The Improvement of Safety and Recycling in the Large Buildings of Boston, MA

http://www.wpi.edu/~khg1/buildings

Interactive Qualifying Project

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ABSTRACT

Our project was to help improve safety and recycling in the large buildings of Boston, MA. We worked in conjunction with the Public Works Department and the Boston Fire Department. We provided both of our sponsors with pertinent information we had gathered and analyzed. From this data that we had collected we were able to draw up recommendations that will now make living in large residential buildings in Boston safer and more environmentally friendly.

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1 Executive Summary

Being one of the richest historical areas in the country; Boston, established in 1630, has always been a hub of commercial and cultural development. For those reasons, amongst many others, Boston is a very desirable city to inhabit causing a high demand for housing. One solution for urban housing has been large residential high-rise structures. Although large buildings are a very effective solution to the urban housing problem, they impose several problems on the city.

One threat is the personal safety of occupants in large residential buildings, particularly those whom are at risk in emergency situations. Due to the high density of people in these large buildings, more safety measures must be implemented. The Boston Fire Department (BFD) in accordance with the National Fire Protection Agency (NFPA) has implemented many standards and ordinances to help maintain the safety of these occupants.

A different problem that the city is faced with regarding large buildings is the creation of extensive waste quantities. In 1999, the United States alone produced an average of 4.6 lbs of trash per person per day. This high production of waste can not be supported by the current landfills and open land, therefore Boston has realized the severe need for recycling. The city of Boston has implemented a thorough recycling plan entitled, *The City of Boston Residential Recycling Plan: Outline for Action.* Large residential buildings are targeted in this plan because of their high population density and the possibility of creating large amounts of waste.

There have been many previous recycling and fire evacuation studies across the United States addressing current issues that are preventable. Some of these troubles are exemplified in the city of Boston.

One of the first events that lead to the conduction of studies to improve fire safety was *The Paramount Fire* in Boston on Feb 19th, 1966 (shown in Figure 1). After the investigation of this fire, it was determined that the high casualty count was due to the lack of fire prevention techniques. This incident and others similar lead to the development of new building codes, regulations, and procedures regarding fire life safety. With new technology, codes are constantly being amended and new investigations conducted. The Federal Emergency Management Agency (FEMA) has performed city and apartment investigations such as *Profile of the Urban Fire Problem in the United States*[1]. In the Profile's analysis of Boston; it determined many factors that affect the safety of the residents of Boston. It was also discovered that the majority of deaths from fire are from the lack of detection and alarm systems in buildings. From these specifications for the city of Boston's urban fire problem, the Fire Department has been able to regulate and control future fires.

Figure 1: Paramount Building Fire

The Boston government has unveiled multiple recycling ventures in the past fifteen years. The first organized recycling in the city was lead by volunteers who created drop-off sites in several neighborhoods where residents could then recycle newspapers and bottles. This inspired the government to perform a piloted curbside collection program in 1990 for 6,500 households in Jamaica Plain, a neighborhood of Boston. In response to this pilot, weekly curbside collection of household recyclables to residents was initiated in 1995[2]. Although this past study is an excellent base to begin our project, it has become outdated. Due to the new advances in recycling technology, there is a constant need for recycling analysis and the intervention of new recycling programs. As of January 2001, Boston is under the direction of a new recycling plan entitled *Residential Recycling Plan: Outline for Action.* It is mainly focused on education, leaf and yard waste collection, household hazardous waste programs, and our focus which is increasing large apartment building recycling.

Figure 2: Recycling Logo

[1] FEMA, United States Administration, National Fire Data Center May 1999 http://www.usfa.fema.gov/
[2] City of Boston Residential Recycling Plan: Outline for Action. Mayor Thomas M. Menino Jan. 2001

Not all large residential buildings are currently participating in the recycling program. The current program is hindered because the PWD is unaware of buildings not presently recycling. It has been a challenge to collect the necessary information of these large dwellings since they are constantly undergoing new renovations and reconstructions. These new additions hinder the recycling program as they do not participate in the ordinance until they are identified. Like the Boston Fire Department, the Public Works Department requires updated information to better serve the public.

Figure 3: Boston Recycling

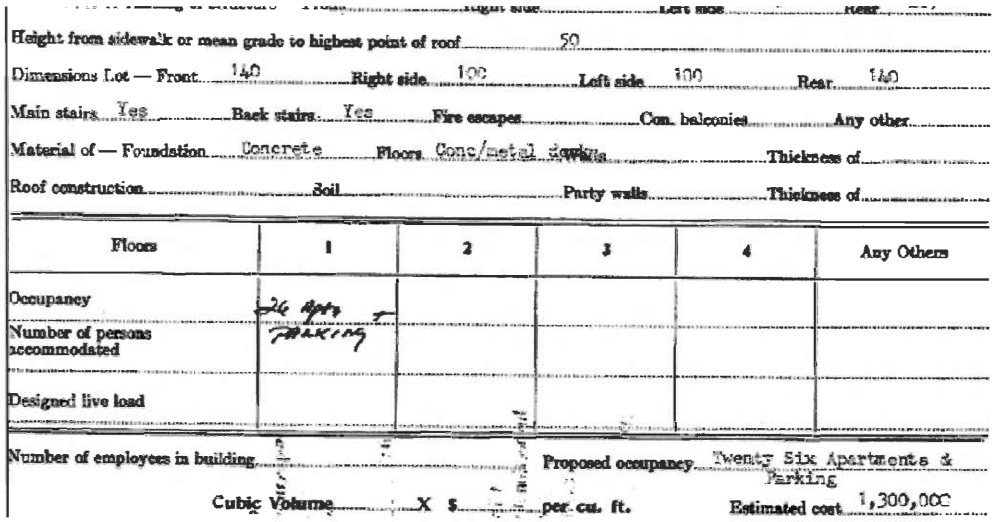
Our main goal for this project was to identify pertinent information to ensure the safety of occupants and to improve the current recycling levels of large buildings in the city of Boston. Our team surveyed and located large establishments and gathered fire and recycling related information. To reduce waste and improve safety in large buildings, our team assembled and analyzed collected information. We worked for the Boston Fire Department (BFD) and the Public Works Department (PWD) in the neighborhood of Brighton in the city of Boston, Massachusetts.

The BFD defined a large building as being seventy feet or higher, while the PWD defined a large building as being seven residential units or more. This difference in specifications slightly affected our identification procedures of large buildings. Initially, we studied the Assessor's database provided to us by the PWD. This database had fields such as address, land use, property type, exempt property code and number of floors. After viewing the Assessor's sortable database, we produced two different building lists. For the PWD, we eliminated buildings that did not qualify for the current recycling program; non-residential and buildings fewer than seven units (shown below). For the BFD, we eliminated buildings that were less than seventy feet.

	PID	ST_NUM	ST_NAME	ST_NAME_	ZIPCOD	NUM_FLOORS	PTYPE	ResU	OWNER
	2101594000	1110	COMMONWEALTH	AV	02134	7	904	82	BOSTON UNIVERSITY TRSTS
	2101029000	1289	COMMONWEALTH	AV	02134		013	8	COMMONWEALTH HOUSING INC
	2101028000	1287	COMMONWEALTH	AV	02134		013	8	COMMONWEALTH HOUSING INC
	2101821000	147	KELTON	ST	02134	4	995	68	KELTON PLACE CONDO TR
	2101849000	2	FIDELIS	WA	02135	6	908	60	BOSTON HOUSING AUTHORITY
▶	2101845000	34	FIDELIS	WY	02135	6	908	60	BOSTON HOUSING AUTHORITY

Figure 4: Public Works Department Database

The next technique in identifying these large buildings was through the Inspectional Services Department (ISD). The ISD records are in database format and searchable by building address. This information is available to the public via the Internet. These records hold building permits which will indicate the amount of units per building as well as the building's use and actual height (shown below).



Height from sidewalk or mean grade to highest point of roof 50

Dimensions Lot — Front 140 Right side 100 Left side 100 Rear 140

Main stairs Yes Back stairs Yes Fire escapes Con. balconies Any other

Material of — Foundation Concrete Floors Conc/metal deck Thickness of

Roof construction Soil Party walls Thickness of

Floors	1	2	3	4	Any Others
Occupancy	26 Apts + Parking				
Number of persons accommodated					
Designed live load					

Number of employees in building Proposed occupancy Twenty Six Apartments & Parking

Cubic Volume X $ per cu. ft. Estimated cost 1,300,000

Figure 5: ISD Building Permit

Our final approach to identifying the remaining large buildings was through field studies. We visited a handful of buildings and determined the amount of mailboxes or doorbells in front of each building to estimate the number of units.

Once we identified these buildings we gathered pertinent information relating to fire safety: hazardous material contents and response times. In order to locate hazardous materials we cross-referenced permits with our current building database. When focusing on large buildings for the fire department, safety was our main concern. Subsequently, to be safe in a building there needed to be a level of low risk. All the buildings we dealt with have low risk associated to them, however some higher than others. These tall buildings located in Brighton are shown in Figure 6 in blue. We wanted to be able to provide the fire department with a database of response times from hospitals and fire stations to each tall building.

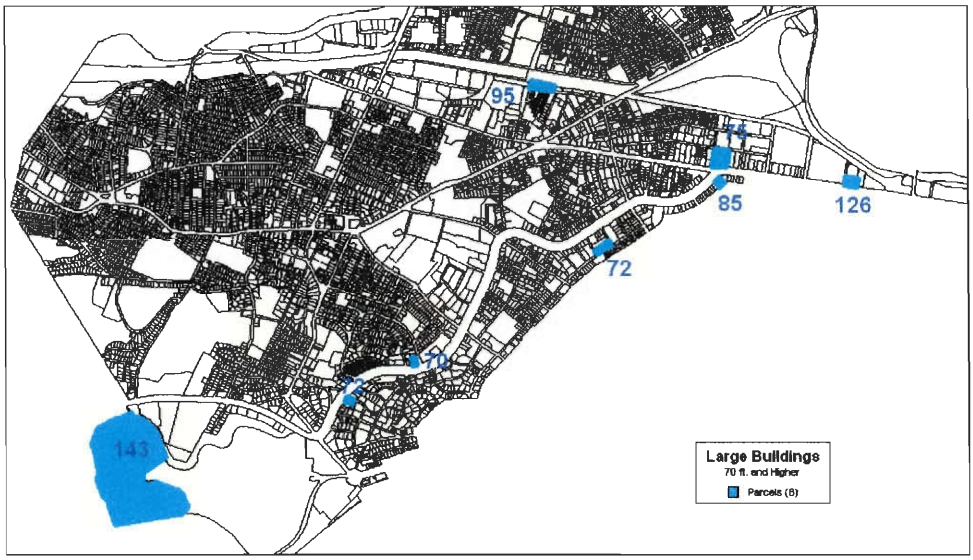


Figure 6: Tall Buildings of Brighton

Our team did not only look at building safety, but we also researched recycling participation. The two factors that we used to determine patterns were economic class and observed participation. These factors were used to draw conclusions to help the PWD target certain groups of buildings for recycling improvements.

Our presented results included all the building locations, size, economic value, usage, hazardous contents, and recycling status in the Brighton neighborhood. These results were divided and presented into the desired formats for the Public Works Department and the Boston Fire Department to better accommodate their needs.

2 Introduction

Large buildings are a common feature in the American urban landscape. Ever since the booming years of immigration into the country in the 1800's, large tenement buildings compensated for the lack of suitable land within easy reach of the commercial and manufacturing cores of cities. Before the arrival of modern transportation, when walking was the primary mode of commuting, cities were inhibited from expanding horizontally, hence the need for taller buildings. As time went on, building size became a symbol of power for commercial and a necessity for residential structures.

Being one of the richest historical areas in the country; Boston, established in 1630, has always been hub of commercial and cultural development. Due to its cosmopolitan environment, Boston is a desirable city to inhabit thus causing a high demand for housing. The urban solution for housing is large residential high-rise structures. Even though this is a solution, it poses many threats due to its high population density. One of these problems is the personal safety of occupants in large residential buildings, who are particularly at risk in emergency situations. Another problem that these buildings cause is the creation of vast amounts of wastes. Recycling is a solution which Boston has already realized and has implemented a thorough recycling plan entitled, *The City of Boston Residential Recycling Plan: Outline for Action.* However, the plan has not yet reached its full potential.

There have been many previous recycling and fire prevention/evacuation studies across the country to address current problems that are exemplified in the city of Boston. The Federal Emergency Management Agency (FEMA) has conducted city and apartment investigations such as *Profile of the Urban Fire Problem in the United States*[3]. Previous studies such as the FEMA Profile can be used as a foundation to further research. The Boston government has unveiled multiple recycling ventures in the past fifteen years. One of the major steps was in 1995, when weekly curbside collection of household recyclables to residents was initiated[4]. Although these past studies are an excellent base to achieve our project, there is still more research to be accomplished.

Not all large residential buildings are currently participating in the recycling ordinance. The current program is hindered because it is unaware of buildings that are not recycling. It has been a challenge to collect the necessary information due to the fact that these large structures are constantly going through new renovations

[3] FEMA, United States Administration, National Fire Data Center May 1999 http://www.usfa.fema.gov/
[4] City of Boston Residential Recycling Plan: Outline for Action. Mayor Thomas M. Menino Jan. 2001

and reconstruction. These new additions pose a threat to the safety of citizens of Boston. Like the Public Works Department, the Boston Fire Department requires updated information to better serve the public.

