

ABSTRACT

Title of Thesis: THE EFFECTS OF SEA LEVEL RISE
ON HISTORIC DISTRICTS AND THE
NEED FOR ADAPTATION

Degree Candidate: Ann D. Horowitz

Degree and Year: Master of Arts in Historic Preservation, 2013

Thesis directed by: Jennifer V. O. Baughn
Welch Center for Graduate and Professional Studies
Goucher College

Shoreline communities are unprepared for the increasing effects of sea level rise hazards on the built environment. As a result, Atlantic Coast historic properties reflecting cultural heritage face degradation or destruction. Numerous scientific studies project that sea level rise will likely inundate shorelines, increase the frequency of flood events, and augment wave damage from severe storms. These natural occurrences worsened by sea level rise could diminish a community's identity and quality of life, often represented by National Register historic districts. To minimize the threat, strategies to adapt to sea level rise can offer protection for communities and their irreplaceable historic resources.

To determine a course of action, my thesis question is: How can hard, soft, and non-structural adaptation methods be applied to protect the cultural heritage of National Register historic districts from the impacts of sea level rise? English Heritage, the

Mississippi Development Authority, and the 1000 Friends of Florida provide helpful insights into methods used to protect historic resources from flooding, storm surge, and erosion—the effects of sea level rise. Additionally, the case study cities of St. Augustine, Florida; Elizabeth City, North Carolina; and Alexandria, Virginia, furnish examples of National Register historic district vulnerability to sea level rise and of adaptation methods addressing current natural hazards. My research findings indicate that adaptation methods can protect historic properties, but may also impact their historic integrity. I discover that the historic preservation community is largely uninvolved in the adaptation planning process. Without an advocate, historic properties on low-lying shorelines face an uncertain future by the year 2100 and beyond.

My findings and recommendations include the importance of adaptation planning at the local level and the urgent need for preemptive adaptation implementation. To ease the political, social and economic obstacles associated with adaptation planning, local decision-makers and stakeholders must be educated on sea level rise science. State legislative endorsements are also necessary for municipalities to successfully implement a broad range of adaption strategies. It is essential that state and the federal governments offer technical and financial support to localities as sea level rise intensifies. Most critically, the historic preservation community must campaign for historic property protection that will also preserve historic integrity. The country's coastal heritage and identity are at stake.

Subject Headings: Atlantic Coast historic districts; sea level rise effects on historic properties; flooding in historic districts; climate change adaptation in historic districts; historic districts and quality of life; St. Augustine, Florida, historic districts; Elizabeth City, North Carolina, historic districts; Alexandria Historic District.

THE EFFECTS OF SEA LEVEL RISE ON HISTORIC DISTRICTS
AND THE NEED FOR ADAPTATION

Ann D. Horowitz

Thesis submitted to the Faculty of Goucher College in partial
fulfillment of the requirements for the degree of

Master of Arts in Historic Preservation

2013

Advisory Committee

Jennifer V. O. Baughn, Chair

S. Jeffress Williams

Hugh C. Miller, FAIA

Copyright by
Ann D. Horowitz
2013

To the best, Daniel and Jonah

ACKNOWLEDGMENTS

This thesis study developed and evolved with expert counsel from Jennifer Baughn, Jeff Williams, and Hugh Miller, my thesis committee. Each offered a unique and valuable perspective, guiding me through a study that merged historic preservation with climate science. I am deeply grateful to them for sharing their time and extraordinary knowledge with me.

Individuals involved in the case study cities generously provided valuable insight into local culture or offered perspectives on sea level rise science. The Senior Research Librarian at the St. Augustine Historical Society, Charles Tingley, shared his encyclopedic knowledge of the area while directing me to pertinent historical resources. Jonathon Burpee, Chief of Interpretation and Education at the Castillo de San Marcos and Martha Graham, St. Augustine's Director of Public Works also provided detailed information on adaptation solutions adopted within the city. For Elizabeth City, Jim Hawhee, Policy and Engagement Manager for the Albemarle-Pamlico National Estuary Partnership, contributed information on the impacts of sea level rise in North Carolina and his organization's public education efforts. The long-term guidance of Al Cox and Catherine Milliaras from the City of Alexandria's Preservation Planning department provided a sound base of knowledge for the study of that city's commitment to historic preservation and its development perspectives. I offer my sincere thanks to these local contacts for assisting me with an accurate portrayal of each case study city.

