average Daily Maximum Temperature by Decade (Summer 1950-2008)				
Decade	Average of Max Temp (F)	StdDev of Max Temp (F)	Average of Max Dewpoint (%)	StdDev of Max Dewpoint (%)
50s	76	10.06	60	8.29
60s	74	9.96	59	7.97
70s	78	9.79	61	7.92
80s	78	9.98	61	8.24
90s	77	10.10	61	8.07
2000s	77	9.97	62	8.12

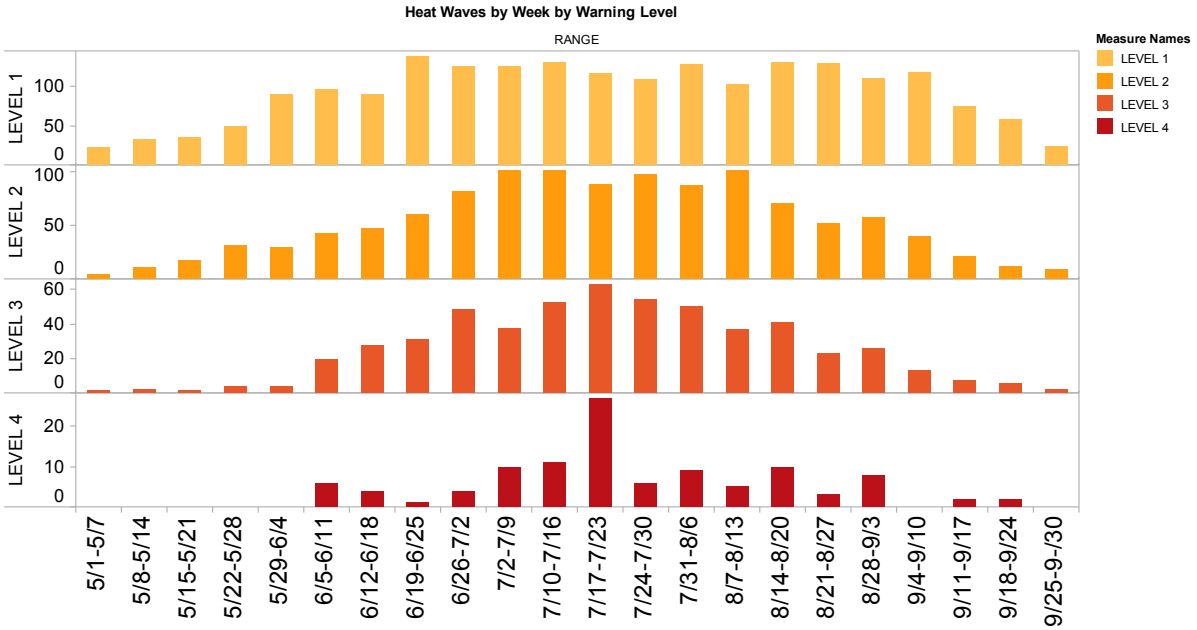
Average Daily Maximum Temperature by Year (Summer 1950-2008)				
YEAR	Average of Max Temp (F)	StdDev of Max Temp (F)	Average of Max Dewpoint (%)	StdDev of Max Dewpoint (%)
1950	74	9.64	59	8.14
1951	75	8.98	61	7.11
1952	77	9.73	61	8.41
1953	77	10.08	60	8.26
1954	73	10.18	59	7.21
1955	78	10.50	62	8.97
1956	74	10.84	59	7.74
1957	77	9.20	61	8.05
1958	74	9.91	59	8.96
1959	78	10.24	63	9.05
1960	76	9.28	60	7.19
1961	76	10.42	61	8.43
1962	74	9.76	59	8.05
1963	76	10.28	58	8.23
1964	74	9.34	60	7.90
1965	75	9.68	60	8.07
1966	75	10.20	59	7.00
1967	72	10.17	59	8.49
1968	73	10.05	59	8.03
1969	75	9.79	60	7.89
1970	76	9.50	62	7.31
1971	76	9.98	60	8.09
1972	75	9.22	60	7.81
1973	78	11.05	61	8.28
1974	76	10.54	60	7.21
1975	79	9.49	60	8.10
1976	80	8.64	61	7.78
1977	80	10.01	63	8.29
1978	78	9.68	61	7.91
1979	78	8.27	63	7.93
1980	80	9.98	60	8.20
1981	79	8.81	61	7.16

1982	76	9.85	58	7.40
1983	82	10.96	63	8.19
1984	80	11.02	63	9.28
1985	77	7.80	62	7.48
1986	77	9.41	61	8.17
1987	77	9.88	60	7.98
1988	79	10.84	62	9.36
1989	75	9.15	61	7.93
1990	77	9.87	61	8.57
1991	81	9.79	61	7.57
1992	74	9.94	60	7.68
1993	80	9.66	61	8.23
1994	80	10.03	62	8.88
1995	78	11.12	60	8.44
1996	75	8.58	61	6.98
1997	74	10.45	60	8.08
1998	76	9.34	63	8.05
1999	77	9.83	63	7.63
2000	76	8.96	62	7.70
2001	78	9.23	63	7.73
2002	79	11.06	62	8.28
2003	77	10.18	63	8.76
2004	77	8.41	61	7.21
2005	78	12.13	62	8.68
2006	77	10.96	61	8.05
2007	80	9.37	61	7.79
2008	77	9.29	60	8.45