Our main goal for this project is to identify pertinent information to ensure the safety of occupants and to improve the current recycling levels of large buildings in the city of Boston. Our team will survey and locate large establishments and gather fire related information. To reduce waste in residential buildings, our team will assemble collected information that will help increase the rate of recycling in the city of Boston. We will be working for the Boston Fire Department and the Public Works Department in the neighborhood of Brighton in the city of Boston, Massachusetts.

3 Background

Boston began as a small colony on the Massachusetts Bay with a strong harbor, and has developed into the largest city in New England. With a population of six hundred thousand people, Boston is one of the nation's most important urban centers. Over the course of its development, Boston has experienced a huge economic growth, which in turn brought about a large increase in population. To accommodate this influx in people large residential housing structures were constructed in the 1800's. These housing structures are an excellent use of space in the city of Boston, but in turn pose a serious threat to the environment and the safety of the occupants.

Boston's early economy was based mainly on shipbuilding and fishing because of its great natural harbor. This great harbor, in the late seventeenth early eighteenth century, allowed Boston merchants to prosper in trading to both coastal areas and to the far West Indies. Boston's economy then progressed to a more manufacturing based economy with the start of the New England Industrial Revolution. Lastly, the growth of a "knowledge-based" economy, which came from Boston's excellent educational and medical research institutions, enabled the city to prosper as the twenty-first century began. Along with Boston's economic prosperity the city of Boston has also grown in size. Filling in marshlands and expanding the coast has given Boston the space it needed to thrive. Still faced with the shortage of land Boston annexed several surrounding areas. One of these areas what is known today as Allston-Brighton. These new areas did help spread the resident's of Boston out, although there was still the re-occurring problem of sufficient shelter. As most cities are faced with the same problem of housing and Boston is no exception. This demand for housing supported the increase in large residential buildings in the city of Boston.

Boston has long been a city focused on the safety of its residents. This safety concern is evident, dating from 1678 when the Boston Fire Department was founded. It was the first paid municipal fire department in the nation in addition, to this present day, Boston is known for its great health care and world-renowned medical facilities. Both are indications of the city of Boston's commitment to the protection and care of its citizens. In this post 9/11 world that we live in the need for greater personal safety and precautionary measures, is in greater demand. One of Boston's largest safety concerns is the personal safety of the occupants of its large residential buildings. The Boston Fire Department, along with several federal agencies, has adapted many codes and emergency procedures to ensure the safety of these building's occupants. This will guide Boston into the future as a city focused on its resident's safety.

Parallel to the concerns described above, Boston has always been a city that has held the environment in high regard. The importance of maintaining a clean and plush environment in the midst of a major urban setting

was evident in the early 17th century with the development of the Boston Common: Boston's first public park and gardens. Today, that environmentally focused city has not changed; Boston now has a parks system comprised of over 2,200 acres[5]. Along with this extensive parks system Boston has a made plans to keep the environment clean for generations to come by implementing a strict recycling plan. One of the major parts of this plan is the focus on the recycling rates of the large residential buildings in the city that came about due to the city's large economic expansion. This focus on the environment through parks and recycling has made Boston not only a major metropolitan area but an environmentally friendly and desirable city to live.

Boston is not only the largest city in New England but also the birthplace of American independence. It is a city of immigrants that has flourished due to its steady economy, yet still is highly concerned with the safety of its residents and the cleanliness of its environment. A city that has endured the test of time is now faced with the problems its large residential buildings produce. The safety of the occupants and the recycling in these buildings are in need of improvement. With this improvement it will allow Boston, the oldest city in the United States of America, continue to flourish as it has for years

3.1 Large Buildings

As urban areas began to expand in the 1800's the need for larger, more space efficient buildings grew. With the development of cheap production methods of steel and the invention of the passenger elevator, buildings could rise to over six stories in height. These new developments, along with further technological advances helped shape the city skyline that we see today.

[5] Kennedy, Lawrence W. The City of Boston. www.ea.grolier.com.

3.1.1 The First Large Buildings

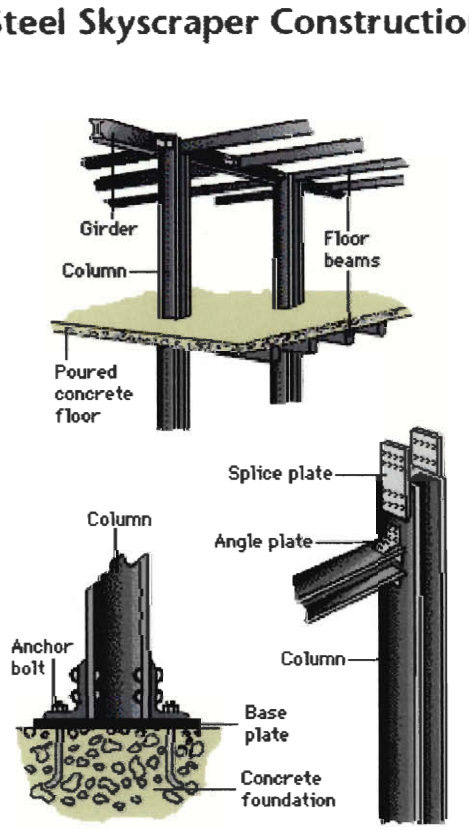


Figure 7: Steel Skyscaper Construction

The building that served as a model for the large building movement was the Home Insurance Company office building in Chicago, Illinois. In 1883, W.L.B. Jenney was commissioned to design a new office building that would be more impressive than any other. In creating this ten-story vision, Jenney needed to engineer an internal structure capable of supporting a building of such size. Jenney took the dead load off the walls and placed it on a skeleton framework of iron concealed inside the masonry-cast iron columns and Bessemer steel I-beams. This new design enabled Jenney to construct a building that would surpass the average six story height and still allow for plenty of window space, making it aesthetically pleasing. (Figure 7) The Home Insurance Company building was completed in 1885 and still stands today on the corner of La Salle and Adams Street in Chicago

"The skyscraper was a response to the growth of cities and business and the concentration of commercial activities housing many people on increasingly congested and expensive urban sites. It's most dramatic technological advance was the quickly erected metal frame and curtain wall. The nonsupporting exterior façade could be clad at any point; it was no longer restricted to rising slowly and weightily from the ground. This was a subject for both scientific and popular notice."

Ada Louise Huxtable[6]

[6] Author of The Tall Building Artistically Reconsidered: The search for a skyscraper style.

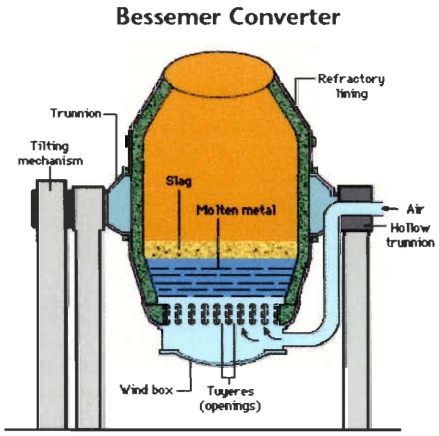


Figure 8: Bessemer Converter

In 1855, Henry Bessemer invented an efficient and rapid process of making steel from regular pig iron, using what is known as a Bessemer converter (Figure 8). The introduction of the Bessemer steel reshaped building styles and techniques. Now, buildings could be as tall as one desired and stronger than any other building. Steel is the perfect building material; it's three times as stiff as aluminum, ten times as stiff as concrete and fifteen times as stiff as wood[7]. With this new cost efficient material urban development was grasping the nation.

3.1.2 Boston's Large Buildings

Similar to all major American cities, Boston, began its building expansion in the late 1800's. The first of the tall buildings in Boston was the Ames Building (Figure 9). Designed by the Shepley, Rutan and Coolidge Architects, the Ames Building was completed in 1893. Its bearing wall construction is one of the last of its kind in Boston; soon all buildings would be made of steel. In the year of 1893 the first steel frame skyscraper in Boston was erected. It was designed by Clarence Blackall, and launched a new trend in tall building design in Boston. The new tall buildings of Boston were all mainly for commercial purposes. It wasn't until after World War II that Boston began creating large residential

Figure 9: Ames Building

[7] Handler, Benjamin A. Systems Approach to Architecture. http://ea-ada.grolier.com

Figure 10: 1472 Washington St. Development

buildings. With the war concluded and the "Baby Boomer" era beginning, the housing problem in Boston was greater than ever. For that reason, Boston built several large residential housing units, dubbed "the projects," to not only accommodate its population but also as a method of condensing the large amounts of people to better control them. This new trend launched a wave of "project" construction all over the city. These high-rise "projects" have now been replaced with a more community type structure design, as seen in the development on 1472 Washington St. in Boston (Figure 10).

As the trend for high-rise residential projects declined in the late 1900's, the development of skyscrapers in Boston was on the rise. Today, Boston's skyline is characterized by seven hundred plus foot tall buildings. For a list of Boston's tallest buildings see *Appendix I:* Boston's Large Buildings. These tall buildings occupy most of downtown Boston, and are also scattered among the city where there is a center of commercial activity. These tall commercial skyscrapers are not only characteristic to Boston but define all major cities around the world.

3.2 Building Safety

All buildings constructed in the present day must meet fire regulations created by federal, state, and city agencies. The most basic of these regulations is the requirement of a smoke detector on each floor of personal residence. Buildings are inspected for such systems upon erection. This kind of regulation would not suit a larger residential or commercial building that contained multiple stories with separate housing units per story; having only one smoke detector per floor would allow a fire to potentially grow strong before the smoke detector was activated. Unique regulations need to be created to account for the different safety situations that can arise.

Large buildings need special safety consideration due to their high concentration of residents confined to a single area. These buildings contain systems designed to provide means of egress and fire life safety. Some examples of these systems include automatic sprinklers, emergency elevator control, emergency communications, and stairway regulations. Newer buildings such as the World Trade Center in New York City are also compartmentalized, indicating that during a fire situation sections are kept separate from one another to preserve the building's integrity for a longer period of time. Regulations must be constantly created and updated to maintain a contiguous level of safety across the nation.

The United States empowers multiple agencies to handle safety and emergency situations. These agencies include The National Fire Protection Agency (NFPA), United States Fire Administration (USFA), and The Federal Emergency Management Agency (FEMA). The NFPA creates codes and regulations while all three agencies provide analysis and case studies on the current safety performances around the nation.

3.2.1 Building Codes and Regulations

Large buildings in the United States of America are required to meet certain criteria that allows for safe occupancy. If these codes aren't met, building administrators are reprimanded to correct flaws immediately or result to condemnation. The NFPA has specific codes for existing apartment complexes (*Appendix F:* NFPA Codes: Chapter 31 Existing Apartment Building Codes), commercial buildings (*Appendix G:* NFPA Codes: Chapter 39 Existing Commercial Building Codes), and Occupancy/Hazardous Material Classification (*Appendix H:* NFPA Codes: Chapter 6 Occupancy and Hazardous Contents).

Large residential buildings have a list of regulations to ensure occupant safety. The notable ones follow. Every housing unit needs two exits remotely located from each other. Buildings without sprinkler systems or with sprinkler systems only in select areas need an exit to a corridor within seventy five feet. Buildings with complete sprinkler or fire modification systems need an exit to a corridor within 125 feet. Buildings containing the following items must be compartmentalized to be fire safe for one hour or be within the range of a sprinkler: boiler or fuel-fired heater, rooms used for storage of hazardous or combustible materials, and trash collection rooms. Any building containing hazardous materials must classify the substances and report them to their local fire department. Lastly, large residential building residents must be annually notified of the alarm system, egress paths, and what to do in a fire or alarm situation[8].

Large commercial buildings have similar codes to ensure safety. There must be at least two separate exits on each floor of the building. These exits must be accessible from every portion of the floor. Exit passage-ways serving an occupant load of more than 50 must have a width of at least forty four inches. Dead end corridors must not exceed fifty feet. The maximum travel distance to an exit must not exceed two hundred feet. Lastly, emergency lighting must be provided in buildings greater than two stories, or containing one hundred or more occupants above or below the exit story, or having a total occupancy of one thousand or more[9].

[8] NFPA Codes, Chapter 31: Existing Apartment Buildings. United States Government; 2000
[9] NFPA Codes, Chapter 39: Existing Business Occupancies. United States Government; 2000

3.2.2 Governing Safety Departments

The city of Boston is constantly expanding, meaning that safety is a growing concern as the population increases. Government departments such as the National Fire Protection Association (NFPA) are constantly creating and improving safety for the public. The Federal Emergency Management Agency's (FEMA) goal is to save lives in emergency situations such as that of September the 11th, 2001. Both of these departments play a crucial role in protecting the lives of the citizens of this nation.

Figure 11: FEMA Seal

The National Fire Protection Association (NFPA) mission is "to reduce the worldwide burden of fire and other hazards to improve the quality of life by providing and advocating scientifically-based consensus codes and standards, research, training and education".[10] This association located in Quincy, MA, has set over three hundred standards used in the United States and around the world. National fire safety is a great concern as there were 381,000 residential fires in 1998, 98,000 of which are apartment and other, where 445,000 civilians died due to fires in apartments.[11]

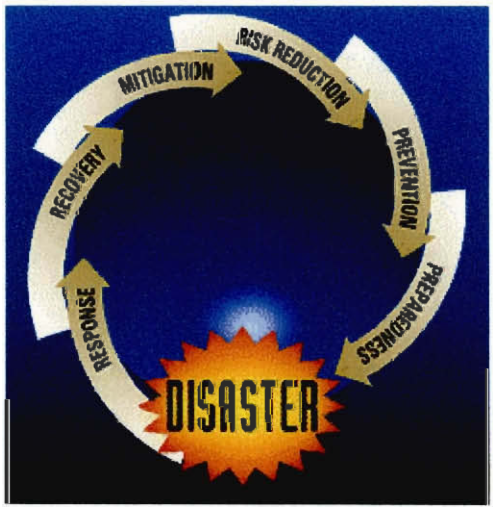


Figure 12: FEMA Disaster Life Cycle

The Federal Emergency Management Agency (Figure 11) is an independent federal agency whose main headquarters are located in Washington, DC with regional offices across the country. FEMA employs 2,600 people and has over 4,000 emergency personnel on standby. FEMA works with state and local emergency agencies, as well as twenty seven federal agencies and the American Red Cross. FEMA exercises the disaster life cycle, this cycle encompasses the goals of the agency and is shown in Figure 12[12].

