Historical Relationships between Land Elevation and Socioeconomic Status in New York City: A Mixed Methods GIS Approach

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Historical Relationships between Land Elevation and Socioeconomic Status in New York City: A Mixed Methods GIS Approach

by

Jennifer Brisbane

A dissertation submitted to the Graduate Faculty in Earth and Environmental Sciences in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

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THE CITY UNIVERSITY OF NEW YORK
ABSTRACT

Historical Relationships between Land Elevation and Socioeconomic Status in New York City: A Mixed Methods GIS Approach

by

Jennifer Brisbane

Adviser: Professor Juliana Maantay

The role that topography has played in the development of New York City is essential to understanding its present urban form and foreseeing its changes. Geographers and economists have generally agreed that for cities in the United States, socioeconomic status increases with land elevation. This seemingly simple relationship between elevation and class, however, is complicated by factors such as technological innovations, economic shifts, politics, cultural perceptions, and the idiosyncrasies of cities and the neighborhoods within them. The lack of comprehensive research in this area coupled with conflicting findings warranted further exploration into the complex and changing relationships between elevation and social class.

This longitudinal study utilized a mixed-methods GIS approach to reveal historical relationships between land elevation and socioeconomic status in New York City, and explain factors that may mediate these relationships.

This study departed from the traditional use of regression results by mapping standardized residuals clusters, which were found to be an extremely efficient way of pinpointing anomalous areas that would be appropriate case study areas for in-depth, qualitative analysis. Relative elevation was found to be a better determinant of socioeconomic status than absolute elevation for three out of ten analysis years examined. The presence of urban fringe uses on high elevation land was affirmed. The persistence of historical settlement
patterns was also affirmed, and it was found that this persistence was able to withstand technological, economic, cultural, and significant physical topography changes. Public policy, such as through the use of zoning tools and eminent domain, was the most influential force in the transformation of historical land use and settlement patterns. Climate change is poised to become another powerful force in the transformation of cities, and should be incorporated into future studies that examine the relationship between physical topography and residential or land use patterns.
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For my father, Linwood J. Brisbane, whose fascination with history has clearly rubbed off on me, for which I am grateful.
# TABLE OF CONTENTS

Abstract ............................................................................................................................................... iv

Acknowledgements ............................................................................................................................... vi

List of Figures ......................................................................................................................................... x

List of Tables ........................................................................................................................................ xiii

Chapter 1: Introduction .......................................................................................................................... 1
  Research Question and Hypothesis ........................................................................................................ 6
  Literature Review ................................................................................................................................... 8
  Significance of Research ....................................................................................................................... 17
  Preliminary Analysis Results ............................................................................................................... 18
  Research Approach .............................................................................................................................. 24
  Data Requirements ............................................................................................................................... 28
  Limitations ........................................................................................................................................... 30

Chapter 2: Quantitative Analysis ............................................................................................................. 34
  Methodology ........................................................................................................................................ 34
    Scatter Plots and Box Plots .................................................................................................................. 34
    Pearson Correlation and Ordinary Least Squares (OLS) Regression .............................................. 36
    Geographically Weighted Regression (GWR) .................................................................................... 39
    Relative Elevation .............................................................................................................................. 40
  Data Preparation .................................................................................................................................. 43
  Analysis ............................................................................................................................................... 46
    Scatter Plots and Box Plots .................................................................................................................. 46
    Socioeconomic Status And Outlier Maps .......................................................................................... 48
    OLS and GWR Results ....................................................................................................................... 49
Significant Findings.................................................................................................................. 54

Chapter 3:  Qualitative Analysis ................................................................................................. 59
  Methodology .......................................................................................................................... 59
  Purpose of Case Study Analysis.............................................................................................. 59
  Case Study Area Selection Justification ................................................................................ 60
  Case Study Area Analysis ....................................................................................................... 64
    New York City Farm Colony – Seaview Hospital Historic District ............................... 64
    Bellevue ................................................................................................................................. 78
    Marble Hill ............................................................................................................................ 97
    Hunters Point ......................................................................................................................... 109
    Coney Island ......................................................................................................................... 126

Chapter 4:  Final Analysis and Conclusion ................................................................................. 146
  Exploratory Data Analysis Using GWR Residuals Results.................................................... 146
  Relative Elevation ................................................................................................................... 147
  The Horizontal and Vertical Fringes ....................................................................................... 148
  Persistence of Historical Settlement Patterns ......................................................................... 150
  Climate Change and Environmental Justice ....................................................................... 154
  Conclusion ............................................................................................................................... 162

Appendices ................................................................................................................................. 167
  Appendix A:  Transformed Variables ..................................................................................... 167
  Appendix B:  Central Business District (CBD) Boundaries ................................................. 170
  Appendix C:  Scatter Plots ....................................................................................................... 172
  Appendix D:  Box Plots ............................................................................................................. 177
  Appendix E:  Choropleth And Outlier Maps .......................................................................... 183
  Appendix F:  OLS and GWR Summary .................................................................................... 188
Appendix G: Best-Fit GWR Elevation Coefficient Maps................................................................. 190
Appendix H: Best-Fit GWR Standardized Residuals and Cluster Maps ...................................... 195
References ...................................................................................................................................... 200
LIST OF FIGURES

Figure 1. Staten Island Topography and Highest Point. The highest point, Todt Hill, is represented by a blue triangle.................................19

Figure 2. Literacy Rates (1910). Darker blues represent higher literacy Census Tracts....................20

Figure 3. Median Household Income (2000). Darker blues represent higher income Census Tracts. ....20

Figure 4. B Coefficient Results of a GWR Regression between 1910 Literacy Rates and Elevation. Redder colors represent more positive B Coefficient values. Bluer colors represent more negative B Coefficient values.................................................................21

Figure 5. T-Values of the B Coefficient Results of a GWR Regression between 1910 Literacy Rates and Elevation. Darker colors represent higher t-values. Census Tracts with t-values < 1.96 have been grayed out. .................................................................21

Figure 6. Large absolute residual results of a GWR regression between 1910 literacy rates and elevation. Red Census Tracts indicate Census Tracts with the highest residuals.................................................................23

Figure 7. Large absolute residual census tract and 1924 aerial Image..............................................23

Figure 8. Top level project flow chart.................................................................26

Figure 9. Data preparation flow chart.................................................................26

Figure 10. Quantitative analysis flow chart.................................................................27

Figure 11. Qualitative analysis flow chart.................................................................27

Figure 12. 2010 Absolute elevation...........................................................................42

Figure 13. 2010 Relative elevation (500 ft.).................................................................42

Figure 14. 2010 Relative elevation (2,000 ft.)................................................................42

Figure 15. 2010 Relative elevation (13,000 ft.).................................................................42

Figure 16. New York City Farm Colony case study area and 1924 aerial photograph.....................65

Figure 17. New York City Farm Colony case study area and 2010 aerial photograph.....................65

Figure 18. New York City Farm Colony – Seaview Hospital Historic District case study area boundaries and 50 ft. DEM........................................................................................................66

Figure 19. New York City Farm Colony residents in the 1902 Annual Report of the Department of Public Charities of the City of New York ........................................................................................................71

Figure 20. Bellevue case study area and 1924 aerial photograph.................................................................79
Figure 21. Bellevue case study area and 2010 aerial photograph..........................................................79

Figure 22. Bellevue case study area and 1782 British Headquarters Map..............................................80

Figure 23. Bellevue case study area and 1865 Sanitary and Topographical map ....................................80

Figure 24. 1770 Ratzer Map showing Keteltas (Ketalta) house.................................................................81

Figure 25. 1782 British Headquarters Map showing the Bellevue Case Study Area................................83

Figure 26. Gas tank at corner of 20th Street and 1st Avenue in 1938. Photograph by Berenice Abbott ....85

Figure 27. Bellevue case study area and PWSs flood zones.......................................................................95

Figure 28. Bellevue case study area with 1872 British Headquarters Map and PWSs flood zones ..........95

Figure 29. Marble Hill case study area and 1924 aerial photograph..........................................................98

Figure 30. Marble Hill case study area and 2010 aerial photograph.........................................................98

Figure 31. Marble Hill case study area and 50 ft. DEM.............................................................................99

Figure 32. Marble Hill area of 1777 Battle of Fort Washington Map.........................................................101

Figure 33. Marble Hill area of the 1820 Randel Farm Maps.....................................................................102

Figure 34. Marble Hill area of USGS – Harlem, NY-NJ Quadrangle Northwest Corner map, 1891.......103

Figure 35. Marble Hill area of USGS – Harlem, NY-NJ Quadrangle Northwest Corner map, 1897.......103

Figure 36. Hunters Point case study area and 1924 aerial photograph......................................................110

Figure 37. Hunters Point case study area and 2010 aerial photograph......................................................110

Figure 38. Hunters Point area of Charles Perkins’s 1853 map....................................................................112

Figure 39. Hunters Point waterfront area of 1873 Beers map..................................................................118

Figure 40. Hunters Point waterfront area of 1913 Ullitz map from Atlas of the Borough of Queens ....118

Figure 41. Hunters Point case study area and PWSs flood zones...............................................................125

Figure 42. Coney Island case study area and 1924 aerial photograph......................................................127

Figure 43. Coney Island case study area and 2010 aerial photograph......................................................127

Figure 44. Coney Island case study area and 1880 Bromley map.............................................................128

Figure 45. Waterfront area between West 30th Street and West 21st Street on 1890 Robinson map ....134

Figure 46. West 37th street jetty area of 1924 aerial photograph...............................................................141
Figure 47. West 37th street jetty area of 2006 aerial photograph. .................................................................141

Figure 48. West 37th street jetty area of 2010 aerial photograph. .................................................................141

Figure 49. Coney Island case study area and rezoning area boundary with PWMs flood zones. ..............144

Figure 50. Temperatures in New York City as measured by Landsat on August 14, 2002 at 10:30 a.m. during a heat wave. (NASA Earth Observatory) .................................................................160

Figure 51. Vegetation in New York City. (NASA Earth Observatory) .............................................................160

Figure 52. Hillshaded Digital Elevation Model of New York City .................................................................160
<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Related Studies</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>1960 U.S. Census Income Ranges and Assigned Values</td>
<td>31</td>
</tr>
<tr>
<td>3</td>
<td>Socioeconomic Status Indicators and Units of Analysis</td>
<td>44</td>
</tr>
</tbody>
</table>
CHAPTER 1: INTRODUCTION

He that will not live long
Let him dwell at Murston, Tehnham or Tong.

(old Kentish proverb, quoted in Dobson, 1997,
Contours of Death and Disease in Early Modern England,
p. 287)

Land topography plays a fundamental role in the shaping of cities. All of the world’s great cities, from ancient times, were born and thrived along oceanic coasts or rivers where water provided access to transportation and trade activities. However, even within these cities, topographic variation largely determined the desirability of land, which in turn guided land use and residential settlement patterns. Areas of low elevation do not drain well, are flood prone, and are more susceptible to smog inversion. Pollutive and noise-producing railroads and highways are more likely to be situated in areas of low elevation. Noxious and hazardous sanitary landfills pollute wetlands and surrounding low-lying areas. In Western medicine, altitude has been recognized as a significant factor in death and disease since the 18th century (Riley, 1987; Dobson, 1997). Prior to understanding that disease-carrying vectors such as mosquitoes thrived in poorly-drained, low-elevation areas, scientists made the correlation between the lowlands and disease. They believed that the “bad air” that emanates from low-lying marshlands was in itself the cause of disease (Viazzo, 1989; Dobson, 1997). Indeed, the word “malaria” itself means “bad air,” derived from the Italian words “mala aria.” The old Kentish proverb “He that will not live long, Let him dwell at Murston, Tehnham or Tong” refers to three low-elevation villages in Kent County, England that were infamous for exceptionally high mortality rates due to “marsh fever” or “swamp fever,” which scientists know now was in fact malaria spread by mosquitoes that thrived in these swampy lands.
Higher lands with cleaner air, pleasurable views, good drainage, and less risk of flooding are generally considered to be more desirable, providing relief for those who can afford these more expensive properties (Burgess, 1929; Hoyt, 1939; Harris & Ullman, 1945; Willie, 1961; Holway & Burby, 1993; Meyer, 1994; Meyer, 2000; Ueland & Warf, 2006). Real estate developers choose names, often deceptively, for new neighborhoods that evoke images of rolling hills and highly elevated land (Meyer, 2005). In New York City, some of these neighborhood names include Forest Hills, Boerum Hill, Cambria Heights, Jackson Heights, and Jamaica Heights.

This study sought to address the following question, “What are the historical relationships between land elevation and socioeconomic status in New York City?” Today, the assumption that socioeconomic class increases with land elevation is rarely questioned by the most geographers or the public. The actual distribution of socioeconomic classes, however, may belie this assumption. For example, an inverse relationship may have existed before transportation technology allowed residents to easily commute between high elevation residences and lower elevation central business districts or port areas (Meyer, 2005; Meyer, 2012). Coastal neighborhoods present another exception as they are currently considered desirable properties and are therefore more easily affordable to those of high socioeconomic status (Ueland & Warf, 2006). Battery Park City in lower Manhattan is one example of an extremely low-lying yet highly sought-after and expensive residential area largely due to its frontage with the Hudson River.

Few studies have attempted to assess the complex and changing relationships between land elevation and socioeconomic class. Those that have examined the topic generally conclude that elevation and class are positively correlated. Although negative correlations have been found in some of these studies, minimal attempts have been made to uncover factors that could
account for these results. Some studies, such as Blumenfeld’s 1948 examination of Philadelphia, omit entire cities or areas of cities from their studies in order to avoid the “distortion” of results (Blumenfeld, 1948). While extensive historical, longitudinal research has been conducted on changing land value patterns within cities, notably Hoyt’s detailed 100-year analysis of Chicago (1933), only Meyer’s 2012 study of Syracuse, New York specifically examined changing land values and neighborhood socioeconomic status as they relate to land elevation over time. This study also takes a historical approach by exploring the multiple and dynamic ways in which land topography has impacted the distribution of socioeconomic classes in New York City over time.

Accurately assessing the role of land topography in residential segregation is also important from an environmental justice perspective. Environmental justice issues refer to situations whereby certain groups of people, typically low-income communities and communities of color, bear a disproportionate burden of the health effects associated with environmental risk. In many countries, slums are often found in flood-prone and landslide-prone lands because these locations are considered hazardous and therefore undesirable. In Brazil, many shanty towns, known as favelas, are located on steep hillsides with a high risk of landslide, particularly during heavy rains. An 1890 United States Census Bureau report revealed that for sanitary districts in New York (now the borough of Manhattan) and Brooklyn, death rates, exclusive of stillbirths, were largely explained by the mean elevation of each district (USCO, 1895). In particular, the death rate from tuberculosis (referred to as “consumption” in the report) was highest in the lowest elevation sanitary districts. This study focuses on environmental justice from a historical perspective, attempting to reveal historical environmental justice issues associated with land elevation in New York City.

One factor that had not been considered in any study of how land topography relates to socioeconomic status is the elevation of land relative to its immediate surrounding area. This
type of elevation, called relative elevation, has been used by physical geographers to model the 
earth’s land and seafloor surfaces for purposes such as landform classification (Tagil & Jenness, 
2008) and habitat modeling (Iampietro et al., 2005). To date no studies have attempted to link 
relative land elevation to demographic variables such as socioeconomic status, race, or ethnicity. 
In addition to the physical environmental implications of relative elevation, such as land 
drainage and air circulation, relative elevation could also capture residential perception of land 
elevation. For example, an area of land may be located at a high absolute elevation (height 
above sea level) yet may feel low if it is in a valley area. Similarly, an area of low absolute 
elevation may feel highly elevated compared to its surrounding area if it is located on a hilltop. 
This perception of height, along with the physical geographic factors associated with relative 
elevation, may be key contributors to the relationships between land elevation and 
socioeconomic status and until now have not been considered in any related studies.

Additionally, this study takes a mixed-methods approach. GIS was used for inductive 
exploratory data analysis prior to in-depth qualitative research. Similar to grounded 
visualization, a concept described by Knigge & Cope (2006) as a process whereby researchers 
use GIS for data visualization to find patterns leading to new opportunities for theoretical 
development, this study utilized choropleth mapping, cluster and outlier analysis, OLS 
Regression, Geographically Weighted Regression (GWR), and cartographic visualization of 
regression results to explore the data, and then find patterns and peculiarities that point to areas 
deserving detailed qualitative historical analysis. Qualitative research including the use of 
archival sources and historical Sanborn fire insurance maps, land use maps, United States 
Geological Survey (USGS) topography maps, and aerial photography helped to interpret 
geographic patterns found in the quantitative analysis process.
The lack of unbiased, comprehensive research on this topic coupled with conflicting findings warrants further exploration into the intricate relationships between land elevation and socioeconomic status. New York City’s diverse terrain, dense population, and rich history make it a perfect study site for the purposes of exploring the role topography plays in urban development. Unlike previous research in this area that generally examined only one slice in time, this study takes a longitudinal approach. The study is the first to investigate the relationship between relative elevation and socioeconomic status. Finally, this study will use a mixed-methods approach whereby GIS was used to conduct exploratory data analysis and cartographic visualization prior to in-depth qualitative historical analysis of selected case study areas.

I hope the results of this study will: 1) contribute to urban growth and environmental justice literature by informing our understanding of city development and residential segregation, 2) demonstrate the use of a spatial data analysis method (GWR) in the exploration of urban geographic phenomena, and 3) serve as a stepping-off point for a more in-depth analysis of how physical topography has helped to create and reshape the human landscape of New York City and other urban areas, and how factors such as public policy and climate change contribute to those transformations.
RESEARCH QUESTION AND HYPOTHESIS

The overarching question addressed in this study is, “What are the historical relationships between land elevation and socioeconomic status in New York City?” I have chosen the plural “relationships” rather than its singular form because I hypothesized that multiple relationships between elevation and class have influenced and continue to affect the ways in which cities develop and change. In order to address the question at hand, a mixed-method quantitative and qualitative approach is taken. Exploratory data analysis, Ordinary Least Squares (OLS) regression, and Geographically Weighted Regression (GWR) were performed on Census data over the last century to find relationships between elevation and socioeconomic status as well as anomalous areas where the surrounding correlation pattern did not fit. The results of the quantitative analysis aided in the selection of case study areas where historical research was then conducted with the use of Census data, historical maps, aerial photography, newspapers, and other archival documents to determine what factors may have contributed to these relationships.

I expected to find a mixture of results for all analysis years: areas of positive correlation, areas of negative correlation, and areas of no significant correlation at all due to wide variation in the ways that different parts of New York City developed. Specifically, I hypothesized that negative correlations would be found for 1910 and 1920 in areas of the city not accessible by trolleys or subway lines, making high elevation areas less desirable. I assumed that some of these areas might exhibit positive correlation after 1940 when transportation technology had improved and expanded such that the desirability of higher lands would be more likely to outweigh the effort to reach those areas. However, I expected that for some neighborhoods, negative correlations would persist. Through qualitative historical research, I attempt to uncover factors that have contributed to the negative or positive correlations between land
elevation and socioeconomic status as well as factors that may have spurred changes in those relationships over time.
LITERATURE REVIEW

Studies that explore the role of land elevation in the distribution of socioeconomic classes have been scarce. Attempts to quantify the relationships are even more rare, perhaps due in part to the complexity and tediousness of calculating and assigning mean elevation values to individual census areas or other administrative districts before the wide availability of GIS. A review of attempts to assess and quantify the role of land elevation in the residential distribution of socioeconomic classes follows.

Though it was theorized prior to industrialization, Johann Heinrich von Thunen’s model of agricultural land use illustrates the balance between transportation costs and land cost (1826). He proposed that for "Isolated States" where cities are centrally located and self-sufficient with no external influences, the value of land decreases as the location moves farther from the city center. One of the assumptions of the model is that the land is completely flat with no terrain interruptions such as rivers or mountains. William Alonso’s bid-rent model builds upon von Thunen’s distance-cost theory by including residential and commercial land uses (1964). Alonso’s model also assumes that land is completely flat with no terrain interruptions. Other geographers and economists have agreed that an inverse relationship exists between land values and distance from a Central Business District (CBD) (Haig, 1926; Alonso, 1960; Hoyt, 1933; Hoyt, 1960; Sefried, 1963; Mills, 1969).

Ernest Burgess’s renowned concentric zone model posited that cities are divided into several rings radiating from the city’s central business district, and that residents of each zone migrate to outer zones as they become more prosperous in an attempt to escape crowding and pollution associated with city centers (Park & Burgess, 1925). Less well-known is his 1929 model of vertical residential segregation. This later model suggests that for cities with substantial hills, vertical distance from the central business district would segregate residents
according to class. Burgess theorized that people would be willing to pay more for the superior amenities offered by high elevations – cleaner, cooler air, and a respite from the pollution, crowding, and noise of the city centers typically located in low elevation areas.

Two decades after Ernest Burgess published his altitude zone theory, Hans Blumenfeld conducted a study of Philadelphia in an attempt to establish a correlation between land elevation and rental value (1948). Based on 1940 data, Blumenfeld concluded that rental values were more closely correlated with elevation than with any other factor he studied, including age of building structure and whether or not the residence was located within the city limits. He suggested six possible reasons why homes at higher elevations command higher rent values in his study:

1) Higher altitudes have a climate advantage, allowing homes to stay cooler in the summer.

2) The rolling piedmont country is scenically more attractive than flat plains.

3) Low-cost housing developments of straight, unbroken houses are not easily built on rolling terrain.

4) Low-lying areas have been developed largely by industry due to their proximity to water and rail transportation; low-income groups live there to be close to their places of work.

5) Residents with economic means move to higher altitudes to avoid smoke, dirt, and noise from industry sources in low-lying areas.

6) Members of high-income groups tend to prefer living with other high-income people, strengthening the separation of social classes. Zoning laws have also strengthened the separation.
In a 1959 article, Blumenfeld expanded upon his ideas and suggested that affluence may have only begun to coincide with land elevation after the turn of the 20th century. It was around this time, he argues, that transportation technology advanced enough to allow wealthier residents to easily commute to and from the urban center. He points to several examples in Paris where aristocratic neighborhoods are located in valleys and working-class neighborhoods are found in the high elevation areas. This observation suggests that the relationship between land elevation and socioeconomic status largely depends upon the time period in which a particular area developed.

In a study of Syracuse, New York, based on 1960 Census data, Charles Willie found that while the age of dwelling units was a better predictor of the socioeconomic status level of a neighborhood, a significant and direct association between elevation and socioeconomic status indeed exists (1961). Willie also remarks that in other countries slums inhabit hilly sites, indicating that the association between land elevation and residential segregation may be largely due to cultural and economic factors.

In his examination of changing land values in Hobart, Australia using data from 1847, 1901, and 1954, Robert Solomon noted that “residential affinity for elevated sites and harbor views is probably the factor which after CBD access has most influenced value-function patterns” (1969). He observed that high and medium residential property values persisted on higher ground in certain areas of the city outside of the study area; however, an in-depth analysis of the dependence of land value on elevation was not conducted.

John Kellogg concurred with the notion that the lowest elevation areas were the least desirable. He noted that for southern cities in 1865, similar to the pattern found in modern times, high elevation residential sites were more valuable than poor drainage low-lying areas (1977). Kellogg proposed that this valuation was partially due to the association of bottomlands
with disease, and found that new African-American settlements were by far most commonly found in these undesirable low-lying areas.

The rural-urban fringe, also referred to as simply the urban fringe, was described by Robert E. Dickinson as existing “on the outer borders of the city, between the areas of urban and rural land use . . . an intermediate zone which shares the characteristics of each” (p. 120). John Swauger’s study of 1815 non-industrial Pittsburgh found that both the poor and the wealthy lived on the urban fringe, theorizing that underdeveloped transportation technology explained the presence of both, as low-income residents could not afford the convenience of living near the urban center while extremely wealthy residents simply did not need to travel to work in the urban center on a daily basis (1978). In his study of Boston’s peripheral communities, Henry C. Binford described urban fringe land uses as a mixture of “scattered residences and small farms with storage and marketing facilities, noxious industries, dumps, prisons and similar institutions, cemeteries, and other land-intensive, city-related but often city-rejected phenomena” (1985, p. 6).

William Meyer examined the correlation between land elevation and mean household income by census tract for seven New England cities, using 1990 Census data (1994). The elevation of each census tract was determined by the highest-value elevation contour line within each census tract. Meyer only studied inland cities because water frontage has been known to increase the desirability of neighborhood, raising the mean household income for those areas. Meyer found positive correlations for each city, with $r^2$ values ranging from 0.57 to 0.74.

Meyer later expanded upon Blumenfeld’s 1959 observation regarding the importance of historical context, arguing that the significance of topography on urban form may be distorted by “the assumption that the same features should always and everywhere matter in the way they do here and now” (2005, p. 774). This important concept is hardly new, yet seldom
acknowledged. In his 1922 observations of Paris, Raoul Blanchard proposed that the same urban site features may be assets in one historical setting, meaningless in another setting, and liabilities in yet another (as cited in Meyer, 2005). Similarly, Homer Hoyt concluded in an examination of land value patterns in United States cities since 1760 that “there is no model or principle for distribution of land values applicable to all times and places” (1960, p. 109). Meyer’s Worcester study suggests that before the 20th century, the difficulty of access to high lands may have outweighed its attractions, leading to its inhabitance by the poor rather than the rich (2005). He dubbed this area the “vertical fringe,” a counterpart to the previously discussed urban fringe, and tested his hypothesis by examining residential patterns of Worcester using 1891 occupation data as a proxy for socioeconomic class. Meyer found that on most of the highest land, slums and working-class residences indeed predominated.

In a more recent study, Meyer examined the historical residential patterns of Syracuse, New York (2012). He proposes three distinct time periods whereby elevation plays the role of either resource or resistance to residents. For the period from 1782 to 1825, elevation was a resource because the better-drained uplands were easier to cultivate, less subject to disease, and presented a military advantage. For 1825 to 1888, elevation was a resistance due to the difficulty of access to upland settlements compared to lowland settlements that were easily accessible by steam powered railroad or water transportation. Finally, from 1888 to the present, Meyer suggests that elevation once again has become a resource as electricity powered railroads and automobiles have allowed easier access to the clean air and pleasurable views of the upland neighborhoods.

In both studies of Worcester and Syracuse, Meyer stresses that while the upland areas became more desirable after transportation technology allowed residents to easily access higher elevations, land uses that were suitable during the period where elevation was a resistance may
still predominate, particularly in older areas of cities. Specifically, facilities and land uses that demanded large areas of cheap land such as hospitals, university campuses, and cemeteries may still be found on higher lands.

Ueland and Warf’s 2006 study of 146 southern cities in the United States based on 1990 and 2000 Census data marked the first time GIS was used to aid in the calculation of altitudinal residential segregation. They tested the hypothesis that Black residents are disproportionately concentrated in lower-elevation areas by calculating correlation coefficients for race and elevation. This study focused on racial segregation instead of income segregation in order to incorporate formal and informal discriminatory practices, differing residential preferences between ethnic groups, and other socioeconomic constraints such as education and access to information about housing opportunities. Results for interior cities confirmed the hypothesis; however, an inverse relationship existed near the coast where White residents dominated high-value coastal areas.