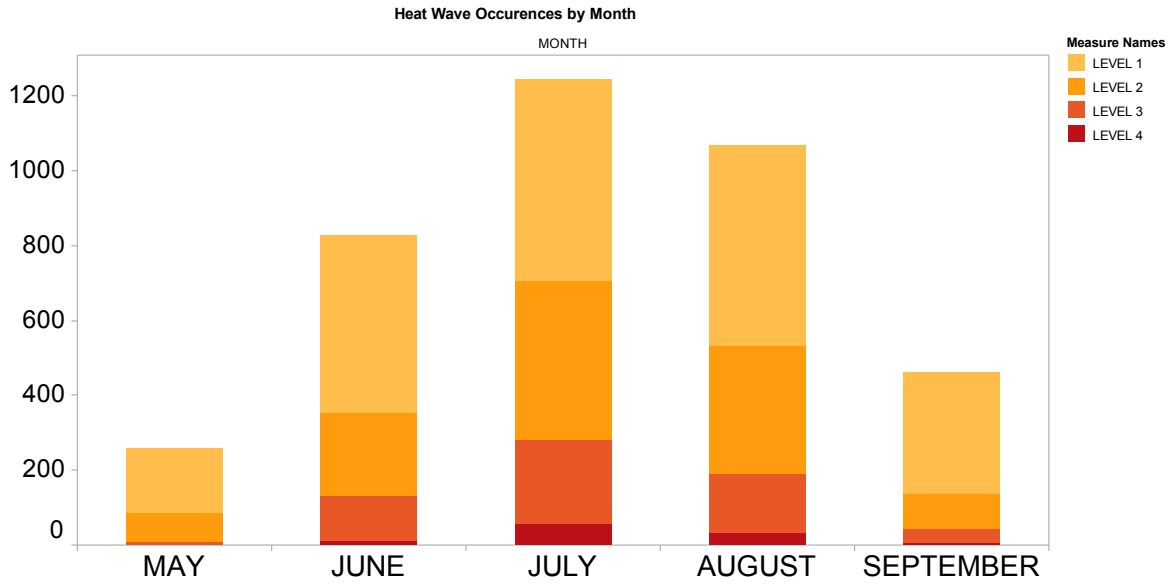
Appendix B: Heat Emergency Graphs



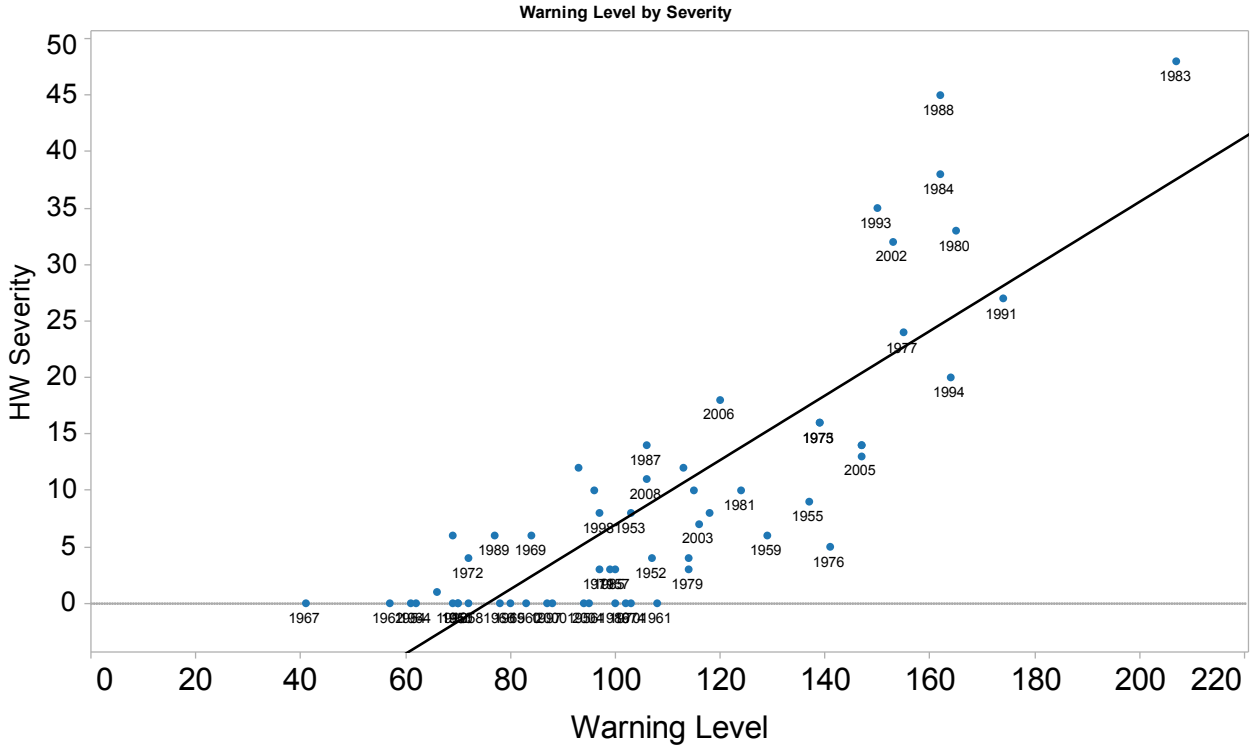
LEVEL 1, LEVEL 2, LEVEL 3 and LEVEL 4 for each RANGE. Detail is shown by week.