[10] NFPA Online www.nfpa.org/ Jan. 25 2003
[11] US Census 2002 No. 378, No. 379 23 Jan. 2003 http://landview.census.gov/prod/2001pubs/statab/sec05.pdf
[12] FEMA Website. Who We Are, What We Do. http://www.fema.gov/about/who.shtm

3.2.3 Residential Building Safety in Boston

Large residential buildings have always established a safety concern. There have been countless fire situations regarding residential buildings in the past. On the cold evening of Friday January 28th, 1966 the wind was gusting up to 40 miles an hour on Boylston St. in Boston, MA. At 6:38 pm there was a natural gas explosion at the Paramount Hotel, an 11 story first class hotel (Figure 13). One of the residents/hotel-handyman Herb McBride identified the gas leaking into the building but could not make it to the main desk before the explosion. The leak was later found to be from a crack in an eight-inch gas pipe located near an electrical conduit that allowed gas to seep into the basement of the Paramount Hotel. A total of fifty seven people were injured and eleven people died due to this accident. As a direct result, Judge Adlow suggested that fire departments be aware of gas control veins; not to be dependent of the gas companies for assistance.

Figure 13: Paramount Hotel Fire

Since these types of fires, sprinkler and fire detection systems have become standards in these buildings. The Boston Ordinance of 1979 stated that all new buildings needed sprinkler systems; older buildings were encouraged to incorporate them into the buildings. Fire departments have improved safety through their own experience and the education of the public, such as the ordinance. The Boston Fire Department (BFD) serves 574,283 people in a 47.3 square mile area. The department became the first paid municipal fire department organized in 1678 and currently provides fire, rescue, and first response emergency medical services to the citizens of Boston, MA[13]. Large residential buildings are a noted safety concern and the country is continually updating its ability to manage emergency situations.

3.2.4 Hazardous Materials

Hazardous materials are chemical substances, which if released or misused can pose a serious threat to the environment and to people's health. These chemicals are mainly found and used in industry, agriculture, medicine, research, and consumer goods. The principle dangers of hazardous materials are toxicity, flammability, and reactivity with other substances. These materials can be found in the form of explosives,

[13] Boston Fire Department http://www.ci.boston.ma.us/bfd/ Feb. 1 2003

flammable and combustible substances, poisons, and radioactive materials. Hazardous materials pose a threat, especially when highly concentrated or dealt with improperly.

When hazardous materials are misused or involved in accidents the emergency scenes can be controlled only when the personnel involved have sufficient information to make informed decisions to deal with these materials. The first personnel to respond to a hazardous material emergency scene needs to know the effects and symptoms of an exposure to the hazardous material. The failure of the first responder to recognize the presence and potential harm of hazardous materials at accidents, fires, spills and other emergencies has caused numerous casualties. To help prevent these casualties many precautionary measures have been taken. Federal, state and local codes have been implemented to classify hazardous materials and to help notify emergency personnel of these dangers. In the end, the more information the emergency personnel have when entering a hazardous material emergency scene the better they will be able to contain it.

3.3 Recycling

As our country disposes large amounts of reusable trash, there are two valuable materials that are abused. Landfills are overflowing their maximum capacity and raw materials are being destroyed at an increased rate. A solution to minimize these problems is recycling. Despite the potential environmental and economic benefits recycling could provide, many people choose not to participate in recycling. The city of Boston has recognized recycling as a solution and it has continued to improve recycling, encouraging more citizens to participate.

Our world was not always so disposable. In the days of our very early ancestors, the concept of waste was unheard of. Native Americans found a use for nearly everything. For example, a hunted buffalo was not only used for a meal. Not only did they eat the meat, but the fur, skin and bones became of use as well. The few body parts that served no use remained for decomposition (almost like an ancient form of recycling). This left little to no waste. Conversely, in 1999, the United States alone produced 230 million tons of trash. That translates to 4.6 pounds of trash per person per day. The amount of trash we produce is not

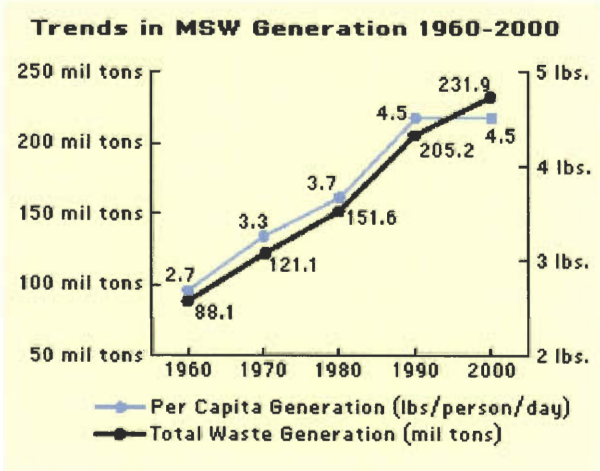


Figure 14: Municipal Solid Waste Trends[14]

[14] http://www.epa.gov/epaoswer/non-hw/muncpl/longdesc/facts-text.htm

decreasing either as demonstrated in Figure 14. With the rate in which we are using raw materials and disposing of them, depletion of our natural resources threatens our existence in the near future. Twenty percent of the world's population is currently using more than eighty percent of the planet's natural resources. One resource that is particularly affected by a lack of recycling is trees; especially those in the rainforest. Rainforests are being cut down at a rate of 214,000 acres a day, an area larger than New York City. Some people question whether the trees will grow back. The trees may grow back but the animal life loses its habitat and this may result in extinction. This is just one example of natural resource depletion. Another threat to our environment is the disposal of trash. In the United States, landfills are being created and expanded upon at a constant rate. Not only does this consume undeveloped land, it is an unpleasant landscape. No one wants a landfill in their backyard.

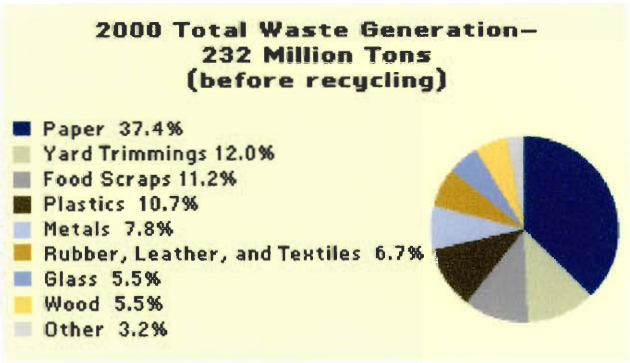


Figure 15: Waste Generation Pie Chart[15]

A solution to all of these problems is recycling. In Figure 15, you notice that we could eliminate 60% of trash by the simple process of recycling paper and putting yard trimmings and food scraps in a compost pile. Even recycling plastics and metals involve a simple process. After recycling is picked up, it is brought to a plant where it is separated by automated machines. Once all the recyclable materials are separated, they are compacted into squares and shipped off to processors that use the recycled material in their products. Many of the recycling processes include economic advantages. Processors want recycled materials because manufacturing with recycled materials uses less energy and cost than manufacturing with raw materials. Also recycling offers an increase in jobs, which benefits the economy. Someone has to collect the recycling and deliver it to the plant. Once the recycling is at the plant machines do some of the work but many employees are needed to run the machines and do some hand sorting.

If recycling has so many benefits, why do people not recycle? Some people are uneducated on the topic of recycling and do not know its advantages while others are aware of its advantages but find it an inconvenience.

[15] http://www.epa.gov/epaoswer/non-hw/muncpl/longdesc/facts-text.htm

3.3.1 Recycling in Boston

The city of Boston has recognized recycling as a solution to the problem of overflowing landfills and the destruction of natural habitats. The fact has been acknowledged that some of the people of Boston are uninformed when it comes to recycling, however those who are aware about recycling, will not participate unless it is convenient (as shown in Figure 16). Boston has developed many recycling plans of action for informing the public about recycling. Boston's major recycling program began in 1987. It started when Boston residents organized drop-off places within each neighborhood for household wastes. The following year the city agreed to manage the drop-off sites. The city's recycling services expanded from then on. In 1994, a well-organized curbside-recycling program for small buildings recycled at least one to two more thousand tons each year. Then in 1995, a seasonal leaf and yard waste curbside collection program was started. Just as curbside recycling did; the amount collected has also increased but at a slower rate until the year 2000 when the amount collected was double than that of the previous year. Since 1995, Boston has continued to expand their recycling program. Below is a timeline of Boston's accomplishments (Table 1).

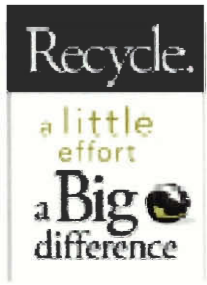


Figure 16: Boston's Recycling Motto

Year	Event
1996	Boston added nine new items to the curbside collection program, and opened three permanent surplus paint and used motor oil recycling centers.
1997	Boston launched the Recycling Participation Campaign in East Boston, which successfully increased recycling awareness among residents in low-participation neighborhood. The Recycling Program opened a fourth surplus paint and used motor oil recycling center.
1998	Boston installed a playground made from recycled materials at the Harborside Community Center in East Boston as a reward for the neighborhood's recycling participation in the "Community Challenge" campaign. Boston expanded its Household Hazardous Waste Collection from once per year to twice per year. STRIVE, the Boston School Department' School-To-Career program, offers recycling collection to all Boston public schools
1999	The City began cathode ray tube recycling, which are contained in televisions and computer monitors.
2000	The City began to provide recycling services to the Boston Housing Authority's developments. The City purchased $627,000 worth of recycled and environmentally preferable products such as recycled copier paper, blue bins, compost bins, toilet paper, and paper towels. The City expanded its seasonal yard waste collection program by two weeks.

Table 1: Recycling Accomplishments

The most recent improvements in recycling are a part of Mayor Thomas M. Menino's *Residential Recycling Plan: Outline for Action*, which was put into effect in January of 2001. The Plan addresses five key actions; *Lead by example, Outreach to Children, Leaf and Yard Waste Collection, Increase in Large Apartment Recycling, and Household Hazardous Waste Program.* Our focus for this project is on large apartment building recycling.

3.3.2 Large Building Recycling

The city offers free recycling services to residents in large buildings: 7 or more units. All he building owners have to do is contact the Public Works Department and express an interest. Once the building owner has contacted the Public Works Department, a recycling coordinator will visit the building to explain the best recycling program and suggest operation options. Even though the recycling is free, the building manager is required to purchase recycling receptacles, which cost no more than seventy-five dollars a piece. The size of the building will determine the number of pairs of receptacles needed a pair being two carts: one for paper and one for containers. After the carts have been delivered to the building, written notifications are sent out to the tenants about their new recycling program.

Figure 17: Boston Recycling

Large buildings are great to target because 32% of the housing in Boston has six living units or more otherwise known as large apartment buildings. How does Boston plan to get all their large buildings to recycle? Its customized recycling programs are convenient and also will reward owners and managers with federal and or state subsidies. Over the past three years, more than five hundred buildings have been visited, resulting in a 50% participation increase in Boston's large apartment buildings recycling rates.

3.4 Brighton, Massachusetts

Our study area Brighton was not always referred to by that name. Before 1807, Brighton was referred to as Little Cambridge which started out as a small farming community with less than three hundred residents. Cattle trade was a large part of Little Cambridge and was the cause of the neighborhood breaking off to form Brighton. When Cambridge's town government did not opt to repair the Great Bridge that linked Little Cambridge to Harvard Square their cattle industry was threatened and hence they seceded from their parent town. As the town grew independent of Cambridge it opened its own school in 1832.

Figure 18: Brighton Emblem

The town continued to prosper on cattle trade until the 1860's when land owners in Brighton saw great opportunities for profit making in residential development. This development was spurred by the introduction of electric powered streetcars in 1889. Their population grew immensely in the next fifty years from six thousand to 47,000 residents. At the turn of the century, Brighton was made up of many prestigious neighborhoods (Figure 19).

Figure 19: Brighton Neighborhood

The population continued to increase, as did frustrations, especially after World War II. There was an increase in the number of motor vehicles and private institutions, intruding on the neighborhood. This, in turn, caused many permanent residents to flock to the outer suburbs. These problems are still an issue today, relatively the population has leveled off at seventy thousand residents and there are community groups actively watching over the neighborhood to maintain its flourishing atmosphere. The Brighton Area is shown in Figure 20.