Further evidence of the complexity of the relationship between land elevation and socioeconomic class can be found in the 1890 United States Census Bureau vital statistics report for the City of New York, which at the time included Manhattan and a part of the Bronx, and the City of Brooklyn. Death rates may be used as an indicator of socioeconomic status of the residents since poorer residents more often experienced living conditions conducive to the spread of disease and generally have less access to proper medical care. For both cities, death rates, exclusive of stillbirths, generally increased as elevation decreased, an indication that socioeconomic status correlates positively with land elevation. The death rate from tuberculosis, a highly contagious bacterial infection that thrives in lower elevation neighborhoods where fresh air is lacking, was indeed greatest in the lowest elevation sanitary districts. The correlation between death rates and elevation was not found to be perfectly linear, however. For both New
York and Brooklyn, the death rate for the highest elevation districts (above 100 feet) was actually higher than districts with average elevations between 80 and 100 feet. For deaths attributed to malaria in New York, the rate was by far highest in the highest elevation sanitary district (USCO, 1895). This finding was interesting because malaria typically thrives in low-lying, poor drainage areas with stagnant waters where mosquitoes breed. One potential explanation for this finding may be that located within Ward 24 was “The Home for the Incurables,” now St. Barnabas Hospital in the Bronx, possibly contributing to the high death rates in this high-elevation area. However, the fact still remains that for both the cities of New York and Brooklyn, the overall death rate for the highest elevation districts was higher than for districts between 80 and 100 feet, an indication that perhaps some of the poorest residents did indeed live on the hilltops, as suggested by Meyer (2005, 2012).

Carlos Villarreal examined the influence of initial environmental conditions at the time of settlement on the distribution of income and housing prices in Manhattan. Low-income households initially settled in poor drainage areas, associated with flooding and disease, because of the low housing prices. He found that from 1830 through 1860, housing prices rose with distance from historical marsh areas, which in turn influenced the distribution of household income values in 1880. At least since 1880, high-income households have preferred to reside away from historical marsh areas where lower income households live. This pattern continued to exist through 2011, well after infrastructure technology and medical advancements rendered the direct influence of poor drainage obsolete (2013).

Table 1 below summarizes previous related studies, and includes the geographic extent of the study, geographic unit of analysis, variables examined, methods utilized, and results.
### Table 1

**Related Studies**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Geographic Extent</th>
<th>Geographic Unit</th>
<th>Variables Examined</th>
<th>Method</th>
<th>Findings</th>
</tr>
</thead>
</table>
| Blumenfeld, 1948 | Philadelphia, PA | - 1940 Census Tracts | - Land elevation  
- Rental values  
- age of housing structure  
- distance from city center  
- within or outside city limits (binary) | Line Graph | Rental values were more strongly correlated with elevation than any other factor |
| Willie, 1961 | Syracuse, NY | - 1950 Census Tracts | - Land elevation  
- Neighborhood socioeconomic status level (based on composite socioeconomic index: average home value, average monthly rental, percent of single family dwelling units, median school year completed by adult pop, percent of working men who were operators, service workers, and laborers)  
- age of dwelling structure | Pearson Correlation | Significant association between elevation and socioeconomic status (Pearson Correlation Coefficient of .73), but age of dwelling structure was a better predictor (.83) |
| Kellog, 1977 | Lexington, KY Atlanta, GA Richmond, VA Durham, NC | - 1970 Census Blocks | - Land elevation  
- Predominantly African-American block or not (binary) | Visual analysis of maps | New African-American settlements were most commonly found in low-lying areas. |

(Table 1 Continues)
(Table 1 Continued)

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Data Source</th>
<th>Methods</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>Hartford, CT</td>
<td>- 1980 Census Tracts</td>
<td>- Land elevation - Mean household income</td>
<td>Pearson Correlation - Moderately strong positive correlations were found between mean household income and land elevation.</td>
</tr>
<tr>
<td></td>
<td>Waterbury, CT</td>
<td>- Cambridge, MA</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Lowell, MA</td>
<td>- Springfield, MA</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Worcester, MA</td>
<td>- Manchester, NH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Syracuse, NY</td>
<td>N/A</td>
<td>- Land use</td>
<td>Visual analysis of maps - 1782-1825: Elevation was a resource. 1825-1888: Elevation was a resistance. 1888-present: Elevation is once again a resource.</td>
</tr>
</tbody>
</table>
SIGNIFICANCE OF RESEARCH

Research on urban residential segregation and urban land use could gain considerably from a geographic approach that explicitly addresses land topography within a historical context. From an environmental justice perspective, the relationships between elevation and social class help us to understand both historical and current quality of life issues for New York City’s most vulnerable residents. Specifically, I hope that the findings of this research will: 1) contribute to urban growth and environmental justice literature by informing our understanding of city development and residential segregation, 2) demonstrate the use of spatial data analysis methods in the exploration of historical urban geographic phenomena, and 3) serve as a stepping-off point for a more in-depth analysis of how land topography has helped to create and reshape New York City’s human landscape, as well as how factors such as public policy and climate change contribute to those transformations.
The purpose of the preliminary analysis was to demonstrate the use of multiple data analysis methods to explore the relationships between land elevation and socioeconomic status, and to give an example of an initial qualitative historical analysis of one chosen area. For a sampling of analysis years (1910, 1950, 1970, and 2000) Ordinary Least Squares (OLS) linear regressions were performed between the mean absolute elevation for each Census Tract (the independent variable) and the variable selected as an indicator of socioeconomic status (the dependent variable) at the city and borough levels. OLS regressions were also performed on two neighborhoods that were known to conform to the traditional theory of the positive association between land elevation and socioeconomic status — Park Slope in Brooklyn and Jamaica in Queens.

For all analyses at the city and borough level, $r^2$ values were extremely low, ranging from 0.00 to 0.16, indicating that none of the variability in socioeconomic status can be explained by land elevation. For the two neighborhoods that were already known to conform to the traditional theory, no significant relationship between the two variables was found in 1910, however, for the subsequent analysis years, positive relationships with large $r^2$ values and significant at the .05 level were found, ranging from .32 to .61 for Jamaica and .39 to .51 for Park Slope. It is important to note that these preliminary OLS regression results may be misleading because the socioeconomic data were not transformed despite the fact that the 1910 literacy rate is negatively skewed and income for all other analysis years is positively skewed.

The highest point in Staten Island, as well as New York City, is Todt Hill, at 410 feet above sea level (Figure 1). Choropleth mapping of the socioeconomic status variables revealed that the highest elevation Census Tract in Staten Island had the lowest literacy rate in 1910 (Figure 2), and a Census Tract in the same area had the lowest median household income in
2000 (Figure 3), confirming William Meyer’s suggestion that high elevation areas of low socioeconomic status may persist despite changing factors such as transportation technology advancement (2005).

*Figure 1.* Staten Island Topography and Highest Point. The highest point, Todt Hill, is represented by a blue triangle.
A Geographically Weighted Regression (GWR) was performed on the 1910 Census Tract data for the entire city. Literacy rates, which were extremely negatively skewed, were transformed to more closely conform to a normal distribution resulting in more normally distributed residuals. The GWR model was specified with mean elevation as the independent variable, literacy rates as the dependent variable, fixed kernel type (as opposed to adaptive), and Akaike Information Criterion (AIC) minimization as the bandwidth selection method.

The GWR regression results included B coefficients, t-values, and residuals. B coefficients were mapped to visualize areas of local positive correlation, local negative correlation, or no local correlation (Figure 4). Redder areas indicate areas of more positive correlation, while bluer areas indicate areas of more negative correlation. T-values for the B
coefficients were then mapped to show statistical significance. Darker colors indicate higher statistical significance. All Census Tracts with t-values of less than 1.96 were grayed out, indicating that we are less than 95% confident that these B coefficient values are indicative of the actual local relationship between land elevation and socioeconomic status (Figure 5). Darker colored Census Tracts have higher t-values, signifying areas of greater confidence in the B coefficient values.

**Figure 4.** B Coefficient Results of a GWR Regression between 1910 Literacy Rates and Elevation. Redder colors represent more positive B Coefficient values. Bluer colors represent more negative B Coefficient values.

**Figure 5.** T-Values of the B Coefficient Results of a GWR Regression between 1910 Literacy Rates and Elevation. Darker colors represent higher t-values. Census Tracts with t-values < 1.96 have been grayed out.

These maps indicate that in 1910, a positive relationship between land elevation and literacy rate existed around lower Manhattan and downtown Brooklyn, particularly in the areas along the East River, and we can be at least 95% confident of these results. Although large areas of negative correlation and small areas of positive correlation are found in the areas farthest
from the Central Business District of New York City, we cannot be 95% confident of these results.

Large absolute residual results from the GWR regression were also mapped to highlight Census Tracts whose B coefficients greatly deviated from that of the surrounding Census Tracts (Figure 6). Census Tracts with large residuals are also good potential candidates for case study areas because through historical analysis we can uncover what specific factors may have contributed to a neighborhood not exhibiting the same relationship between land elevation and socioeconomic status as its surrounding area.

In this example, I have focused in on a Census Tract in the Bronx with a large absolute residual value (Figure 7). The model predicted a much higher literacy rate than was found in this particular Census Tract. The mean elevation of the Census Tract was only slightly lower than the surrounding Census Tracts. However, the literacy rate for the people who lived within this Census Tract (64%) was much lower than the literacy rates for the adjacent Census Tracts (99%, 91%, 96%, 99%, and 99%). Using a 1924 aerial photograph of New York City, I was able to determine that a rail yard existed within this Census Tract in 1924. Further research using a 1921 Bromley Map showed the presence of residential dwellings along with a poultry market, steam laundry, and various junkyards throughout the area surrounding the rail yard. A 1908 Sanborn Map of the area confirmed the existence of the rail yard in 1908 along with residences and manufacturing facilities. These factors may have made living in this area undesirable, therefore lowering the value of the land, allowing for low-income residents with presumably lower literacy levels to live in this neighborhood. Further historical research could help determine whether this particular Census Tract remained a consistently low socioeconomic status area relative to its surroundings throughout the 20th century, and whether the decommissioning of the rail yards and subsequent development of recreational, commercial,
and institutional facilities over the former rail yard site affected the relative socioeconomic status of this area.

**Figure 6.** Large absolute residual results of a GWR regression between 1910 literacy rates and elevation. Red Census Tracts indicate Census Tracts with the highest residuals.

**Figure 7.** Large absolute residual census tract and 1924 aerial Image.

These preliminary results support the hypothesis that the relationship between land elevation and socioeconomic status is not a static positive correlation. As previously discussed, OLS linear regression models are global and therefore may mask relationships between spatially distributed variables. The relationships depend upon the scale of analysis as well as the historical context of the area in question. These results reaffirm the necessity of integrating both quantitative and qualitative methods in studying the relationships between land elevation and socioeconomic status, an approach which may be applicable to other studies of urban form.
The following section is a broad presentation of the research approach I have utilized to explore the relationships between land elevation and socioeconomic status. The mixed-methods approach I have chosen is explained and project flow charts are presented to summarize the methods involved in each step of the approach. The detailed quantitative and qualitative methodologies are presented separately in the Quantitative Analysis and Qualitative Analysis sections.

Exploratory Data Analysis (EDA) techniques were performed for each analysis year in order to understand the major characteristics of the data sets such as whether a discernible relationship exists between elevation and socioeconomic status, the direction of the relationship, or whether no relationship exists at all. Ordinary Least Squares (OLS) regressions were conducted so that results could be compared with previous studies as well as to demonstrate how this global statistical method may not be the most appropriate technique to use when working with spatially distributed data. The local spatial statistical method Geographically Weighted Regression (GWR) was performed on the same data to generate a regression coefficient and standardized residual value for each observation. These quantitative analyses were performed on data for 1910, 1920, 1940, 1950, 1960, 1970, 1980, 1990, 2000, and 2010. Note that the year 1930 is not included because socioeconomic data were not publicly available at the Census Tract or Health District level for that year.

Six types of maps were generated for each year: a choropleth map based on the socioeconomic status indicator value (literacy, median years of education, income, etc.), a socioeconomic status outlier map, a regression coefficient map, a regression coefficient map with a local $r^2$ transparency overlay, a standardized residuals map, and a map of the standardized residuals clusters. These maps helped to pinpoint areas of the city where critical
variables are missing from the explanation of the relationship between land elevation and socioeconomic status and are thus deserving of further qualitative research. Through historical research of the case study areas using resources such as newspaper archives, aerial photography, tenement housing maps, and Sanborn fire insurance maps which contain detailed land use information, I attempted to uncover factors that explain how these relationships may have developed and changed over the past century and how they might continue to evolve.

The following project flow charts outline the data input and major processing steps involved in the study. Figure 8 is the overall project flow chart which incorporates the data preparation, quantitative analysis, and qualitative analysis steps. Figure 9 details the data preparation process, specifically the use of elevation and Census data to create Census geographies containing demographic information along with absolute and relative elevation data. The flow chart in Figure 10 shows how Exploratory Data Analysis (EDA), Ordinary Least Squares (OLS) regression, and Geographically Weighted Regression (GWR) were used to better understand the data as well as generate statistical output and maps that aided in the selection of five case study areas. Finally, Figure 11 presents the qualitative analysis steps, including the synthesizing of information from historical maps, aerial photography, and archival research to uncover possible explanations for the relationships between land elevation and socioeconomic status found in the chosen case study areas that may be applicable to other New York City neighborhoods as well as other urban areas.
Figure 8. Top level project flow chart.

Figure 9. Data preparation flow chart.

\(^1\) SES = Socioeconomic Status
Figure 10. Quantitative analysis flow chart.

Figure 11. Qualitative analysis flow chart.
DATA REQUIREMENTS

The following is a list of data requirements for this project.

1. Base Maps
   a. New York City borough boundaries
   b. New York City street centerlines
   c. Other geographic layers as needed for visual layout and analysis

2. United States Census Polygon Boundaries and Data
   a. 1910 Census Tracts (Literacy Rate)
   b. 1920 Census Tracts (School Enrollment)
   c. 1940 Health Areas (Median years of school completed)
   d. 1950 Census Tracts (Median Income of Families and Unrelated Individuals in 1949)
   e. 1960 Census Tracts (Median Family Income in 1959 – Derived from Group Frequency Distribution)
   f. 1970 Census Tracts (Mean Family Income in 1969)
   g. 1980 Census Tracts (Median Household Income in 1979)
   h. 1990 Census Block Groups (Median Household Income in 1989)
   i. 2000 Census Block Groups (Median Household Income in 1999)
   j. 2010 Census Block Groups (Median Household Income 2006-2010)
3. Digital Elevation Model
   b. Historical Census boundary maps
4. Historical maps reflecting topography, land use, property ownership, and building material
5. Historical aerial photography
6. Newspapers, official reports, and other historical resources for archival research
LIMITATIONS

Several limitations must be taken into account when considering the results of this study. Income data were not publicly available from the United States Census for the years 1910-1940. Literacy rate was used as a proxy for socioeconomic status for analysis year 1910. For 1920, the percentage of people between the ages of 5 through 20 who were enrolled in school was used. No data was available at the Census Tract level or Health District level for Census Year 1930, so this year was skipped in the quantitative analysis altogether. For 1940, no suitable socioeconomic data was available at the Census Tract level; however, “median years of education” was available at the Health District level, therefore this variable was used in the quantitative analysis. While income data are available at the Census Block Group level for the years 1990, 2000, and 2010, these data are only available at the larger Census Tract level for the analysis years from 1950 through 1980.

For the 1960 Census, family income data was released as a grouped frequency distribution. To determine the median family income for each Census Tract, the total number of observations per Census Tract was divided by two in order to determine which observation’s income value would be used as the median income value for that Census Tract. The next step was to determine which income range category that observation falls into. Finally, the midpoint of that income range was calculated and assigned to the observation as its median family income value. Since midpoints could not be calculated for the income categories “Less than $1,000” and “$25,000 and over”, the assigned values were $999 and $25,001, respectively. All 1960 income ranges and their assigned values are listed in Table 2 below. It should be emphasized that unlike other Census years where median income is used, these assigned values are not the actual median income – they are estimates of the median income derived using the described method.
### Table 2

**1960 U.S. Census Income Ranges and Assigned Values**

<table>
<thead>
<tr>
<th>Universe</th>
<th>Income Range</th>
<th>Assigned Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Families</td>
<td>Less than $1,000</td>
<td>$999.00</td>
</tr>
<tr>
<td></td>
<td>$1,000-$1,999</td>
<td>$1,499.50</td>
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<td>$15,000-$24,999</td>
<td>$19,999.50</td>
</tr>
<tr>
<td></td>
<td>$25,000 and over</td>
<td>$25,001.00</td>
</tr>
</tbody>
</table>
For decennial Census years 1940 through 2000, the United States Census included two questionnaires. The “short form,” which is distributed to all residents, gathers information such as age, sex, race, and Hispanic origin. The “long form,” which is distributed to about one in every six residents, asks the same questions as the short form along with 50 additional questions concerning housing and socioeconomic information, including household income. Beginning with the 2010 United States Census, the long form was no longer distributed. Instead, housing and socioeconomic data is gathered through the American Community Survey. The American Community Survey randomly chooses about 3 million addresses every year to participate in the survey. Household income data is available at the block group level from the 2006-2010 ACS 5-Year Summary File only. Therefore, the 2010 analysis for this project is actually examining median household income for the 5-year period preceding 2010 rather than a snapshot of the population in 2010. When comparing income between 2000 and 2010, it should be recognized that the differences did not occur after a precise 10-year gap as with the other analysis years. Indeed the effects of the global financial crisis on household income that began in 2008 may not be as evident in the 2010 data since the median income was calculated using data collected from 2006 to 2010.

The American Community Survey uses “jam values” which represent situations where there is an absence of data or the information is an open distribution. One of the jam values for median income, “250001”, actually means “250,000 or more”. In the 2006-2010 ACS 5-Year Summary File, 11 Block Groups have a median income of $250,000 or more, as indicated by the jam value. These Census Blocks may actually have median incomes well above $250,000; however, the ACS data does not show values greater than this number. This suppression of data could skew results because there is no indication of how far above $250,000 the actual median incomes for these 11 block groups are, and what the variance is among these block groups. A vast difference may exist between these 11 block groups; however, the statistical calculations and
data visualization assume they all have a median household income value of exactly $250,001. Suppression of the highest median income values should be taken into account in all of this study’s statistical and visual analyses.

Other data limitations include the fact that the United States Census historically undercounts low-income households, which is problematic for this study since part of the research involves understanding where low-income families live and how elevation affects those settlement patterns. Also notable, this study uses mean and median income as a proxy for socioeconomic class, yet this variable does not account for extreme wealth unrelated to income that is characteristic of many New York families. For both situations (the undercounting of low-income households and the unknown number of extremely wealthy households), qualitative research yielding information such as where undercounting may occur is a good way to supplement the quantitative data.

Finally, it should be acknowledged that elevation changes have taken place across the city over the study period, and these changes are not accounted for in the quantitative analysis. However, after using historical surveys and maps within GIS to calculate the elevation changes in Manhattan between 1819 and 1999, Rose-Redwood and Li concluded that although specific locations experienced significant elevation changes, “the broader spatial pattern of topographic variation has remained largely constant for nearly the past two centuries” (2011, p. 403). The Digital Elevation Model (DEM) utilized for each year of the quantitative analysis was created by clipping a 2000 DEM with the Census geography outline for each year. The qualitative portion of this study describes in detail the historical changes to the physical topography of each case study area.
CHAPTER 2: QUANTITATIVE ANALYSIS

METHODOLOGY

The purpose of the quantitative analysis was to better understand the data using Exploratory Data Analysis (EDA) techniques and to use results from Geographically Weighted Regression (GWR) to help illuminate areas of the city that would be appropriate case study areas for historical, qualitative analysis. Examples of potential case study areas are neighborhoods that do not exhibit the traditionally accepted positive correlation between elevation and socioeconomic status or anomalous parts of the city that do not exhibit the same relationship as the immediate surrounding area. The EDA techniques and statistical methods used are described in detail in the following sections. Finally, the concept of relative elevation and the process of creating a relative elevation model are explained. The quantitative analysis steps are summarized in the Quantitative Analysis Flow Chart depicted in Figure 10 of the Research Approach section in Chapter 1.

SCATTER PLOTS AND BOX PLOTS

Scatter plots help us to better understand the relationships between the independent variable (elevation) and the dependent variable indicative of socioeconomic status (literacy rate, median years of education, income, etc.) such as whether a relationship is present or whether no relationship exists at all. They may also indicate the direction of the relationship (negative or positive) and the degree of correlation between two variables. Scatter plots revealing a pattern of dots that seem to fall along a line indicate a linear relationship which may be appropriate for further analysis through OLS regression, discussed below. A scatter plot with no distinct pattern
of dots indicates that a simple linear relationship does not exist between the two variables; however, this does not mean that a relationship between the two variables does not exist. Localized relationships that vary across space may still exist, and could be revealed through Geographically Weighted Regression (GWR), explained later in this section.

The box plot, also known as the box and whisker plot, succinctly shows the median, dispersion, and outliers within the data. The bottom and top edges of the box, also known as the lower and upper hinges, represent the lower quartile (25th percentile) and upper quartile (75th percentile) of the data, respectively. Therefore, the length of the box indicates the IQR (Interquartile Range) where 50% of the data resides. A horizontal dotted line near the middle of the box represents the 50th percentile. The maximum length of the vertical lines which extend above and below the box (whiskers) is 1.5 times the IQR; however, whiskers will only extend out to the lowest and highest data values. Mild outliers, those that occur between 1.5 and 3 times the box length away from the lower and upper hinges are represented by a circle. Extreme outliers, those that occur more than 3 times the box length away from the lower and upper hinges, are represented by a star.

Box plots are useful to this study because data from the independent variable (elevation) can be divided into three different categories (low, medium, and high elevation) to create three separate box plots juxtaposed against each other in one graphic so that the distribution of the dependent variable within each elevation category can be examined and compared with the other categories. For example, in a given year low absolute elevation Census Tracts may have a larger interquartile range of income values (represented by a larger box) than Census Tracts at medium and high elevations due to more of a variety of income levels living at lower elevations in the city. For this scenario, the distribution of data is more easily visualized by box plots than the scatter plot technique. Relative elevation can also be divided into three categories: low,
medium, and high relative elevation indicating valleys, flat areas, and hilltops, respectively. Box plots can then be created to examine the distribution of the data within those categories.

In this study, scatter plots and box plots were created using the dependent variable (elevation) and the independent variable (the socioeconomic status indicator variable) for each analysis year. The results of the scatter plot analysis helped to determine which box plots would be helpful for further data exploration. In the Analysis section, results of the scatter plot and box plot analyses are discussed.

### PEARSON CORRELATION AND ORDINARY LEAST SQUARES (OLS) REGRESSION

Previous studies that have attempted to quantify the association between land elevation and a sociodemographic measure such as mean income or proportion of African-Americans have calculated the Pearson Product-Moment Correlation Coefficient (PMCC), also known as Pearson’s r (Willie, 1961; Meyer, 1994; Ueland & Warf, 2006). Correlation is a measurement of the association between two variables and does not necessarily designate either variable as independent or dependent. OLS Regression examines the relationship between a dependent variable and one or more explanatory variables. The results of the Pearson Correlation are Pearson’s r, a value ranging from -1 to +1 that describes the direction and strength of the relationship between two variables, and the significance level. OLS Regression results also indicate the direction, strength, and significance of the relationship, as well as how many units the dependent variable changes when the independent variable changes by one unit.

Both Pearson Correlation and OLS Regression assume several conditions, including normally distributed variables and continuous data. One very important assumption is that the
correlation measures a linear relationship between two variables, and therefore the resulting significance value may be misleadingly small or large when a non-linear relationship exists. This is particularly noteworthy when considering that the relationship between land elevation and socioeconomic status may not be perfectly linear. A scatter plot of the data may reveal whether a curvilinear relationship exists between two variables. Neither Pearson’s r nor OLS regression results would capture a curvilinear relationship, resulting in output values indicating weak significance.

Another important assumption to consider, variable independence, applies to standard methods of correlation and regression analysis, such as Pearson Correlation and Ordinary Least Squares (OLS) regression. This assumption is violated when working with spatially distributed data such as land elevation and socioeconomic data. Geographic data almost always exhibit positive spatial autocorrelation, a condition where data from observations located near each other in space are more likely to be similar than data from observations more distant from each other. Walter Tobler succinctly described this concept, commonly referred to as Tobler’s First Law of geography (TFL), by stating, “everything is related to everything else, but near things are more related than distant things” (1970, p. 234). The use of traditional statistical techniques on spatial data may yield inaccurate results, specifically, Type I errors, due to the fact that these methods underestimate the true sampling variance when spatial autocorrelation exists (Haining, 1991). In other words, traditional statistical techniques may lead an investigator to incorrectly reject a null hypothesis believing that there is a relationship between two measured phenomena when in fact the relationship is due to spatial proximity. Spatial autocorrelation may be measured by the Moran’s I statistic, ranging from -1.0 to +1.0, where a positive Moran’s I value indicates clustering, a negative value indicates dispersion, and value of zero indicates randomness (ESRI, 2013).

Additionally, OLS regression, like Pearson Correlation, is a global statistical technique,
which means that the resulting coefficient explains the relationship between the independent and dependent variables throughout the entire study area. This method will not capture spatial variations in relationships between variables throughout a study area. For example, a strong, highly positive correlation may exist between elevation and socioeconomic status in the neighborhoods of West and East Harlem in Manhattan, while the relationship may be strong and highly negative in the western section of lower Manhattan including Battery Park City. Standard regression and correlation analyses between geographically distributed variables would mask rather than capture these very different relationships within the borough of Manhattan.

Past similar studies have used standard, non-spatial methods such as Pearson Correlation to determine the association between land elevation and socio-demographic variables despite the fact that spatially distributed data violate the assumptions of a variable independence. Additionally, Pearson Correlation and OLS Regression assume a linear relationship and are both global measures. For both these reasons, Pearson Correlation and OLS Regression are poor choices for assessing the potentially complex relationships between land elevation and socioeconomic status.

This study first calculates OLS Regression results in order to compare results with previous studies and to demonstrate how this traditional non-spatial statistical technique can generate misleading or inconclusive results when used on spatially distributed data. For each year, OLS regressions were performed between the independent variable (absolute or relative land elevation) and the dependent variable (socioeconomic status measure). Distance from CBD was also included as an independent variable. The results of the OLS regressions were used to determine which independent variable combination is the best predictor of socioeconomic status at the citywide level. The model with the lowest Akaike Information Criterion (AIC) value
was selected as the best-fit OLS model. In the next section, I explain why a geostatistical method, specifically, Geographically Weighted Regression (GWR), was used to assess relationships between spatially distributed variables.

**GEOGRAPHICALLY WEIGHTED REGRESSION (GWR)**

Geographically Weighted Regression (GWR) is a local geostatistical method that can reveal the spatial variation of relationships between independent and dependent variables (Fotheringham et al., 2002). GWR captures and measures the non-stationarity of spatial relationships by performing separate regressions at each observation using other observations that fall within a user-defined neighborhood, weighting closer observations higher than farther observations. The result is a regression equation for each observation rather than a global result for the entire study area. The coefficients and standardized residuals may then be symbolized on a map for visual interpretation of the spatial variation that may exist between the independent and dependent variables.

Traditional statistical techniques regard large standardized residuals as undesirable because they indicate a misspecified model where important variables may be missing from the equation. Qualitative analysis has the potential to reveal missing variables that could eventually be plugged into a Multiple Linear Regression. In this study, large residuals help to highlight areas where local processes may account for unexpectedly low or high socioeconomic status values and therefore would be appropriate for historical, qualitative analysis. This non-traditional use of GWR regression results is evaluated.
Thus far no studies have attempted to assess how the elevation of an area relative to its immediate surroundings may be associated with socioeconomic class. Relative elevation not only may indicate areas of poor drainage or poor air circulation, it could also capture residential perception of height. The Topographic Position Index (TPI) is a measure of relative elevation and provides an indication of whether a location is on a hilltop, valley, slope, or flat plain (Jenness, 2006). I will construct relative digital elevation models from a standard Digital Elevation Model (DEM) using a tool created by Thomas Dilts for ArcGIS Desktop (2009). This Topographic Position Index tool is based on scripts by Jeff Jenness, who created an ArcView 3.x extension that automates the topographic position methodology and concepts originally conceived and published by Andrew Weiss (2001).