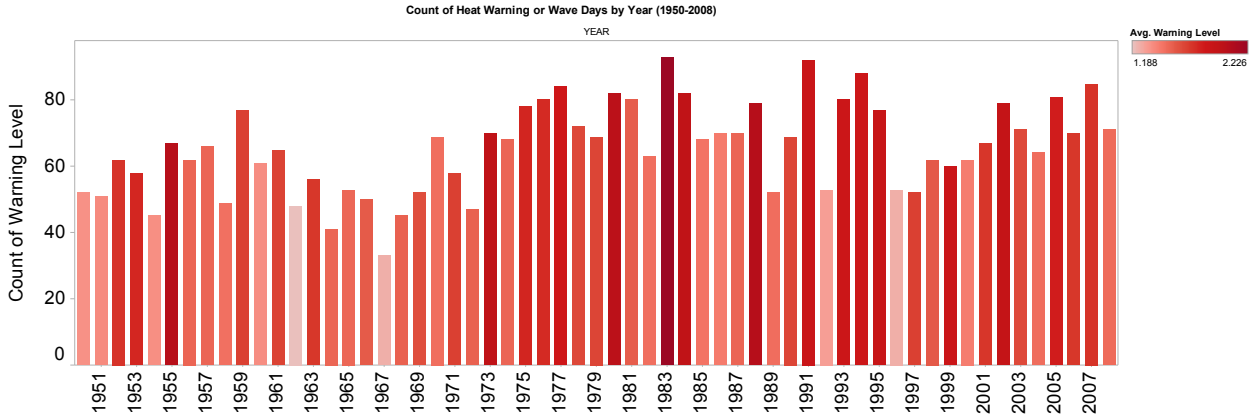
LEVEL 1, LEVEL 2, LEVEL 3 and LEVEL 4 for each RANGE.



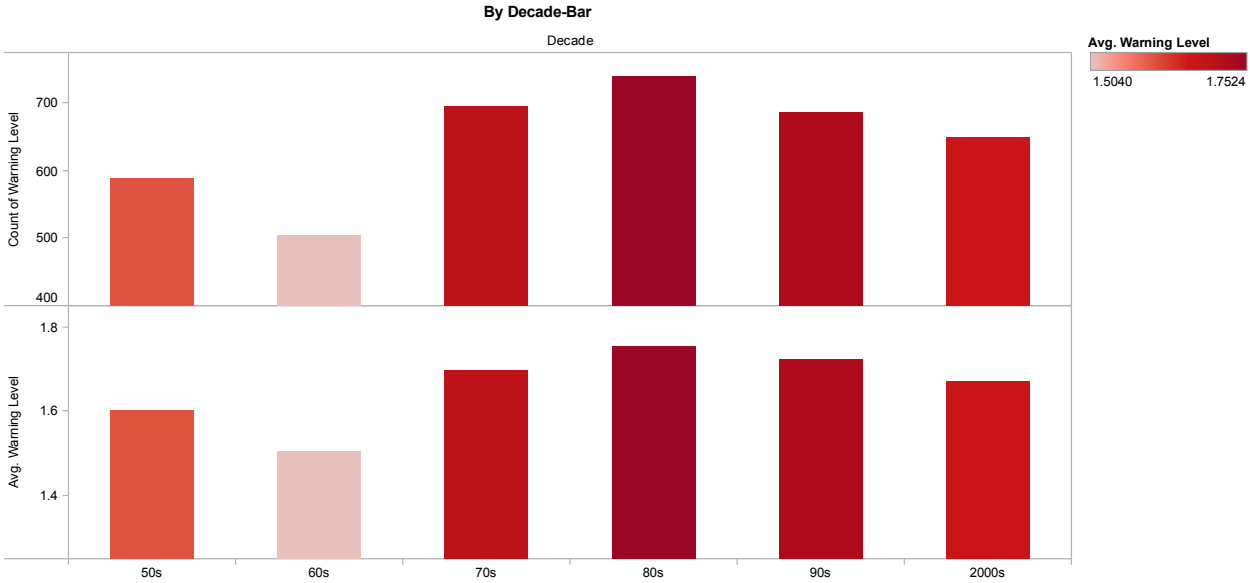
LEVEL 1, LEVEL 2, LEVEL 3 and LEVEL 4 for each MONTH.



This chart shows heat wave warning level against heat wave severity. As you can see, the majority of the high level combinations occur since 1980



Count of Warning Level for each YEAR. The Darker the color, the higher the average warning level for the year.



Count of Warning Level and average of Warning Level for each Decade. Color shows average of Warning Level.

Appendix C: Boston Heat Alert Press Release

Heat Alert

Mayor Thomas M. Menino reminds residents to prepare for the hot and humid weather by taking precautions to stay healthy.

Children and the elderly are particularly vulnerable to heat-related illnesses and injuries, but everyone should remember to limit their activities during very hot weather, drink plenty of fluids, and avoid beverages that contain caffeine or alcohol. Additional measures to beat the heat include avoiding cooking, taking cool showers or baths, and wearing loose, light-colored clothing.

Elderly
The Boston Commission on Affairs of the Elderly reminds residents to check on their elderly neighbors. The elderly are advised to call the Elderly Commission at 617-635-4366 or the Mayor's 24 Hour hotline at 617-635-4500 if they experience problems and to drink plenty of water and avoid outside activity. Boston seniors can also take advantage of Senior Shuttle service to and from the cooling centers. Additional information is available by calling the Elderly Commission at 617-635-4366.
Heat Fact Sheet for the Elderly »

Homeless
Extremely hot weather poses additional hardships for homeless people who may be elderly, disabled, suffer from medical conditions such as diabetes or high blood pressure, or who take medications that cause sensitivity to the hot sun.
Guide to Helping the Homelss During Extremely Hot Weather »

Utilities
If any areas are without power, residents should call NSTAR at 1-800-592-2000 or call the Mayor's 24 Hour Constituent Service at 617-635-4500 with concerns or questions.

Cooling Centers and Pools
Community Centers and pools will be open. Call the Mayor's 24 Hour Hotline at 617-635-4500 for the cooling center closest to you.
BCYF Cooling Centers »
BCYF Pool Hours »

Residents are reminded that fire hydrants should not be tampered with or opened; doing so may hinder fire extinguishing capabilities.