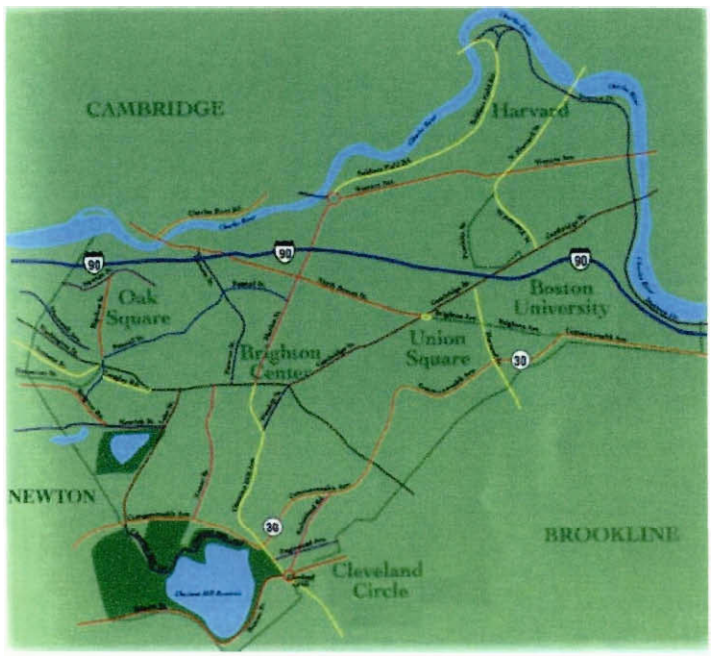


Figure 20: Map of Brighton

4 Methodology

Our main goal for this project was to identify building information, which ensured the safety of occupants and improved the current recycling levels of large buildings in the city of Boston. Our team surveyed and located large establishments in the neighborhood of Brighton, Massachusetts. For all these establishments, we gathered building unit numbers, usage, and hazardous material contents information.

The primary objectives to fulfill this project were as follows:

1. Identification of Buildings
2. Determination of Large Building Classification

The remainder of this chapter will adhere to the following methods:

- **Section 4.1** explains specific definitions and parameters that are needed to further aid the comprehension of this project.
- **Section 4.2** designates the following study area which was researched through data interpretation and field studies while representing a city as a whole.
- **Section 4.3** identifies the methods in locating large buildings that follow the criteria that were set by our sponsors: Boston Fire Department and the Public Works Department.
- **Section 4.4** determines large building usage signifying whether they are residential or commercial.

4.1 Domain of Inquiry and Definitions

We ensured safety in buildings by first identifying those which stand seventy feet or higher; as defined by the Boston Fire Department. We then determined whether each building was categorized as a residential or commercial building. Within each building, we evaluated possible hazardous materials that may be within these buildings.

We identified buildings which hold seven residential units or more; as defined by the Public Works Department. We then determined which residential buildings were involved in the recycling program. To improve the recycling rates in our target area, we identified the buildings that were not recycling and were not of the required unit size and reported them to the Public Works Department via database.

4.2 Study Area

This project was conducted in the neighborhood of Brighton in the city of Boston, Massachusetts. These areas were evaluated and multiple maps were produced to further the understanding of factors in each large building. A map was created to scale of large buildings, residential and commercial, specifying whether they have hazardous materials contained within. A second map was drawn to scale of large residential buildings

that are not currently participating in the city of Boston recycling program. To extend this map, we identified any trends that these buildings might have. We conducted this project research on a weekly basis; Monday through Friday during normal business hours.

4.3 Identification of Buildings

Boston has developed to become one of the most affluent cities east of the Mississippi River. The city Boston is known for having the largest number of colleges and universities, which play a huge role in populating the city throughout the year. The neighborhood we are focusing on, Brighton (Figure 21 shown below) is adjacent to three large higher level education institutions. The first university is one of the largest independent universities in North America: Boston University. The second college is home to one of the oldest and most prominent Jesuit and Catholic Universities in the United States: Boston College. Lastly, the third college is the oldest college in North America: Harvard University. Due to the large amounts of students each year that attend Boston University, Boston College and Harvard University, larger buildings are in a higher demand to accommodate these students.

Figure 21: Brighton GIS Layer

4.3.1 Identification of Buildings 7 Units and More

Boston University, Boston College and Harvard University combined produces over 100,150 undergraduate, graduate students and employees each year which implies an abundance of large residential buildings. In accordance with the Public Works Department (PWD) and the recycling ordinance that the city of Boston implemented, a large residential building consists of seven units or more[16].

[16] Public Works Department, Recycling Ordinance of Boston: Boston City Hall, 2001

4.3.1.1 Public Works Department Brighton Information

To locate large residential buildings, we started with the Assessor's Access Database of 14,625 buildings and areas in Brighton, which was provided by the Public Works Department (PWD). A portion of this database is shown below in Figure 22.

PID	ST_NUI	ST_NAME	ST_N	ZIPCOD	PTYPE	LU	ResUnits
2100552000	1	ASHFORD	CT	02134	112	A	24
2100553000	65	ASHFORD	ST	02134	105	R3	3
2100554000	67	ASHFORD	ST	02134	111	R4	5
2100555000	0	ASHFORD	ST	02134	390	CL	
2100556000	0	MALVERN	ST	02134	337	CL	
2100557000	20	MALVERN	ST	02134	332	C	
2100558000	1	BRIGHTON	AV	02134	332	C	
2100559000	0	BRIGHTON	AV	02134	337	CL	
2100560000	19	BRIGHTON	AV	02134	112	A	15
2100561000	23	BRIGHTON	AV	02134	112	A	16
2100562000	0	BRIGHTON	AV	02134	337	CL	
2100563000	37	BRIGHTON	AV	02134	031	RC	
2100564000	0	BRIGHTON	AV	02134	337	CL	
2100565000	55	BRIGHTON	AV	02134	320	C	
2100566000	57	BRIGHTON	AV	02134	995	CM	35

Figure 22: Public Works Department Database Snapshot

The data clearly has some holes within it. The street number column has zeros for some of the addresses, and the residential unit field is incomplete throughout the entire document. This large building list was reduced in size by eliminating buildings with land use (R1, R2, R3, R4, CC, CP, C, CL, I) and exempt property codes (31, 32, 33, 34, 35, F, J) which are further explained in Appendix K: Property Classification System. The exempt property codes are not included the database shown above; this field is in the complete Assessor's Database available online[17]. From Figure 22, both 65 and 67 Ashford St. were eliminated because of their land use code of R3 and R4, they do not contain at least seven residential units. Next, we removed more non-residential properties by a three digit property type (PTYPE). This code is also explained in Appendix K: Property Classification System. For example, the property type 320 for address 55 Brighton Ave. in Figure 22 would be eliminated from the list, even though it already would have been due to its land use entry of 'C' (commercial). Property type 320 is a retail, warehouse or service building, not residential. Geographic Information System (GIS) layers were also provided by the PWD and were used to further eliminate buildings that were located on open space areas resembling parks or fields. The exempt code from the complete Assessor's Data also eliminated parks and fields, this avenue of elimination should be pursued before resorting to the GIS Layers of open space areas. Lastly, a list of current buildings signed up for recycling in the Brighton Neighborhood was provided by the PWD. We matched this list with our existing

[17] Boston Redevelopment Authority: The Boston Atlas. http://www.cityofboston.gov/bra/maps.asp

large building list to identify even more residential number of units per building. Once we had exhausted the data that the PWD has supplied, we were left with two final options to identify residential number of units: the Inspectional Services Department and field work.

4.3.1.2 Inspectional Services Department

The Inspectional Services Department (ISD) is a governmental agency that holds various permits for the City of Boston. These permits range from zoning permits to building additions permits that have been kept in their records since the 1800s. More importantly, we were more interested in building occupancy permits which told us the amount of units per building, building height and building usage. Initially, we called the ISD to inquire whether we needed any special authorization to pull these building records. We found that building permits were open to the public and any civilian is allowed to pull these records. We went into the ISD office to pull the building permits of the buildings that we needed to identify. We found that all the building permits that the ISD has in their records are scanned into a database which can be reached via the web[18]. We found this method to be simpler and less tedious then pulling all the records manually. Along with this database, they also had a binder which contained all the addresses available online for the City of Boston. This was used to help identify abbreviations that we might have been inputted into the database incorrectly.

4.3.1.2.1 Queries of the Database

We encountered difficulties regarding the database that is provided by the Inspectional Services Department (ISD). One problem we faced was that some of the buildings had multiple addresses allocated to them. We solved most of these problems by using the binder as our main source to see if any addresses were hyphenated which would indicate the multiple addresses for one building. Next, we were able to identify more building uses and number of residential units. Another difficulty that we had concerned missing addresses in the database. Some of the addresses existed in the binder; however they did not exist in the database. To overcome this problem, we called the ISD to set up an appointment to see these building permits in paper form. Lastly, we found that the ISD database was running off a very unstable server which resulted in frequent crashing. It might have taken us less time to identify these buildings, but we would have been more productive if the server was more stable. This applies to the online database as well as the database machines located at the ISD Office.

4.3.1.3 Field Work

Our final approach to identifying large residential buildings was through field work. The field work procedure contained two processes which involved visiting the buildings themselves. The first step we took

[18] Inspectional Services Department Online Document Room, http://www.cityofboston.gov/ISD/docroom

was by visiting the buildings that we had missing information for and recorded their buzzers or mailbox. From their amount of buzzers and mailboxes, we can get the exact amount of units per apartment building. And if they aren't residential buildings, we can determine the building usage through observation enabling us to complete our project study.

4.3.2 Large Buildings Standing at 70 Feet or More

The neighborhood of Brighton has an adequate amount of large buildings that are used for housing or for commercial use (Figure 23). According to the Boston Fire Department, a large building is identified as a building that stands at seventy feet or higher.

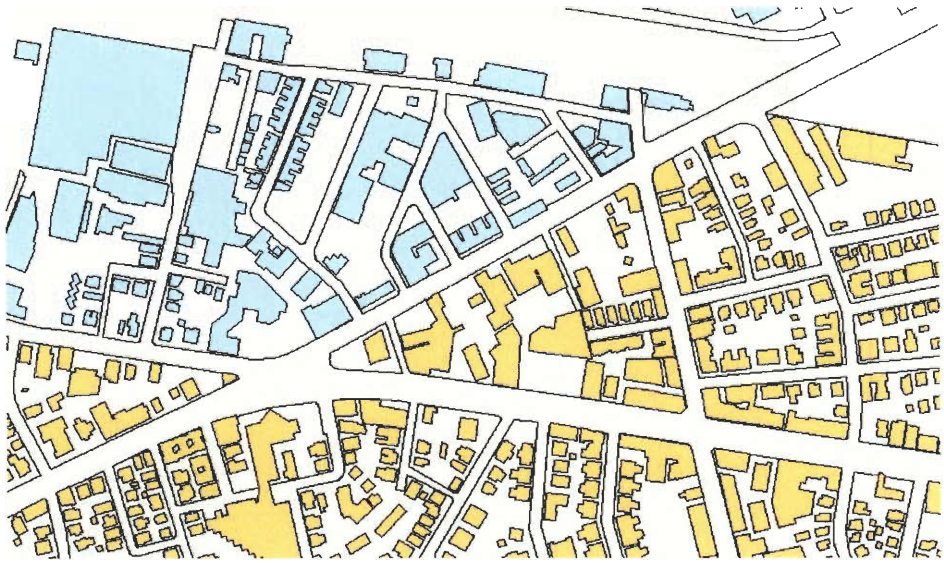


Figure 23: Brighton Buildings

4.3.2.1 Assessor's Office

We accumulated most of this knowledge from the Assessor's Office, which we contacted through our sponsors. From the Assessor's data, we configured the heights of buildings through the amount of floors. This data was gathered through a database system that displayed the exact size of the building. In some instances the database only offered the amount of floors for each building, we then approximated through engineered guesses and found the approximate height of the building. We approximated though engineering guesses that a normal building floor ranged between 10 and 12 feet. This would result in buildings with 6 or more floors would classify as a large building in accordance to the Boston Fire Department.

4.3.2.2 City Permits Records

The second tactic of identifying large buildings was through examining the City Permit Records for each building. These records held all building permits stating whether the buildings were new, old or reconstructed. This information was located through government agencies like our sponsors: the Public

Works Department and the Boston Fire Department. Through our sponsors, we contacted the Inspectional Services Department and accumulated blueprints for each building.

4.4 Determination of Large Building Classification

The safety of Boston's citizens has always been of the first and foremost importance of the Boston Fire Department. When determining safety in larger buildings, there are more risks that are more evident than those within smaller buildings. In accordance with the Boston Fire Department, a large building was defined as one that stands at seventy feet or higher. At this point we had already located all the large buildings in the neighborhood of Brighton.

4.4.1 Building Usage

In the area of Brighton, the majority of buildings are either residential or commercial; our job is to differentiate between the two. The first tactic implemented to determine whether it was a residential or a commercial building was through the Assessor's Office. Through the assessor's database system, we discovered the use of the building. Some buildings were not identified in the assessor's database requiring us to check with the Boston Inspectional Services. Here we went through the targeted buildings Long Form Permits and within this permit it is clearly stated what the purpose of the building is. We accumulated this information from our sponsors in a database format.

Another tactic was through conducting field studies, which was our final resort. Through field work, we determined the type of building and what the building was used for simply through walking the streets and taking observational notes. If it was a commercial building, it had an area for customers or an office. If it was a residential building, it had mailboxes and doorbells at the entrances of these buildings.

4.4.2 Hazardous Material Permitting

Whether hazardous materials are contained within a residential or commercial building, everyone is still at risk. If there are any hazardous materials, the Boston Fire Department will be informed. This will result in the building obtaining a special permit. The permits vary in classification with respect to how dangerous the materials are and their amounts. These classifications are set up by the National Fire Protection Association and other government agencies. Our focus was on buildings that required Title III permits. We determined whether the building can be categorized as a Title III by checking the files in the Boston Fire Department. After speaking with several officers of the Boston Fire Department we discovered the right contact. The records of the hazardous materials permits are public knowledge but due to the terrorism threats of living in a post-9/11 world they are only available upon request. We contacted Robert Calobrisi the Department Chief of the Boston Emergency Management Agency of the Boston Fire Department. We notified him of our

project and requested the Title III permits for our targeted buildings over seventy feet tall. From these, we discovered if there are any hazardous materials or if it states the building as a Title III building. This information was acquired through our sponsors.