Relative elevation models are created by calculating a TPI value for every cell in a raster grid. The TPI value of each pixel is calculated by subtracting the average elevation of its neighborhood from that particular pixel’s elevation value. Locations that are highly elevated relative to the surrounding neighborhood will have positive TPI values, while locations that are low compared to the surrounding neighborhood will have negative TPI values. Flat areas and areas of constant slope result in TPI values near zero.

Neighborhoods may be defined by the user by indicating a radius shape and distance from the center cell. For this study, relative digital elevation models were created with the Topographic Position Index tool using a circular radius of the following sizes: 500, 1000, 1500, 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000, 10,000, 11,000, 12,000, and 13,000 feet. Images of four elevation models for analysis year 2010 are below. Figure 12 shows the DEM using absolute elevation. Figures 13, 14, and 15 are relative elevation DEMs. Note that the
topography of the 500-foot relative elevation model (Figure 13) exhibits a fine-grained bumpiness, while the models calculated with larger neighborhood radiiuses have larger, smoother bumps. Also note that the larger the neighborhood radius, the closer the model becomes to the absolute elevation model. The relative elevation model calculated with the highest neighborhood radius (Figure 15) most closely resembles the original absolute elevation model (Figure 12).
Figure 12. 2010 Absolute elevation.

Figure 13. 2010 Relative elevation (500 ft.).

Figure 14. 2010 Relative elevation (2,000 ft.).

Figure 15. 2010 Relative elevation (13,000 ft.).
DATA PREPARATION

United States Census Tracts were used as the unit of analysis for Census years 1910, 1920, 1950, 1960, 1970, and 1980 because they are the smallest geographic units that contain socioeconomic data for these analysis years. The 1940 analysis utilized health areas since these were the smallest geographic units of analysis publicly available that contain socioeconomic data. Census Block Group analysis will be performed for the Census years 1990, 2000, and 2010 since Census Blocks are the smallest geographic unit containing income data for those years. The year 1930 was excluded from the analysis because no socioeconomic data was available at the Census Tract or Health District levels for this year. All Census Tract geographic files are available for public download from the National Historical GIS (NHGIS) website.

Income was used as a proxy for socioeconomic status where available. While not a perfect indicator, income is used by most researchers as a standard proxy of socioeconomic status. For other years, the proxy variables used were literacy rate, school enrollment, and educational attainment. To reduce the effect of extreme values, median values were used instead of the mean. Table 3 below summarizes the socioeconomic status indicators and the geographic unit of for each analysis year.
Table 3

*Socioeconomic Status Indicators and Units of Analysis*

<table>
<thead>
<tr>
<th>Analysis Year</th>
<th>SES Indicator</th>
<th>Unit of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1910</td>
<td>Literacy</td>
<td>Census Tract</td>
</tr>
<tr>
<td>1920</td>
<td>School Enrollment</td>
<td>Census Tract</td>
</tr>
<tr>
<td>1940</td>
<td>Median Years Education (Males)</td>
<td>Health District</td>
</tr>
<tr>
<td>1950</td>
<td>Median Family Income</td>
<td>Census Tract</td>
</tr>
<tr>
<td>1960</td>
<td>Median Family Income</td>
<td>Census Tract</td>
</tr>
<tr>
<td>1970</td>
<td>Mean Family Income</td>
<td>Census Tract</td>
</tr>
<tr>
<td>1980</td>
<td>Median Household Income</td>
<td>Census Tract</td>
</tr>
<tr>
<td>1990</td>
<td>Median Household Income</td>
<td>Census Block Group</td>
</tr>
<tr>
<td>2000</td>
<td>Median Household Income</td>
<td>Census Block Group</td>
</tr>
<tr>
<td>2010</td>
<td>Median Household Income</td>
<td>Census Block Group</td>
</tr>
</tbody>
</table>

A 20-meter resolution Digital Elevation Model (DEM) of New York City was created by interpolating elevation points within ArcGIS. Using the historical Census boundary polygons, the DEM was modified to reflect city boundaries for each analysis year. Relative digital
elevation models were created with the Topographic Position Index tool in ArcGIS Desktop using neighborhoods defined by a circular radius of the following sizes: 500, 1000, 1500, 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000, 10,000, 11,000, 12,000, and 13,000 feet. The zonal analysis tool was then used to calculate the mean absolute elevation and mean relative elevation values for each geographic unit (Census Tract, Census Block Groups, or Health Districts) for each analysis year.

Input variables were transformed in order to achieve normal distribution of the residuals. Histograms were used to assess the skewness of all data sets, including mean elevation and distance from CBD for each elevation unit, and all measures of socioeconomic status for each analysis year. Methods such as natural log and cube root were used to transform the data, minimizing the absolute skewness statistic and bringing the kurtosis value as close as possible to three – the kurtosis value of a normal distribution. Some variables did not require transformation as their distributions were already close to normal. For 1940, median years of education for males and females were available as separate data sets, yet only the education data for males was chosen because the distribution of that data set was close to normal without transformation. A list of all variables used in the quantitative analysis and how they were transformed is included in Appendix A.

As previously mentioned, an inverse relationship may exist between socioeconomic status and distance from a CBD. CBD boundaries were created for each analysis year, and distance from a CBD was calculated for each geographic unit so that it could be used as a second independent variable in the regression analyses. CBD boundaries were estimated based on historical maps and textual descriptions of business districts, and polygons were created to correspond with those boundaries. A description of the CBD boundaries used for each year can be found in Appendix B.
SCATTER PLOTS AND BOX PLOTS

Scatter plots depicting the relationship between elevation and the proxy for socioeconomic status were created for all analysis years. For each analysis year, a scatter plot was created using each elevation model – the absolute elevation model and 15 relative elevation models calculated using neighborhood radiiuses from 500 feet to 13,000 feet. For all analysis years, no clear association between absolute elevation and socioeconomic status could be derived from the scatter plots (Appendix C).

Scatter plots depicting the relationship between relative elevation and socioeconomic status were also inconclusive. Although New York City exhibits many areas of rugged terrain, most of the city is level, therefore, almost all relative elevation values hover close to zero. These scatter plots tended to show almost all data points clustered around the midpoint (zero) with relatively few data points extending out toward the horizontal edges of the scatter plot. For this reason, box plots were created as an alternative way to visualize the distribution of socioeconomic status by absolute elevation and selected relative elevation calculation levels as described in the next section.

Box plots, described below, were created as an alternate way to view the distribution of the data. Rather than creating box plots for every analysis year and elevation model, box plots were generated for three analysis years (1910, 1940, and 2010) using absolute elevation and three relative elevation calculation levels (500, 1000, and 2000 feet). The box plots were created in order to determine if they could give us better information than the scatter plots. Box plots can be found in Appendix D.
By dividing the independent variable (elevation) into distinct categories (low, medium, and high elevation) the distribution of the dependent variable data can be more carefully examined with box plots. For each independent variable category, box plots were juxtaposed against each other in order to compare the distribution of the data within each category. This method also allowed the relative elevation data to be explored in a way that was not possible using scatter plots. Relative elevation for three different calculation levels (500, 1000, and 2000 feet) was divided into low, medium, and high relative elevation, and box plots were created to examine the distribution of the data within those three relative elevation categories. Low relative elevation areas are located in dips or valleys in the land, medium relative elevation areas are generally flat, and high relative elevation areas are located on the tops of hills.

In the absolute elevation box plot for 1910, the category with the lowest median literacy value was the low absolute elevation category. In the relative elevation box plots for 1910, at all three calculation levels (500, 1000, and 2000 feet) the median literacy value did not differ much between the three categories (low, medium, and high relative elevation). The whiskers in the relative elevation box plots calculated at the 2000 foot level indicate that the highest literacy rate residents live in all three relative elevation categories; however, the lowest literacy Census Tracts were located within the medium relative elevation (flattest) areas.

The 1940 box plots show that the absolute elevation category with the least median years of education for males was the low elevation category. The box plots created using relative elevation showed that median years of education for males was almost the same for all three relative elevation categories. However, at both the 1,000 and 2,000 foot calculation level, with the exception of one outlier, the Census Tracts with the highest and lowest median years of education for males were located in the medium (flattest) areas.
Similar to the scatter plots for 2010, no discernible relationship between absolute elevation and median household income could be derived from either the absolute or relative elevation box plots. This determination supports the idea that for 2010 and all other analysis years where the scatter plot did not reveal a correlation between the independent and dependent variables, a global relationship between elevation and socioeconomic status most likely does not exist.

For absolute elevation, the box plots revealed that in 1910 and 1940, in general, the lowest socioeconomic status residents tended to live on the lowest elevation land, however this finding did not hold for 2010. The relative elevation box plots concluded that in 1910 and 1940, the lowest socioeconomic status residents tended to live in the flattest areas, particularly when relative elevation was calculated at the 2,000 foot level; however, in 2010, no association between socioeconomic status and relative elevation was found.

SOCIOECONOMIC STATUS AND OUTLIER MAPS

For each analysis year, choropleth maps depicting the variation in socioeconomic status across New York City were created. The transformed dependent variable selected as the socioeconomic status indicator (literacy, years of education, income, etc.) was classified using the Natural Breaks (Jenks) method and symbolized by a light brown to dark brown color gradient, where darker browns represented higher socioeconomic status.

Outliers were then mapped in order to visualize where high socioeconomic areas are surrounded by low socioeconomic areas (symbolized in red), and where low socioeconomic areas are surrounded by high socioeconomic areas (symbolized in blue). Some of these outlier areas were considered for further examination to determine if elevation or another local process
contributed to the outstanding socioeconomic status values in these outlier areas, and are discussed in the Significant Findings section.

Both the choropleth and outlier layers were set to a 50% transparency in order to show the data draped over the hillshaded DEM (Digital Elevation Models) of the city. This method allows the map user to easily interpret areas of high and low elevation as well as the slopes, dips, valleys, and mountainous areas. Choropleth and outlier maps for all analysis years can be found in Appendix E.

<table>
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<th>OLS AND GWR RESULTS</th>
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### ANALYSIS OF OLS AND GWR RESULTS

As explained in the Methodology section, Ordinary Least Squares (OLS) is a common regression technique that assumes a global model to predict the dependent variable (socioeconomic status) using the independent variable (absolute or relative land elevation). Geographically Weighted Regression (GWR) provides estimates of regression coefficients for each geographical location, rather than a global estimate. OLS and GWR regressions were performed for each Census year using the same independent and dependent variables. Models were run using absolute elevation as well as relative elevation calculated at neighborhood radiiuses of 500, 1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000, 10,000, 11,000, 12,000, and 13,000 feet. The results are summarized in the table in Appendix F.

For each analysis year, this table provides the adjusted $r^2$ values and p values for the OLS regressions between absolute elevation and socioeconomic status, absolute elevation plus distance from the CBD and socioeconomic status, and the OLS regression equation that
produced the lowest AIC (Akaike Information Criterion) value for each year. The table also provides the adjusted $r^2$ values for the GWR regressions between absolute elevation and socioeconomic status using a 1 mile bandwidth as well as the GWR regression with the lowest AIC value for each year.

The adjusted $r^2$ value is the proportion of variability in the dependent data that is explained by the regression model while accounting for the number of independent variables. For all analysis years, the adjusted $r^2$ values were very low in the OLS regression models where the independent variable was absolute elevation, with the highest value (.120) resulting from the 1910 regression of literacy against absolute elevation. The addition of distance from CBD only marginally improved the model, producing an adjusted $r^2$ value of .140. Distance from CBD improved the 1950 model most, which had adjusted $r^2$ values of .025 and .225 with and without distance from CBD, respectively. The lowest AIC among all OLS regression models was selected as the “best” OLS model for each analysis year. The best OLS models for 1910, 1940, and 1950 utilized absolute elevation as an independent variable rather than relative elevation. For all other years, the best OLS models used relative elevation calculated with a 13,000 foot neighborhood radius, with the exception of 1920 which used relative elevation calculated with a 9,000 foot radius.

Similar to the OLS regressions, the lowest AIC among all GWR regression models was selected as the “best” GWR model for each analysis year. In the GWR models, the addition of distance from CBD as an independent variable produced a lower AIC value for all but two analysis years, 1960 and 1970. Relative elevation was found to be a better determinant of socioeconomic status than absolute elevation for three of the ten analysis years, 1910, 1960, and 1970. The relative elevation calculation level that yielded the best results was 13,000 feet with the exception of analysis year 1960, which was 12,000 feet. As described in the Relative
Elevation section, the maximum relative elevation calculation level used was 13,000 feet. Since relative elevation calculated at this level was found to have the lowest AIC of all models tested for 1910 and 1970, it is possible that larger calculation levels may yield even lower AIC values for those years.

For each analysis year, the AIC values for the best OLS or GWR models were compared to select the best model. The AIC for the best GWR model was lower than the best OLS model for all time periods, indicating the local model is a more stable model, and that the relationship between land elevation and socioeconomic status is a local relationship rather than a global relationship. Some parts of the city may see a strong positive relationship between the independent and dependent variables, other areas may have a weak positive association between variables, and still in other parts of the city a negative relationship may exist. In each of the GWR models, as the bandwidth was lowered, so, too, was the AIC value. Since lower AIC values indicate a better fit model, this suggests that a very localized relationship may exist between the independent and dependent variables. Further discussion of the regression results will mainly refer to the GWR regression analysis results as the GWR models were found to be better fits for this study than the OLS models.

The highest local $r^2$ value for the 1920 GWR model was only .177, much lower than the $r^2$ values for all other analysis years. This extremely low $r^2$ value indicates an unstable model where the data may be unreliable. For this reason, no 1920 maps were used in the case study area decision process. Since the GWR model performed better than the OLS model in all analysis years, the decision was made to visualize the best-fit GWR results for all analysis years, with the exception of 1920 because the best-fit model for that year was determined to be invalid.
GWR COEFFICIENT MAPS

GWR analysis results include a coefficient, one for each geographic unit, expressing the local relationship between the independent and dependent variables. These coefficients were then mapped using a blue to red color gradient (Appendix G). Polygons with negative coefficient values were symbolized as blue, with more negative coefficient values represented as deeper blue. Positive coefficient values were symbolized from the beige to red color gradient, with more positive coefficients symbolized as closer to red. These maps indicate areas of the city where negative associations between elevation and socioeconomic status may exist, and areas where positive associations may exist.

The GWR analysis results also include an \( r^2 \) statistic indicating the goodness of fit of the local model, in other words, how well the independent variable or variables explain the variance in the independent variable. I created the following formula to transform the \( r^2 \) statistic to a value that was utilized to set the transparency level of a white overlay feature class.

\[
(\text{local } r^2) + (1 - (\text{maximum local } r^2 \text{ value for entire dataset}) \times 100)
\]

Geographic units with higher \( r^2 \) values were assigned a higher transparency value in the white overlay feature class. The desired effect is that areas of the city with higher \( r^2 \) values, indicating a good local fit, stand out, while areas with lower \( r^2 \) values indicating the local model did not fit as well are obscured by the overlay feature class. GWR coefficient maps with the transparency overlay indicating goodness of are also located in Appendix G. For most analysis years, the effect of using the transparency overlay to allow geographic units with higher \( r^2 \) values to stand out was not successful. Future attempts to use local \( r^2 \) values in a transparency overlay to highlight areas of the city where the model fits well may consider other formulas to transform the \( r^2 \) statistic.
The GWR analysis also generates standardized residual values, one for each observation. These residual values express the degree to which the local model over or under predicted the dependent variable value. The standardized residuals from the best-fit GWR models were mapped in order to pinpoint areas where the model greatly underestimated or overestimated the dependent variable values (Appendix H). In well-specified regression models, residual values will be randomly distributed throughout the entire analysis area. Locations where high residuals or low residuals cluster indicate areas where the model is missing at least one key explanatory variable. For this study, areas where clustering occurs were considered to be potential candidates for case study analysis, since further qualitative research would be necessary to uncover missing variables that could help explain the local relationships between elevation and socioeconomic status.

A Moran’s I spatial autocorrelation test was performed on the GWR residuals to determine spatial randomness or clustering. As expected, the residuals for all GWR regressions for all analysis years were found to be autocorrelated, or clustered. For all analysis years, the clustering was found to be significant at the .01 level, indicating less than 1% likelihood that the clustered pattern could be the result of random chance. Clustering of the residuals indicates that at least one critical explanatory variable is missing from the model. In areas where negative residuals clusters are found, variables other than elevation and distance to a CBD may be contributing to the lower socioeconomic status values. Examples of these types of variables include the presence of public housing and close proximity to noxious land uses. Conversely, clusters of positive residuals indicate areas where local processes other than elevation and distance to a CBD contribute to higher socioeconomic status numbers, for example proximity to public transit or other amenities.
SIGNIFICANT FINDINGS

Scatter plots (Appendix C) and box plots (Appendix D) were created to better understand the major characteristics of the data as well as the relationships between elevation and socioeconomic status. For analysis year 1910, scatter plots revealed no clear correlation between absolute elevation and literacy rate. Box plots created for the same year showed that when absolute elevation was divided into low, medium, and high elevation categories, the lowest median literacy was found in the lowest elevation category. The box plots created using the relative elevation categories (low, medium, and high relative elevation) indicate that the highest literacy Census Tracts are situated in all three categories; however, the lowest literacy Census Tracts were situated in the flattest areas of the land. For 1940, scatter plots showed no clear correlation between absolute elevation and median years of education for males. Box plots showed that of the three absolute elevation categories (low, medium, and high absolute elevation) the low absolute elevation category had the lowest median years of education for males. The box plots created using the relative elevation model calculated at the 2000-foot neighborhood radius revealed that the Census Tracts with the highest and lowest median years of education all lived in the flattest parts of the city. For all other analysis years, no clear association between absolute elevation and socioeconomic status could be derived from the scatter plots or the box plots. This finding supports the idea that the relationship between land elevation and socioeconomic status is not a linear association that can be applied globally throughout the city.

OLS and GWR regressions were performed for each analysis year, with elevation and distance from CBD as the independent variables and the proxy for socioeconomic status as the dependent variable. The model with the lowest Akaike Information Criterion (AIC) value was selected as the best-fit model for each analysis year. For every analysis year, the model with the
lowest AIC value was a GWR model (instead of an OLS model), indicating that the relationship between land elevation and socioeconomic status is local rather than global. Among the GWR models, as the bandwidth was lowered, the AIC values also became lower, suggesting a very localized relationship. The addition of distance from CBD as an independent variable produced lower AIC values for all analysis years except 1960 and 1970. This finding suggests that distance from CBD should be taken into account when examining the relationship between elevation and socioeconomic status. Relative elevation was found to be a better determinant of socioeconomic status than absolute elevation for three of the ten analysis years (1910, 1960, and 1970), suggesting that relative elevation may be an important determinant of socioeconomic status and should be considered in this analysis as well as in future related studies.

While the GWR models did perform better than the OLS models, the adjusted r² values of the best-fit GWR models ranged widely. The best-fit GWR models for analysis years 1910, 1920, and 1940 all yielded very low adjusted r² values (.193, .087, .251, respectively) indicating a misspecified model. The adjusted r² values for the remaining analysis years were slightly higher, ranging from .405 to .565. However, it should be noted that whereas in most studies, regression analyses resulting in low adjusted r² values are generally considered undesirable, in this study the low values support the theory that the relationship between land elevation and socioeconomic status is not a simple linear relationship and is most likely influenced by local processes that may vary over both geographic space and time.

Choropleth maps (Appendix E) created for each analysis year revealed areas of high socioeconomic status and areas of low economic status that persisted over time, such as the Upper West Side of Manhattan and the Lower East Side of Manhattan, respectively. These neighborhoods do conform to the prevailing theory that land elevation is positive correlated with socioeconomic status. However, these maps also show that in some large areas, mainly in
the outer boroughs, a checkerboard-like mix of socioeconomic statuses is found that does not seem to be solely related to elevation. One particular area that stands out is the highest elevation Census Tract in Staten Island in 1910 which has a very low literacy rate. This particular area of Staten Island continued to show up as a low socioeconomic status area for every year where data was available through the last analysis year, 2010. This area was noted as a possible case study area ripe for historical analysis.

Outlier maps, also located in Appendix E, show areas of high socioeconomic status that are mostly surrounded by areas of low socioeconomic status (“HL” areas, depicted as red on the maps) as well as areas of low socioeconomic status mostly surrounded by areas of high socioeconomic status (“LH” areas, depicted as blue on the maps). While HL and LH areas are scattered throughout the city and do not appear to be geographically stable over time, some HL areas (such as Brooklyn Heights) remained consistent over almost all of the analysis years. As the name implies, Brooklyn Heights is situated on a bluff that rises sharply from the East River. Other HL outlier areas that appear in multiple years were found along the ridge of the terminal glacial moraine which runs along the backbone of Long Island, particularly in the 1940, 1950, 1960, and 1980 outlier maps. These HL areas support the notion that higher socioeconomic status residences are found on high elevation areas. In general, LH outlier areas were not as consistent over time. This could be partially explained by the creation of public housing developments beginning in the 1930s that placed high concentrations of low-income families throughout the city, causing some of these areas to show up as LH outlier areas on the maps. One LH outlier area that prominently appears in both 2000 and 2010 is the high elevation area of Staten Island discussed earlier, supporting the decision to select it as a case study area.

Elevation coefficients were mapped for the best-fit GWR models for all analysis years using a blue-to-red color gradient (Appendix G). A transparency based on the local r² was
draped on top so that areas with higher local $r^2$ values, suggesting a better-fit local model, showed through more clearly than areas with lower local $r^2$ values. These maps revealed areas of consistently positive correlations between elevation and socioeconomic status throughout the middle of Manhattan and the western portion of Queens, with the exception of analysis year 1950. Conversely, Staten Island rarely exhibited any areas of consistently positive coefficients throughout the 100-year study period. In general, other than these two areas, neither consistently positive nor consistently negative correlations were evident. This finding suggests that the relationships between elevation and socioeconomic status are dynamic and are not consistent over geographic space or time.

The standardized residuals from the best-fit GWR models were also mapped in order to find areas where the model greatly underestimated or overestimated the dependent variable values (Appendix H). Positive standardized residuals indicate areas where the observed dependent variable value (literacy rate, median years of education, income, etc.) is higher than the predicted value. Negative standardized residuals indicate areas where the observed dependent variable value is lower than the predicted value. In addition, cluster maps of the standardized residuals, also found in Appendix H, were created for each year in order to highlight areas where standardized residual values were clustered together rather than randomly dispersed. Similar to the undesirability of low adjusted $r^2$ values discussed above, most studies generally regard large standardized residuals as undesirable because they indicate a misspecified model. However, in this study, large standardized residuals are useful in that they help point us to areas where local processes not included in the model may account for unexpectedly low or high socioeconomic status values.

Several areas were notable for their consistently large standardized residuals throughout the 100-year analysis period. For all analysis years except 1940, the eastern portion of Coney
Island exhibited highly positive standardized residuals, indicating higher socioeconomic status values than were predicted by the best-fit GWR models for each year. Most of the remainder of Coney Island, particularly the middle section, generated negative standardized residuals. The waterfront area of Coney Island is a good potential case study area; despite the consistently low elevation of the entire area, the socioeconomic status of the residents greatly varies from west to east and that pattern is relatively stable over the analysis period.

The waterfront neighborhood of Hunters Point did not exhibit large residuals in the first half of the 20th century; however, for most of the analysis years between 1950 and 2000, positive residuals clusters were found in the neighborhood, indicating areas where the observed income was higher than the value predicted by the best-fit GWR model. For 1910 and 1950, socioeconomic status choropleth maps revealed that the Hunters Point waterfront area exhibited lower literacy and lower median income, respectively, than the inland area. The 1920, 1940, and 1960 choropleth maps did not show a clear distinction between the waterfront and inland blocks. However beginning with 1970, in each analysis year the Hunters Point waterfront area exhibited higher income values than the inland area.

The eastern portion of the midtown Manhattan next to the East River exhibited moderately negative residuals for 1910. However, for each subsequent year beginning with 1940, this area was shown to have consistently highly positive standardized residuals, suggesting a distinct shift in the socioeconomic status of this waterfront area of Manhattan from 1910 to 1940. The shifts in socioeconomic status observed with both the Bellevue and Hunters Point neighborhoods make both of these areas good candidates for the qualitative case study areas.
CHAPTER 3:  QUALITATIVE ANALYSIS

METHODOLOGY

In the quantitative analysis, maps were generated for each analysis year to help pinpoint areas of the city where critical variables are missing from the explanation of the relationship between land elevation and socioeconomic status and are thus deserving of further qualitative research. In the following qualitative analysis, through historical research of selected case study areas, I explore factors that may have affected how these relationships developed and changed over the past century as well as how the relationship may continue to evolve. In addition, I weighed the applicability of these explanations to other neighborhoods in New York City. These steps are summarized in the Qualitative Analysis Flow Chart depicted in Figure 11 in the Research Approach section in Chapter 1.

PURPOSE OF CASE STUDY ANALYSIS

As demonstrated in the quantitative analysis, relationships between land elevation and socioeconomic status in New York City are most likely local rather than global, meaning there is not one single relationship that can be applied across the whole city for the entirety of the study period. The relationships vary across both space and time. The purpose of the case study analysis was to gain a more in-depth understanding of how the relationships between land elevation and socioeconomic status play out over time at a local scale. Five case study areas, one in each borough of the City, were chosen for historical, qualitative analysis.
CASE STUDY AREA SELECTION JUSTIFICATION

The results of the quantitative analysis helped to pinpoint areas of interest that may be appropriate for qualitative, historical analysis. However, the quantitative analysis results alone were not enough to decide upon the case study areas. The chosen case study areas were: the New York City Farm Colony – Seaview Hospital Historic District, the Bellevue neighborhood in Manhattan, the Marble Hill Neighborhood which is now part of the Bronx mainland, Hunters Point in Queens, and the waterfront area of Coney Island in Brooklyn. The rationale behind the selection of each case study area follows.

Choropleth maps created in the preliminary analysis for Staten Island revealed that Census Tracts at the highest elevations of the island had either a very low literacy rate or a very high literacy rate, suggesting that both the poorest and the wealthiest people lived at the highest elevations of the island. This same area of Staten Island continued to exhibit low socioeconomic status even into analysis year 2010, confirming William Meyer’s suggestion that high elevation areas of low socioeconomic status may persist despite transportation technology advancement (2005). This area also prominently showed up as an LH (Low-High) outlier (a low socioeconomic status area surrounded by high socioeconomic status areas) in both 2000 and 2010. These quantitative findings fit in with Meyer’s theory that an inverse relationship may have existed before transportation technology provided residents convenient access between high-elevation residences and lower-elevation central business districts (Meyer, 2005; Meyer, 2012). I wanted to find out whether the factors that influenced these residential settlement patterns reflected or differed from Meyer’s findings in his studies of Worcester, Massachusetts and Syracuse, New York. For these reasons, this high-elevation area in the middle of Staten Island was chosen as a case study area.

The second case study area selected is the Bellevue area on the east side of midtown
Manhattan. Choropleth maps created during the quantitative analysis revealed that this area along the East River exhibited moderately negative residuals for 1910, indicating that literacy rates were lower than predicted by the best-fit GWR model. In addition, maps created by the Bellevue-Yorkville Health Study, a longitudinal study begun in 1926, showed that infant mortality and tuberculosis mortality rates remained consistently high throughout the 9-year period from 1922 to 1931. However, the standardized residuals clusters maps created for subsequent analysis years beginning with 1950 showed consistently high positive standardized residuals for the selected socioeconomic status indicators, indicating higher than expected values for this area. These results suggest that a distinct shift in the socioeconomic status of this waterfront area occurred between 1930 and 1950, a finding that historical qualitative analysis might explain. For both of these reasons, this area of midtown Manhattan along the East River was chosen as a case study area.