For more information anytime, residents can call the Mayor's Office at 617-635-4500.

Appendix D: Mayor Menino Reminds Residents to Keep Cool

Mayor Menino Reminds Residents to Keep it Cool in Hot Weather

For Immediate Release
August 18, 2009
Released By:
Mayor's Office

For More Information Contact:
Press Office

With temperatures expected to top 90 degrees this week, Mayor Thomas M. Menino issued a heat advisory and reminds residents to prepare for the hot weather by taking precautions to stay healthy. It is also a great time for Boston residents to take advantage of some of the cool offerings around the city – take a tour of the Copley library, or head to the Museum of Fine Arts, "Seeing Songs" show. Visit the USS Constitution Museum's new exhibit, "All Hands on Deck A Sailor's Life in 1812"or head to the movies, all of these fun activities can be done indoors with air conditioning.

"Everyone should enjoy the weather, but be safe while doing so," said Mayor Menino. "Children and the elderly are particularly vulnerable to heat-related illnesses and injuries, but everyone should remember to limit their activities during very hot weather."

Additional measures to beat the heat include avoiding cooking, taking cool showers or baths, and wearing loose, light-colored clothing.

The city's pools and community centers are now open for summer activities. Mayor Menino urges residents to utilize these facilities. For additional information, residents can contact the Mayor's 24-Hour Hotline at 617-635-4500 or www.cityofboston.gov/bcyf. Residents are reminded that fire hydrants should not be tampered with or opened; doing so may hinder fire prevention capabilities.

The Mayor's Commission on the Affairs of the Elderly has been proactively informing seniors of staying healthy during hot, humid weather through community seminars and contacting homebound seniors. The elderly are advised to call the Elderly Commission at 617-635-4366 or the Mayor's 24 - Hour hotline at 617-635-4500 if they experience problems and to drink plenty of water and avoid outside activity. Additional information is available by calling the Elderly Commission at 617-635-4366.

The warning signs for heat illness include: dizziness, weakness, fainting and vomiting, stomach cramps or cramping of the legs or arms, and confusion and agitation. If anyone experiences any of the symptoms listed above, they should first stop what they are doing and, if possible, move themselves to a cooler area. If symptoms persist, they should call 9-1-1 immediately. Family, friends and neighbors are also urged to check in frequently with elderly residents who may need assistance during the hot weather.

For questions about heat-related city services, residents should call the Mayor's 24-Hour Hotline at 617 635-4500.

Appendix E1: Boston Heat Fact Sheet

Commission on Affairs of the Elderly

THOMAS M. MENINO
Mayor

ELIZA F. GREENBERG
Commissioner

Heat Fact Sheet

The following populations are at risk for heat disorders due to sustained heat and humidity:

- Elderly
- Chronically disabled or unable to care for self
- Those with heart disease or diabetes
- Those taking medication such as: HCTZ, Lasix, Inderal, Elavil, Benadryl, Thorazine, Scopolamine, Mellaril
- Those in top floor apartments

Warning signs of heat illness (HEAT EXHAUSTION):
Dizziness Weakness Fainting Vomiting

Life threatening signs of heat illness (HEAT STROKE):
Confusion, Agitation, Unresponsiveness, Hot Skin, anyone with prolonged heat exposure and behavioral changes must be evaluated for Life Threatening Heat Stroke

Preventative Measures:

- Limit outside activities to early AM or late PM
- Use a fan or air conditioner; if no air conditioner is in the house, access a building where it's available
- Drink fluids (water, juice)
- Take frequent baths/showers
- Wear a hat; Wear loose and light colored clothing
- Open the windows at the top and bottom; keep the shades down during the day
- Avoid using the oven
- Keep an eye on neighbors who are at risk for heat disorders – "buddy system"

Emergency Measures:

- Call 911 if any warning of life threatening signs present
- If patient not traumatized, remove to a cool environment
- Remove clothing
- Apply cool water or ice to entire skin
- Fan patient
- If patient is conscious, give fluids

Appendix E2: Tips for Preventing Heat-Related Illness

EXTREME HEAT

Tips for Preventing Heat-Related Illness

The best defense is prevention. Here are some prevention tips:

- Drink more fluids (nonalcoholic), regardless of your activity level. Don't wait until you're thirsty to drink. Warning: If your doctor generally limits the amount of fluid you drink or has you on water pills, ask him how much you should drink while the weather is hot.
- Don't drink liquids that contain caffeine, alcohol, or large amounts of sugar–these actually cause you to lose more body fluid. Also, avoid very cold drinks, because they can cause stomach cramps.
- Stay indoors and, if at all possible, stay in an air-conditioned place. If your home does not have air conditioning, go to the shopping mall or public library–even a few hours spent in air conditioning can help your body stay cooler when you go back into the heat. Call your local health department to see if there are any heat-relief shelters in your area.
- Electric fans may provide comfort, but when the temperature is in the high 90s, fans will not prevent heat-related illness. Taking a cool shower or bath, or moving to an air-conditioned place is a much better way to cool off.
- Wear lightweight, light-colored, loose-fitting clothing.
- NEVER leave anyone in a closed, parked vehicle.
- Although any one at any time can suffer from heat-related illness, some people are at greater risk than others. Check regularly on:
    - Infants and young children
    - People aged 65 or older
    - People who have a mental illness
    - Those who are physically ill, especially with heart disease or high blood pressure
- Visit adults at risk at least twice a day and closely watch them for signs of heat exhaustion or heat stroke. Infants and young children, of course, need much more frequent watching.