5 Results

Upon the conclusion of our methodology, the results section has been generated. In this section, we produced two different building lists, a tall building list for the Boston Fire Department and a recycling list for the Public Works Department. The following lists are provided in Microsoft Access database format. The results in this section come directly from the evaluation of the methodology.

5.1 Boston Fire Department: Safety

The Boston Fire Department has multiple responsibilities in regards with securing the safety of the residents of Boston. Amongst these responsibilities is the protection of residents and workers in large buildings, which as defined stand taller than seventy feet. We have narrowed down a study area which sufficiently represents the entire city of Boston: the neighborhood of Brighton. Brighton has its fair share of large buildings due to its rapid growth in population, which resulted in the construction of both large residential and commercial buildings.

We researched the neighborhood of Brighton to identify these large residential and commercial buildings. Our team identified a total of eight buildings that stand greater then seventy feet in height. Out of these buildings, two were residential, four were commercial and two were residential/commercial buildings. Shown below is Table 2, which contains the eight buildings including the residential units per building.
To better visualize these eight tall buildings and to better understand their pattern throughout the city, we

NUM	STREET NAME	SUF	Building Usage	Height	ResUnits
881	COMMONWEALTH	AV	Offices, Clinic, Storage, Cafeteria	126	0
1687	COMMONWEALTH	AV	Residential	70	34
1800	COMMONWEALTH	AV	Residential	72	36
59	BRAINERD	RD	Warehouse, selling, auto repair / Garage for 9 Buses	72	0
1079	COMMONWEALTH	AV	182 Apt, Commercial Office and Storage	75	182
1110	COMMONWEALTH	AV	Research Lab, Garages, 82 Apartments and Lounges	85	82
129	BRAINTREE	ST	Offices, Art Studio, Storage	95	0
2601	BEACON	ST	Recreational Facility	143	0

Table 2: Tall Building List: Height and Usage

have produced a thematic map of the neighborhood of Brighton. These tall buildings are categorized by height as shown below in Figure 24. There are two extreme outliers in this map which stand at 126 feet and

143 feet respectively. As seen, most of the taller buildings are concentrated along Commonwealth Avenue which is the dominant road along the southeastern part of the neighborhood.

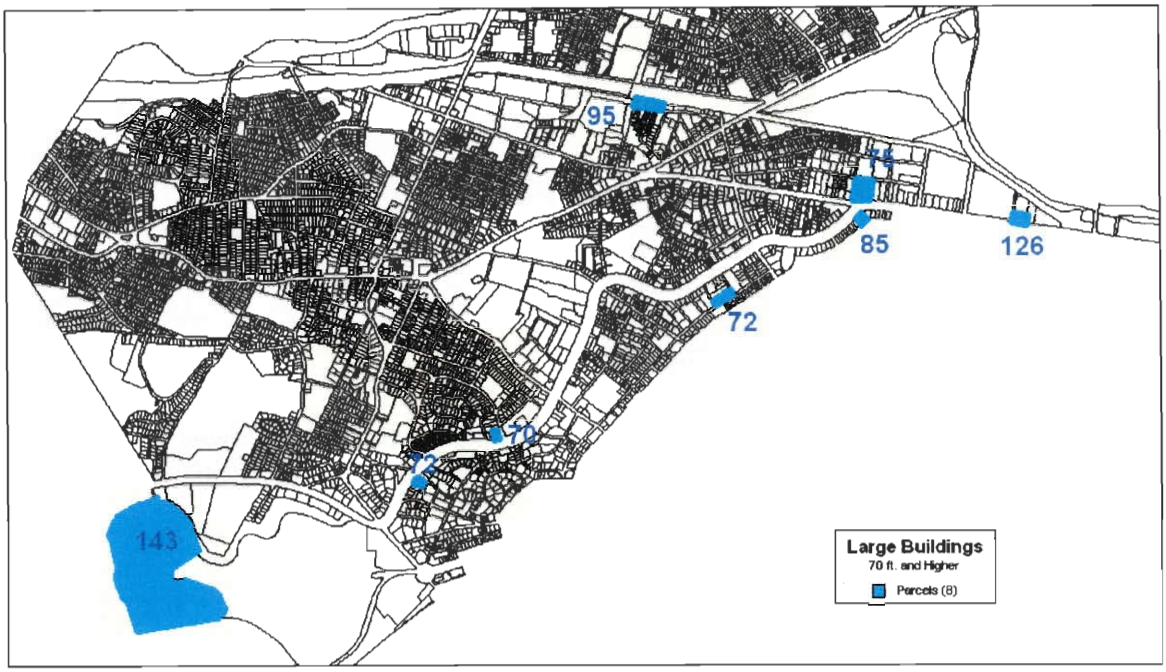


Figure 24: Brighton Tall Buildings by Height

5.1.1 Hazardous Materials

The knowledge of a building containing hazardous materials is extremely helpful during an emergency situation. When these buildings are at risk, there are specific procedures in dealing with the hazardous material. From the tall buildings that we found in Brighton, we extended our research to identify any hazardous materials contained in these buildings. For this reason, we contacted Philip Wornum and Robert Calobrisi of the Fire Department, who held all hazardous material permits. We found that there was one building in the entire neighborhood of Brighton that contained hazardous materials. This building is a recreational facility, Boston College's Silvio O. Conte Forum, which houses a hockey rink and a basketball court containing ammonia. This building is located at 2601 Beacon Street.

5.1.2 Emergency Response

The total distance an emergency response unit would travel from their station to the distressed building is the definition of an emergency response. In this project, we have identified all these emergency stations for the

NUMBER	STREET NAME	SUF	HOSPITAL
736	CAMBRIDGE	ST	St. Elizabeth's Medical Center
296	ALLSTON	ST	St. John of God Hospital
1515	COMMONWEALTH	AV	Vencor Hospital of Boston

Table 3: Hospitals in the Neighborhood of Brighton

neighborhood of Brighton. These stations consist of three hospitals and three fire stations. As presented in the following Table 3, we found three hospitals in the neighborhood of Brighton along with their names. We

also found three fire stations in this neighborhood each with different special fire trucks. Shown in Table 4 is the list of fire stations that we found including their fire trucks. Furthermore, each acronym is explained to understand each of the special fire trucks: E is an engine truck, L is a ladder truck, and Car is the District Chief. During an emergency situation, we gathered the response distances from the closest fire station and hospital to the distressed large building. These response distances were found through an Internet site which allocates the distances to and from each suggested addresses[19]. Shown below in Table 5 are the large

NUMBER	STREET NAME	SUF	FIRE STATION TRUCKS
138	CHESTNUT HILL	AV	E29, L11, Car11
460	CAMBRIDGE	ST	E41, L14
425	FANEUIL	ST	E51

Table 4: Fire Stations in the Neighborhood of Brighton

buildings and their distances and response times from each fire station and hospital.

NUMBER	STREET NAME	SUF	Fire Distance (miles)	Hospital Distance (miles)
881	COMMONWEALTH	AV	1.17	1.52
1687	COMMONWEALTH	AV	0.6	0.53
1800	COMMONWEALTH	AV	0.43	0.64
59	BRAINERD	RD	0.76	1.04
1079	COMMONWEALTH	AV	2.04	1.08
1110	COMMONWEALTH	AV	0.81	0.98
129	BRAINTREE	ST	0.2	0.83
2601	BEACON	ST	0.6	1.04

Table 5: Tall Building Response Distances

5.2 Public Works Department: Recycling

The Public Works Department for the city of Boston is undergoing a recycling ordinance to decrease the amount of waste produced daily. This recycling ordinance was enacted by the current mayor, Mayor Thomas Menino[20]. The city of Boston has a target recycling participation rate of 75% which justifies the importance of large residential buildings participation. As defined by the Public Works Department, large residential buildings are those that contain seven or more residential units. Since a large residential building has more

[19]Mapquest Service. http://www.mapquest.com

[20] City of Boston Residential Recycling Plan: Outline for Action. Mayor Thomas M. Menino Jan. 2001

units than a single family dwelling, the city can yield much higher recycling participation by focusing on larger residential buildings.

In our study area, we have generated a list containing 33 buildings that have seven and more residential units (Brighton_7ups_ourdata.mdb). The following map, Figure 25, was produced to better visualize all the large buildings and their number of units in the neighborhood of Brighton.

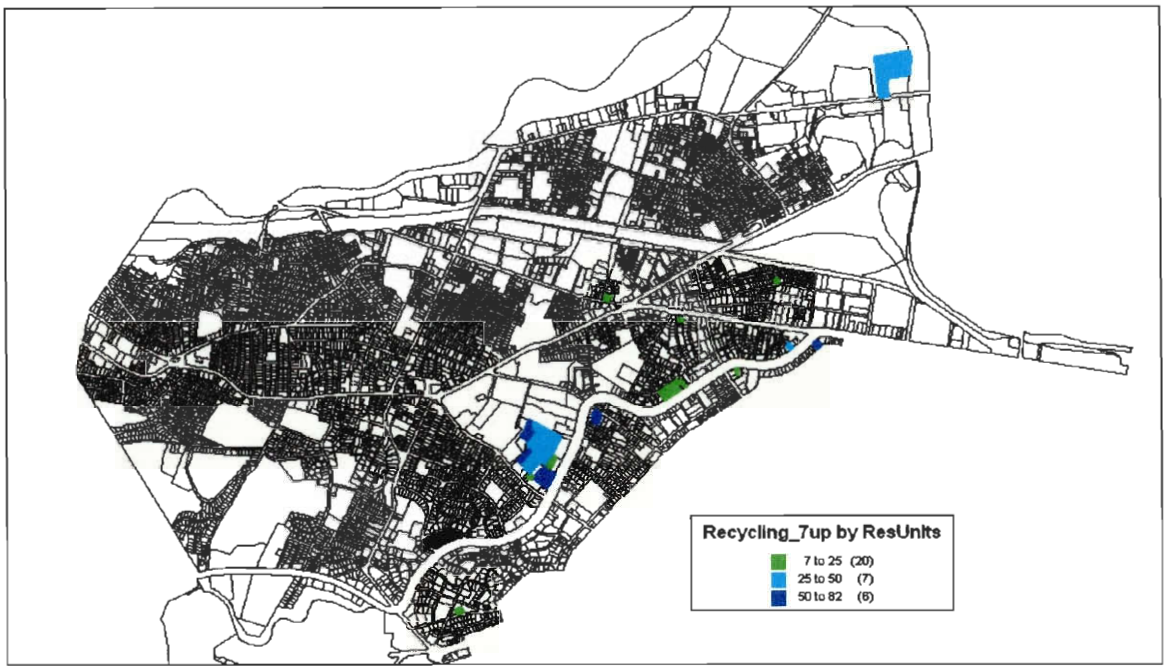


Figure 25: Large Building Number of Units

The Public Works Department provided information about the buildings that were already participating in the recycling program. We combined this data with our buildings database, that were seven units and up, to create a complete list of all the large buildings in Brighton. This list contained an online field containing three different options. These options are defined numerically from zero to two; zero indicating that the building is not recycling, one indicating that the building is currently signed up for recycling, and two indicating that the building is signed up for recycling but hasn't started recycling. Shown below in Table 6 is a portion of the final list which includes 358 large residential buildings that are considered to be large by the Public Works Department (Brighton_7ups_all.mdb).

PID	ST.NUM	STREET NAME	SUF	Online	ResUnits
2100963000	17	RADCLIFFE	RD	2	12
2100964014	20	RADCLIFFE	RD	1	48
2101027000	1285	COMMOWEALTH	AV	1	239
2101028000	1287	COMMONWEALTH	AV	0	8
2101029000	1289	COMMONWEALTH	AV	0	8
2101030000	1291	COMMONWEALTH	AV	0	6
2101032000	1295	COMMONWEALTH	AV	0	16
2101033000	1299	COMMONWEALTH	AV	0	16
2101034000	1301	COMMONWEALTH	AV	0	16
2101035000	1305	COMMONWEALTH	AV	0	16
2101037000	1309	COMMONWEALTH	AV	0	16
2101038000	1315	COMMONWEALTH	AV	2	43
2101041000	82	GLENVILLE	AV	0	16
2101043000	74	GLENVILLE	AV	0	16
2101044000	70	GLENVILLE	AV	0	16
2101045000	66	GLENVILLE	AV	0	16
2101046000	62	GLENVILLE	AV	0	16
2101047000	58	GLENVILLE	AV	0	16
2101049000	48 52	GLENVILLE	AV	1	37
2101058000	1375	COMMONWEALTH	AV	2	36
2101068000	120	GLENVILLE	AV	1	37
2101071000	114 118	GLENVILLE	AV	1	37
2101072000	10	LONG	AV	1	37
2101102000	1387	COMMONWEALTH	AV	2	20
2101103000	1391 1395	COMMONWEALTH	AV	2	42
2101183000	514	CAMBRIDGE	ST	1	95
2101192000	6	ISLINGTON	TE	0	4
2101221000	592	CAMBRIDGE	ST	1	12
2101238000	45	RIDGEMONT	ST	0	2
2101252000	38-40	RIDGEMONT	ST	1	12
2101266000	73	GORDON	ST	0	2

Table 6: Recycling Online and ResUnits Fields

5.2.1 Recycling Rates

There are numerous buildings that are currently online for recycling in the neighborhood of Brighton. However, these buildings that are online may have discontinued their recycling habits. Therefore we conducted a participation study to observe these residential buildings. We ranked their participation on a numeric scale from zero to three; zero indicating no recycling bin, one indicating a bin but low participation, two indicating medium participation and three, indicating high participation. The following, Table 7, is a portion of the complete recycling list for Brighton. As seen in the field labeled level, there are non-integer

entries; this is due to multiple recycling bins at one location and their participation level therefore being averaged. When the pickup site is not mentioned, this explains that these bins have no determined location.