The selection of the Marble Hill neighborhood as a case study area is an example of how quantitative analysis alone was not enough to pinpoint areas appropriate for in-depth qualitative analysis. This study area was chosen based on the unique physical topographical history of the neighborhood. The neighborhood on a hill was once physically a part of Manhattan. When the Harlem River Ship Canal was completed in 1895 to allow larger ships to navigate between the East River and the Hudson River, Marble Hill became an island neighborhood. Two decades later, landfill physically connected the neighborhood to the Bronx. Census maps reveal that the neighborhood has remained solidly middle class throughout the past century, conforming to neither traditional geographic theory nor Meyer’s “poor on the hilltops” theory. For this reason and because of its unique topographical history, Marble Hill was chosen as a case study area.
Residuals maps created during the quantitative analysis revealed that although the Hunters Point area did not exhibit large residuals in the first half of the 20th century, for all of the analysis years between 1960 and 2010, positive residuals clusters were found, indicating areas where the observed income was higher than the value predicted by the best-fit GWR model. The 1910 and 1950 socioeconomic status choropleth maps revealed that the Hunters Point waterfront area was of lower socioeconomic status than the inland area, while the maps from 1970 onward showed higher income values for the waterfront area than the inland area. The pattern inversion that began in 1970 warrants in-depth historical analysis to understand how this shift happened. In addition, Hunters Point is currently undergoing a rapid land use change as the industrial waterfront is converted to a residential area with high-rise luxury condominiums. For these reasons, Hunters Point was selected as a case study area.

The final case study area is the western section of Coney Island bordered by West 20th Street, Surf Avenue, West 21st Street on the east, and the water bodies of Gravesend Bay to the north and the Atlantic Ocean to the south. Coney Island initially stood out during the quantitative analysis because the choropleth maps revealed that despite the consistently low elevation of all of Coney Island, the socioeconomic status of the residents greatly varies from west to east, a pattern which remained relatively stable over the past century. The standardized residuals clusters maps revealed negative residuals clusters between 1950 and 2000, particularly in the central and western portions of the peninsula, with the exception of the westernmost tip of the island where the private Sea Gate community is located. The narrower case study area was selected because of the drastic socioeconomic differences between the Sea Gate community and the adjacent neighborhood in the eastern portion of the study area that contains a large cluster of public housing developments.
The Hunters Point and Coney Island case study areas are both low-lying, waterfront neighborhoods that are vulnerable to climate change-related events such as sea level rise, flooding, and storm surge. In 2012, the Coney Island case study area was severely impacted by Hurricane Sandy. The Hunters Point case study area was also affected, though not as severely as Coney Island. In addition to the previously stated reasons, these two areas were also chosen for the qualitative analysis in order to closely examine the neighborhoods’ experiences with past storms as well as how they may fare in the face of more frequent and intense storms due to climate change.
CASE STUDY AREA ANALYSIS

NEW YORK CITY FARM COLONY – SEAVIEW HOSPITAL HISTORIC DISTRICT

No healthier spot within miles of Greater New York can be found, situated on the western slope of Todt Hill, the highest land in Greater New York—it being 368 feet above sea level—a beautiful site with its fertile fields, where any kind of vegetable thrives.

(Annual Report of the Department of Public Charities of the City of New York, 1902, p. 283)

BOUNDARIES OF THE CASE STUDY AREA

The boundaries of this Staten Island case study area correspond directly to the boundaries of the New York City Farm Colony – Seaview Hospital Historic District, designated on March 26, 1985 by the New York City Landmarks Preservation Commission. This study area is bounded by Eastman Avenue, Colonial Avenue, Steers Street, Forest Hill Road, Walcott Avenue, Brielle Avenue, two fences enclosing the Susan E. Wagner High School site, Manor Road, and Rockland Avenue. These boundaries were chosen because the history of the designated district as a former poor farm and a former tuberculosis hospital potentially explains the low literacy of the area in 1910 and the low median income of the area in 2010. This case study area encompasses approximately 0.545 square miles or 349 acres.
Figure 16. New York City Farm Colony case study area and 1924 aerial photograph.

Figure 17. New York City Farm Colony case study area and 2010 aerial photograph.

TOPOGRAPHICAL DESCRIPTION OF THE CASE STUDY AREA

The case study area falls within the high elevation hills in central Staten Island formed by two glacial moraines, the Ronkonkoma and the Harbor Hill moraines. Less than 4,000 feet to the northwest of the study area stands Todt Hill, the highest point of elevation on Staten Island, at 409 feet above sea level (USGS, 2013).
Figure 18. New York City Farm Colony – Seaview Hospital Historic District case study area boundaries and 50 ft. DEM.

HISTORY OF THE CASE STUDY AREA

The following section presents a history of the study area and a discussion of how the topography of the land has played a role in that history. Note that throughout this discussion, the names “Seaview Hospital” and “Sea View Hospital” refer to the same entity, and that the names have been used interchangeably throughout its history. When not quoting sources, I have chosen to use “Seaview” as this is the name used in the New York City Farm Colony – Seaview Hospital historic designation report.
The historic district designation report states that this area’s greatest significance is that it represents the City’s commitment “to improve the quality of both the social and health-care services received by members of its dependent community” (Zavin, 1985). Prior to the establishment of any poorhouse or poor farm on the island, as in much of the United States, the destitute people of Staten Island resided in private homes (Clute 1877). Among the first documented accounts referring to people as objects of public charity on Staten Island is a 1692 petition by local residents to the General Assembly seeking permission to use funds toward the support of indigent residents of the island. By 1710, the existence of a publicly supported house for the poor is evidenced by the Richmond County Supervisors’ decision to build a jail in Cuckelstow, now Richmond Town, on the land “adjoining ye site of ye County poor-house” (Morris, 1898).

A century later, on May 2, 1803, town supervisors and poor masters purchased property for the purpose of providing a county poorhouse. This property, located on Richmond Road between Richmond and New Dorp, was purchased from Joseph Barton, a carpenter, and his wife for $262.50, and included two acres of land including a small frame house. The land was located “near Richmond opposite the Parsonage of Saint Andrew’s Church” (Clute, 1877). The institution functioned for a quarter of a century as a County poorhouse (Morris, 1898). Two decades later, the New York State Legislature passed “An Act to Provide for the Establishment of County Poor-Houses” which provided detailed guidelines in how the poorhouses should be created and run, including the duties of the Board of Supervisors and poorhouse superintendents, how paupers are to be sent to the house, how to deal with disorderly persons, and how to deal with beggar children (“An Act to Provide for the Establishment of County Poor-Houses,” 1824).

Poor farms on which able-bodied residents worked the land were common in the United States beginning in the 19th century. In January of 1829, Richmond County Supervisors held a
public meeting to decide upon the most efficient way of supporting the poor “as the taxes were becoming burdensome” (Clute 1877). The proposition “to purchase a farm large enough to enable the poor to earn their subsistence by their own labor” was adopted, and a committee was appointed to ascertain the purchase prices of available farms. On April 8, 1829, “An Act to Provide for a County Poor-house, in the County of Richmond” was passed, specifying that a sum not exceeding $4,000 was to be raised by a tax for the purpose of purchasing a farm for the poor. The Act also stated that the old poorhouse was to be sold and the proceeds would go toward the purchase of a new poor farm.

§1 The Act entitled An Act to provide for the establishment of County Poor Houses passed November 27th 1824 shall apply to and include the county of Richmond the exception in the said Act notwithstanding but the sum to be raised by a tax as specified in the first section shall not exceed four thousand dollars.

§2 It shall be lawful for the Supervisors of the said county of Richmond to sell the house and ground at present possessed by the county and heretofore appropriated as a poor house and to apply the proceeds towards the purposes expressed in the said Act and to no other purpose. (p. 446).

Shortly thereafter, the county purchased a farm near the highest peak of Staten Island in the town of Northfield for around $3,000 (Clute 1878). A physician was hired at the rate of $19.50 annually to attend to residents, and the farm was furnished with fertilizing materials, wagons, horses, cows, and agricultural equipment (Clute 1877). As of December 1, 1832, 26 people (16 males and 10 females) resided on the farm, though the total number of people supported during the entire year was 38. In 1836, the Supervisors acquired 14.8 acres of salt meadow. Six years later, five acres of woodland adjoining the farm on the west was purchased (Clute 1877).
During the 1850s and 1860s, the poor farm, now part of the political machinery of Richmond County, fell into corruption. The editor of the Richmond County Standard set out to expose the condition of the institution with the help of the most senior member of the Board of Supervisors. Reports from the Board meetings referred to the poor quality of food provided to farm residents and described expensive machinery and farming equipment which were neglected and ruined by weather exposure, revealing the carelessness of the management of the farm. In 1890, Board members presented a bill to the State Legislature that would completely bring about a new management system for the poor farm. Despite efforts by the supporters of the existing farm’s management, the bill was passed and signed by the governor. The keeper of the farm was discharged, and Benjamin J. Bodine was hired to fill the vacancy. Bodine “found the premises in a most demoralized form, and it took much time, labor and money to place the institution and its surroundings in a condition consistent with decency and safety” (Morris, 1898, p. 438).

Until this time, care of the indigent, infirm, and criminals all fell under the umbrella of one City agency—the Department of Public Charities and Correction. On June 5, 1895, then-Governor Levi Morton signed into law Chapter 912, “an act to abolish the department of public charities and correction in the city of New York, and to provide for the establishment of two separate departments in place thereof, to be known respectively as ‘the department of public charities of the city of New York’ and ‘the department of correction of the city of New York’ . . .” (as cited in SCAA, 1895, p. 94). The new law assigned responsibility to the Department of Public Charities for “all hospitals, asylums, almshouses and other institutions belonging to the City or County of New York which are devoted to the care of the insane, the feebleminded, the sick, the infirm, and the destitute . . .” (as cited in SCAA, 1895, p. 96). The Department of Corrections, meanwhile, was given responsibility for “the care, custody and disposition of all criminals and misdemeanants in the City and County of New York . . .” Mayor William L.
Strong, in his first annual message to the Common Council, stated that he was “clearly of the opinion that the care of the indigent should be separate from the discipline of those who have broken the law ...to continue these branches together prevents proper assistance to those incapable of self-support and prohibits the best results from being obtained from corrective discipline” (“Mayor Strong’s Message”, 1895, p. 1). Among the reasons for separating Public Charities from Correction, reformers were worried that law-abiding poor and ill citizens were stigmatized by being associated with convicted criminals.

The consolidation of New York City in 1898 mandated that charitable institutions throughout the five boroughs, such as the Staten Island Poor Farm, be incorporated within the Department of Public Charities. The poor farm was renamed the New York City Farm Colony. The 1902 Annual Report of the Department of Public Charities of the City of New York paints a picture of an idyllic farm community, one that is well maintained and self-sufficient.

While the inmates at other institutions under the Department of Public Charities look around and have nothing whatever to do, here they pay for their board twofold by their labor, working on the farm raising vegetables, not only for themselves but for other unfortunates. No healthier spot within miles of Greater New York can be found, situated on the western slope of Todt Hill, the highest land in Greater New York—it being 368 feet above sea level—a beautiful site with its fertile fields, where any kind of vegetable thrives. (NYCDPC, 1902).

A list of vegetables and fruits successfully grown on the farm is provided in the report. Eggs were produced along with 2,000 pounds of pork and 3 calves. The report also indicates that at least one-third of the vegetables was sent to Blackwell’s Island, now Roosevelt Island, which at the time was home to almshouse residents, hospital and asylum patients, and prison inmates. A lake that furnishes all the ice necessary for the colony’s summer usage and a clean
and abundant water supply is also described: “No less than seven natural springs are on the farm. . . A constant stream of pure spring water is passing through the farm on its way to the Staten Island Sound . . .” (p. 326). The report also indicates that there had been no outbreak of contagious disease in that year.

For experimental purposes, epileptic patients were transferred to the poor farm from various institutions in 1902. The experiment proved to be a success: “light work was set for them with outdoor work, and it proved a boon. Their attacks of fits were less, and they are now our best workers.” The report includes a photograph (Figure 19, below) of “epileptics and semi-able-bodied inmates of New York City Farm Colony at work on farm” (p. 284). A woman holding a baby can be seen, and according to the report one female was born on the farm during this year.

*Figure 19. New York City Farm Colony residents in the 1902 Annual Report of the Department of Public Charities of the City of New York.*
The United States Census Bureau report entitled “Paupers in Almshouses 1904” states that in New York State as of December 31 of the preceding year, 10,793 paupers were living in almshouses. Males accounted for 65 percent of almshouse residents in the state. Ninety-eight percent of New York State’s almshouse residents were White. Among foreign-born almshouse residents in New York State, 62 percent were from Ireland. Seventy-one percent of residents in the Richmond County almshouse were foreign-born. Three percent of residents in New York State almshouses were under the age of 5. In the “North Atlantic” division of states which includes states from Maine to Pennsylvania, 3 percent were illiterate, 49 percent were single, and 40 percent of women had been widowed (USCB, 1904). The report also notes that although “in earlier times the almshouses were the ordinary institutions for the care of unfortunates of nearly every class” a gradual segregation had begun to take place separating those who would formerly seek refuge at an almshouse to be distributed among “hospitals for the sick or for the insane, schools for the feeble-minded or the deaf and blind, children’s homes, colonies for epileptics, and a multitude of variously named benevolent institutions” (USCB, 1904, p. 8).

Meanwhile, by 1900, tuberculosis had become the second leading cause of death; the first was pneumonia (CDC, 1999). Although tuberculosis had plagued humans for thousands of years, it was not identified as a single disease based on a set of symptoms until the early 1800s. In 1882, a German bacteriologist, Dr. Robert Koch, discovered the bacterium that causes tuberculosis, also known as “consumption” and “the white plague.” During this time, the only prescribed treatment was abundant fresh air, rest, sunshine, and a nutritious diet.

In 1889, the New York City Department of Health became the first municipal health department to declare tuberculosis a communicable disease. Five years later, the Health Department mandated the reporting of tuberculosis incidents for all public institutions while instituting free diagnosis and home visitations. In 1901, the Department of Health mandated that patients with tuberculosis be segregated from the general hospital population, a difficult
task due to the absence of adequate facilities for tuberculosis patients. The first municipal hospital for tuberculosis patients in the United States opened in Cincinnati in 1897, and the second on Blackwell’s Island in 1902. The opening of the facility on Blackwell’s Island allowed patients to be transferred from hospitals and almshouses from around New York City (Zavin, 1985).

Government entities were beginning to recognize that the dark, poorly ventilated conditions in older tenements contributed to the spread of communicable diseases. The New York State Tenement House Law of 1901, among other requirements, mandated that new constructions include outward-facing windows in every room, an open courtyard, and proper ventilation systems. Doctors believed that a rural environment, preferably elevated, provided the best setting for tuberculosis patients because of the abundant fresh air and light that such a site would provide. A report presented at the Annual Conference of Charities in 1896 entitled “Hospitals for the Sick: Their Construction and Management” addressed the topic of the ideal geographic location of hospitals.

Where should it be located? By preference, upon an open elevated site, that the free circulation of the air currents may not be interfered with; in no near proximity to swamps, low grounds, or the openings of ravines or long narrow valleys, the miasmatic vapors or cold winds from which cannot but be injurious . . .” (Conner, 1896, p. 238).

The site selected for the new tuberculosis hospital was a 25-acre former estate of Charles Schmidt. The estate, known as “Ocean View,” was located adjacent to the grounds of the New York City Farm Colony, just east of Brielle Avenue. The City purchased the site for $15,000 in 1905. The Annual Report of the Department of Public Welfare of the City of New York for that year summarized the decision to locate the proposed new tuberculosis hospital on this land:
To meet then the unavoidable condition of success in such a progressive movement it became primarily necessary to choose a location that would not only meet the requirements of an adequate and healthy site, such as protection by rising ground and woodland from the north, northeast and northwest, good natural drainage with consequent warm soil, extended and diversified views for the distraction of patients — but one that would be easily accessible in the sense of transportation of patients with the minimum risk and discomfort to the patients and the community at large; accessible in the sense of proximity, thereby permitting the visiting of friends with the minimum expense of time and money. (p. 19).

The report goes on to explain that the ideal site would provide the surroundings of the country and be naturally protected from the encroachment of growth of the city, removed from “unpleasant and unattractive associations whether sentimental or actual.” The architect chosen by the City to design the new tuberculosis facility, Raymond F. Almirall, described the site as one that provides "extended sea and landscapes (of) . . . unusual visual interest" (as cited in Zavin, 1985, p. 16). The attractive surroundings and beautiful views were believed to help patients avoid depression associated with long periods of confinement.

Seaview Hospital was formally dedicated on November 12, 1913. The New York Times declared Seaview to be "the largest and finest hospital ever built for the care and treatment of those who suffer from tuberculosis in any form . . . ." with its location “on the crest of the highest point on the coast between Maine and Virginia.” Michael J. Drummond, Commissioner of Public Charities, who presided over the ceremony, remarked, “Sea View Hospital is a magnificent institution that is vast, ingenious, practical, convenient, sanitary and beautiful. . . . the greatest hospital ever planned in the world-wide fight now being waged against the 'white plague.'” Frank H. Mann, the Chairman of the Tuberculosis Committee of the Charity
Organization Society, stated, “I say it has been built at the right place, because it is both in the city and in the country . . .” (“City’s $4,000,000 Hospital Now Ready,” 1913, p. 6).

Throughout the next several years, the City acquired an additional 200 acres of adjacent land and constructed a sanitarium. In 1915, The Farm Colony was merged with Seaview Hospital and the entire area became known as Seaview Farms. In 1946, Dr. Selman Waksman at Rutgers University developed the antibiotic streptomycin which inhibited the tubercule bacillus from multiplying. The drug had numerous undesirable side effects. At Seaview Hospital, Dr. Edward Robitzek and Dr. Irving Selikoff conducted the first clinical trials on the use of hydrazides which, when used in combination with streptomycin, was found to successfully mitigate the unwanted side effects. In the early 1960s, Seaview was phased out as a tuberculosis hospital and transformed into a geriatric facility. Today, many of the century-old buildings are utilized by Sea View Hospital Rehabilitation Center and Home which functions as a long-term care facility.

In 1985, the area encompassing the former New York City Farm Colony and Seaview Hospital was designated as a historic district by the Landmarks Preservation Commission. Although the City has issued numerous requests for proposals for the site of the New York City Farm Colony, no plans for the landmarked area have come to fruition. Although the site is closed to the public, at least one of the graffiti-covered, dilapidated buildings is viewable from Brielle Avenue.

SIGNIFICANT FINDINGS

This highly elevated area, far from any population center, and on land that could be easily cultivated, made the location ideal for a poor farm. Meyer suggests that facilities with little funding that require large amounts of land would have been pushed to the hills before transportation technology allowed easy access to upland areas (2012), which also could have
contributed the City’s decision to locate a poor farm in this area. In his 2005 study of Worcester, Massachusetts, Meyer recognized that the residences and land uses of the urban fringe in horizontal space were similar to those found on the urban fringe in vertical space, referring to this area as the vertical fringe. He observed a pattern whereby both the poor and the well-to-do resided on the vertical fringe, similar to Swauger’s findings regarding the urban fringe in 1978. Data from the 1900 United States Census for the Enumeration District containing the farm colony affirms this theory. The district included two charitable institutions as well as the homes of many affluent families. Thirty-five women and about 250 children from the ages of 2 months to 16 years old lived at the nearby Nursery and Child’s Hospital, a charity institution that “furnishes a home, temporarily, to destitute women and children” (NYBC, 1902, p. 889). Wealthy residents could be identified on the Census by their occupations and the presence of live-in help. These occupations included physicians, lawyers, and bankers. The relationship of the live-in help to the head of the family was listed as “servant” or “help,” and their given occupations included coachman, cook, farm help, companion, and nursemaid (USCO, 1900). This pattern of the poor living within close proximity of the well-to-do on the vertical fringe continues to exist today. The Sea View Hospital and Rehabilitation Center and Home complex now exists on the site of the former tuberculosis facility. The 2010 Census Tract that covers most of this case study area is adjacent to one of the highest income Census Tracts in Staten Island, with median household incomes of $12,283 and $106,212, respectively.

The ostensible explanation for the siting of the 25-acre tuberculosis facility adjacent to the poor farm, according to the 1905 Annual Report of the Department of Public Welfare of the City of New York, was that the location met the requirements of an “adequate and healthy site,” including natural drainage, extended and diversified views for the distraction of patients, easy accessibility to minimize risk and discomfort to the patients, and protection from the
encroachment of growth of the city. I propose that an additional requirement could be derived from the last item: protection of the ever-expanding city from an unwanted land use.

An 1887 Beers map shows that “Ocean Hill,” a property owned by C. F. Schmidt, occupied the site of the future tuberculosis hospital. The largest tract of land adjacent to this site is the Poor House Farm. The surrounding area remained sparsely populated. Adjacent farms and estates contained few residential buildings. The City purchased the site from Schmidt in 1905, and a 1907 Robinson map shows the site as an extension of the New York City Farm Colony owned by the City of New York. Seaview Hospital opened in 1913, and two years later the Farm Colony was merged with Seaview Hospital. On a 1917 Bromley map, the site is labeled as both “Sea View Hospital” and “New York City Farm Colony” with about 50 building structures indicated. The merge between the two city institutions allowed for shared facilities and services such as laundry service (Zavin, 1985). In contrast, a proposal to site the facility in a densely populated area in the early 1900s surely would have been met with strong opposition from surrounding communities. While the highly elevated land with fresh air and expansive views was indeed ideal for tuberculosis patients, political feasibility was very likely a decisive factor.
BELLEVUE

Gas, leaking from the tanks, made the neighborhood a pesthole. Only the poorest families—at first predominantly Irish, later joined by Germans and Jews—could be drawn into the district, and flimsy tenements were built to accommodate them.

(Federal Writers’ Project, the WPA Guide to New York City, 1939, p. 187)

BOUNDARIES OF THE CASE STUDY AREA

The Bellevue case study area boundaries are 19th Street, First Avenue, 34th Street, and the East River. These boundaries were chosen for two reasons: 1) according to the 1930 United States Census, the median monthly rental rate for this area was very low compared to the rest of Manhattan, and 2) the area sustained an extremely high infant mortality and tuberculosis mortality rate throughout a 10-year period ending in 1931 according to the Bellevue-Yorkville Health Demonstration. The selected area includes the 1930 Sanitary Areas 60 and 62 and encompasses approximately 0.183 square miles or 117 acres.
Figure 20. Bellevue case study area and 1924 aerial photograph.

Figure 21. Bellevue case study area and 2010 aerial photograph.

TOPOGRAPHICAL DESCRIPTION OF THE CASE STUDY AREA

Most of the Bellevue case study area is built on landfill, as can be seen by the 1782 British Headquarters Map (Figure 22) below. Egbert Viele’s 1865 Sanitary and Topographical map (Figure 23) reveals that by the end of the Civil War, half of the study area had been landfilled. The 1894 Tenement-House Committee map uses land boundaries that closely correspond with the 1924 New York City aerial photograph, evidence that landfill activities had stopped sometime between 1865 and 1894. This generally flat, low-lying area falls completely within New York City’s hurricane evacuation zones, with the majority of it designated as Zone 1, the most hazardous zone.
HISTORY OF THE CASE STUDY AREA

In 1671, Jacobus Kip obtained a grant for land “bounded on the Northeast & Southwest side with two small creeks or Kills on the Southeast side with the East River and on the Northwest with the Old Highway towards New Harlem” which came to be known as Kip’s Bay Farm (Stokes, 1928, p. 112). The Kip family built a large home by the East River, known as “The Kip’s Bay House.” The land remained in the Kip family until Peter Ketaltas bought the land around 1766 and later expanded the estate. The following 1770 Ratzer map (Figure 24) shows the Ketaltas house, including formal gardens, on a cliff on the river. The structure stood until 1851 when the land was graded for construction of 35th Street, as the City expanded the street grid north (Post, 1894).
On January 27, 1788, the estate was advertised in newspapers for sale or to let. The property, referred to in advertisements as “Belvue,” is described as a “beautiful Country Seat . . . situated on the banks of the East-River, about 3 miles from the city.” (as cited in Stokes, 1928, p. 109). In 1793, the estate, now owned by Lindley Murray, who at the time was living in York, England, was transferred to Brockholst Livingston, the son-in-law of Peter Ketaltas (Stokes 1928).

In 1794, New York Hospital, now the New York-Presbyterian Hospital, had been open for three years on land which is now just west of Broadway between Duane Street and Worth Street (Cornell University, n.d.). However, in preparation for the potential yellow fever epidemic, the city saw a need to establish a place to house residents infected with contagious diseases. On
September 10, 1794, the Common Council addressed that need and decided that the most eligible place to house these patients was the Bellevue estate on the East River, owned by Brockholst Livingston. The following text from the Minutes of the Common Council of the City of New York (1917) for that day provides reasoning behind the Council’s decision to find a place to house patients with contagious diseases, but does not include details as to how the Belleview estate was chosen.

The Committee appointed by the Gov’r for the purpose of taking Measures to preserve this City from the danger of contagious Diseases [sic] having represented to the Board the necessity of providing some safe Place for the reception & accommodation of such Persons as might be found afflicted with any such Complaint. That, after due Enquiry, the most eligibl[e] place appears to be that of Brockholst Livingston, situate on the Bank of the East River opposite the three Mile Stone . . . Whereupon the Board determine that from the exposed situation of this City and in order to quiet the Minds of the Inhabitants it is indispensably necessary that a proper place should be provided And that under the present Circumstances the Place above mentioned appears to be most suitable for the Purpose . . . (pp. 100-101).

The following 1782 British Headquarters Map (Figure 25) provides a picture of the urban development of Manhattan around the time of the Common Council’s decision slightly over a decade after the time of its survey. The network of streets is laid out only as far north as what is now Grand Street, with the densest development occurring below what is now Reade Street. Development north of this area was very sparse, as indicated by the building structures scattered about throughout the rest of the island. The Bellevue case study area, outlined in red, includes the area that had not yet been built out by landfill. The estate selected for the purpose of
building a pest house was located on the waterfront about halfway down the middle of the case study area.

![Figure 25. 1782 British Headquarters Map showing the Bellevue Case Study Area.](image)

Shortly after the Common Council’s site selection in 1794, a five-acre plot of land of the Bellevue estate was leased to the City in order to provide a place to house patients with contagious diseases (Griffin, 1915). On April 19, 1798, Brockholst Livingston sold the estate in fee simple to the City of New York (Stokes, 1928). In 1811, the City purchased an additional six acres of land for the purpose of relocating the New York City Almshouse from City Hall Park to a
more remote location. The new, larger almshouse was completed and formally opened in 1816. That same year, a penitentiary for minor offenders was constructed in close proximity to the almshouse. Ten years later, a hospital was built near the penitentiary and almshouse. These three institutions, including over 20 acres of surrounding land, became known as the Bellevue establishment (Richmond, 1918).

By the 1820s, Bellevue Hospital had become overcrowded partially due to the influx of patients turned away from New York Hospital, which had begun to exclude cases deemed to be dangerous or morally reprehensible. Those with chronic or contagious diseases as well as patients with sexually transmitted diseases were turned away from New York Hospital and directed to the Bellevue pesthouse, hospital, or almshouse (Burrows and Wallace, 1998).

In 1826, a report of the “Medical Committee of Investigation” recommended that the penal component at Bellevue be removed to another location. The City acquired Blackwell’s Island in 1828, and Bellevue’s prison inmates were moved to the penitentiary on Blackwell’s Island. Once the almshouse was also moved to Blackwell’s Island in 1848, Bellevue became a purely medical facility (Richmond, 1918).

While the land use of the northern section of the study area had become institutional, the southern end had developed into a densely populated tenement neighborhood. The 1894 Tenement-House Committee map shows that the residents of the Bellevue case study area were predominantly Irish and German immigrants. The area was also a minor transportation hub, with commuters traveling from Greenpoint to the East 23rd Street pier. According to the Traveler’s Guide to the City of New York published in 1871, the four-cent ferry was scheduled to depart from the pier every 15 minutes from 6 a.m. to 9 p.m. daily.