If you must be out in the heat:

- Limit your outdoor activity to morning and evening hours.
- Cut down on exercise. If you must exercise, drink two to four glasses of cool, nonalcoholic fluids each hour. A sports beverage can replace the salt and minerals you lose in sweat. Warning: If you are on a low-salt diet, talk with your doctor before drinking a sports beverage. Remember the warning in the first "tip" (above), too.
- Try to rest often in shady areas.
- Protect yourself from the sun by wearing a wide-brimmed hat (also keeps you cooler) and sunglasses and by putting on sunscreen of SPF 15 or higher (the most effective products say "broad spectrum" or "UVA/UVB protection" on their labels).

This information provided by NCEH's Health Studies Branch (www.cdc.gov/nceh/hsb).

For more information, visit www.bt.cdc.gov/disasters/extremeheat, or call the CDC public response hotline at (888) 246-2675 (English), (888) 246-2857 (español), or (866) 874-2646 (TTY).

May 18, 2004 Page 1 of 1

DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTERS FOR DISEASE CONTROL AND PREVENTION
SAFER • HEALTHIER • PEOPLE™

Appendix E3: Boston EMS Hot Weather Tips

Boston *EMS*

Thomas M. Menino
Mayor of Boston

Hot Weather Safety Tips

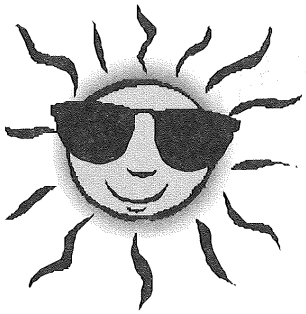
Do	Don't
• DO drink lots of water and sport drinks. • DO wear loose fitting, light weight, light colored clothing. • DO check on elderly persons. • DO use SPF 15 (or higher) sunblock and wear a hat. • DO rest often in shady areas. • DO go to an air conditioned place such as a shopping mall during severe heat. • DO listen to the news and public announcements for heat advisories.	• DON'T underestimate the seriousness of heat-related emergencies! • DON'T leave children or pets unattended in a vehicle. • DON'T drink alcoholic or caffeinated beverages. • DON'T stay in the hot weather if you feel sick. • DON'T overexert yourself or work outside without taking breaks. • DON'T hesitate to call EMS and seek medical attention!

Heat-related Emergencies

Heat Stroke	Heat Exhaustion
• Victim is often confused, disoriented • Skin is often HOT, RED, DRY • Body temperature is VERY HIGH	• Skin is COOL, PALE, MOIST • Body temperature near normal • Heavy sweating • Possible headache, nausea, dizziness, vomiting
What to do:	**What to do:**
• Heat stroke is an immediate medical emergency. Call 9-1-1. • Move the victim to a cool location out of the heat. • Place in front of a fan or in an air-conditioned room. • Place ice packs under armpits and groin. • DO NOT give the victim ANYTHING to eat or drink!	• Call 9-1-1 immediately. • Move the victim to a cool location out of the heat. • Lay victim on his or her back and elevate legs. • Remove/loosen clothing. • Cool victim by fanning or applying cold packs, wet sheets, or towels.

EMERGENCY – EMS, Fire, Police
Dial 9-1-1

Appendix F: BHA Heat Info



BEAT THE HEAT

ATTENTION

Boston Senior Citizens
Beat the Heat this Summer

- Drink plenty of fluids
- Avoid caffeine and alcohol
- Take cool baths or showers
- Avoid exertion
- Avoid cooking and hot foods
- Use the "Buddy System"
- Wear loose, light colored clothing
- Watch for signs of heatstroke; fatigue, headaches, nausea

For more information call the Elderly Commission Hotline
(617) 635-4366
Nights & Weekends, please call the Mayor's 24 hour hotline (617) 635-4500

City of Boston
Commission on Affairs of the Elderly
Thomas M. Menino, Mayor
Eliza F. Greenberg, Commissioner

Appendix G: Helping the Homeless During Extremely Hot Weather

THOMAS M. MENINO ~ MAYOR
CITY OF BOSTON ~ EMERGENCY SHELTER COMMISSION
JIM GREENE ~ ACTING DIRECTOR

Helping the Homeless During Extremely Hot Weather

Mayor Thomas M. Menino and the City of Boston recognize that extremely hot weather poses additional hardships for homeless people who may be elderly, disabled, suffer from medical conditions such as diabetes or high blood pressure, or who take medications that cause sensitivity to the hot sun. The Mayor has asked the Emergency Shelter Commission to offer the following information as part of a citywide effort to respond proactively to the health and wellbeing of all City residents and visitors during the heat wave. Thank you.

How You Can Help

Please Be Our Eyes And Ears In The City: If a homeless person in need approaches you or is observed by you to be in need of help, please show them the same courtesy as you would any of your fellow citizens. A list of programs and emergency contacts is provided below.

If Someone Appears to Be Passed Out: If a person presumed to be homeless appears to be passed out, please do not assume that they are "just drunk." People become dehydrated rapidly in extremely hot weather, and anyone "passed out" should be considered medically at risk. People lying in the sun or badly sunburned are additionally at risk. **If you see anyone passed out on the streets or sidewalks, *PLEASE CALL 9-1-1.***

Water, Water Everywhere: Many homeless persons lack resources or do not feel entitled to walk into some establishments and ask for water. It is both compassionate and helpful to offer a cup of cold water, bottled water or sports drinks to homeless persons. Offer sunscreen or a baseball cap to protect from the sun. Reminders to move into a shaded area can help as well.