NUM	STREET NAME	SUF	Res. Units	Level	Pickup Day	Pickup Site	Online Date
84	Sutherland	Rd	13	2	Tuesday	curb corner next to 56 Selkirk behind 84 Sutherland	12/3/2002
114	Strathmore	Rd	23	2.14	Thursday		4/1/2000
137	Englewood	Av	86	0	Thursday		5/9/2002
2 4	Ayr	Rd	40	2.5	Tuesday	Curbside	4/1/1999
6 10 14	Orkney	St	80	2.5	Tuesday	alley behind 42 Strathmore (same as 6 -14 Orkney)	11/19/2002
42	Strathmore	Rd	26	1	Tuesday	alley behind 42 Strathmore (same as 6 -14 Orkney)	11/19/2002
1960 1970 1980	Commonwealth	Av	150	1	Wednesday	In front of 1980 between hydrant and pole	12/11/2002
2018	Commonwealth	Av	34	0	Thursday	curbside on Wade St	3/4/2003
1940 1950	Commonwealth	Av	70	2	Thursday	curbside at 1950 Commonwealth	11/20/2002
1871 1875	Commonwealth	Av	16	0	Unknown		
153	Chiswick	Rd	12	2	Thursday		9/9/2002
146	Chiswick	Rd	8	0	Monday	curbside across from 145 Chiswick	12/2/2002
153	Strathmore	Rd	28	2.5	Thursday		11/1/2000
67	Nottinghill	Rd	8	2.5	Tuesday	Curbside	1/29/2003
1687	Commonwealth	Av	36	1.67	Tuesday		9/1/2000
1691	Commonwealth	Av	34	1.5	Wednesday	curbside on carriage road	3/19/2003
41-45	Chestnut Hill	Av	30	0	Wednesday	next to dumpsters in lot	12/4/2002
69	Holton	St	80	2	Friday	driveway behind 210 Everett, place next to dumpster	11/1/2002
28	Brentwood	St	16	2	Friday		10/1/2000
77-81	Empire	St	15	2.5	Friday	curb corner of alley & North Harvard near Allston Food & Spirits	12/6/2002
15	North Beacon	St	125	0	Friday		8/12/2002
441	Cambridge	St	38	0	Friday		3/1/2000

Table 7: Recycling Participation Levels

6 Analysis

The main part of our project was gathering safety and recycling information about large buildings in Brighton, MA. After we found information about Brighton's large buildings we wanted to analyze it in a way that would help to further improve large building safety and recycling. In order to do this we looked at safety and recycling separately.

6.1 Building Safety Assessment

When studying large buildings for the Boston Fire Department, safety is their main concern. To achieve a high safety rating there needs to be a minimal risk of emergency. The buildings we are dealing with all have low risk and are safe buildings. However, there are some factors that we looked at that make one building safer than another. Therefore we wanted to be able to provide the fire department with a map of large buildings that are at higher risk in the case of a fire than others. To determine the safety level of the large buildings in Brighton, MA we focused on five factors: distance from the nearest fire station, distance to the nearest hospital, height of the building, hazardous material contents, and occupancy.

6.1.1 Distance from BFD Station to Building

This simply is the distance from the nearest fire station to the building. This distance was found by using the computer program Mapquest[21]. This is a major factor in building safety because the shorter the distance that the fire department needs to travel the quicker the response time for the in emergency situations the safer it is.

6.1.2 Distance from the Building to the Nearest Hospital

This is the distance traveled from the buildings to the nearest hospital. This distance was also found using the computer program Mapquest[21]. We considered this to be a factor in determining the building safety level because in emergency situations the shorter the distance to be traveled the quicker any injured persons can get treatment at a hospital the better their chances of recovery are.

6.1.3 Height of the Building

This is the height of the building measured in feet. We focused only on buildings that are taller than seventy feet as defined by the Boston Fire Department.

[21] Mapquest Service. http://www.mapquest.com

Building height was considered a factor for this analysis because it proved to be an efficient technique for relating building size to safety. This being that the taller the building the more serious a threat it could pose on society and the firefighters, due to its density of people and limited ground floor exits. In tall buildings fire fighters need to deal with many major concerns like building collapse, bringing equipment and hoses from floor to floor and evacuating mass amounts of people through exit stairwells. These tall buildings also require them to bring specialized fire trucks, ladder trucks, to help aid in the evacuation and suppression of fire. Therefore we concluded that we would get a better safety rating by looking at the height of the building.

6.1.4 Hazardous Materials Contents

This is a factor in building safety because when hazardous materials are misused or mishandled they can prove lethal. The fire department has special units set up to handle hazardous materials correctly; knowing that a building contains a hazardous material greatly helps the fire department in emergency situations but poses a large threat on the residents of the building. If a building contained a hazardous material we assigned it a factor of two, meaning high risk, while if it didn't have any hazardous materials it was assigned a one, meaning moderate to no risk.

6.1.5 Occupancy Factor

The element of the equation we deemed the "occupancy factor" is a combination of two separate factors that gave us a measure of the amount of people in a given building at a given time. It takes into account whether the building is commercial or residential and whether it is daytime or nighttime. This gave us a building daytime safety rating and also a building night time safety rating. This is important because building occupancy varies during the course of the day. The general rule we followed was that residential buildings are more occupied at night while commercial buildings are more occupied during the daytime. If a building was residential its daytime occupancy multiplier was assigned a one while its nighttime occupancy multiplier was a two. If a building was commercial its daytime occupancy multiplier was two while its nighttime occupancy factor was one.

Time of day and building usage were added elements to this because a buildings population changes from daytime to nighttime with relation to whether it's commercial or residential.

6.1.6 Building Safety Assessment Equation

From the factors previously mentioned an equation was derived to give us an overall building rating.

The equation is stated as:

(D1 + D2) x Height x Hazardous Material Presence x Occupancy Factor = Risk Level

Where:

D1 = Distance from BFD station to building

D2 = Distance from the building to the nearest hospital

For the buildings in Brighton that are over seventy feet in height here are their risk levels (divided by 100 to make for a scale of zero to ten).

Code	ST_NUM	ST_NAME	ST_NAME_SUF	Building Usage	Height (feet)	Res_Units	Daytime Safety Level (scaled)	Nightime Safety Level (scaled)	Fire Station Distance (mi)	Hospital Distance (mi)	Hazardous Materials Presence
1	881	COMMONWEALTH	AV	Commercial	126	0	6.78	3.39	1.17	1.52	No
2	1079	COMMONWEALTH	AV	Residential	75	182	2.34	4.68	2.04	1.08	No
3	59	BRAINERD	RD	Commercial	72	0	2.59	1.30	0.76	1.04	No
4	1110	COMMONWEALTH	AV	Residential	85	82	1.52	3.04	0.81	0.98	No
5	1800	COMMONWEALTH	AV	Residential	72	36	0.77	1.54	0.43	0.64	No
6	1687	COMMONWEALTH	AV	Residential	70	34	0.79	1.58	0.6	0.53	No
7	129	BRAINTREE	ST	Commercial	95	0	1.96	0.98	0.2	0.83	No
8	2601	BEACON	ST	Commercial	142.8	0	9.37	4.68	0.6	1.04	Yes

Table 8: Tall Building Safety Level

To put these ratings on a better scale we divided the safety levels by one hundred and were left with the below results in Figure 26.

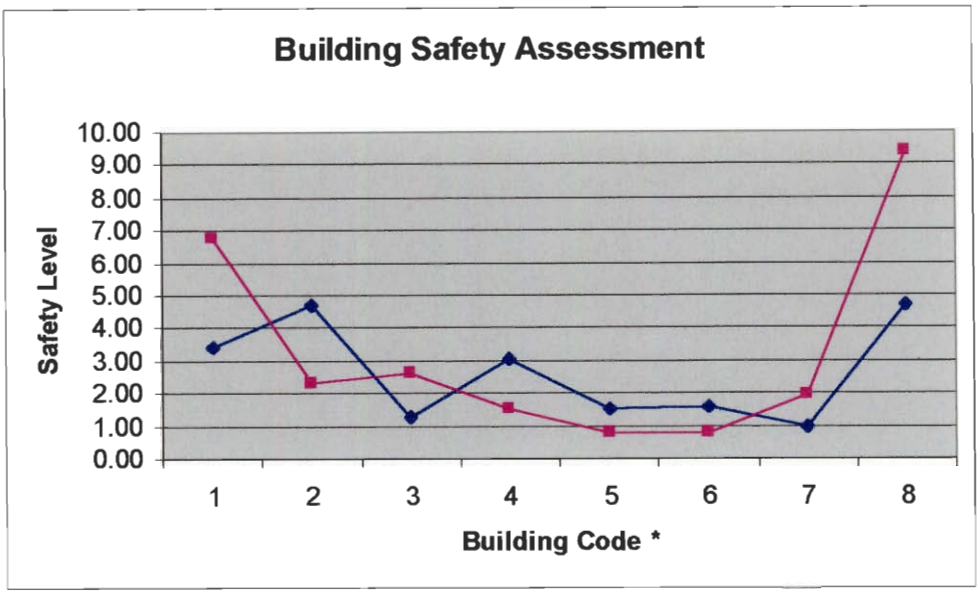


Figure 26: Building Safety Assessment

6.2 Recycling Involvement

When focusing on large buildings for the Public Works Department (PWD) our main concern was to maintain and increase recycling levels. The recycling data we collected included the number and locations of buildings seven units and up as well as a list of buildings that were registered for recycling through the PWD. We found 392 large buildings in Brighton of which 92 were currently recycling and 91 were signed up to recycle. To maintain recycling levels we wanted to find out if these 91 buildings were all still recycling and if so how actively they were participating. Once this was determined we wanted to analyze why some buildings were not participating as much as others. We looked at building value and occupant's income, age, and education. Our hypothesis is that one or more of these factors affect participation levels. We came up with this hypothesis on the hopes that from our findings we will be able to suggest which areas of Brighton the PWD needs to focus its recycling participation efforts on.

6.2.1 Recycling Participation

We analyzed the participation of the buildings that are registered with the recycling program. The Public Works Department has the challenging task of signing buildings up for recycling and initiating the recycling process. Once they are registered there is no one verifying if they recycle or not. We wondered if all the people who had originally signed up were still recycling and if so, how actively they were participating.

6.2.1.1 Methodology

The only way to determine if the people registered were still recycling and how actively they were recycling was to visit the sites on their recycling pick up day and visually check their participation. We knew which buildings were signed up for recycling and their day of pick up, but the problem was that not all of the buildings had a pick-up day listed, some were unknown. We decided we would visit the unknown buildings everyday until we found their recycling pick up day.

We had to determine when the best time of day was to visit these buildings. Through basic research at the Public Works Department we found that the bins are supposed to be on the street by 6am and the trucks start their first pick up after 7 am. That gave us one hour to drive to all the buildings in the respective area. On Tuesday, Wednesday and Thursday we were out past 7am so the trucks could have already picked up the recycling and there was the chance that we could have recorded that there was no recycling participation for a building when in actuality the recycling had already been picked up.

To find the buildings we plotted them in MapInfo and set each pick up day with a different color in Figure 27 below.

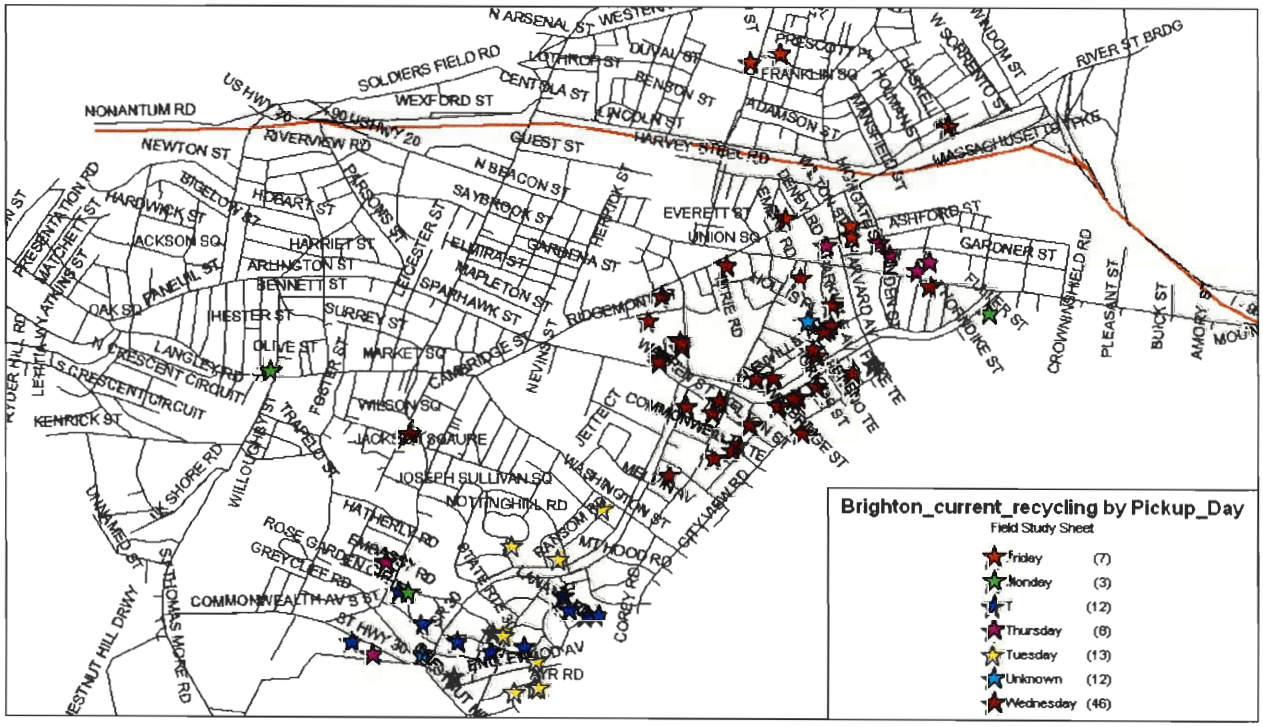


Figure 27: Recycling Field Map

Once we arrived at the building we went on foot around it to find the bins, once the bins were located we opened the lid and visually inspected the level of recycling and recorded it. To keep track of the recycling level, we had a scale of 0-3 for each bin; zero being no bin, one being low level, two being medium level, and three depicting a high level (clip shown below). If there was no bin found it did not necessarily mean that building is no longer recycling, because some recycling bins were kept inside which we did not have access to. This number alone would not be enough for us to rate the recycling participation, because some buildings are larger than others. To address this issue we divided the recycling level by the number of units in the building to get a recycling level per unit then scaled the numbers to a realistic value (multiplied by 10).