In 1842, the first gas storage tank was built at East 21st Street near the East River, with several other gas storage tanks to follow. The large, imposing gas storage tanks, also known as “gas houses,” supplied gas throughout the city. A fourteen-block area near the East River,
known for the strong smell of gas, which leaked from the storage tanks, was referred to as the Gas House District. The WPA Guide to New York City describes The Gas House District as being bounded by 14th Street, First Avenue between 14th Street and 18th Street, Third Avenue between 18th Street and 23rd Street, Park Avenue between 23rd Street and 27th Street, 27th Street, and the East River (Federal Writers’ Project, 1939). The following 1938 photograph (Figure 26) of East 20th Street facing east toward First Avenue illustrates the imposing size of the gas tanks relative to the surrounding buildings.

![Figure 26. Gas tank at corner of 20th Street and 1st Avenue in 1938. Photograph by Berenice Abbott.](image)

The gas storage tanks also became associated with danger because of a local disaster that occurred on December 13, 1898. A new gas storage tank, owned by Consolidated Gas of New York (later renamed Consolidated Edison), on East 20th Street, just west of Avenue A, collapsed. Large quantities of water, used as a seal in gas storage tanks, flooded nearby residential buildings and streets. According to a New York Times article, residents on the ground floor of their homes were swept into the streets, clinging to whatever they could to keep
from drowning (“Huge Gas Tank Collapses,” 1898). Considered an undesirable place to live, the Gas House District was populated predominantly by immigrant families living in low-rent tenements. According to the WPA Guide, “Only the poorest families—at first predominantly Irish, later joined by Germans and Jews—could be drawn into the district . . .” (1939, p. 187). Adding to the undesirability of the neighborhood was the noise and soot from the Second Avenue elevated train line, which ran north along First Avenue, turned west at 23rd Street, and then ran north along Second Avenue. Crime was particularly high in the neighborhood. The WPA Guide mentions the notorious “gashouse gangs” who “terrorized the Gashouse district for half a century” (1939, p. 187).

In 1895 the New York State Legislature passed a law requiring certain cities, including the City of New York, to establish and maintain free, public baths as deemed necessary by their local boards of health (NYCCU, 1906). An 1896 survey of the Lower East Side, a neighborhood very similar, demographically, to the Gas House District, revealed an average of one bathtub for every 79 families (DPR, n.d. a). The following year, construction began on the Rivington Street Bath, which was completed in 1901. In June of 1902, at the insistence of philanthropic organizations, the Board of Estimate and Apportionment authorized $105,000 for the purchase of public bath sites and their construction in Manhattan (NYCCU, 1906). According to the Bureau of City Betterment of the Citizens Union of the City of New York, the expenditure justification was not based on making residents of these communities more comfortable, but rather more practical reasons.

It is not believed, however, that any one justifies the expenditure of vast sums of the city’s money merely on the ground that by such means certain members of the community are made physically comfortable. On the contrary, the public provisions of free bathing facilities involves two assumptions: First, that bathing is a means of safeguarding the public welfare by the prevention of disease and by
raising the standard of personal cleanliness and morality; second, that by the maintenance of free public baths universal bathing is more nearly and most economically accomplished. (NYCCU, 1906, p. 99).

In 1904, the Milbank Memorial Free Public Baths was opened on East 38th Street just a few blocks north of the case study area. This facility, built at a cost of $150,000, was the gift of Elizabeth Milbank Anderson. The public baths were built to accommodate 4,800 bathers daily (“Development of Free Public Baths,” 1904). Within the case study area, in 1908, the East 23rd Street Bathhouse, later renamed the Asser Levy Public Baths, opened on Avenue A on land released by the Department of Docks and Ferries (DPR, n.d. a). The building is now maintained by the Department of Parks and Recreation and functions as a recreation center with an indoor pool, an outdoor pool, and a playground.

Begun in 1926, the Bellevue-Yorkville Health Demonstration was a seven-year experiment in neighborhood disease prevention and health improvement which was funded by the Milbank Fund. The purpose of the experiment was to show whether health could be improved in a defined geographic area by applying the best scientific knowledge about disease prevention and management available, and by stimulating community interest in overall health improvement. The program provided modern health services for residents of the Bellevue-Yorkville district, an area established between 14th Street, Fourth and Sixth Avenues, East 64th Street, and the East River. At that time, approximately 153,000 people were living in this district (Downes and Barnard, 1936). About half of the 43,539 families were classified as foreign born, with most being of Italian or Irish descent. The Bellevue-Yorkville district was one of the areas of Manhattan with a tuberculosis mortality rate much higher than the average, making the control of tuberculosis one of the major goals of the program (Downes and Barnard, 1936). The general death rate within the Bellevue-Yorkville district was 43 percent higher than the New York City death rate. The infant mortality rate for the district exceeded the New York City rate.
by 37 percent. The district’s pulmonary tuberculosis death rate was 59 percent higher than the rest of the city.

The Milbank Public Baths building on 38th Street was converted to a health center to house the program and its many clinics and services. Within five years, the district had a zero diphtheria death record for 52 months (Winslow & Zimand, 1937). During the seven-year experiment, the program achieved a 29 percent decrease in the tuberculosis death rate for the area, and a 22 percent decrease in the infant mortality rate (Milbank Memorial Fund, 2005). In addition, a citywide system of health districts organized around 30 health centers was established.

The residential portion of the case study area began to change very rapidly around the time of the Second World War. The WPA guide noted that at the time of writing, 1939, only four gas storage tanks remained near the East River and an increasing number of modern apartments were being built while older buildings were being renovated. Construction of the East River Drive, later known as the Franklin D. Roosevelt (FDR) East River Drive, had also begun. During the War, the port city of Bristol, England, was bombed numerous times between November 1940 and April 1941. American supply trips, requiring ballast for stability on the return trip to the United States, were loaded with rubble from the demolished buildings of Bristol. The rubble from the returning ships was used as landfill for the base of the East River Drive from 23rd Street to 34th (Pollack, 2009). A plaque at nearby Waterside Plaza memorializes the site. The following is an excerpt from the plaque’s inscription.

Beneath this East River Drive of the City of New York lie stones, bricks and rubble from the bombed City of Bristol in England ... Brought here in ballast from overseas, these fragments that once were homes shall testify while men love freedom to the resolution and fortitude of the people of Britain.
In 1940, Mayor Fiorello LaGuardia requested that Park Commissioner Robert Moses "induce insurance companies and savings banks to enter the field of large-scale slum-clearance" (Moses, 1943, para. 1). Moses approached Frederick Ecker, chairman of the Metropolitan Life Insurance Company, with the "rehabilitation project" proposal to raze so-called slum areas and build private middle-class housing. Metropolitan Life selected the area bounded by 14th Street on the south, First Avenue on the west, 23rd Street on the north, and the East River Drive, and Avenue C on the east, covering about 80 acres of land. The new housing developments would be called Peter Cooper Village and Stuyvesant Town. The entirety of Peter Cooper Village and the northernmost portion of Stuyvesant Town lie within the Bellevue case study area.

The project was immediately controversial. Councilman Stanley Isaacs asserted that the development would create “a medieval walled city, privately owned, in the heart of New York” (as cited in Henderson, 2000, p. 128). The likelihood that existing residents would be able to afford rent in the new housing development was very low, considering that rent in the Gas House District was about 5 dollars per room but those in Stuyvesant Town would be 14 dollars per room. Among other issues raised were the use of eminent domain for private purposes, the reversion of public streets and land to private ownership, and the rights of the company to select or reject tenants based on their race, religion, or marital status.

In May of 1943, Ecker publicly revealed that Stuyvesant Town would be strictly for White tenants. Councilman Isaacs and Councilman Adam Clayton Powell, Jr. attempted, unsuccessfully, to include a provision in the contract that would forbid racial or religious discrimination in tenant selection (Henderson, 2000). In 1945, 18 blocks of tenements, stores, and warehouses, including 3,100 families, were moved out of the Gas House District to make way for Stuyvesant Town and Peter Cooper Village. Stuyvesant Town’s first tenants moved in August 1, 1947 (“Stuyvesant Town to Get Its First Tenants,” 1947).
Opponents of the development claimed that the housing development was a public undertaking subject to the equal protection clause of the 14th Amendment, citing that the land was acquired through eminent domain and would receive a partial tax exemption from the city. In 1947, the New York State Supreme Court denied a motion brought by three African-American war veterans, ruling that the development “is not now and never was a public project” and therefore had the right to refuse tenants based on their race. The court further stated that “housing accommodation is not a recognized civil right. It is neither a violation of any provision of the Federal and State Constitutions to refuse such accommodations on the grounds of race, color or religion; nor is it a violation of any statutory provision applicable to Stuyvesant Town” (“Race Housing Pleas Quashed,” 1947, p. 23). However, the issue galvanized fair housing advocates, and after years of protest, legislation prohibiting discrimination in all New York City housing was passed. In 1952 Metropolitan Life relented to the new laws (Henderson, 2000).

A 1951 aerial image of the case study area shows the completed Stuyvesant Town and Peter Cooper Village. Just north of the new housing development, an empty site can be seen between 23rd Street and 25th Street, indicating that buildings that occupied these two blocks had been razed. The Veterans Administration Hospital was completed on this site in 1953. In 1974, Waterside Plaza, a mixed-use residential complex containing four towers ranging from 31 to 37 stories, was built to the east of the FDR East River Drive across from Bellevue Hospital. The land for Waterside Plaza was built over 2,000 concrete pilings drilled 80 feet into the East River. The complex contains 1,470 apartment units in addition to office and retail space, and a landscaped plaza. A pedestrian bridge was built at 25th Street over the FDR East River Drive to allow access to Waterside Plaza (Waterside Plaza, n.d.).

In October of 2013, the entire case study area was heavily impacted by Hurricane Sandy. Most of the case study area fell within the zone that was issued a mandatory evacuation prior to the storm, Zone A. The remainder of the case study area fell within either Zone B or Zone C and
was not under a mandatory evacuation order. The Manhattan VA Hospital began evacuating patients to Veterans Affairs facilities in Brooklyn and the Bronx on October 28, the day before the storm was forecasted to reach New York City (USDVA, n.d.). Many residents within the mandatory evacuation zone chose to stay because they believed the storm would not be as severe as predicted and that their homes were safer than the City’s temporary shelters. The previous year’s major hurricane to hit the region, Hurricane Irene, was less powerful and damaging than forecasts had predicted, and some residents felt the same would be true with Hurricane Sandy.

On October 29, the day of the storm’s arrival, the storm surge caused power outages around 8:00 p.m. to most of the east side of midtown Manhattan. The basements of Bellevue Hospital, NYU Langone Medical Center, and the Manhattan VA Hospital, where switches and computer servers were located, were inundated with sea water. At NYU Langone Medical Center, the backup power system failed, and patients were evacuated to nearby hospitals beginning that evening (Goodman & Moynihan, 2012). Next door at Bellevue Hospital, elevators were out of service and the water pumps stopped functioning. On October 31, water pressure deteriorated and backup generators failed, and the decision was made to evacuate all patients from Bellevue to other nearby hospitals (Bernstein & Hartocollis, 2012).

Meanwhile, both Waterside Plaza and Peter Cooper Village-Stuyvesant Town were inundated by flood water and lost power and heat on the evening of the storm’s arrival on October 29. Electricity and water were restored to most Waterside Plaza buildings 8 days after the storm and to all buildings 2 days later (Waterside Plaza, 2012). At Peter Cooper Village-Stuyvesant Town, electricity, heat, and water were restored to most buildings by November 7 (Socha, 2012). As of February 12, 2013, three and a half months after Hurricane Sandy, many of the buildings’ intercom systems were still not working, and basements where storage and laundry facilities are located remained boarded up (Weinstein, 2013).
SIGNIFICANT FINDINGS

In 1794, when the Common Council of the City of New York saw the need to establish a pest house in preparation for a potential yellow fever epidemic, they decided upon a 5-acre plot of land on the East River, about 1.7 miles from the developed part of the city. This now-bustling area of midtown Manhattan was at the time on the urban fringe of the city, a pastoral location on the waterfront dotted by estates of the wealthy. The decision to locate a pest house, then a hospital, and later a prison and almshouse on the urban fringe of the city falls in line with Binford’s observations that unwanted land uses, such as “city-related but often city-rejected phenomena” could be found here (1985, p. 6).

With the placement of a poor farm on the highest elevation area of Staten Island, Richmond County exemplified an unwritten policy of locating city-related, city-rejected phenomena on the remote, urban fringe. Likewise, the selection of the Bellevue Estate on the East River as the site of a pest house demonstrated the City’s tacit policy to house infected patients far from the city center. The subsequent siting of other city-related, city-rejected phenomena next to these land uses, such as the tuberculosis facility in Staten Island and the penitentiary and almshouse at Bellevue, may have been the path of least resistance, or they may be examples of an unwritten policy to cluster unwanted land uses far from the city center and adjacent to existing unwanted land uses before zoning was introduced to New York City. The City’s purchase of Blackwell’s Island in 1828 for the purposes of building a penitentiary and eventually an asylum and hospital for inmates and the indigent is another prime example of the clustering of unwanted city-related land uses on the urban fringe.

Today, this area is home to the largest concentration of health facilities in New York City. Along First Avenue, south of Bellevue Hospital, are the Hunter College Health Sciences building and the VA Hospital, and to the north, is NYU Langone Hospital. Throughout and within close proximity of the case study area, both inpatient and outpatient care facilities can be
found. Since 1998, the Bellevue Psychiatric Hospital building has been used as a homeless shelter. The shelter, named the 30th Street Men’s Shelter, is now New York City's largest homeless shelter. The predominant land use in the Bellevue case study area has remained institutional for over two centuries.

Public bathhouses also remained in institutional hands. The Milbank Memorial Free Public Baths at 325-327 East 38th Street just a few blocks north of the case study area became the central office of the Bellevue-Yorkville Health Demonstration. Today, the building serves as the home for several foreign embassies. The East 23rd Street Bathhouse on Avenue A is now maintained by the Department of Parks and Recreation and functions as a recreation center.

An 1890 Census Bureau report revealed that death rates, exclusive of stillbirths, were largely explained by the mean elevation of each district (USCO, 1895). The association between low elevations and disease was well established at the time; however, the cause was generally attributed to miasma or “bad air” that emanated from swampy areas rather than the disease-carrying vectors that lived in the stagnant waters. The Gas House District, the neighborhood just south of Bellevue largely built upon landfill and marsh areas, was considered an undesirable place to live for many reasons, including the odor and safety hazard from towering gas houses and the high crime rate. Villarreal found that since the late 1800s, high-income households have preferred to reside away from historical marsh areas where lower income households live (2013). This could explain why some low-lying neighborhoods that are built on marshes and landfills, such as the Gas House District and the Lower East Side, were home to some of the City’s poorest residents, and in the case of the latter, continues to be.

The WPA Guide, published in 1939, noted that all but one gas house had been removed, and modern apartments were being constructed in the neighborhood, a possible explanation for the slight increase in socioeconomic status indicator values in the quantitative analysis for 1940. The drastic jump in socioeconomic status values for this area occurred in the 1940s when the
City used its powers of eminent domain to condemn a large swath of the Gas House District in order to make way for the private, middle-class housing development, Peter Cooper Village-Stuyvesant Town. The persistence of low-income neighborhoods on historical marsh areas was interrupted by the development of Peter Cooper Village-Stuyvesant Town. This was not a solely private endeavor – the City approached Metropolitan Life, asking the company to consider a proposal that could be executed with the help of the City’s powers of eminent domain. Without the City’s intervention, the Gas House District may have continued as a low-income tenement neighborhood similar to the Lower East Side.

The Bellevue neighborhood was severely impacted by Hurricane Sandy and the resulting storm surge. Most of the case study area fell within Evacuation Zone A which was issued a mandatory evacuation order by the City prior to the storm. In 2013, New York City released new hurricane evacuation zone designations. The City’s contingency plans are based on six evacuation zones that represent varying levels of potential flooding from storm surge. Evacuation orders begin with Zone 1 and more are added depending on the forecasted strength, track, and surge of the storm. Most of the case study area, including all of its major hospitals, falls within Zone 1.

More detailed flood information can be found in the Federal Emergency Management Agency (FEMA) Preliminary Work Maps (PWMs) released in 2013. The PWMs include the results of a full coastal study begun before Hurricane Sandy plus a more refined analysis of shoreline conditions conducted post-Sandy. These maps are considered the best available flood hazard data until the preliminary Flood Insurance Rate Maps (FIRMs) are released. In Figure 27, the PWMs flood zones are superimposed onto the 2012 tax lots. The map on the right (Figure 28) superimposes the flood zones on the 1782 British Headquarters Map. In the PWM flood zone maps, Zone AE, the yellow shaded area, shows areas subject to inundation by the 1-percent annual chance flood event. Zone AO, the blue shaded area, represents areas of shallow
flooding where average depths are between one and three feet. Both AO and AE zones are high-risk flooding areas. The shaded red area is Zone VE, representing areas subject to storm-induced wave action (a three-foot or higher breaking wave) from the 1-percent annual chance flood event.

Figure 27. Bellevue case study area and PWMs flood zones.

Figure 28. Bellevue case study area with 1782 British Headquarters Map and PWMs flood zones.

Figure 27 shows that within the case study area, piers and sections of the FDR East River Drive are subject to storm-induced wave action. Approximately two-thirds of the remaining study area are vulnerable to flood inundation by the 1-percent annual chance flood event, including all of the hospitals within the study area and about half of Peter Cooper Village. In Figure 28, the edges of the superimposed flood zones seem to fall along the original shoreline. The flooding caused by Hurricane Sandy proved that the neighborhood’s topographic legacy
could not be escaped, as structures built on landfill were flooded by the same ocean waters that once occupied this space.
The natural physical line of division should be the Harlem Ship Canal . . . It seems most undemocratic to keep these good people of Marble Hill in Manhattan bondage when they want to be residents of the Bronx, the borough of universities and culture and the most beautiful borough in the world.

(Bronx Borough President James J. Lyons, March 9, 1939, quoted in “‘Sudenten’ Claimed by Bronx Fuehrer,” The New York Times, p. 1)

BOUNDARIES OF THE CASE STUDY AREA

The boundaries of the Marble Hill case study correspond to Census Tract boundaries that persisted from 1910 to 2000. The Census Tract boundaries were modified slightly for the 2010 Census. Interestingly, the boundaries do not correspond to streets but rather to the topography of the land, neatly enclosing the hill. The selected area includes approximately 0.118 square miles or 76 acres.
The Marble Hill case study area was chosen because of the unique physical topographical history of the neighborhood. Once physically part of Manhattan, the neighborhood on a hill became an island when the Harlem River Ship Canal was created to allow larger ships to navigate between the East River and the Hudson River. Marble Hill remained an island for two decades before landfill physically connected the neighborhood to the Bronx. While Marble Hill is not part of the City’s hurricane evacuation contingency plan, all of the land surrounding the hill falls into one of the designated evacuation zones.
Figure 31. Marble Hill case study area and 50 ft. DEM

HISTORY OF THE CASE STUDY AREA

Marble Hill, named for the marble rock from which it was formed, was once physically a part of Manhattan. Upper Manhattan and the Bronx were separated only by a narrow, winding strait called the Spuyten Duyvil Creek. "Spuyten Duyvil" means "Devil's Spout" in Dutch; a reference to the strong and wild currents found at that location. Just west of 230th Street and Broadway, a ford allowed people to traverse the creek at low tide. The location of this link between the island of Manhattan and the mainland became so vital that in 1669, Johannes Verveelen moved his ferry operations here from the Town of New Harlem (Tiek, 1968). In 1693,
a toll bridge named the King’s Bridge, in honor of the King of England, replaced the ferry. In 1713, a sturdier King’s Bridge with a wooden deck laid over stone supports was constructed slightly to the west of the original, where it remained for more than 200 years. In 1758, the Free Bridge was built along what is now 225th Street east of Broadway, in order to avoid the tolls of the King’s Bridge.

During the Revolutionary War, the Continental Army constructed a fort on Marble Hill, one of many defensive forts in the hilly area of upper Manhattan and the nearby mainland including Fort Washington and Fort Independence. The hill possessed excellent views of the tactically important Kings Bridge and Free Bridge. Following the Battle of Harlem Heights, retreating American soldiers took down the Free Bridge. The British rebuilt the structure, naming it the Queen’s Bridge, and it was later known by a handful of other names including the Farmers’ Bridge, Hadley’s Bridge, and Dyckman’s Bridge.

By November of 1776, Hessian soldiers, fighting on behalf of the British, took over the fort and renamed it Fort Prince Charles in honor of Charles, Duke of Brunswick. Three years later, the fort was destroyed (NYSMM, 2006). An 1894 New York Times article announcing July 4th activities in Marble Hill described the suitability of the land as a fort: “The hill on which Fort Prince Charles was situated is naturally adapted for a fortress. From its top an extensive view of the surrounding country is obtained, and with a few breastworks planted with bristling cannon it would prove a formidable barrier for any advancing army” (“Will Celebrate the Fourth,” 1894, para. 5). The following topographical map utilized during the Revolutionary War map shows Marble Hill as part of Manhattan along with the Kings Bridge and Dyckmans Bridge (Sauthier, 1777).
Figure 32. Marble Hill area of 1777 Battle of Fort Washington Map.

The Randel Farm Maps, which cover Manhattan from Houston Street to Marble Hill, illustrate in detail the structures that existed in the case study area in 1820. The following portion of the Randel maps (Figure 33) shows that the hill, owned primarily by Jacob Hyatt, contained several marble quarries, a blacksmith shop, a flour mill, and three dwelling houses. Just to the north and south of the hill are mills for sawing marble. The remains of the Fort Prince Charles structure can be seen in the middle of the hill.
Because of the shallowness of Spuyten Duyvil Creek, large boats and ships traveling between the Hudson River and the Long Island Sound had no choice but to take the 25-mile detour around lower Manhattan. To alleviate this inconvenience, the Army Corps of Engineers began construction of the United States Ship Canal in 1888, known locally as the Harlem River Ship Canal. When the canal was completed in 1895, the neighborhood of Marble Hill had become an island (Hermalyn, 1983). A New York Times article from that year regarding the establishment of Marble Hill’s first volunteer fire company described the topography and character of Marble Hill:
It was formerly the northern tip of Manhattan Island. Now that the Harlem Ship Canal has been cut through, it has become a little island by itself. Sixty families or more have built tasteful homes within the last two or three years on the slope or crest of the hill. (“To Fight Fire in Marble Hill,” 1895, para. 5).

The following 1891 and 1897 USGS maps of the area show extensive changes in both physical topography and urbanization of Marble Hill between these two years. The 1891 map (Figure 34), surveyed during the seven-year construction of the Harlem River Ship Canal, shows a small water passage to the south of the neighborhood, no mapped streets, and relatively few building structures. The 1897 map (Figure 35) shows the completed Harlem River Ship Canal, landfill extending Marble Hill east past Broadway, and numerous homes on newly laid out streets that curve around the hill rather than the falling along grid lines typical of most of Manhattan.

In 1897, the cornerstone was laid for the still-standing Saint Stephen’s United Methodist Church at the intersection of Marble Hill Avenue and 228th Street. The first church service was
held on November 6, 1898 (SSUMC, 2012). At the time, the red-shingled church overlooked the Kings Bridge and Spuyten Duyvil Creek.

By the turn of the century, Marble Hill had become a solidly middle-class neighborhood. The 1900 United States Census sheets for Marble Hill’s Enumeration District accounted for 504 total residents and revealed a range of occupations from laborer to physician and lawyer. The most common occupations listed were clerk, policeman, and carpenter. Many residents were homeowners, with more households owning than renting on Terrace View Avenue, Jansen Place (now Adrian Avenue), Van Corlear Place, and Wicker Place (now 227th Street between Adrian Avenue and Marble Hill Avenue). Twenty-eight White servants and three Black servants were counted. The remaining residents of the neighborhood, most of whom were born in the United States, reported their race as White. On Jansen Place (now Adrian Avenue), seven residents were second-generation Cuban, four were born in Cuba, and two were from Peru (USCO, 1900).

The first part of the 20th century saw several significant changes in the neighborhood. Railroad transportation arrived in 1905, and the elevated IRT train in 1907, further enticing residents to the neighborhood. In 1917, Spuyten Duyvil Creek was landfilled around Marble Hill, and the historic Kings Bridge, which was now over 200 years old, was destroyed. The church, which once overlooked the historic bridge and creek, now faced a road to the Bronx where the Kings Bridge once stood. In the 1920s and 1930s, many apartment buildings up to six stories high were built (Tiek, 1968). According to the WPA Guide to New York City, at the time of its writing in 1939, Marble Hill was “a relatively quiet neighborhood. Modest Apartment Houses look out across the New York City Central tracks and the Harlem River, but many of the residences along its hilly streets are two-story frame cottages.” (Federal Writers’ Project, 1939, p. 306) By 1940, most of the residents of Marble Hill
lived in relatively new apartment buildings, however many houses were occupied by their owners. The residents who lived on West 228th Street all owned their homes. Homeowners made up about half of the households on Fort Charles Place, Van Corlear Place, and Terrace View Avenue. And although Adrian Avenue was now dominated by apartment buildings, they shared the street with 22 homeowners (USCO, 1940).

On March 8, 1939, Bronx Borough President James J. Lyons called for the annexation of Marble Hill on the grounds that the Harlem Ship Canal is the legal division between the two boroughs, and that “the residents of the area are linked to the people of the Bronx by common tradition, language, culture and community life” (“‘Studenten’ Claimed by Bronx Fuehrer”, 1939, March 9, p. 1). The Borough President elaborated,

the natural physical line of division should be the Harlem Ship Canal . . . It seems most undemocratic to keep these good people of Marble Hill in Manhattan bondage when they want to be residents of the Bronx, the borough of universities and culture and the most beautiful borough in the world. (“‘Studenten’ Claimed by Bronx Fuehrer”, 1939, March 9, p. 1)

An informal New York Times survey of neighborhood business owners, property owners, housewives, school children, and laborers found that annexation was almost unanimously opposed (“Marble Hill Boos Bronx ‘Anschluss,’” 1939). As a publicity stunt, on March 11, Lyons and a staff member climbed to the top of a rocky promontory at the corner of Jacobus Place and 225th Street and planted the Bronx County flag, declaring, “In the name of the Bronx, of which I am the President, I hereby proclaim this territory of Marble Hill to be part of my borough” (“Marble Hill Area Annexed,” 1939, p. 43). Residents of the usually quiet neighborhood, already outraged at Lyons’s suggestion that they want to become part of the Bronx, booed the Borough President. The Marble Hill Civic Association organized to fight legal annexation, and a petition
was sent to Governor Lehman expressing their desire to remain a part of the borough of Manhattan (“Marble Hill Mobilizes,” 1939). In December of that year, Mayor LaGuardia recommended that Marble Hill be annexed by the Bronx, but a subsequent Board of Estimate meeting held to act on the mayor’s proposal was well attended by Marble Hill residents who demanded a chance to vote on the issue. Lyons, knowing that the residents would not vote in favor of annexation, conceded, stating “…it is not surprising to find some Marble Hillians who would not want to be freed from the excessive taxation and who would resent the injection of the new and finer culture characters of the Bronx… We have no room in the Bronx for the intolerant or snob” (“Lyons renounces Anschluss claim,” 1939, December 9, para. 10-11).