If someone is in need of shelter:	
☎ ***Shelter For Women:***	***Shelter For Men & Women:***
~Rosie's Place 617-442-9322	~ Woods-Mullen Shelter 617-534-7101
~Pine Street Women's Inn 617-521-7110	~Boston Homeless Services 617-534-2526
☎ ***Shelter For Men:***	~Shattuck Shelter 617-971-3229
~Pine Street Men's Inn 617-521-7202	***Homeless Youth:***
☎ ***Daytime Drop-in Centers:***	~Bridge Over Troubled Waters 617-423-9575
~St. Francis House 617-542-4211	***Homeless Families in Need***
~Women's Lunch Place 617-267-1722	~Department of Transitional Assistance 617-989-6100
~Cardinal Medeiros Ctr. (45+) 617-451-9331	~Traveler's Aid Family Services 617-542-7286
☎ ***Women's Safety Hotline*** 1-877-785-2020	

For Medical Or Safety Emergencies for the Homeless Please Call 9-1-1 for Boston Emergency Medical Services (EMS) & the Boston Police Department. Cell phones, Call 617-343-4911

For All Other Calls, Concerned Citizens Should Call the Mayor's 24 Hour Service 617-635-4500.

Appendix H1: BCYF Cooling Centers 2009

Thomas M. Menino
Mayor

Boston Centers for Youth & Families

Daphne Griffin
Executive Director

BOSTON CENTERS FOR YOUTH & FAMILIES (BCYF)
SUMMER 2009 COOLING CENTERS & POOLS LIST

The following BCYF sites are available, based on required needs, as Cooling Centers and/or Pool Sites when Mayor Menino declares a Heat Emergency or after the City of Boston's temperatures have reached 90 degrees or higher for three (3) or more consecutive days.

Because the BCYF Cooling Center / Pool Site List is subject to change, all City departments using this list must call the Mayor's 24 Hour Services for updates on which BCYF sites are open during any/all Heat Emergencies.

BCYF sites with an asterisk (*) are Pool Only sites.

BCYF Cooling Centers

Agassiz Community Center	20 Child Street, Jamaica Plain	635-5191
Archdale Community Center	125 Brookway Rd, Roslindale	635-5256
Blackstone Community Center	50 West Brookline Street, Boston	635-5162
Charlestown Community Center	255 Medford Street, Charlestown	635-5169
Cleveland Community Center	11 Charles Street, Dorchester	635-5141
Condon Community Center	200 D Street, South Boston	635-5100
Curley Community Center (L St.)	1663 Columbia Road, South Boston	635-5104
Curtis Hall Community Center	20 South Street, Jamaica Plain	635-5193
Gallivan Community Center	61 Woodruff Way, Mattapan	635-5252
Golden Age Center	382 Main Street, Charlestown	635-5175
Grove Hall CC (Burke)	51 Geneva Ave, Dorchester	635-1484
Harborside Community Center (Umana)	312 Border Street, East Boston	635-5114
Hennigan Community Center	200 Heath Street, Jamaica Plain	635-5198
Holland Community Center	85 Olney Street, Dorchester	635-5144
Hyde Park Community Center	1179 River Street, Hyde Park	635-5178
Jackson-Mann Community Center	500 Cambridge St, Allston	635-5153
Kent Community Center	50 Bunker Hill St, Charlestown	635-5175
Marshall Community Center	35 Westville Ave. Dorchester	635-5148
Mattahunt Community Center	100 Hebron Street, Mattapan	635-5159
Mildred Avenue Community Center	5 Mildred Ave., Mattapan	635-1328
Nazarro Community Center	30 North Bennet Street, North End	635-5166
Ohrenberger Comm. Center	175 West Boundary Rd., West Roxbury	635-5183

Appendix H2: BCYF Cooling Centers 2010

DATE: March 9, 2010

TO: Samantha Harris

FROM: Pat McDonough, BCYF

RE: **BOSTON CENTER FOR YOUTH & FAMILIES (BCYF) SITE LIST**

Listed below are the Boston Centers for Youth & Families (BCYF) sites with addresses, phone numbers and contact names of staff who are the Supervisory and/or Management Staff person at each BCYF buildings/sites itself.

This list has been broken out to 1st reflect the BCYF sites located in Boston Public School (BPS) buildings and then the BCYF free-standing sites which we solely operate.

BCYF SITES IN BPS BLDS./ADDRESSES		SITE CAPACITIES
Agassiz CC	20 Child St., Jamaica Plain 02130	250
BCNC (Quincy School)	885 Washington Street, Boston 02111	250
Blackstone CC	50 W. Brookline St., Boston 02118	250
Charlestown CC	255 Medford St, Chas.02129	200
Cleveland CC	11 Charles St., Dorchester 02122	400
Condon CC	200 D St, South Boston 02127	200
Grove Hall CC	51 Geneva Avenue, Dorechester	250
Harborside CC (Umana High School)	312 Border St., East Boston 02128	300
Hennigan CC	200 Heath Street, Jamaica Plain 02130	300
Holland CC	85 Olney Street, Dorchester 02121	250
Jackson-Mann CC	500 Cambridge St, Allston 02134	150
JP/English CC	144 McBride St, Jamaica Plain 02130	350
Kent CC	50 Bunker Hill St., Charlestown 02129	150
Leahy-Holloran CC (Murphy School)	1 Worrell Street, Dorchester 02122	250
Madison Park CC	55 New Dudley St, Roxbury 02119	250
Marshall CC	35 Westville Ave. Dorchester 02124	250

Appendix I: Operation Heat Wave

March 05, 2008

OPERATION HEAT WAVE

AN OPERATIONAL GUIDELINE FOR EXCESSIVE HEAT EMERGENCIES

Extreme Heat Emergency

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Statement of Purpose

Weather patterns in the Great Lakes Region frequently result in extended periods of extremely high temperatures during the summer months.