6.2.1.2 Results

Our recycling participation per unit ranged from zero to four as shown in Figure 28. Seventy-five percent of the buildings were recycling at a rate between 0-.9, sixteen percent were recycling at a rate between 1-1.9, seven percent were recycling at a rate between 2-2.9, and one percent was recycling at a rate between three and four.

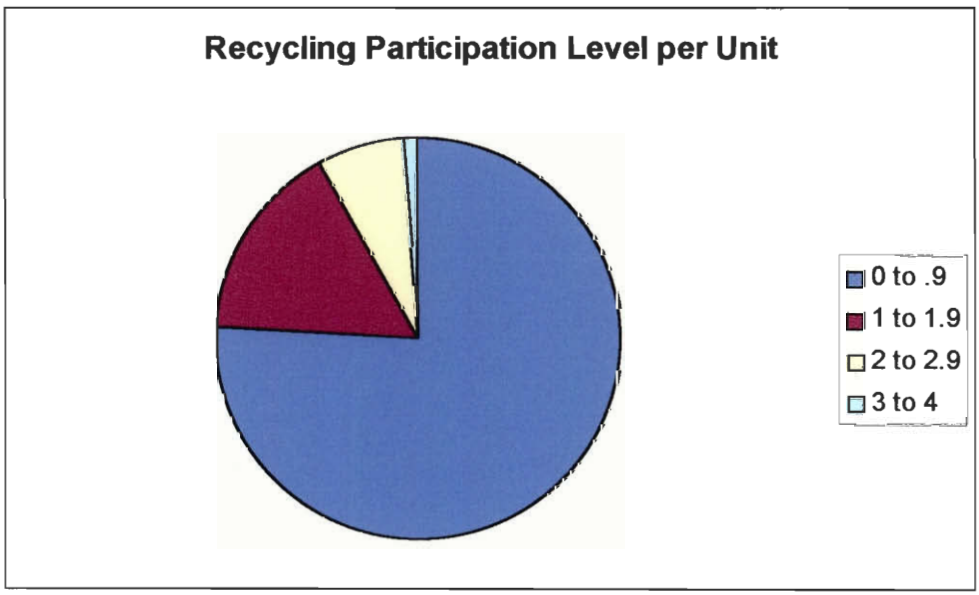


Figure 28: Recycling Participation Level per Unit

6.2.2 Recycling Factors

Now that we know the participation levels per unit we wanted to examine why the participation levels varied. Our hypothesis is that economic factors (building value and occupant's income), age, and education have some effect on the recycling participation.

6.2.2.1 Economic Factors

6.2.2.1.1 Building Value

Unlike the other three factors building value reflects upon the ownership of the building, not the occupants. The owner of the building only has control over the recycling registration. Once the building is registered, it is up to the occupants to recycle. So we compared the building value of all the large buildings to the list of buildings that are registered for recycling.

6.2.2.1.1.1 Methodology

To complete this comparison we needed to determine which large buildings in Brighton are registered with the recycling program and the building's value. We already had obtained the list of large buildings in Brighton and their recycling information; the challenge was to gather their respective value. In the assessor data, which we downloaded from Boston Atlas, we found a field called gross tax which is reflective of the building value. We then matched the buildings that recycle with their respective gross taxes in a MapInfo table. We sorted the buildings by gross tax and then divided the buildings evenly into low (479-5,178), middle (5,491-13,362), and high classes (13,551-88,163). For each class, we counted the number of buildings that were recycling and divided it by the total number of buildings to get a percentage of which buildings are participating in recycling.

6.2.2.1.2 Results

We found that of the low building values only 29% are signed up where both the middle and the high

PID	OnLine	Gross_tax
2101411000	2	7,305.49
2102167000	0	4,776.87
2102385000	1	16,600.02
2102177000	1	21,540.88
2102518000	2	11,034.94

Table 9: Gross Tax Field

building values have close to 50% signed up as seen below in Figure 29.

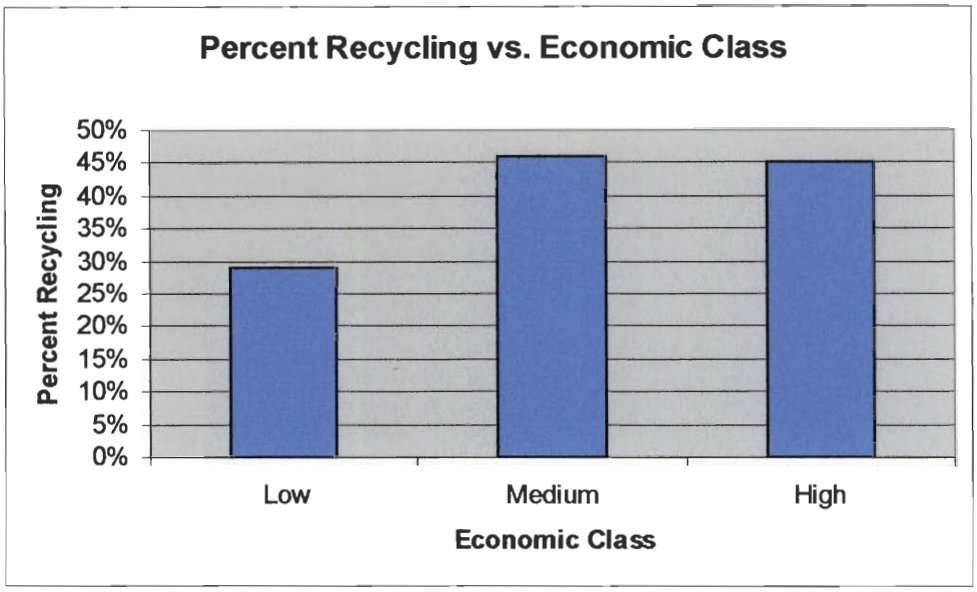


Figure 29: Percent Recycling vs. Economic Class

We plotted the results on MapInfo to look at the locations of the low building value areas in Brighton. There is a cluster of low value in the same location shown in the highlighted area of Figure 30.

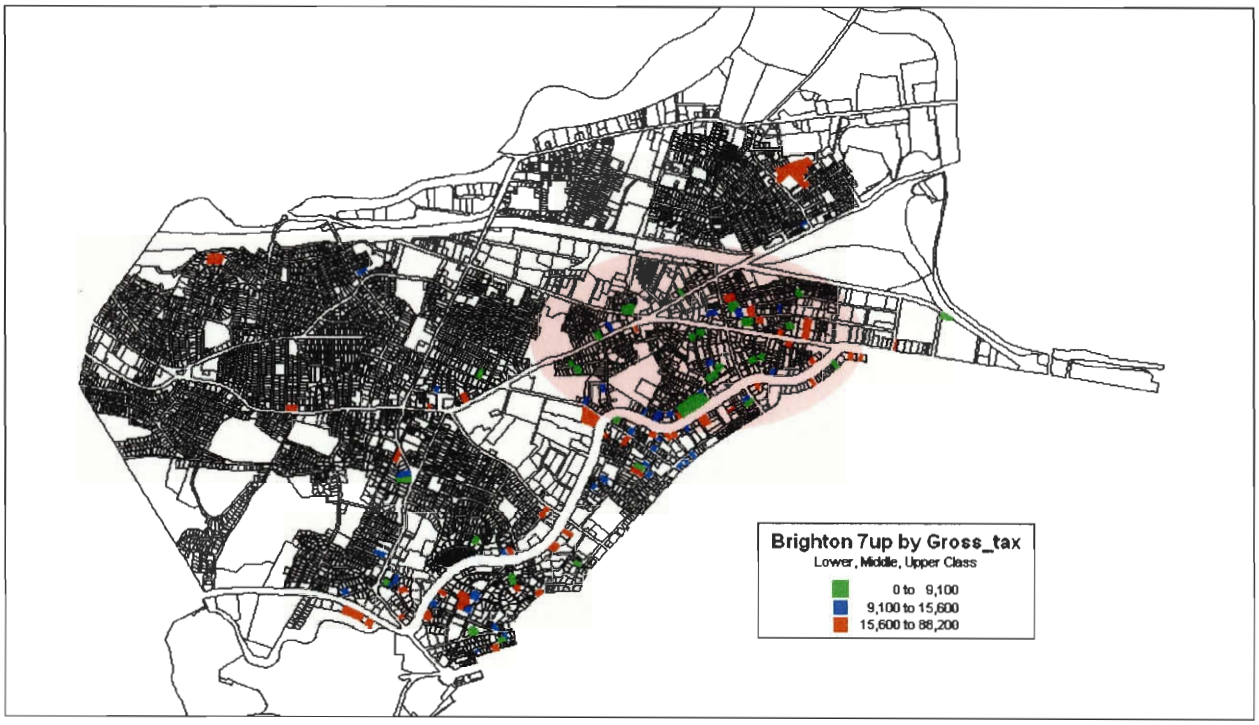


Figure 30: Brighton 7up by Gross Tax

6.2.2.1.3 Occupant's Income

We hypothesized that income may have an effect on the recycling participation levels of large buildings. We compared the two to see if there was any correlation.

6.2.2.1.3.1 Methodology

Before we could make a comparison we had to find the incomes of the occupants in the buildings which are involved in recycling. To do this we turned to the Census 2000 data online[22]. We could not find an income for each building, because the census data is by blocks and tracts. So we searched for each income by entering the address to find which tract and block group that specific building was in. Block group was the smallest division that contained income information. So we matched each block group household income (median_household_income field) to their respective building and participation information. Once we matched every building that was participating in the recycling plan we plotted the level of participation per unit with the income. Multiple buildings had the same income, so we took the average of the participation levels so we could see the points on a graph. We then created a best fit line (r squared) for the points on the graph.

6.2.2.1.3.2 Results

We found a direct relationship between income and recycling participation. The lower the income the more participation.(shown below) This contradicts the earlier comparison run on building value vs. recycling where the higher the value the more signed up for recycling. This shows that the building owners of lower value buildings are hesitant to register recycle, however the ones that do have high participation from their low income residents.

[22] Census 2000 Online. www.census.gov

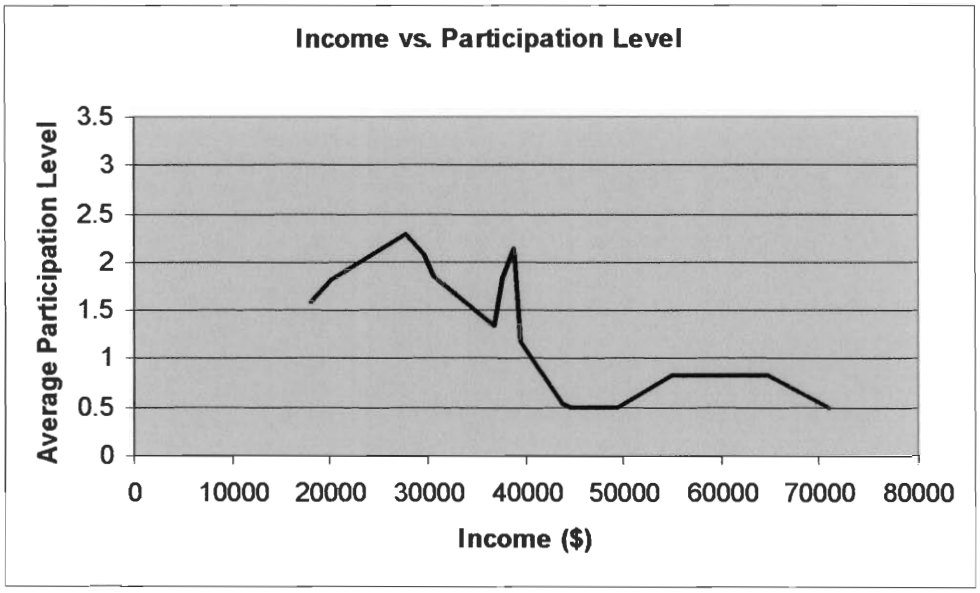


Figure 31: Income vs. Participation Level

6.2.3 Age

Not only did we believe income could effect recycling participation, we also believed age could be a reason for the large variation in participation. In order to determine this we compared the age of the residents to their participation level per residential unit.

6.2.3.1 Methodology

The way we did this was identical to our income comparison. We used the same census data, but instead of the median household income field we used the age field. We also used the same process to match age with recycling participation levels. Just like the income we had to take the average of the participation levels for each age group in order to graph our points.