In 1948, the City acquired about 16 acres of land east of Broadway for the purpose of building the Marble Hill Houses, an 11-building public housing complex. The land was built out during the construction of the Harlem Ship Canal and the filling of Spuyten Duyvil Creek (DPR, n.d. c). A 1913 Sanborn map of the area showed seven structures situated on a small section along Broadway, while the remainder of the area was indicated as “American League Base Ball Grounds.” According to Tiek, this land had not yet been built upon because the foundation work required to build on the landfill was cost-prohibitive (1968). The City undertook the extensive foundation work required, and the Marble Hill Houses opened in 1952 (NYCHA, n.d. c). Seven of the buildings fall within the borders of Manhattan, while the other four are in the Bronx. In 1972, just to the west of Marble Hill, the 32-story Promenade Apartments, a state-subsidized Mitchell-Lama building, was completed (Wisnieski, 2011). In that same year, just north of the Promenade Apartments, the campus of John F. Kennedy High School opened on a campus built upon former railroad tracks and land that was created when the Spuyten Duyvil Creek was filled. Five other district high schools are currently co-located on the John F. Kennedy High School Campus (NYCDOE, 2011).
The 2010 United States Census presented a very different demographic picture of Marble Hill from that of the 1900 Census in terms of racial and ethnic diversity. For the Census Blocks that intersect the Marble Hill case study area boundaries, only nine percent of Census respondents identified as non-Hispanic White. Thirty-two percent of respondents identified as non-Hispanic Black. Sixty-five percent of residents identified as Hispanic of any race. Despite the very different racial demographics of the neighborhood between 1900 and 2010, the median household income for Census Block Groups in Marble Hill, with the exception of the Block Group containing the Marble Hill Houses, continued to reflect the middle-income status of the residents. In 2010, the median income for New York City was $51,270. For the Census Block Groups that fell entirely within the case study area boundaries, the median incomes were $50,394, $43,929, $39,896, and $17,224, with the last figure representing the Census Block Group containing seven buildings of the Marble Hill Houses.

SIGNIFICANT FINDINGS

In his 2012 study, Meyer proposed three distinct time periods whereby elevation plays the role of either resource or resistance to residents. The evolution of Marble Hill from a military fort to a stable, middle-class neighborhood can largely be explained by these three periods. For the period from 1782 to 1825, Meyer described how elevation presented a military advantage. Both Continental and British troops used Marble Hill’s elevation to their benefit during the Revolutionary War. During the period for which Meyer described elevation as a resistance because of the difficult of access of upland settlements, from 1825 to 1888, Marble Hill did not experience significant growth. However, during the final period which began in 1888, Marble Hill exhibited significant change. During this period, Meyer proposed that elevation once again became a resource with the advent of electric-powered railroads and
automobiles, allowing upland areas to become accessible residential neighborhoods with fresh air and pleasurable views. It was during this period that the circular streets of Marble Hill were laid out, the railroad and elevated trains came to the neighborhood, and the residential boom began.

The 1950s saw the building of Marble Hill Houses on landfill to the east of the hill, while the state-subsidized Promenade Apartments and John F. Kennedy High School were built to the west of the hill on landfill and former railroad tracks in the 1970s. However while many New York City neighborhoods experienced sizable changes in land use or socioeconomics throughout the past century, the core of Marble Hill, the residential area established in the late 1800s and early 1900s, has remained remarkably stable. While the racial demographics have changed drastically from 1900 to 2010, the socioeconomic status of Marble Hill residents has remained solidly middle class. This could be attributed to the fact that many of the residents of the detached houses characteristic of Marble Hill are homeowners. Marble Hill homeowners tend to keep their homes for generations, such that even high-income potential buyers who are wooed by the quaintness of Marble Hill have a difficult time finding property for sale in the neighborhood. A 2003 New York Times article from the real estate section highlights the low turnover rate of the neighborhood, noting that “despite its diversity, Marble Hill is like an exclusive club. Houses almost never go on the market and are likely to be sold privately” (Jackson, 2003, p. RE5). The ability of this quiet, middle-income neighborhood on a hill to resist socioeconomic and even political change despite dramatic physical topographical changes over the past century exemplifies the strength of historical settlement persistence.
HUNTERS POINT

Hunter’s Point is known to New Yorkers as the depot of the Long Island R.R., the terminus of a ferry and an ill-smelling neighborhood through which one should pass holding his nose.

(The Brooklyn Times, November 1867, as cited in Seyfried, 1984, p. 91)

BOUNDARIES OF THE CASE STUDY AREA

The Hunters Point case study area is bounded by the East River, Anable Basin to the north, Vernon Boulevard to the east, Borden Avenue and 2nd Street, 54th Avenue, 5th Street, and Newtown Creek to the south. This area was selected because of its recent rezoning actions resulting in less manufacturing and more residential, commercial, and mixed-use activities, as well as the rapidly changing demographics of the area. The northern portion of the case study area includes the Queens West development while the southern portion includes the Hunters Point South Waterfront Park development area. This case study area encompasses approximately 0.221 square miles or 141 acres.
TOPOGRAPHICAL DESCRIPTION OF THE CASE STUDY AREA

The Hunters Point case study area is situated on low-lying, waterfront land. Most of the study area falls within Flood Zone 1, the most hazardous of New York City’s flood zone categorization system. The remaining land within the study area falls into Flood Zone 2. Historically, the area contained vast meadows frequently flooded by the East River (Seyfried, 1984).
HISTORY OF THE CASE STUDY AREA

The land now known as Hunters Point was settled in the first half of the 17th century by Dutch Colonists and purchased from the government of the Netherlands by Reverend Everard Bogart, the first minister of the Dutch Church in New Amsterdam, who named the land Dominie’s Hook. Upon Reverend Bogart’s death, the property was decreed to his widow, Annettie Jans. In 1697, Captain Peter Praa purchased the property, which extended from present-day Ravenswood down to Williamsburg, from the heirs of Annettie Jans. Over the next century, the property passed down through this family and was eventually willed to Anne and Captain George Hunter, who changed the estate name to Hunters Point. Captain Hunter died in 1825, bequeathing the property to his wife, who in turn willed the estate to their three sons with the right to divide the property and sell it as they deemed most advantageous (Kelsey, 1896).

On June 17, 1835, a representative of the Eliphalet Nott, the president of Union College in Schenectady, bought the land from the family for $100,000 as speculative property. In 1853, a plan was developed to level the hill that formed the center of the estate and use the soil to extend the shoreline into the East River (NYCLPC, 1968). On a map of the area made by surveyor Charles Perkins in 1853 (Figure 38), proposed lot lines are superimposed on the natural topography of the Hunters Point case study area including a prominent hill and the original coastline. The “hook” in “Dominie’s Hook” and the “point” in “Hunter’s Point” can clearly be seen jutting into the East River just north of Newtown Creek.
Figure 38. Hunters Point area of Charles Perkins’s 1853 map.

Hunters Point was still reliant upon boats and stage coaches for transportation in and out of the village during this time. Meanwhile, the Flushing Railroad Company had been searching for a place on the waterfront to terminate their railroad. The main ferry terminals on the Brooklyn waterfront were located in heavily populated commercial areas, making the task of acquiring approval for the project difficult. An application to the Common Council of Williamsburg was rejected on the grounds that the railroad would depreciate property values, particularly if the trains were powered by steam. The directors of the railroad company then looked to Greenpoint which was still sparsely populated at the time, and, therefore, less likely to
oppose the plan. In April of 1853, the Common Council granted the Flushing Railroad a route through Greenpoint, which was quickly met with public outcry and subsequently vetoed by Mayor Berry of Williamsburg (Seyfried, 1963).

Four months later, the directors announced that the railroad would terminate at the as-yet unsettled, swampy waterfront in Hunters Point. Union College had donated $20,000 worth of land to the Flushing Railroad Company to locate its terminus at 54th Avenue and 5th Street near a newly constructed dock on the East River. The area was "low meadow and swamp land, covered with salt grass and dotted with the occasional rock outcroppings" (Seyfried, 1963, para. 12). The location was ideal because the railroad company owned the land for the full route, and nearly all the land was level, and, therefore, cheaper to build. Because ferry service did not yet exist at Hunters Point, the railroad company acquired two small steam ferry boats to run between Hunters Point and Fulton Street Slip in Manhattan. The company also built an embankment at the water’s edge where a wharf extended out into the river. Railroad service began on June 26, 1854, running east along the bank of Newton Creek and through Maspeth, Elmhurst, and Flushing. After several years of financial troubles, in March of 1859, the railroad company was reorganized and reincorporated under the name of New York & Flushing Railroad Company. The company hired a new and larger boat for ferry service and modernized the poorly designed depot at Hunter's Point, building a new pier and covered ferry terminal.

In November of 1855, the Common Council of New York passed a resolution to establish ferry service from East 34th Street in Manhattan to Hunters Point, offering a ten-year lease on the land adjacent to the Flushing Railroad Company Station to the highest bidder. The original highest bidder failed to meet the requirements of the Common Council, and two years later the Common Council advertised the lease again. The operator of the newly incorporated East River Ferry Company was the highest bidder and obtained the lease. He acquired the landing needed
to begin operating in 1858 and invested $40,000 to fill two acres of marsh land and build a foundation suitable for a road. The ferry terminal was located at what is now the Waterfront Crab House at the corner of Borden Avenue and 2nd Street. The 34th Street Ferry was opened to the public on April 20, 1859. Five months later, a second ferry service was added—this one between Hunters Point and James Slip in Lower Manhattan (Seyfried, 1984). According to the Traveler’s Guide to the City of New York published in 1871, ferries from 34th Street charged four cents and departed every 15 minutes in the morning and every seven minutes in the afternoon, while ferries departing from James Slip cost six cents and left every half hour.

The president of Union College appointed the son of his wife’s sister, Henry Sheldon Anable, as estate manager in 1855. Anable was perhaps most responsible for the shaping, both figuratively and literally, of Long Island City. Since 1836, the Long Island Rail Road had been operating from Atlantic Avenue in Brooklyn to Jamaica and farther east. Merchants and homeowners on Atlantic Avenue, concerned with the noise and soot from the steam locomotives, convinced the Legislature to outlaw the running of the locomotives inside city limits. The Long Island Rail Road was forced to terminate at East New York and rely on horse cars into the city. Anable was instrumental in convincing the Long Island Railroad to end its line at Hunters Point. In 1859, work on the new railroad from Jamaica to Hunters Point began. The railroad company purchased all the land on the south side of Borden Avenue and dumped rock fill into the water to create 10 acres of new land. Here, a new railroad yard and depot were built adjacent to the Flushing Railroad’s right of way.

Following the extensive physical makeover of Hunters Point, the Long Island Railroad Hunterspoint Avenue station opened in 1860, with the Long Island City station opening just one year later. Travelers from Manhattan would disembark at Hunters Point from the 34th Street Ferry and transfer to the Long Island Railroad. These transportation links encouraged both
commercial and industrial growth, and soon factories were built along the entire Hunters Point waterfront. Inns, restaurants, and saloons were opened to accommodate passengers. Private homes and boarding houses were established for new residents who had found jobs here. In 1868, Anable oversaw the excavation of a canal along 12th Street (now 45th Road) from the East River to Vernon Avenue to allow industrial plants easy access for bringing in raw materials and shipping out manufactured goods. This canal, called Anable Basin, forms part of the northern boundary of this case study area.

Under Anable’s management, the Hunters Point waterfront was “docked and filled, hills were cut down, swamps filled in, and a system of streets and avenues was laid out and graded, at an expense of more than $400,000 by Union College” (Kelsey, 1896, p. 155). Hunters Point had become the freight gateway to Long Island. Freight cars were sent to Hunters Point by barge where they were transferred to rail with the support of gantries, also known as “gallow frames” or “supporting towers.” Two gantries have been preserved and are the centerpieces of Gantry Plaza State Park, serving as a reminder of the neighborhood’s role as the freight gateway to Long Island.

Before alterations to this land were made, the area east of Vernon Avenue and south of Broadway was a tidal marsh through which Sunswick Creek and its tributaries flowed with an outlet to the East River just south of Broadway. The natural rise and fall of the tides flooded and drained the meadows daily. In 1679, the mouth of the creek was dammed to create a mill pond. The damming, which cut off the daily flushing of the meadow lands and the free flow of salt water, was not a problem until the Hunters Point’s industrial boom. Factory sludge, manure, refuse, and slaughterhouse waste became lodged in the meadows, putrefying and creating nauseating odors. The stagnant water also became infested with mosquitoes. By 1866 chills and fever were becoming endemic in Hunters Point, especially over the summer months (Seyfried,
In November of 1867, the Brooklyn Times wrote, “Hunter's Point is known to New Yorkers as the depot of the Long Island R.R., the terminus of a ferry and an ill-smelling neighborhood through which one should pass holding his nose” (cited in Seyfried, 1984, p. 91). The following excerpt from an 1877 Brooklyn Eagle article described the dire situation of Long Island City.

Hundreds of people in some of the wards are confined to their homes by malaria disease in one form or another and the attendance at some of the schools has been decreased by 60%. There is a general outcry for drainage but it is made too late... The present poisoning of our people by swamp miasma must not for another season be suffered if we are to save some of the finest and most promising sections of the city from utter ruin. (“Plague,” 1877, para. 1)

The Improvement Commission, which had built embankments along newly mapped streets, had actually created more drainage problems by blocking off drainage canals and culverts that were installed in 1870. The new streets, 6 to 12 feet higher than the surrounding lands, created pockets of stagnant, disease-breeding waters. In the summer of 1879, the draining of the Ravenswood swamp greatly reduced the threat of disease to the residents of Long Island City (Seyfried, 1984).

In 1870, Hunters Point chose to join the villages and hamlets of Astoria, Ravenswood, and Steinway to become part of the proposed Long Island City. The 1873 Beers map (Figure 39) surveyed shortly after the Long Island City consolidation, shows transportation land uses dominating the southern portion of the waterfront, such as the Long Island Rail Road Depot and the Flushing and Central Rail Road Depot. Two ferry landings, one to 34th Street and one to James Slip in Manhattan are situated adjacent to the Long Island Rail Road Depot. The land use of the northern section of the Hunters Point waterfront is mainly industrial; property
owners included the Warren Chemical and Manufacturing Company and the Standard Oil Company. The land uses in the blocks east of the waterfront, between West Avenue (now Fifth Street) and Central Avenue (now Vernon Boulevard) are a mix of residential and industrial, including a lard oil works, an ink manufactory, and a metal foundry.

Long Island City became part of the consolidation of New York City in 1898, after which the New York State Legislature authorized moving the Queens County seat to Long Island City. Hunters Point became the new seat of government for the entire county. A few blocks north of the study area, in 1909, the Queensboro Bridge was opened, encouraging further development of the area. A 1913 map of the Hunters Point waterfront (Figure 40) shows that it continued to be dominated by industrial and manufacturing uses. A multiple-block sugar refinery is situated near the lower border of the case study area and the Power House of Queens County Electric Company just north of the Long Island Rail Road Depot. The Vulcanite Paving Company had joined the chemical and oil companies on the waterfront. The blocks east of the waterfront have added even more industrial uses, such as paint factories, a varnish factory, and a freight depot.
Hunters Point continued to flourish as an industrial hub through the next several decades, peaking during World War II, when Long Island City was an active shipping port for the distribution of aircraft parts and weapons. In 1961, despite the fact that the neighborhood had long had a mix of housing and industry, the City passed a new zoning resolution
establishing Hunters Point as a heavy manufacturing M3-1 district. The heavy manufacturing designation encouraged the expansion of industrial uses while discouraging residential growth.

The decline of manufacturing in the United States in the 1970s led to the neighborhood’s ongoing creative reuse process whereby former industrial buildings and land were converted into residential and cultural uses. In 1971, the Institute for Art and Urban Resources Inc., now MoMA PS1, was founded, dedicated to transforming abandoned and underutilized buildings in New York City into artists’ exhibition and performance spaces (MoMA PS1, 2013). Artists followed, establishing studios throughout Long Island City in buildings cheaper than similarly sized spaces in Manhattan and Brooklyn. In 1983, Silvercup Studios began operating in the former flour silo room of the Silvercup Baking Factory just south of the Queensboro Bridge, and became the largest television and film production studio in New York City (Silvercup Studios, n.d.). In 1988, the Museum of the Moving Image opened in a building that was formerly part of the Kaufman Astoria Studios complex (Museum of the Moving Image, 2013). In 1986, the City created the Court Square Subdistrict to encourage high-density commercial office development (Department of City Planning, 2013). Subsequently, the 50-story Citigroup tower at 1 Court Square was completed in 1990, becoming the tallest building in New York City outside of Manhattan.

Seeing a need to regulate the evolving mix of industrial, residential, and commercial uses, the City established the Special Hunters Point Mixed Use District in 1981. This designation allowed new manufacturing and commercial uses while permitting limited enlargements and alterations to existing residential buildings as-of-right (Department of City Planning, 2013). The Queens West mixed-use development project was announced in the 1980s. The site covered 74 acres of the Hunters Point historically industrial waterfront from Anable Basin to Newtown Creek. The project included plans for 2,200 apartment units,
parkland, two public schools, a public library, and retail space. In 1992, the Queens West Development Corporation (QWDC), a subsidiary of the Empire State Development Corporation, was formed (PANYNJ, n.d.). Development in Queens West is governed by the General Project Plan (GPP) which overrides New York City zoning regulations. As a subsidiary of the Empire State Development Corporation, QWDC has the authority to override local zoning laws and construct buildings for residential and commercial uses in areas zoned for heavy manufacturing. The GPP specifies the use type, height restrictions, bulk, and design guidelines for each development parcel.

In 1995, the rezoning of a portion of the Special Hunters Point Mixed Use District was adopted, rezoning primary corridors such as Jackson Avenue and Vernon Boulevard from light manufacturing districts to residential and commercial districts. The Queens Plaza Subdistrict was established in 2001 to facilitate commercial development at higher densities while allowing new residential areas to integrate with commercial and light industrial business areas development (Department of City Planning, 2013). Beneficiaries of this rezoning include the New York City Department of Health and Mental Hygiene which relocated some of their operations to a modern 21-story office tower in Queens Plaza, and JetBlue which moved approximately 1,000 employees into the Brewster Building, originally constructed as an automobile and aircraft factory in the early 1900s (Jet Blue, 2013).

In 2004, the City Council approved the rezoning of the Hunters Point Subdistrict, allowing for more residential, light industry, commercial, and cultural activities (Department of City Planning, 2013). New York City’s bid for the 2012 Olympics was partially a catalyst for the rezoning of the southern portion of the Queens West site, as it was intended to be developed into the Olympic Village for the athletes. New York did not win the Olympics bid, and the land was
subsequently bought by private developers. Water Taxi Beach, a publicly accessible artificial beach built on an old wharf near the corner of Borden Avenue and 2nd Street, opened in 2005.

The Special Southern Hunters Point District was established in 2008 with the goal of transforming “an underutilized waterfront area into a higher-density mixed use development with residential and retail uses, community facilities, a public park and waterfront open space” (DCP, n.d. b). Within this district, two subdistricts have been created with specific use, bulk, height, and setback provisions to produce, among other things, a varied skyline, active pedestrian-oriented ground floors, and publicly accessible open space.

In 2009, approximately 30 acres of property in the Queens West development site, along with Water Taxi Beach, was transferred to the City of New York for development of the Hunters Point South project. The project includes 5,000 units of housing, 60 percent of which will be for “middle income” residents (QWDC, n.d.). On March 4, 2013, ground was broken on the first two residential buildings at Hunters Point South. The building plans include resiliency measures to mitigate the impact of future severe weather events, including emergency generators located on the rooftops, concrete bases up to floodplain elevation levels for building frontages, and exterior doors designed to accommodate flood gates (New York City, 2013c).

Today, in Gantry Plaza Park on the waterfront, the red neon Pepsi-Cola sign stands as a symbol of Hunters Point’s industrial past. Since 1936, the sign stood on top of the PepsiCo bottling plant on the Hunters Point waterfront until the plant was demolished in 1999 to make way for apartment buildings (Lippincott, 2000; Blumenthal, 2009). The gleaming residential buildings under construction in Queens West tower over the older buildings in Hunters Point, with the current tallest building at 41 stories. The Hunters Point South Waterfront Park opened to the public in August of 2013.
SIGNIFICANT FINDINGS

Falling in line with Meyer’s theory that hills and high elevation areas were not coveted resources from the 1820s to the late 19th century, a time period which coincides with the rapid industrial growth period of Hunters Point, the need for firm land to build upon actually outweighed the advantages of hills. Hills were leveled to be used as landfill, both to fill swamps and to extend the land into the East River. As described in the following excerpt from an 1867 Brooklyn Times article, hills were sometimes purchased for the sole purpose of cutting down to provide dirt to be used as landfill.

“A large hill on the northeast, and one which years back existed immediately back of the ferry, has been cut away for filling purposes, and Mr. Peter Halsey of this city has recently bought a hill with which he intends to fill swamps purchased by him . . . “ (as cited in Seyfried, 1984, p. 92)

The consequences of living in low-lying land soon became evident in Hunters Point. Due to the damming of Sunswick Creek three centuries earlier, the meadowlands were no longer being flushed with the daily tide. Lodged with factory sludge, manure, refuse, and slaughterhouse waste, they had become a breeding ground for disease-carrying mosquitoes. Exacerbating drainage problems, the Improvement Commission built embankments along long newly mapped streets, blocking off drainage canals and culverts. Hunters Point and surrounding area had become known as an ill-smelling neighborhood, and chills and fever had become endemic. Only after Ravenswood Swamp was drained in 1879 did the threat of disease finally subside.

The quantitative analysis revealed that for 1910 and 1950, socioeconomic status values were lower on the waterfront than the inland areas. Given the numerous industrial and
manufacturing uses along the waterfront and dispersed throughout the residential blocks, and the close proximity to the steam engine railroad, it can be assumed that the case study area was not considered a desirable place to live and was primarily populated with residents who could not afford to live farther from these noxious uses. In contrast to the low-lying meadow lands that had become infamous for odor and disease, two blocks to the northeast of the case study area lies the street block once known as “White Collar Row.” The well-preserved houses on this tree-lined block, now a historic district, were constructed in stone in the 1800s, a time when most houses were made of wood. The original residents were old American families who were eventually replaced by families of Irish descent, many of whom were involved in Long Island City government including the last mayor of Long Island City (NYCLPC, 1968).

In Hunters Point, the 1961 Zoning Resolution designated Hunters Point as a heavy manufacturing M3-1 district, encouraging the expansion of heavy industrial uses. The noise and pollution associated with industrial areas established Hunters Point as an undesirable place. From the 1970s onward, the pattern of poorer residents living closer to the water while upper class residents lived farther inland in Hunters Point reversed. This inversion of socioeconomic status patterns between the waterfront and inland area of Long Island City in the latter half of the 20th century was sparked by the decline of manufacturing and the subsequent creative reuse process. However, drastic demographic changes occurred only after City policy makers recognized the potential for residential development of the neighborhood, establishing the Special Hunters Point Mixed Use District and approving the Queens West development project in the 1980s. Further rezoning solidified Hunters Point as a middle and upper-class residential neighborhood.

Hurricane Sandy’s impact on Hunters Point was minimal compared to other waterfront communities in the city, although the entire case study area falls within New York City Flood
Evacuation Zones 1 and 2. More specific flood information can be found in PWMs released by FEMA in 2013. These maps include the results of a full coastal study begun before Hurricane Sandy plus a more refined analysis of shoreline conditions. In the PWM flood zone map below (Figure 41), Zone AE, the yellow shaded area, shows areas subject to inundation by the 1-percent annual chance flood event. Zone AO, which would be shaded blue but is not present on this map, represents areas of shallow flooding where average depths are between one and three feet. Both AO and AE zones are high-risk flooding areas. The shaded red area is Zone VE, representing areas subject to storm-induced wave action (a 3-foot or higher breaking wave) from the 1-percent annual chance flood. Most of the Hunters Point case study area falls within Zone AE. The map also shows the Hunters Point Historic District, “White Collar Row,” just outside the high-risk flood area.
Meyer theorized that the historical period determines whether certain topographical features are considered either resources or resistances, which in turn influenced the desirability and value of the land. With global climate change, it may be the socioeconomic status of residents that determines whether the waterfront will be a resource or resistance for them. For residents who can afford to rent or purchase properties with mitigation infrastructure, such as the new high-rise buildings in the Hunters Point case study area, the waterfront will continue to be an amenity. But for those without the luxury of protection from the water during severe weather events, the waterfront may return to the hazard it was once perceived to be.

Figure 41. Hunters Point case study area and PWMs flood zones.
CONEY ISLAND

Coney Island came near blowing out to sea. The cyclone swept the beach almost clean and wrecked many bathhouses and other buildings. The ends of both iron piers were torn away. The sea made a savage attack on Brighton Beach. It lashed its waves right up to the front door of the big hotel, and for a time some of the more timid guests were afraid the huge building would float off the beach.


BOUNDARIES OF THE CASE STUDY AREA

The Coney Island case study area encompasses the western end of Coney Island. The boundaries of this case study area are West 20th Street, Surf Avenue, West 21st Street on the east, and the water bodies of Gravesend Bay to the north, and the Atlantic Ocean to the south. This area was selected because of 1) the drastic socioeconomic differences between the Sea Gate community on the western tip of the case study area and the neighborhood to its east which contains a large cluster of public housing developments, and 2) the area was heavily impacted by Hurricane Sandy. The evolution of the two neighborhoods and the differences in the responses to Hurricane Sandy were examined. The study area generally excludes the historic amusement section of Coney Island. This case study area encompasses approximately 0.905 square miles or 579 acres.
TOPOGRAPHICAL DESCRIPTION OF THE CASE STUDY AREA

The Coney Island case study area encompasses the western portion of the low-lying sandbar of the same name. Coney Island was once an island separated from the mainland by a creek before most of it was landfilled. Historically, the case study area was almost completely
marshland and sand dunes. Coney Island differs from other barrier islands along the south shore of Long Island because it was shaped by wave action from both the Atlantic Ocean and the New York Bay. Human alterations to the topography of Coney Island have include the leveling of sand dunes, landfilling, and the building of piers which have allowed sand to accumulate, expanding the beach in a southerly direction. The entire case study area lies within Zone 1 of the designated New York City hurricane evacuation zones.

Figure 44. Coney Island case study area and 1880 Bromley map.

HISTORY OF THE CASE STUDY AREA

The following analysis focuses on the topographical and land use history of that part of Coney Island that falls within the case study area. The rich and extensive history of the primary amusement area between Ocean Parkway and West 37th Street is only touched upon in this analysis in order to give context to the changes that occurred within the study area.
In 1643, Lady Deborah Moody and a group of persecuted Anabaptists from England settled at the southwestern end of Long Island (Denson, 2002). Their settlement became the town of Gravesend, and it included Coney Island, which was then a sandbar to the south of a shallow creek that meandered through a 7,000-acre salt marsh. At the time, Gravesend was the only English town in New Netherland as well as the only American colony founded by a woman. Other settlers as well as the native Canarsee and the Nyack also had claims to Coney Island. In May of 1654, the settlers signed an agreement with the Nyack for the purchase of the land. The agreement detailed the settlers’ legal rights regarding use of the common land for cattle grazing.

Guisbert Op Dyck, a farmer who had been granted a 1642 Dutch patent for the island, believed that the Gravesend patent was only an easement that permitted cattle grazing. In 1661, Op Dyck offered to sell Coney Island to Gravesend, but the town turned down his offer, claiming that it already owned the island. In October of 1661, Op Dyck sold his land to Derick DeWolf, a Dutch businessman who opened a salt works that trapped and evaporated seawater from the creek that could be collected and sold. After DeWolf informed the town of Gravesend that they could no longer allow their cattle to graze on the island during the winter, the townspeople stormed the salt works and destroyed it by fire. Gravesend was eventually granted ownership of Coney Island.

In 1679, while seeking a site to settle their religious community, Jaspar Dankers and Peter Sluyter observed the following:

a low sandy island of about three hours’ circuit, its westerly point forming with Sandy Hook, on the other side the entrance from the sea. It is oblong in shape and is grown over with bushes. Nobody lives upon it, but it is used in winter for keeping cattle, horses, oxen, hogs and others which are able to obtain there
sufficient to eat the whole winter, and to shelter themselves from the cold in the thickets. (Dankers and Sluyter, 1867, pp. 118-119).