Health experts agree that the combination of high temperatures, high humidity and poor air quality constitute a threat, especially to certain groups of people: children, the elderly and those with respiratory or other health problems.

Heat-related illnesses range from minor problems, such as heat stress and heat cramps, to serious illnesses such as heat exhaustion and heat stroke. Heat exhaustion often occurs after several days of high temperatures during which the patient loses water and salt through perspiration. Symptoms include dizziness, weakness, fatigue and nausea.

Heat stroke, the most dangerous heat-related illness, can be fatal. It occurs when body temperature rises above 105 degrees. The patient initially feels lethargic, then often becomes confused and eventually loses consciousness.

In an effort to increase public awareness to the threat Extreme Heat Emergencies (EHE) pose to our communities, Kane County has developed a framework by which an EHE incident can be effectively mitigated prior to the incident developing into a county-wide disaster with the loss of life.

March 05, 2008

OPERATION HEATWAVE

Situations and Assumptions

A. Situation

There exists the possibility that given Kane County's climatic weather patterns during the summer months, temperatures may rise to over 100° F with a temperature heat index in excess on 130° F for one or more successive days.

There is also the possibility that during the above situation, power outages could occur in one or more locations through out the county, thereby exacerbating the situation and increasing the threat.

The occurrence of either or both of the above conditions could result in extreme physical stress being placed on certain individuals and populations within the community, primarily the very young, the elderly and those individuals with medical problems.

In such an event, "**OPERATION HEATWAVE**" will be implemented.

B. Assumptions

As a member of the Multi-County Severe Weather Warning System it is the responsibility of the Office of Emergency Management to monitor weather conditions as they develop identifying any severe weather events that may threaten our communities.

It is assumed that electrical power will be available for OEM monitoring functions at the Emergency Operations Center (EOC) located in the lower level of the Public Safety Building at 777 Fabyan Parkway in Geneva IL.

A further assumption is made that if commercial power is lost at the EOC, its backup generator will be fully functional, this would become the primary base of emergency operations during an EHE event.

Concept of Operations

The Kane County has developed a three stage approach to managing Extreme Heat Emergencies. These stages are a "Watch", "Advisory" and "Warning" conditions. The triggers for each of these conditions are outlined below:

WATCH

Should the temperature heat index rise to over 94° F for three consecutive hours or more and the low temperature for the day does not drop below 75° at night the Extreme Heat Emergency (EHE) – "Watch" process will be activated indicating conditions are favorable that an EHE may occur.

ADVISORY

Should the temperature heat index rise to over 105° F and the low temperature for the day does not drop below 75° at night the Extreme Heat Emergency (EHE) – "Advisory" process will be activated indicating conditions are expected to remain below the EHE warning threshold, but are still a significant threat to the public health.

WARNING

In the event the temperature heat index rises to over 114° F and the low temperature for the day does not drop below 75° at night the Extreme Heat Emergency (EHE) – "Warning" process will be activated indicating that an Extreme Heat Emergency event poses an immediate threat to life and/or property is occurring or is imminent.

Should an EHE warning be issued close coordination with area hospitals will be necessary to identify the affect the event is having on Kane County's population. The establishment of municipal cooling centers or shelter and the need to relocate populations from extended care facilities may be necessary.

In the event the EHE continues for an extended period of time a State of Emergency may need to be declared by the County Board Chairman activating the County Emergency Response Plan.

March 05, 2008

Extreme Heat Emergency "Watch" Checklist

1. _____ If conditions exist that meet the criteria for the issuance of an EHE Watch the Office of Emergency Management will develop incident objectives and a situation report for the next 12 hour operational period.

2. _____ The OEM operational staff will notify the County Board Chairman, all County department heads, the Health Department and Animal Control that Kane County is under an EHE Watch.

3. _____ All OEM personnel will be placed on STANDBY ALERT

4. _____ OEM operations personnel will notify Community Contacts (847-697-8800), Kane County Senior Services (630-897-4184), and the Greater Elgin Senior Services Association (847-741-0404) of the increasing heat threat.

5. _____ The heat watch information will be broadcast county-wide via EMnet.

6. _____ OEM Personnel will review heat advisories as may be received via National Weather Service and/or the Multi-County Severe Weather System notifications.

7. _____ Extreme Heat message will be released by the PIO to the media

March 05, 2008

Extreme Heat Emergency "Advisory" Checklist

_____ 1. If conditions exist that meet the criteria for the issuance of an EHE Advisory the Office of Emergency Management will develop incident objectives and a situation report for the next 12 hour operational period.

_____ 2. OEM will notify the County Board Chairman and the County Department Heads that the EHE Advisory criteria has been met.

_____ 3. OEM, Animal Control and the Health Dept. will develop joint messages describing mitigation efforts and release them to the public.

_____ 4. Health Care and extended care facilities will be notified of the EHE Advisory via EMnet.

_____ 5. Municipalities and Elected officials will be notified of the EHE advisory via EMnet or fax.

_____ 6. Release joint messages to the news media.

_____ 7. If necessary encourage the municipalities to establish cooling centers.

_____ 8. Assess OEM & Medical Reserve Corp. volunteer availability.

_____ 9. In the event of wide-spread power outages activate the Power Outage Procedures.

Extreme Heat Emergency "Warning" Disaster Checklist

NO Immediate POWER OUTAGE

1. _____ If conditions exist that meet the criteria for the issuance of an EHE Warning the Office of Emergency Management will develop incident objectives and a situation report for the next 12 hour operational period.

2. _____ Joint messages OEM, Public Health and Animal Control will be developed pertaining to the warning status.

3. _____ Information pertaining to the extreme heat warning will be distributed to the media.