6.2.3.2 Results

We found no correlation between age and recycling participation levels shown in Figure 32.

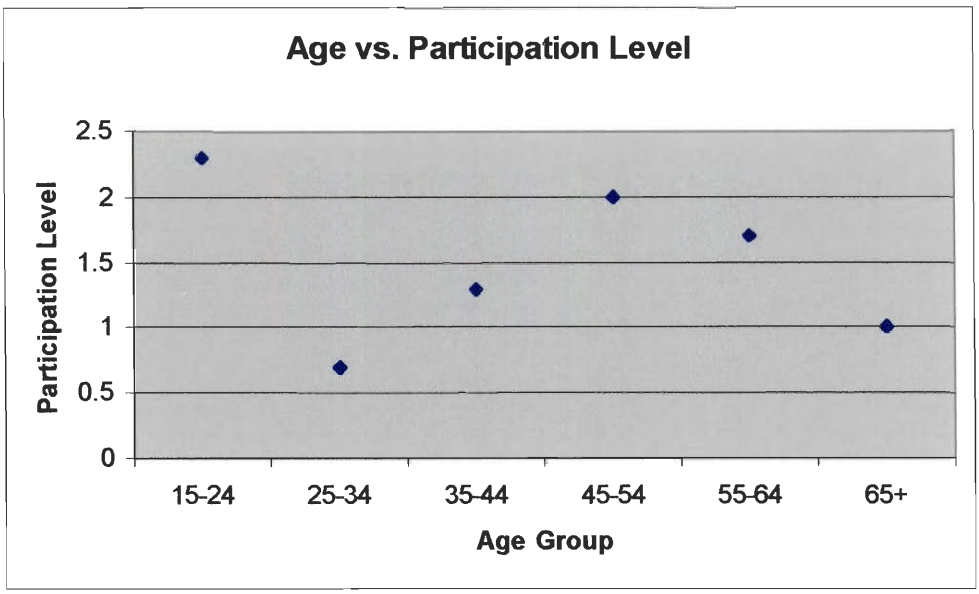


Figure 32: Age vs. Participation Level

6.2.4 Education

Lastly we strongly believed that education had an effect on recycling participation. We believed that the more one knew about recycling and its positive effects the more willing one would be to recycle. We assumed that the higher one's education in school could be linked to one's education on recycling.

6.2.4.1 Methodology

The way we determined this was identical to our income and age comparisons. We used the same census data, but used the education field. However, unlike income and age the block group did not contain education information. We had to use the larger area, tracts, instead. The census data broke education down into two groups with different fields for different degrees. We simplified this information into three fields: less than high school diploma, high school diploma, and bachelor's degree (BA) or higher shown in Table 10. Due to the fact that each tract was a different size and the entries needed to be normalized in order to be compared to each other. We created percents for these education fields shown in the data entries below.

Unit_Level	<HS	HS	BA+
2.5	5	26	70
.5	24	35	41
1	24	35	41
0	30	60	10

Table 10: Census 2000 Education Percentages

In order to compare education and recycling level we took the BA plus column show above which is the percent of people for that building which have a bachelor's degree or greater and compared that with the recycling level per unit. Just like the income and age we had to find the average of the participation levels for each percent of the age group in order to graph our points. For example, the two forty-one percents above in the BA+ column would get one entry .75 ((1+.5)/2).

6.2.4.2 Results

We found a strong relationship between education and recycling participation levels. As shown below, the higher the education the higher the participation level.

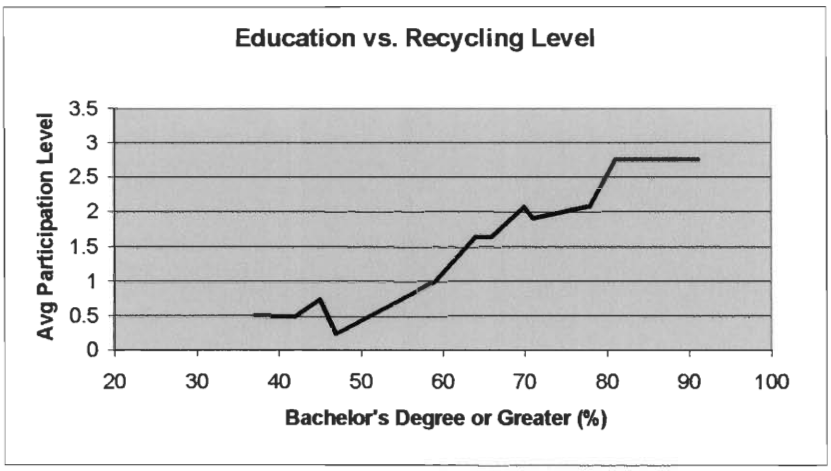


Figure 33: Education vs. Recycling Level

7 Recommendations

This section discusses the suggestions that we have produced over our project term from the information that we gathered and analyzed. For each of our sponsors we have specific recommendations to improve recycling participation and public safety respectively.

7.1 Boston Fire Department

The Boston Fire Department is constantly keeping the public safe from the dangers of fire and other emergencies. The more the fire department is aware of, the better it can serve the public. We have provided the usage and hazardous materials contents information for the large buildings in Brighton. The future plan is to have this type of knowledge for all of Boston.

The building list contains 8 addresses, uses, hazardous materials contents, and response distances. All of the buildings in Brighton have optimal response distances, the longest being a mere 2 miles to a fire station and hospital. The next step is to do this type of study for all of Boston. We have provided our methodology and all of the contacts used to complete this pilot study of Brighton. Building heights are on file at the Inspectional Services Department and hazardous material permit records are also available at the Boston Fire Department Headquarters at 1010 Massachusetts Avenue. We were glad to contribute to the improvement of public safety.

7.2 Public Works Department

The City of Boston and the Public Works Department has done an excellent job of increasing present day recycling rates in Boston, Massachusetts. The future of the recycling program revolves around the increasing recycling participation and the monitoring of that participation.

Based on our analysis of building value from gross tax payments for the large buildings in Brighton, the lower valued have a lower recycling percentage than that of the middle and upper valued buildings. The concentration of lower valued buildings is show in Figure 34 below.

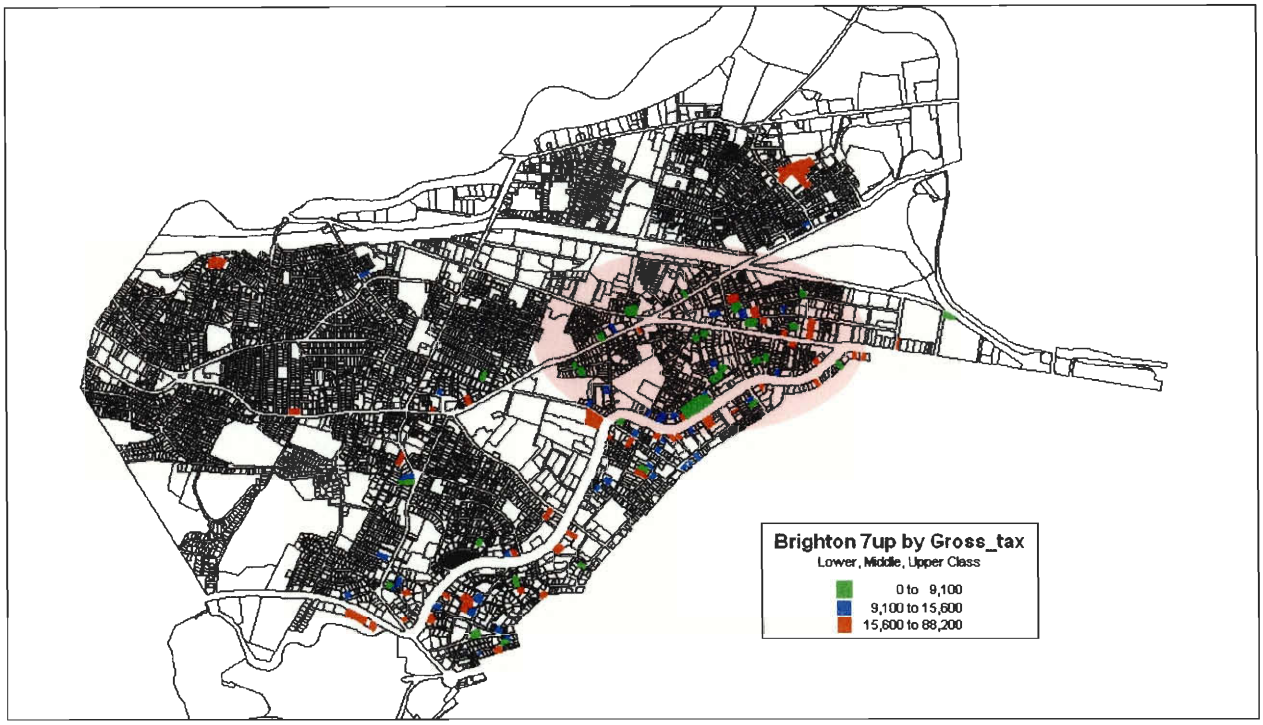


Figure 34: Brighton 7up by Gross Tax

We suggest contacting the buildings owners of these buildings of low value. The list of owners and their addresses is included on the project CD in the database folder as the file Brighton_Low_Building_Value.mdb.

In relation to the second part of our recycling analysis, the levels of observed participation, we have two recommendations. As stated in the recycling analysis section we compared occupant education to participation level. The areas of lower education had a lower recycling participation level in our study. We recommend a recycling education program for areas that are of low education. The area in Brighton that fits this requirement is highlighted in Figure 35 below.

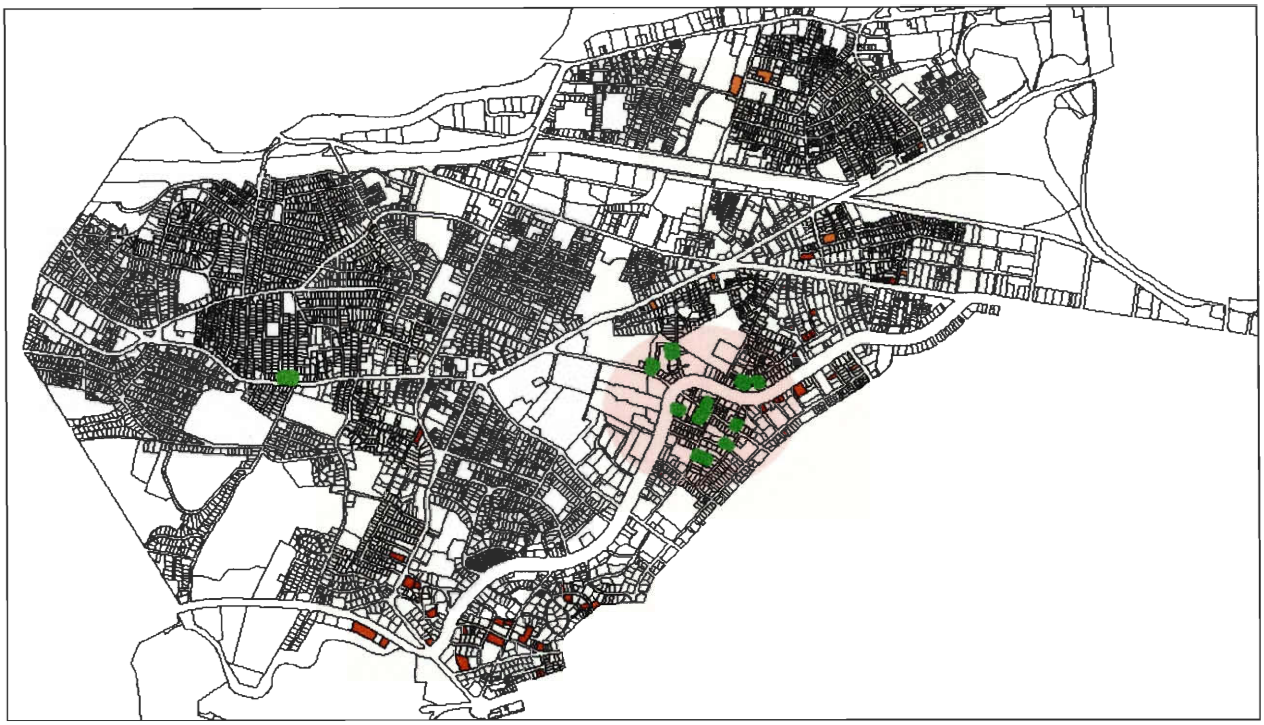


Figure 35: Recycling Low Education Area

For all of the buildings that are signed up for recycling but may not be participating as actively any longer, a booster program could be started. The recycling coordinator could initiate the annual dispensing of flyers to these buildings, reminding them about recycling.

Our recycling participation study was very tedious and only represented a weeks worth of participation, not enough data to be conclusive. To propose a new method, every day of the week there are recycling trucks collecting recyclables, we suggest that if these trucks recorded the participation of their recycling route, this data would be conclusive, and trends could be viewed over years of entries. This participation study would take much work to enact, but the end result would be complete participation knowledge of an area.

The methodology we created and executed throughout this project can be used to identify and involve all of Boston in the recycling program. All of the contacts we used are attached as Appendix L: Project Contacts List, so the Public Works Department can utilize them. The main source for building information was found to be the Inspectional Services Department (ISD). The ISD holds the building permits for the entire city. This information is accessible by appointment in the document room, on computer at the ISD, or via the Internet[23]. Best wishes in your goal for a better tomorrow, we were glad to contribute to that.

[23] Inspectional Services Department. http://www.cityofboston.gov/isd/docroom/docsearch.htm

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