The entirety of the island was considered common property owned by the town of Gravesend until 1677 when the arable portion of the land was divided into 39 fifteen-acre shares owned by the families of the town’s original 39 patentees. In 1702, the western end of the island was leased to John Griggs and the fees were distributed among the Gravesend townspeople, a practice that continued until the late 1700s. In 1766, common land on the eastern half of the island was divided into two new divisions: Sedge Bank, now known as Manhattan Beach, and the Western Division, now known as Brighton Beach. Each division was apportioned into 39 lots for the families of the original 39 patentees.

In 1811, increasing interest in the common property from outside of Gravesend led the townspeople to appoint a committee, the Commissioners of the Common Lands, to negotiate all leases. Ten years later, the last division of the island was made, leaving only one remaining area as “common lands.” This area, located between today’s Ocean Parkway and West 37th Street, became the neighborhood that is now known to visitors as “Coney Island.”

Until the 1820s, the only way to access Coney Island, other than by boat, was to cross a shallow section of the creek at low tide. A toll road was constructed, consisting of a wooden bridge over the creek and the mile-long Shell Road, paved with oyster shells. Visitors soon began streaming into the island and makeshift shelters began cropping up on the common lands along the shoreline. The town of Gravesend authorized the formation of the Coney Island Road and Bridge Company. In 1829, the company built a hotel at the end of Shell Road, named Coney Island House, and other hotels soon followed. In 1845, the western end of the island was leased to Alonzo Reed who opened a dance hall, called the Pavilion. The tent-covered, circular dance platform was considered the neighborhood’s first “amusement.” A pier was built near the Pavilion, and steamboat service between South Ferry and Coney Island began. In 1850, a
second toll road, called the Coney Island Plank Road, opened to connect Flatbush and Coney Island. By 1862, the Coney Island and Brooklyn Railroad had opened a horse car line on this road. Five years later, Coney Island’s first steam railroad was completed.

On the eastern half of the island, development by two ambitious entrepreneurs was about to begin. With the help of Gravesend surveyor William Stillwell, in 1868, a businessman named William Engemen purchased several hundred acres of shorefront property in the Western Division from the families of the original 39 Gravesend patentees. Engemen used the “dirt and loam carted from the city’s hills . . .” to fill a marshy area of his property in preparation for a racetrack (Stockwell & Stillwell, 1884, p. 52). In 1878, he completed the 275-room Hotel Brighton, named after the British resort town, on the shorefront, and the area became known as Brighton Beach. During the 1880s, the hotel was threatened by severe beach erosion from a series of storms and the ocean’s naturally occurring littoral drift that was depositing sand from the east end of Coney Island onto the west end (“Sliding to the Sea,” 1890, p. 8). In April of 1888, Brighton Beach Hotel was moved back 595 feet from the ocean in one piece with the help of six steam locomotives. Meanwhile, toward the western side of the island, property owners were gaining land from the sand deposits. At West 10th Street, the shorefront lot of Feltman’s Restaurant had increased by about 800 feet into the ocean. Taking advantage of the enlarged beachfront, the restaurant was moved toward the ocean in April of 1890, also in one piece, by the same movers who had relocated the Brighton Beach Hotel.

Around the same time, another story had been unfolding on the other side of Brighton Beach—on the eastern tip known as Sedge Bank. In the early 1870s, Austin Corbin, a banker and railroad executive, traveled to Coney Island with his convalescing son on doctor’s orders to take in the clean sea air. Corbin visited the marshy area on the eastern end of the island and saw the potential for an upscale seaside resort. Also with the help of William Stillwell, he purchased the lots that made up Sedge Bank from the families of the Gravesend patentees. By 1878, Corbin
had built the luxurious Manhattan Beach Hotel and two railroads that led to his new resort. Two years later, he opened the lavish Oriental Hotel, which was patronized by celebrities and the political elite.

Meanwhile, along the shoreline from what is now West 8th Street to West 37th Street, the Commissioners of the Common Lands leased out waterfront lots where hotels and chowder houses were being built. In 1869, John McKane, a builder and town constable, was elected as one of the three Commissioners of the Common Lands. He doubled the fees for leases of the common lands, but unbeknownst to the townspeople, he received kickbacks from the lessees. For years, Gravesend farmers had been able to prevent the first steam railroad into Coney Island from running through their farms; however, with McKane in power, the state legislature allowed railroads to be built directly through their farms by condemning land along the right-of-way.

By the 1870s, Coney Island had built a reputation as the people’s beach, not suitable for the sophisticated and elite. An 1874 article in The Atlantic Monthly proclaimed, “The fact that it is within one hour’s journey from New York by steamboat, and but little more than that by the horse-cars from Brooklyn, renders Coney Island unfashionable, since its advantages are attainable by all” (Shanly, 1874, p. 306). It was around this time that the entire western tip of Coney Island became known as Norton’s Point, named for Mike “Thunderbolt” Norton, the owner of a hotel called the Pavilion. This hotel, along with a nearby hotel, the Point Comfort House, were well-known for gambling, prizefighting, and prostitution. McKane formed his own police force and appointed himself chief of police, intentionally overlooking the gambling and prostitution for which Coney Island was now notorious. An 1893 New York Times article referred to Coney Island as “Sodom-by-the-Sea” (De L’Epee, 1893, p. 21). Among many letters to the Brooklyn Daily Eagle advocating for the cleanup of Coney Island, former congressman Darwin R. James lamented, “West End, Coney Island, has been a foul sink of iniquity and
disgrace to Brooklyn for many years” (1900, July 30, p. 5). Reverend D. H. Overton, pastor of the Greene Avenue Presbyterian Church, wrote:

> There is no doubt that vice is regnant and rampant at Coney Island. . . You find there that which appeals to the unnatural appetites and the base passions of humanity. . . vice has no right to be there. It is there to the shame and disgrace not only of those who commit it, but of our officials who allow it to exist. This pest house of vice, this hell hole of iniquity, ought to be cleaned out. (1900, July 30, p. 5).

In 1892, the Norton Point Land Company purchased all of the land west of West 37th Street for the development of a private residential community named “Sea Gate.” The neighborhood’s sand dunes were leveled and sewers were installed. Five years later, the public lands underwater were granted to the company, giving the Sea Gate community its own private beach. A 1917 brochure promoted the community as “cool in summer, warm in winter . . . as isolated from disturbing or objectionable influences as if surrounded by a Chinese wall” and touted its private police force, which patrolled “night and day to keep out the peddlers, beggars, picnickers, hurdy-gurdies and other jarring factors” (as cited in Denson, 2002, p. 29).

As evidenced by the Robinson map in Figure 45 below, by 1890, health and charitable institutional land uses had also found their way to the Coney Island shoreline. In this map of the shoreline of the case study area, three sanitariums and the New York Children’s Aid Society are located within close proximity to one another. These sanitariums were health resorts, no doubt situated on the waterfront to take advantage of the fresh sea air. The Children’s Aid Society, founded in 1853, provided lodging houses, schooling, and foster home placement for poor and homeless youths. The Coney Island branch of the Children’s Aid Society functioned as a convalescent home and seaside retreat for the children (NYHS, 2009).
Figure 45. Waterfront area between West 30th Street and West 21st Street on 1890 Robinson map.

An 1893 New York Times article praised the efforts of the charitable institutions of Coney Island:

No one not familiar with the various charities of the city could form an idea of the extent and number of different benevolent institutions and efforts here, designed every summer to give fresh air, country food, sea bathing, medical care, and rural pleasures to the worn and sickly children of our overcrowded tenement houses. These kindly and generous charities, which are not bounded by the limits
of race or sect, have been imitated by other large American cities. (“Summer Charities,” 1887, September 12, p. 4)

The 1907-1908 Bromley map of the same area reveals that the waterfront health and charitable institutional land uses persisted and expanded after the turn of the century. The sanitarium between 21st Street and 22nd Street became the Seaside Hospital of the Brooklyn Children’s Aid Society. Another sanitarium was replaced by the St. John’s Coney Island Summer Home of the Roman Catholic Orphan Asylum. The New York Children’s Aid Society exists in the same location. The Brunswick and Hotel Windsor have been replaced by Sea Breeze, a summer home for convalescing patients managed by the New York Association for Improving the Condition of the Poor.

The 1900 United States Census enumeration district 561 encompassed the entire case study area, including the new Sea Gate community, along with a relatively small portion of Coney Island east of the case study area to 16th Street. In 1900, most residents of this enumeration district were of middle socioeconomic status; however, the most frequently listed occupations were servant and laborer. The third most common occupation was hotel proprietor, followed by clerk and salesman. Other notable jobs included three ship caulkers and a showman. The final occupation listed for residents of enumeration district 561 is “Light House”, referring to the job of Thomas Higgenbotham, the first keeper of the Coney Island Lighthouse (USCO, 1900; USCG, 2013).

By the early 1900s, Coney Island was easily accessible by road, rail, or water. While the various transportation options now brought many visitors cheaply and quickly to Coney Island, it also made day trips possible, which in turn made the hotels obsolete. In 1904, Joseph P. Day purchased the former Sedge Bank division from Corbin and divided the land into residential lots (Cohen, 2000). That same year, William Engemen’s son began illegally filling in the marshland at Coney Island Creek in order to develop the northern portion of the property as residential
lots. The Manhattan Beach Hotel and Oriental Hotel were demolished in 1911 and 1916, respectively, to make way for new residential communities (Denson, 2002). In 1920, the completion of the BMT subway line allowed city dwellers to travel to Coney Island for five cents, and attendance on a hot summer day sometimes surpassed one million (DPR, n.d. b). Childs Restaurant, a large restaurant chain that provided a basic, clean environment for wholesome food at reasonable prices, was constructed on the boardwalk on the southeastern corner of the case study area (LPC, 2003). Throughout the Great Depression, Coney Island remained a popular daytrip destination for city dwellers eager to enjoy the beach and inexpensive amusement. In 1926, Congress approved the widening of the Coney Island Creek to build a shipping canal; however, the plans never came to fruition (Denson, 2002). In the 1930s, the creek was filled in further to accommodate the Belt Parkway (Schneider, 2008).

In 1934, Robert Moses was appointed Commissioner of the New York City Department of Parks. Moses believed Coney Island’s beach was corrupted by private misuse and could be rescued by public policy. As President of the Long Island State Park Commission, Moses had overseen the planning of Jones Beach. Unlike Coney Island, the land had not already been developed, and therefore Moses was able to build the area exactly as he wanted. Jones Beach opened in 1929 with spacious, sandy beaches, a well-maintained boardwalk, clean changing facilities, playgrounds, and a swimming pool. In a report to the Rockaway Chamber of Commerce, Moses expressed his opinion that older beach neighborhoods such as those in the Rockaways and Coney Island were difficult to turn into viable oceanfront communities, and that they “lend themselves to summer exploitation, to honky tonk catchpenny amusement resorts, shacks built without reference to health, sanitation, safety and decent living” (as cited in Kaplan & Kaplan, 2003, p. 15).

In 1937, jurisdiction of Coney Island’s beach and boardwalk was transferred from the Brooklyn borough president to the New York City Parks Department. Moses prepared a report
entitled “The Improvement of Coney Island, Rockaway and South Beaches” which included the following edict:

There must be more land in public ownership, less overcrowding, stricter enforcement of ordinances and rules . . . less mechanical noise-making and amusement devices and side shows, and a more orderly growth of year-round residents. . . This will be not be accomplished overnight, but only over a period of several years. (as cited in Denson, 2002, p. 66).

In 1949, the federal government passed the Housing Act of 1949, which included the Title I program, a law that provided federal financing for slum clearance programs associated with urban renewal projects. The Gravesend Houses development, consisting of 15 seven-story buildings, was completed in 1954 on mostly vacant land adjacent to Gravesend Bay. Next, Moses focused on a tract of shorefront land between West 29th Street and West 32nd Street that he unsuccessfully attempted to convert to a 500-car parking lot several years earlier. In 1953, the City Planning Commission approved Moses’s plans to build the Coney Island Houses development, made up of five 14-story buildings, on this same site (NYCHA, n.d. b).

In 1961, Fred Trump acquired property just west of Ocean Parkway for the site of a new middle-class housing development, Trump Village (Denson, 2002). Much of the existing neighborhood, known as “The Gut,” was poor and had a history dating back to the 1890s when workers from the stables at the Brighton Beach Race Track lived in shacks along the railroad tracks. Property owners in the neighborhood received financial compensation and were given an opportunity to relocate to Trump Village. Other residents, mostly African-Americans, were unable to afford the apartments and were relocated with the City’s assistance to summer bungalows in the West End. Long-time, mostly White residents moved from the West End into
the new Trump Village and other high-rise developments of Coney Island, leaving many vacancies.

In 1967, the area bounded by Coney Island Creek, West 33rd Street, Neptune Avenue, and West 37th Street was declared the Coney Island West Urban Renewal Area. The following year, the City established the larger Coney Island I Urban Renewal Area, bounded by Neptune Avenue, Stillwell Avenue, Surf Avenue, and West 37th Street (ODMED, 2009). The New York City Housing Authority was given the green light to bulldoze entire blocks of densely packed bungalows and replace them with high-rise housing developments. The high-rise towers of Surfside Gardens, O'Dwyer Gardens, and Carey Gardens were completed in June of 1969, December of 1969, and November of 1970, respectively (NYCHA, n.d. a; NYCHA, n.d. d; NYCHA, n.d. e). In some cases, lots were razed but never developed and have remained vacant since the 1960s.

The Urban Development Corporation (UDC), created by the State of New York in 1968, acquired a number of sites within the Coney Island I Urban Renewal Area. Some of the housing developments built on the acquired sites include the Sea Park Apartments, Sea Rise Apartments, and the Scheuer House, all participants in the Mitchell-Lama Housing Program. As of 2013, Coney Island has one of the highest concentrations of public and publicly supported housing in the city, with 37 New York City Housing Authority (NYCHA) buildings and approximately 6,300 Mitchell-Lama units (SIRR, 2013).

Although most of the historic buildings in and around the Coney Island case study area were razed in the name of urban renewal, the Childs Restaurant building was salvaged. Constructed in 1923, the Childs Company maintained a restaurant in this building until it closed in the 1950s along with many other neighborhood businesses due to disinvestment by the City. The New York City Landmarks Preservation Commission designated the ornate former Childs Restaurant building on the boardwalk as a landmark in 2002 (LPC, 2003). The vacant building
was purchased in the 1950s to be used as a candy manufacturing facility, which ceased operations in 2003. In July of 2013, the Landmarks Preservation Commission voted 9 to 0 in favor of a private architecture firm’s plans to preserve and repair the face to match the original details of the building while converting it into a performance space and restaurant, to be named the Seaside Park and Community Arts Center (Dailey, 2013).

After the turn of the century, public policy would once again take its turn in the transformation of Coney Island. In the summer of 2009, the City Planning Commission and the City Council provided final approval on the Coney Island Comprehensive Rezoning Plan. The plan established a new special zoning district, the Special Coney Island District, encompassing 17 blocks between the Coney Island Aquarium and West 22nd Street, and at least partially overlapping three blocks in the southeast corner of the case study area. The rezoning aims to expand amusement uses in the historic boardwalk section, and to redevelop vacant and underutilized land as affordable housing and neighborhood retail and services. The rezoning area that overlaps the case study area would create a park on vacant waterfront land and mixed-use buildings including residential and retail space on the same block where the landmarked Childs Restaurant is situated.

The low-lying topography and geographic location of the study area have made it vulnerable to storm waves and flooding for centuries, though, as evidenced by Hurricane Sandy in October of 2012, the impact is not the same throughout the case study area. During Sandy, storm waves severely damaged homes on Sea Gate’s waterfront, knocking out the first floors of some structures. Owners who had built bulkheads at the edges of their properties suffered less damage (SIRR, 2013). The remainder of the case study area suffered extensive flood inundation, much of it originating from the area’s bays, creeks, and inlets, rather than from the ocean. Residents were temporarily displaced due to the flooding of ground-floor residences as well as the damage to electrical, heat, and elevator systems in high-rise buildings which took two
to four weeks or longer to repair (SIRR). Many residents had nowhere else to live and opted not to go to shelters, while others, including the many elderly and disabled residents of high-rise assisted living facilities, were physically unable to leave their homes.

The extensive wave damage to Sea Gate’s waterfront buildings was largely the result of human alterations to the topography of the Coney Island coastline. In the 1990s, the United States Army Corps of Engineers (USACE) began work on the Coney Island coastal storm risk reduction project; however, the Sea Gate homeowners association opted out of some measures because it would have required them to open their beaches to the public. The USACE moved forward with the project for the rest of Coney Island, which included the building of a rock jetty at West 37th Street (Mooney, 2007). Due to littoral drift, ocean waters have caused a buildup of sand to the east of the jetty, while sweeping sand away from Sea Gate’s southern beaches and onto property facing Gravesend Bay and Coney Island creek. As shown in Figures 46, 47, and 48 below, Sea Gate’s southern beach has severely diminished over the years, leaving the community’s waterfront homes extremely vulnerable to storm surge.
In 2013, the USACE announced it would spend $30 million to restore Sea Gate’s beaches by constructing four rock jetties, a controversial project because the beaches are not publicly...
accessible (Bredderman, 2013). The USACE has stated that the work in Sea Gate is a continuation of the original Coney Island coastal storm risk reduction project that began in the 1990s, and benefits Coney Island as a whole (USACE, n.d.). Meanwhile, the USACE plans to restore the beaches along Coney Island and Brighton Beach to their pre-Sandy conditions by replenishing approximately 272,000 cubic yards of sand that were washed away during the storm.

SIGNIFICANT FINDINGS

The historical research revealed the evolution of the socioeconomic distribution within Coney Island. The exclusive Sea Gate community, developed in the late 1890s, accounts for higher literacy rates relative to the remainder of the case study area in 1910. The pattern continues from 1950 to 2010, with higher income values for the Sea Gate neighborhood than the adjacent neighborhood, which experienced an influx of high-rise public housing developments beginning in 1954. From 1910 to 1980, the eastern tip with the highest socioeconomic status section starts around Coney Island Avenue; from 1990 to 2010, the section begins at Corbin Plaza. This neighborhood, known as Manhattan Beach, was established as a luxury resort area in the 1870s and became a residential community with mostly spacious, detached homes beginning in the 1920s.

Beginning in the 1950s with the Gravesend Houses and Coney Island Houses, public policy played the dominant role in the transformation of the west side of Coney Island from a community of small bungalows to large-scale housing developments. As urban renewal areas were designated across almost all of Coney Island west of Stillwell Avenue and north of Surf Avenue, the City razed large swaths of bungalows and other low-rise buildings to construct more high-rise housing projects. Even after the high-rise public housing approach was deemed
unsuccessful, the City continued to create more low-income projects near existing public housing, as development in other locations of the city was politically infeasible. The clustering of public housing in Coney Island and the Rockaways echoes the centuries-old practice of clustering city-related institutions that are considered unwanted land uses, such as penitentiaries and almshouses, on the urban fringe.

As of 2013, 77 percent of Manhattan Beach residents own their homes, and the median property value is $922,300 (SIRR, 2013). Sea Gate’s home ownership rate is 48 percent, still significantly higher than the 33 percent city average, with a median property value of $614,600 for this neighborhood. By contrast, the percentage of homeowners for the section of Coney Island between West 37th Street and Brighton Beach is only 22 percent, and the median property value is $320,000, almost half that of Sea Gate. High rates of home ownership in Sea Gate and Manhattan Beach suggest that these areas will continue to be occupied by residents of a high socioeconomic status relative to the remainder of Coney Island.

The Coney Island rezoning plan, which allows for high-rise residential development as well as services and amenities such as retail and parkland, is another example of the City’s attempt to transform the neighborhood through public policy. The impact on the overall socioeconomic status of the central portion of Coney Island remains to be seen as the threat of flooding from stronger and more frequent storms increases with climate change. The entire Coney Island peninsula falls within Zone 1 of the City’s six designated hurricane evacuation zones issued in 2013. As described earlier, the City issues evacuation orders beginning with Zone 1 and more zones are added depending on the forecasted strength, track, and surge of the storm. The PWMs flood zones map, seen in Figure 49 below, indicates that with the exception of several small patches in the Sea Gate neighborhood, the entire case study area is subject to either high-velocity wave damage or flood inundation. The rezoning area also falls within the area that is at a high risk of flood inundation from the 1-percent annual storm. Resiliency
measures to mitigate the impact of future storms are often financially prohibitive, yet will be required in order to attract potential residents to any new developments within the rezoned area.

Figure 49. Coney Island case study area and rezoning area boundary with PWMs flood zones.

Almost a century before Coney Island became home to one of the highest concentrations of public housing in the city, the area was known for another type of land use also intended to aid poor and less fortunate residents of the city – health and charitable institutions. Seaside homes for poor or sick children and sanitariums dotted the boardwalk before Coney Island
became famous for its amusement parks. While the area was once a well-known refuge from the disease-conducive living conditions of the urban environment, it is now widely considered among the most hazardous places to live in the city. Its vulnerability to direct wave impacts and flooding from severe weather events are only expected to increase in frequency and intensity with climate change. Coney Island’s ability to transform into a safe and desirable neighborhood once again may rely on the City’s policies toward climate change and its ability to implement flood mitigation practices stemming from those policies.
EXPLORATORY DATA ANALYSIS USING GWR RESIDUALS RESULTS

Traditional regression aims to minimize residuals by including in the model all variables that are thought to contribute to a process. This study is different in that a misspecified model is already assumed after the preliminary analysis indicated that elevation alone is not a significant global predictor of socioeconomic status, and therefore, large residuals were expected throughout the city. In this study, GWR standardized residuals results were mapped as a way to explore the data in order to identify anomalous areas that either had much higher or much lower values than what was predicted by the local regression equation. Standardized residuals clusters were also mapped to more clearly see where clusters of large residuals, both negative and positive, were found. Both types of maps can be seen in Appendix H.

Mapping the standardized residuals helped me to generally understand where the areas of negative and positive residuals were located; however, the results were a bit overwhelming because information was provided for every geographic unit regardless of how large the residual statistic was or whether it stood alone or in a cluster of geographic units with similar residual values. The standardized residuals cluster map, on the other hand, proved to be an extremely efficient way to explore the data as it helped to quickly pinpoint areas of where large residual values were grouped together and may be appropriate for in-depth, qualitative analysis. In the case study selection process for this project, the residuals clusters analysis guided me toward the Bellevue and Hunters Point neighborhoods, where positive residuals clusters were found, and the western area of Coney Island where negative residuals clusters were found. Subsequent studies involving the exploration of geographic areas where a regression model does not work
also may find the mapping of residuals clusters to be a useful and efficient tool to highlight those areas.

**RELATIVE ELEVATION**

This study was the first to consider how relative elevation is associated with socioeconomic status. Relative elevation was examined because of its potential to measure drainage and air circulation as well as residential perception of height. Low relative elevation areas are located in dips or valleys, medium relative elevation areas are generally flat, and high relative elevation areas are located on the tops of hills or ridges.

Box plots were created in order to gauge the relationship between relative elevation and socioeconomic status at three points in time: 1910, 1940, and 2010. For each analysis year, three relative elevation calculation levels were examined: 500 foot, 1,000 foot, and 2,000 feet. Relative elevation values were then divided into three categories: low, medium, or high. These box plots concluded that in 1910 and 1940, the lowest socioeconomic status residents tended to live in the flattest areas, particularly when relative elevation was calculated at the 2,000-foot level. For 2010, no association between socioeconomic status and relative elevation was found, a finding that suggests that relative elevation had less effect on the socioeconomic distribution of people than it had in previous years.

In the GWR Regression analyses, relative elevation was found to be a better determinant of socioeconomic status than absolute elevation for three of the ten analysis years: 1910, 1960, and 1970. For two of these analysis years, the relative elevation calculation level that yielded the best results was 13,000 feet, the maximum level that was calculated. This finding suggests that larger calculation levels may yield even lower AIC values. In this study, the time spent creating
the relative elevation DEMs was prohibitive—the larger the calculation level, the more time required. For example, a relative DEM calculated at the 13,000-foot level took more than 48 hours to complete. As computer processors become more powerful, processing time should be greatly reduced such that future studies could evaluate relative elevation calculated at larger levels.

THE HORIZONTAL AND VERITICAL FRINGES

Prior to industrialization, the urban fringe of American cities was characterized by land-intensive uses such as parks and cemeteries, noxious uses such as dumps and factories, and city-related unwanted uses such as pest houses and prisons. Two waterfront case study areas, Bellevue and Coney Island, are representative of the urban fringe. For Bellevue, this began in 1794 with the Common Council’s decision to place a pest house for yellow fever patients on the waterfront far from the urbanized areas of the city. Similarly, maps of Coney Island from 1890 and 1908 revealed that sanitariums, charitable institutions, and an orphanage had made their homes on the urban fringe in this southernmost part of Brooklyn.

Meyer proposed that the urban fringe did not exist only in horizontal space, but also in vertical space (2005). Dubbed the “vertical fringe,” he argued that many of the same urban fringe land uses would be found in the higher elevations of cities prior to the availability of electric-powered railroads and automobiles that made reaching those areas easier. The establishment of the Richmond County Poor Farm on the highest elevation land in Staten Island is a prime example of an urban fringe land use found on the vertical fringe.

Swauger found that both poor residents and the very well-to-do resided on the horizontal urban fringe (1978). Meyer observed a similar pattern for the vertical fringe. The 1900 Census data for the highest elevation area of Staten Island reflected this pattern, with residents of the
poor farm and a charitable institution for women and children living within close proximity to very wealthy households. As of 2010, this pattern still persists with one of the lowest income Census Tracts in Staten Island directly adjacent to one of the highest income Census Tracts.

The clustering of unwanted land uses is also characteristic of the urban fringe. After the establishment of a pest house on the waterfront of the Bellevue case study area, a hospital and later a penitentiary and almshouse were constructed all within a confined space. This clustering of city-related institutions is illustrative of the City’s need to place these unwanted land uses in an area far from the city center and adjacent to an existing unwanted land use where it would meet the least resistance. The City’s purchase of Blackwell’s Island in 1828 for the purposes of building a penitentiary, and eventually an asylum and hospital for inmates and the indigent, is another prime example of the clustering of unwanted city-related land uses on the urban fringe. An example of this clustering on the vertical fringe of the city is the establishment of the Richmond County Poor Farm in the rural uplands of Staten Island in 1829, and the subsequent decision to build a tuberculosis hospital adjacent to the poor farm. Similarly, the clustering of public housing in Coney Island and the Rockaways, the southernmost fringes of the city, echoes the centuries-old practice of the clustering of City-related yet City-unwanted institutions.

The Bellevue, Coney Island, and Staten Island case study areas demonstrate how very geographically different areas may all represent the urban fringe and display similar phenomena. The Bellevue area is now a part of bustling midtown Manhattan, yet was on the urban fringe in the late 1700s when the decision was made to site a pest house there. Coney Island, on the southernmost land in Brooklyn, remains on the urban fringe of the city, with its high-rise housing developments standing as evidence of past City policies. Meanwhile the highest elevation area of Staten Island illustrates the reality of a vertical fringe, where the Richmond County Poor Farm and later a tuberculosis hospital were established.
James Wredford Watson called areas of historical persistence “relict areas” and proposed that relict geography permits “... a description of the present which is sufficiently illuminated by the past to throw its shadow into the future, and make us realise that place and time are continuously and inextricably bound together” (1959, p. 143). To a large degree, the persistence of historical settlement patterns was found to be a powerful force in all of the case study areas. In general, this persistence was able to withstand technological, economic, cultural, and significant physical topography changes. Public policy, such as through the use of zoning tools and eminent domain, was the only major influence that significantly transformed the historical land use and settlement patterns of the neighborhoods studied.