4. _____ Information pertaining to the extreme heat warning will be distributed to municipal, elected, and healthcare officials via EMnet, email or fax

5. _____ OEM will be placed on a level 2 activation.

6. _____ The Director or his/her designee will contact the American Red Cross (both Fox Valley and Mid-America chapters) as well as the Salvation Army to advise that an EHE Warning has been issued placing the agencies on standby..

7. _____ OEM Personnel will continually monitor the weather forecasts through weather radar imaging, National Weather Service and Multi-County Severe Weather System to predicted length of the EHE.

8. _____ Municipalities will be encouraged to identified and established Cooling Centers as needed.

9. _____ The OEM will check on the Special Needs registrants.

10. _____ OEM will monitor the communities for wide-spread power outages.

11. _____ The OEM will develop and maintain a situational awareness of the incident keeping the County Board chairman informed.

12. _____ The OEM Director or his/her designee will update and distribute the situation report as needed.

13. _____ Public awareness advisories will be broadcast at regular with this information sent via EMnet or faxed to all ESDA's/EMA's, municipalities, Kane County departments and the media in Kane County. This information will contain warnings on the EHE, how to care for ones self during a EHE, what to do if the power goes out and emergency numbers (9-1-1, Sheriff's

Dept., Kane County OEM, Health Dept.) if assistance is necessary. Fliers containing this information can also be given to the Meals on Wheels/Salvation army for distribution to seniors.

14. _____ OEM personnel will have electric generators ready to be activated and a list of resources available for use as may be necessary.

15. _____ OEM personnel will respond to requests for assistance if able to do so and if within OEM's scope of operations. If not, alternative avenues of help will be sought, including mutual aid assistance. Kane County Office of Emergency Management **will not** provide transportation to cooling centers.

16. _____ The operations staff will log a record of all EHE related activities and times executed on the DMIS crisis management system.

17. _____ Has the situation escalated? If so activate the County's Emergency Response Plan.

Post Extreme Heat Emergency Checklist

Immediately following the **HEATWAVE** disaster period the following actions will be taken:

1. _____ OEM personnel will assess the decreasing components of the HEATWAVE disaster (break in temperature, restoration of power, etc.) and advise the Director or his/her designee.

2. _____ The County Board Chair or the OEM Director or his/her designee will make a decision to CEASE ALL HEATWAVE RESPONSE OPERATIONS upon assessment of current conditions.

3. _____ The Director or his/her designee will contact the American Red Cross and the Salvation Army of the decision to CEASE HEATWAVE OPERATIONS and DE-ACTIVATE any cooling center(s). OEM Personnel will assist the American Red Cross with closing of the cooling center(s) and inform the centers' owner.

4. _____ OEM personnel will broadcast DE-ACTIVATE OF HEATWAVE OPERATIONS via the EARS system, EMnet and Fax to all county ESDA's/EMA's, municipalities and media.

5. _____ The OEM Director or his/her designee will inform the County Board Chairman of the de-activation of operations and implementation of the damage assessment plan.

6. _____ OEM personnel will advise the IEMA regional office of de-activation of operations and implementation of damage assessment plan.

7. _____ OEM personnel will ACTIVATE DAMAGE ASSESSMENT OPERATIONS per the Damage Assessment annex in the County ERP and advise the IEMA regional office.

8. _____ All logged activities pre, during and post **HEATWAVE** disaster are to be printed and forwarded to the Director.

All activities on the **Post HEATWAVE Disaster Checklist** are to be checked off as performed.

ANNEX A

Emergency Telephone Numbers

Hospitals	
Delnor Community Hospital	(630) 208-3000
Provena-Mercy Center Hospital	(630) 859-2222
Rush-Copley Memorial Hospital	(630) 978-6200
Elgin Mental Health Center	(847) 742-1040
Provena - St. Joseph Hospital	(847) 697-3200
Sherman Hospital	(847) 742-9800
Saint Alexius Medical Center	(847) 843-2000
IEMA Region 3	(815) 357-8963
American Red Cross – Fox River Chapter – South	(630) 443-8844
Mid-America Chapter – North	(312) 729-6100
Salvation Army	(800) 564-9004
Community Contact	(630) 232-7600
Elgin Senior Center	(847) 741-0404
Senior Services Assoc. of Kane County	(630) 897-4184
National Weather Service - Romeoville	(815) 834-0666
Commonwealth Edison (See Director or Deputy Director for other numbers)	(800) 334-7661
Geneva Power & Electric (See Director or Deputy Director for other numbers)	(630) 232-1503

March 05, 2008

ANNEX B

Heat Index Conversion Table

TEMPERATURE DEGREES FAHRENHEIT	HEAT INDEX TEMPERATURE																				
115	103	107	111	115	120	127	135	143	151												
110	99	102	105	108	112	117	123	130	137	143	150										
105	95	97	100	102	105	109	113	118	123	129	135	142	149								
100	91	93	95	97	99	101	104	107	110	115	120	126	132	138	144						
95	87	88	90	91	93	94	96	98	100	101	104	107	110	114	119	124	130	136			
90	83	84	85	86	87	88	90	91	93	95	96	98	100	102	106	109	113	117	122		
85	78	79	80	81	82	83	84	85	86	87	88	89	90	91	93	95	97	99	102	105	108
80	73	74	75	76	77	77	78	79	79	80	81	81	82	83	85	86	86	87	88	89	91
75	69	60	70	71	72	72	73	73	74	74	75	75	76	76	77	77	78	78	79	79	80
70	64	64	65	65	66	66	67	67	68	68	69	69	70	70	70	70	71	71	71	71	72
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
	RELATIVE HUMIDITY (Percent)																				