Although today, the land on the highest elevation area of Staten Island would be ripe for luxury housing development, it remains in the hands of the local government, as it was almost 200 years ago when the Richmond County Poor Farm was first established. The City later acquired another large tract of land across the road from the farm colony, and eventually built the City’s largest tuberculosis hospital here. Although the poor farm and tuberculosis hospital have long since closed, City-related institutional uses continue to dominate this area that was landmarked in 1985. The new uses, while still City-related, are no longer unwanted—they include a Parks Department playground, a rehabilitation home, and the Staten Island ballet.

In the Bellevue case study area, institutional land uses have also persisted for centuries, despite the fact that it is located on prime waterfront real estate. In 1794, the Common Council selected the site for a yellow fever pest house. Two decades later, the City purchased land adjacent to the site and constructed a new penitentiary and almshouse to replace the one at City Hall Park. Ten years later, a hospital was constructed, and the three institutions including the 20 acres of surrounding land became known as Bellevue. The penitentiary and almshouse were
eventually moved to Blackwell’s Island, and Bellevue became a purely medical establishment. Medical institutions continue to be the dominant land use in the case study area north of 23rd Street, though there are some non-medical city-related uses, such as the 30th Street Men’s shelter.

South of 23rd Street, a tenement neighborhood, known as the Gas House District, was populated by mostly low-income immigrant families. This changed in the 1940s when 80 acres of land between 14th Street, First Avenue, 23rd Street, the East River Drive, and Avenue C were condemned and razed to make way for Peter Cooper Village–Stuyvesant Town, a private, middle-class housing development that excluded non-White applicants. Rather than a project by a private developer, this was a City-led plan whereby the developer was asked to consider a proposal that promised to condemn blocks of so-called slum areas in the name of urban renewal. This political move by the City completely changed the sociodemographic makeup of this area, which continues to be middle-class today. Without the City’s intervention, the neighborhood would likely have remained a low-income, low-rise neighborhood, similar to the Lower East Side today.

The site now known as Marble Hill functioned as a military fort, first for the Colonialists, then later for the British, during the Revolutionary War. During the 19th century, the hill evolved from a sparsely developed outpost on the road between Manhattan and the mainland into a solidly middle-class residential neighborhood. Although the demographic makeup of the residents has changed enormously in the past 50 years, the residents remain largely middle-class. The high rate of homeownership in the neighborhood coupled with the fact that turnover is extremely low could account for this persistence of residential socioeconomic status.

Notably, Marble Hill experienced the most drastic human-made changes to its physical topography. In 1895, the Harlem River Ship Canal was completed, transforming Marble Hill
into an island. In 1917, Spuyten Duyvil Creek was landfilled, physically connecting the neighborhood with the borough of the Bronx. These topographical changes had major impacts on transportation to and from Marble Hill. In addition, the landscape of the neighborhood, particularly around its periphery, was hugely affected. The St. Stephen United Methodist Church at the corner of Marble Hill Avenue and 228th Street which once had a bucolic view of Spuyten Duyvil Creek, now overlooks apartment buildings and a gated playground. The digging of a ship canal and filling of a creek, with all of its inconveniences, had no dramatic effects on the socioeconomic status of the neighborhood.

The Hunters Point case study area is an excellent example of how City zoning policy can drastically reshape a neighborhood. For nearly a century, the area thrived as an industrial center of the city. The 1916 Zoning Resolution designated the entire area as “Unrestricted” implying that all uses, including the heaviest manufacturing uses, were acceptable here. In 1961, the City passed a new citywide zoning resolution. Despite the fact that Hunters Point had a long history of mixed industry and residential uses, the neighborhood was designated as a heavy manufacturing M3-1 district, encouraging the expansion of industrial uses while discouraging residential growth.

However with the decline of the manufacturing industry in the 1970s, the City realized the need to allow non-industrial uses to fill the vacant lots and buildings that manufacturing businesses had left behind. In 1981, the Special Hunters Point Mixed Use District was established, permitting limited as-of-right enlargements and alterations of existing residential buildings in addition to new infill residential construction. A little more than a decade later, the City approved the rezoning of primary corridors, such as Vernon Boulevard and Jackson Avenue, from light manufacturing to residential and commercial. The process of transforming this industrial neighborhood into a full-fledged mixed-use residential area was underway.
In 1992, the Queens West Development Corporation (QWDC) was established to implement the Queens West project, covering 74 acres of the historically industrial waterfront from Anable Basin to Newton Creek. As a subsidiary of the Empire State Development Corporation, QWDC has the right to override local regulations, such as the City’s M3-1 heavy manufacturing zoning designation. In 2001, the Hunters Point Subdistrict was created as part of the Special Long Island City Mixed Use District and was subsequently rezoned “to promote a vibrant mix of housing, light industry, commercial enterprises and cultural activities in Hunters Point” (DCP, n.d. a). Finally in 2008, the Special Southern Hunters Point District was established to solidify this area of the waterfront as a high-density mixed-use neighborhood for residential, retail, and community uses including a public park and open space on the waterfront.

The rapid increase in the socioeconomic status of the Hunters Point case study area from 1990 to 2010 can be attributed to public policy, including zoning changes and the power of state corporations to override local zoning laws. This increase is evidenced by the huge jumps in median household income for the Census Tract encompassing the waterfront area of the neighborhood between 1990, 2000, and 2010, which was $46,250, $85,898, and $117,750, respectively. The physical landscape of Hunters Point has also been drastically altered, as the waterfront area has been transformed from a low-rise mixed manufacturing and industrial neighborhood to a high-rise residential and commercial community.

The City is attempting another neighborhood transformation through public policy with the Coney Island rezoning plan, which received final approval with modifications in 2009. While the Hunters Point case study is an example of public policy’s capability to reshape neighborhoods, climate change may prove to be a more powerful force, with the potential to prevent a similar land use and socioeconomic transformation in Coney Island. Although the
area has experienced storm damage and flooding for centuries due to its low-lying topography and geographic location on the open waters of the Atlantic Ocean, Coney Island’s vulnerability was made painfully clear with Hurricane Sandy in 2012. The peninsula was severely impacted by wave damage and flood inundation.

The Coney Island rezoning plan established the Special Coney Island District, encompassing 17 blocks between the Coney Island Aquarium and West 22nd Street, and allows for high-rise residential development as well as services and amenities such as retail and parkland. The entire Coney Island peninsula falls within Zone 1, the most hazardous of the City’s six designated hurricane evacuation zones. As indicated by the PWMs flood zone maps, the entire rezoning area is at high risk of flood inundation from the 1-percent annual storm. The use of zoning tools is no longer enough to guide the land use and socioeconomics of the City’s waterfront neighborhoods. In order to attract new residents and businesses to rezoned areas, such as in Coney Island, the City will need to ensure the safety of the neighborhood by implementing coastal resiliency measures that would mitigate the impact of future storms.

CLIMATE CHANGE AND ENVIRONMENTAL JUSTICE

Environmental justice can be used to describe issues surrounding the disproportionate exposure of vulnerable groups of people, including low-income communities and communities of color, to environmental health hazards such as water and air pollution. Climate justice, a type of environmental justice, is often discussed on a global scale, referring to the idea that wealthy, industrialized nations are responsible for changes to the atmosphere that have contributed to climate change, while developing nations bear the brunt of the environmental issues that have arisen because of climate change. On a local scale, the climate justice discussion includes recognizing that within cities and villages, vulnerable groups are often the most exposed to the
adverse effects of climate change, such as flooding, landslides, and heat-related mortality. Low-income communities are even more vulnerable to disaster because they often lack the political and financial means to recover from disaster as quickly and easily as more affluent groups. In August of 2005, Hurricane Katrina caused severe physical damage and loss of life along the Gulf Coast. The uneven devastation and recovery brought the issue of climate justice to the forefront of topics surrounding global climate change.

Historically, low-lying lands have been associated with disease and mortality. In the 1860s, the low-lying neighborhood of Hunters Point, known for its putrid, stagnant waters, suffered from a plague of malaria. The cause was generally attributed to miasma or “bad air” that emanated from swampy areas rather than the disease-carrying vectors that lived in the stagnant waters. Regardless of the presumed reasons for the association between low-lying lands and disease, those who could afford to live elsewhere avoided these areas. An 1890 Census Bureau report for New York City and Brooklyn revealed that death rates, exclusive of stillbirths, were largely explained by the mean elevation of each district (USCO 1895). This could be attributed to the actual environmental hazards associated with low-lying land or the conditions associated with poverty such as sanitation and access to health care. Villarreal (2013) found that for Manhattan in the 1800s, housing prices rose with distance from historical marsh areas, a pattern that largely persisted into the 21st century; however, private development in some low-lying areas such as Peter Cooper Village-Stuyvesant Town and Battery Park City have interrupted this pattern.

As Meyer (2005) has theorized, the historical period is a determinant of whether certain topographical features, such as hills or rivers, were considered either resources or resistances, which in turn influences the desirability of those features. In the coming years, the socioeconomic status of residents may determine whether the waterfront will be a resource or
resistance for them. For residents who can afford to rent or purchase properties with mitigation infrastructure such as those in the new Hunters Point South high-rises, the waterfront will be a resource. But for those without the luxury of protection from the water during severe weather events, such as low-income housing residents in Coney Island, the waterfront will be a resistance. A stark, bivariate pattern may emerge whereby upper-income residents who can afford measures to counter storm surge and flooding live next to poor residents who have no choice but to live in inexpensive housing in flood-prone areas.

In New York City, this bivariate pattern can already be seen. Maantay and Maroko found that for New York City in 2000, minority populations were not disproportionately represented within the 100-year floodplain (2008). This may be explained by the influx of high-income households to new luxury developments, such as those in Battery Park City, in coastal and landfilled areas. The increased desirability of living on the waterfront is part of a cultural perception shift that coincided with deindustrialization. With Hurricane Sandy in 2012, flooding in parts of Staten Island, the Rockaways, and Coney Island caused severe damage in both poor and wealthy neighborhoods. Climate justice issues in New York City, then, may focus more on resiliency and recovery rather than on the disproportionate exposure of low-income and minority communities.

Hurricane Sandy’s aftermath revealed the disproportionate rate of recovery throughout the city. Those without the financial means to temporarily relocate elsewhere could only either stay put and wait for assistance or move into overcrowded and often unsafe shelters. Hundreds of homebound seniors and disabled residents had no choice but to remain in their buildings without power, heat, or water. In high-rise buildings, such as the NYCHA developments and many senior housing facilities in Coney Island, no electricity meant elevators and toilets did not function, leaving many residents trapped in unsanitary conditions.
Electricity returned to most of lower Manhattan within a week, one of the shortest recovery times in the city. Heat, power, and hot water were restored to all NYCHA buildings by November 18, almost three weeks after the storm (New York City, 2013a). A New York Times article published three months after Sandy noted that the recovery process had been uneven (“Recovery Remains Spotty,” 2013). In Staten Island, which bore a heavy brunt of the storm, City officials estimated that as of January 2013 when the article was written, power and heat had not yet been restored to about 300 buildings. The article also reported that 10 NYCHA buildings in Red Hook, Coney Island, and the Rockaways were still utilizing mobile boilers, run by generators.

After Hurricane Sandy, FEMA published new flood elevation maps for New York City. In January of 2013, the Department of Buildings subsequently updated the building code to require that flood resistant construction comply with the new, higher flood elevation levels (DOB, 2013). The Department of City Planning in turn released a proposed zoning text amendment affecting zones in the 100-year floodplain (DCP, 2013). The new regulations, such as raising height maximums, would allow reconstructed and new buildings to comply with the new building code requirements. As of August 2013, the proposed zoning amendment was in the approval process.

In June of 2013, Mayor Michael Bloomberg released a comprehensive plan containing recommendations for rebuilding neighborhoods damaged by Hurricane Sandy and increasing the resilience of buildings and infrastructure. The report acknowledged that along the length of Williamsburg, Greenpoint, and Long Island City, significant new development is expected, and the City plans to investigate resiliency strategies that rely on both public and private solutions that can be implemented incrementally over time. Some of the possible strategies include edge elevations along esplanades and open spaces, increased street elevations, and parks designed
with flood mitigation infrastructure. The report also proposes the Newtown Creek surge barrier and raising bulkheads in low-lying areas (New York City, 2013b). For NYCHA buildings, the report suggests that the City should attempt to “retrofit public housing units damaged by Sandy and increase future resilience of public housing” (SIRR, 2013, p. 347). However, the same report states that due to the nature of the city’s structural inventory, flood protection measures such as elevating or dry flood-proofing existing structures are “prohibitively expensive, physically infeasible, or both” (SIRR, 2013, p. 79). This statement negates the possibility of the City’s suggestion to retrofit existing NYCHA buildings in the 1-percent floodplain, which means a larger, more expensive, region-wide solution would be required to protect existing public housing in Coney Island.

Adding to the desirability of upland neighborhoods are higher average temperatures and the increasing frequency of extreme heat events linked to global warming. Inland neighborhoods situated at high elevations generally offer better air circulation than low-lying inland areas, providing some relief during the hottest months of the year. More abundant vegetation, which also has a cooling effect, can usually be found in the hilly upland areas of cities. In a New York Times real estate article about Todt Hill, the affluent neighborhood that shares the same high elevation ridge as the former New York City Farm Colony, a resident explained that the exterior temperature reading on her dashboard rises as she descends the neighborhood (Flegenheimer, 2011).

In the following thermal and land cover maps created by NASA using Landsat data, surface temperatures recorded on one of the hottest days in the summer (Figure 50) are spatially coincident with vegetative cover (Figure 51). This spatial coincidence can be explained by the urban heat island effect whereby densely developed urban areas experience warmer temperatures than surrounding rural areas. The warmer temperatures are attributed mainly to
the larger presence of impervious land surfaces such as sidewalks, street pavement, and buildings that retain more heat than vegetation. Additionally, trees that reduce building and surface temperatures by providing shade also improve local air quality by sequestering carbon dioxide (Nowak, 1993). Vegetative cover is in turn spatially coincident with hilly terrain (Figure 52) such as the high ridges of the terminal glacial moraine, which run diagonally from southwest to northeast across Staten Island, Brooklyn, and Queens.
**Figure 50.**
Temperatures in New York City as measured by Landsat on August 14, 2002 at 10:30 a.m. during a heat wave. (NASA Earth Observatory)

**Figure 51.**
Vegetation in New York City. (NASA Earth Observatory)

**Figure 52.**
Hillshaded Digital Elevation Model of New York City.
On a local level, the uneven exposure of certain communities to higher temperatures, particularly during heat waves, is a climate justice issue. In 1972, Ellis found that the proportions of non-White people who died from excessive heat or insolation were approximately double that of the proportions for White people. Using data gathered for eight neighborhoods in Phoenix, Arizona, Harlan et al. found that lower socioeconomic and ethnic minority groups were more likely to live in warmer areas of the city than their non-minority counterparts, and were more vulnerable to heat exposure because they had fewer social and material resources to cope with the extreme heat, such as air-conditioning or alternate places to stay (2006). Rosenthal found that in surface urban heat island regressions, data at the Community District, UHF, and Census Tract levels all suggest that surface urban heat island temperatures are indeed correlated with income levels, with temperatures tending to be higher in low-income areas (2010). These findings suggest that low-income communities and communities of color are disproportionately exposed to higher temperatures and less likely to be able to cope with the heat.

A draft summary from the Intergovernmental Panel on Climate Change warns that sea levels could rise by more than three feet by the end of the century if greenhouse emissions continue at the current pace (Gills, 2013). The draft also estimates that if carbon dioxide levels in the atmosphere doubled, which at the current rate would be in a matter of decades, temperatures would increase by at least 2.7 degrees, though many climate scientists suggest that an increase above 5 degrees is more likely, leading to, among other issues, extreme heat waves. Increased temperatures and flood events as a result of climate change have the potential to radically change existing residential patterns throughout the city.
CONCLUSION

It is generally accepted among environmental geographers that there is no such thing as a natural disaster. In every phase and aspect of a disaster—causes, vulnerability, preparedness, results and response, and reconstruction—the contours of disaster and the difference between who lives and who dies is to a greater or lesser extent a social calculus.

(Neil Smith, 2006, There’s no such thing as a natural disaster, in Understanding Katrina, perspectives from the social sciences, para. 1)

In many ways, physical topography had a significant influence on original settlement patterns in New York City and continues to shape the residential, land use, and socioeconomic landscape. Geographers have generally agreed that highly elevated land with its clean air and present views are valued over areas of low elevation with poor drainage and risk of flooding. However, some studies have pointed to the historical presence of low-income groups in high-elevation areas and the evolution of the waterfront from an industrial zone to a residential amenity. Sea level rise along with frequent and more intense storms associated with climate change may also affect the desirability of the waterfront. This goal of this study was to address the question, “What are the historical relationships between land elevation and socioeconomic status in New York City?“

To answer this question, a longitudinal, mixed-methods approach was implemented. Quantitative methods included traditional exploratory data analysis and regression techniques as well as a non-traditional method of mapping regression residuals to highlight anomalous areas deserving of historical, qualitative analysis. Qualitative methods utilized archival research methods including the analysis of historical maps and documents. The possibility that relative elevation, the elevation of land relative to its
surrounding area, plays a role was also examined. Findings were discussed in the context of climate change and environmental justice.

This study departed from the traditional use of regression results in that a misspecified model was assumed after the preliminary analysis indicated that elevation and distance from a Central Business District alone were not significant predictors of socioeconomic status. The GWR standardized residuals were mapped as a way to explore the data and identify anomalous areas that either had much higher or much lower values than what was predicted by the local regression equation. Standardized residuals clusters were also mapped to more clearly see where clusters of large residuals, both negative and positive, were found. The standardized residuals cluster map proved to be an extremely efficient way of quickly narrowing down areas that would be appropriate for in-depth, qualitative analysis, such as the Bellevue, Hunters Point, and western Coney Island neighborhoods.

For the first time, the association between relative elevation and socioeconomic status was investigated. Box plots created for three points in time, 1910, 1940, and 2010, showed that for the first two points in time, residents of low socioeconomic class tended to live in the flattest areas. For 2010, no association between median income and relative elevation was found, a finding that suggests relative elevation had less effect on the socioeconomic distribution of people for this year than in previous years. Interestingly, relative elevation was found to be a better determinant of socioeconomic status than absolute elevation for three of the ten analysis years: 1910, 1960, and 1970. For two of these analysis years, the maximum relative elevation calculation level, 13,000 feet, yielded the best results, suggesting that larger calculation levels may yield even lower AIC values. The amount of computer processing time required to create the relative elevation models was prohibitive, with larger calculation levels requiring more time. For future studies, processing time should be greatly reduced with more powerful
computer processors, and therefore they could evaluate relative elevation calculated at larger levels.

This study confirmed the findings of Meyer that many of the same urban fringe land uses found in horizontal space, such as land-intensive and unwanted uses, are also found in vertical space, a place he dubbed the “vertical fringe.” The co-existence of poor and well-to-do residents and the clustering of city-related yet city-rejected land uses, also characteristic of the urban fringe, were found on both the horizontal and vertical fringes of the city. Also affirming previous findings, the persistence of historical settlement patterns was evident in nearly all of the case study areas. In general, historical settlement persistence was able to withstand technological, economic, and cultural perception changes as well as major alterations to the physical topography. In the five case study areas examined, public policy, enabled through the use of zoning tools and eminent domain, was the major force that significantly transformed historical land use and settlement patterns of the neighborhoods. The socioeconomic impact of some public policies, such as the City's redevelopment plan for Coney Island, is yet to be seen, as the entire rezoning area is at high risk of flood inundation from the 1-percent annual storm. Cultural perception of the waterfront is once again changing. Seen less as an amenity and more as a flood risk, waterfront property will become far less desirable unless the City implements coastal resiliency measures to mitigate the impact of future storms, an often cost-prohibitive action.

Climate change and environmental justice are inextricably linked, a fact that became evident on the local level in the aftermath of Hurricane Katrina in 2005 and Hurricane Sandy in 2012. In New York City, given the range of income classes found on the waterfront, uneven resiliency and recovery should be a focus of climate justice issues. Global climate change has the potential to be a powerful force in shaping the socioeconomic landscape of the city. Property in
the hilly areas of the city may become even more desirable, and thus more expensive and less attainable by low-income residents. Land values may fall in low-lying waterfront areas, making coastal neighborhoods more affordable. Wealthier households with the financial means to implement flood mitigation measures may continue to view the waterfront as an amenity.

A potential means to partially address some of the climate justice issues is to build affordable and mixed-income housing on underutilized City-owned land in highly elevated areas. As this study has confirmed, many of the same land uses found on the urban fringe, often land-intensive and city-related uses, are also found on the vertical fringe, such as the former poor farm and tuberculosis hospital in Staten Island. A significant number of these types of institutions have closed or are otherwise underutilized. In a city with limited space and a desperate need for more affordable housing, these spaces are ideal for new residential development because they offer protection from climate change-related hazards such as flooding. Moreover, the abundant vegetation of these hilly areas keeps the area cooler than overdeveloped areas in lower lying areas. Another advantage is that these lands are often already city-owned and are generally sparsely populated, therefore, creating affordable housing may be more politically feasible here than in already densely developed areas.

In some of these high-elevation areas, zoning to allow for residential development and public transit options such as expanded bus routes may need to be implemented. In the case of the New York City Farm Colony area, any plan for residential development is complicated by its landmarked status, which would require complying with strict rules regarding the preservation and use of existing buildings on the land. However, other vertical fringe areas of New York City that were not examined in this study should also be considered as sites for new affordable or mixed-income developments. Other cities may also want to examine their vertical fringes to see if similar underutilized land would be appropriate for new affordable housing developments.
Future research of a similar nature should further explore the potential for relative elevation to explain socioeconomic distribution. The steepness of terrain, or slope, may also be investigated as another possible determinant. More accurate conclusions could possibly be achieved with smaller units of analysis, such as tax lots which contain assessed values or Census Block groups which contain race and ethnicity data. For longitudinal studies that examine periods where no Census data is available, addresses in real estate advertisements could be geocoded in order to assess the geographic distribution of wealth. The effects of climate change, as well as the changing cultural perceptions of land as a result of climate change, should be incorporated into any study that attempts to assess the relationship between physical topography and residential or land use patterns. In New York City, the forces of land use persistence, public policy, climate change, and cultural perception are playing out in Coney Island. Future related studies and climate justice studies should keep a close eye on this and other coastal neighborhood redevelopments that are being carried out in cities struggling to balance the need for safe, affordable housing with political feasibility, economic viability, and the forces of climate change.
### APPENDICES

#### APPENDIX A: TRANSFORMED VARIABLES

<table>
<thead>
<tr>
<th>Analysis Year</th>
<th>SES Indicator</th>
<th>Transformation</th>
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</thead>
<tbody>
<tr>
<td>1910</td>
<td>Literacy</td>
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<td>DEM</td>
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<td>square root of distance from CBD</td>
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<td>DEM</td>
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<tr>
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<td>Distance from CBD</td>
<td>square root of distance from CBD</td>
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(Appendix A Table continues)

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^2 Reflection is computed by subtracting all of the values for a variable from one plus the absolute value of the maximum value for the variable. This results in a positively skewed distribution with all values larger than zero.
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<td>DEM</td>
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<td>square root of distance from CBD</td>
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<td>Mean Family Income</td>
<td>natural log of mean family income</td>
</tr>
<tr>
<td></td>
<td>DEM</td>
<td>natural log of mean DEM value</td>
</tr>
<tr>
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<td>Distance from CBD</td>
<td>square root of distance from CBD</td>
</tr>
<tr>
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<td>natural log of median household</td>
</tr>
<tr>
<td></td>
<td>DEM</td>
<td>natural log of median household</td>
</tr>
<tr>
<td></td>
<td>Distance from CBD</td>
<td>square root of distance from CBD</td>
</tr>
<tr>
<td>Year</td>
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<td>natural log of median household</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------</td>
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### APPENDIX B: CENTRAL BUSINESS DISTRICT (CBD) BOUNDARIES

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<tr>
<th>Analysis Year</th>
<th>CBD Areas</th>
<th>CBD Description</th>
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<tbody>
<tr>
<td>1910</td>
<td>Lower Manhattan</td>
<td>Lower Manhattan boundary bordered by Barclay Street, Church Street, Chambers Street, Lafayette Street, Beekman Street, Gold Street, Fulton Street, and the waterfront</td>
</tr>
<tr>
<td>1920</td>
<td>Lower Manhattan</td>
<td>same as above</td>
</tr>
<tr>
<td>1940</td>
<td>Lower Manhattan</td>
<td>Lower Manhattan boundary extended to include all areas south of Chambers Street</td>
</tr>
<tr>
<td></td>
<td>Midtown Manhattan</td>
<td>Midtown Manhattan boundary bordered by Ninth Avenue, 60th Street, Columbus Circle, 59th Street, Third Avenue, and 31st Street</td>
</tr>
<tr>
<td>1950</td>
<td>Lower Manhattan</td>
<td>same as above</td>
</tr>
<tr>
<td></td>
<td>Midtown Manhattan</td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>Lower Manhattan</td>
<td>Lower Manhattan and Midtown Manhattan same as above</td>
</tr>
<tr>
<td></td>
<td>Midtown Manhattan</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Downtown Brooklyn</td>
<td>Downtown Brooklyn bordered by Court Street, Cadman Plaza East, Tillary Street, Ashland Place, Lafayette Avenue, and Schermerhorn Street</td>
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(Appendix B Table continues)
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<td>Midtown Manhattan</td>
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APPENDIX C: SCATTER PLOTS

1910

1920
Median family income values for this year were derived from frequency distributions, explaining the lack of variation along the Y axis.
Median Years of Education (Males) grouped by Absolute Elevation

Median Years of Education (Males) grouped by Relative Elevation (500 ft)
APPENDIX E: CHOROPLETH AND OUTLIER MAPS

For outlier maps:
HL = high SES surrounded by low SES
LH = low SES surrounded by high SES
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<tr>
<th>Analysis Year</th>
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<th># Units of Analysis</th>
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<td></td>
<td></td>
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<td>Abs. Elev. Adjusted R²</td>
<td>Abs. Elev. + Dist. from CBD Adjusted R²</td>
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<td>702</td>
<td>.120 p &lt; .001</td>
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(Appendix F Table Continues)
(Appendix F Table Continued)

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<th>Year</th>
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APPENDIX G: BEST-FIT GWR ELEVATION COEFFICIENT MAPS

1910 Literacy Rate
Best GWR Elevation Coefficient

1910 Literacy Rate
Best GWR Elevation Coefficient
With Local R2 Transparency

Elevation Coefficient
-0.099516 - -0.066952
-0.066951 - 0.000000
0.000001 - 0.010332
0.010333 - 0.015574
0.015575 - 0.035357

Elevation Coefficient
-0.099516 - -0.066952
-0.066951 - 0.000000
0.000001 - 0.010332
0.010333 - 0.015574
0.015575 - 0.035357
For cluster maps:
HH = positive standardized residuals clusters
LL = negative standardized residuals clusters
ABBOTT, B. (Photographer). (1938). Manhattan: 20th Street - 1st Avenue [photograph]. Retrieved from: http://images.okaboo.com/photo/m/East_20th_St_northside_towards_1st_Ave_1938_m.jpg

An Act to Provide for the Establishment of County Poor-Houses, New York State Laws ch. 331, § 8 (1824).


Island, Volume 1, Wards 1, 2 & 3, from Actual Surveys and Official Plans [map].
Philadelphia: G. W. Bromley & Co.


201


New York City. (2013c). Mayor Bloomberg Joins Phipps Houses, Related Companies and Monadnock Construction to Break Ground on First Two Residential Buildings at


New York City Department of Information Technology and Telecommunications (DOITT). (1924). New York City [air photo]. Scale not given. New York City, NY.


Perkins, C. (1853). *Plan of property situate in the town of Bushwick, Kings County, town of Newton, Queens County belonging to Mess. Crane & Ely, as subdivided into building lots* [map]. New York, NY: s.n.