TABLE OF CONTENTS

List of Tables		iv
List of Figures		v
Chapter I:	Introduction	1
	Statement and Discussion of Hypothesis	1
	Suppositions	2
	Analytical Framework	6
	Existing Literature	7
	Research Methods, Evaluation, and Data Collection	8
	Chapter Summaries	9
Chapter II	A Changing Climate Threatens Historic Resources	11
	Introduction	11
	Global Climate Change	12
	Climate Change and Sea Level Rise Effects	13
	Historic and Cultural Resources at Risk	16
	Cultural Heritage of the United States at Risk	19
	Preserving Cultural Heritage to Sustain Quality of Life	21
	Conclusion	28
Chapter III	Adapting Historic Resources to Changing Climate Conditions	30
	Introduction to Adaptation	30
	Adaptations Accommodate and Protect	33
	Adaptation Methods Benefitting Historic Resources	41
	Involvement of the Historic Preservation Community in Adaptation	50
	Adaptation Decision-makers and Stakeholders	58
	Conclusion	61
Chapter IV	Atlantic Coast Case Studies	63
	Introduction to the Case Studies	63
	St. Augustine, Florida	64
	Summary of Findings: St. Augustine, Florida	105

	Elizabeth City, North Carolina	108
	Summary of Findings: Elizabeth City, North Carolina	135
	Alexandria, Virginia	137
	Summary of Findings: Alexandria, Virginia	171
	Conclusion for Case Studies	174
Chapter V	Case Study Data Analysis	177
	Introduction	177
	Sea Level Rise Threats	178
	National Register Historic Districts	180
	Building Materials	181
	Comparison of Local Adaptation Approaches	183
	Decision-makers and Stakeholders	192
	Conclusion	197
Chapter VI	Findings and Recommendations	199
	Introduction	199
	Plan Adaptations in Anticipation of Sea Level Rise	199
	Design Adaptation Strategies at the Local Level	201
	Adaptations May Compromise Integrity	207
	Add Social and Environmental Benefits to Cost-Benefit Analysis	208
	Educate Local Decision-makers and Stakeholders on Sea Level Rise	210
	Local Governments: Expand Adaptation Planning Groups	213
	State and Federal Governments: Support Adaptation Efforts at Local Levels	214
	Further Research	217
	Conclusion	218
Chapter VII	Conclusion	220
	Glossary	223
	Endnotes	228
	Bibliography	257

LIST OF TABLES

1.	Hard Adaptations	34
2.	Soft Adaptations	35
3.	Non-Structural Adaptations: Infrastructure	36
4.	Non-Structural Adaptations: Building Retrofits	37
5.	Non-Structural Adaptations: Flood Resilience	38
6.	Case Study Adaptations by Type	184

LIST OF FIGURES

1.	Graph of historic levels of atmospheric carbon dioxide concentrations	13
2.	Graph of sea level rise projections	15
3.	Environmental effects of hard adaptations	39
4.	Galveston, Texas historic districts map	42
5.	Galveston seawall, 1910–1920	43
6.	Elevating Galveston	44
7.	Maeslant Barrier, Rotterdam, The Netherlands	45
8.	Proposed “Ike Dike,” Galveston	45
9.	Norfolk, Virginia historic districts map	47
10.	Berm protecting Norfolk home	48
11.	Floodgate at historic home	52
12.	Window barriers on historic homes	52
13.	Piers elevating historic property supplemented by brackets	54
14.	Elevated historic homes with compatible setbacks, heights, and porch design	56
15.	Elevated historic home with architecturally compatible sub-story	56
16.	Landscaping and elevated historic properties	57
17.	St. Augustine, Florida aerial view	64
18.	St. Augustine Town Plan District	66
19.	Castillo de San Marcos	67
20.	St. Francis Barracks	67
21.	View of St. Augustine, 1855	69
22.	St. George Street	70
23.	St. Augustine historic districts map	72
24.	Joaneda House, British period	73
25.	Ximenez-Fatio House, second Spanish period	74
26.	Llambias House, first Spanish period	74
27.	Ponce de Leon Hotel, now Flagler College	76
28.	Alcazar Hotel interior, now City Hall and the Lightner Museum	77
29.	Gonzalez-Alvarez House loggia	81
30.	Flooded parking lot at the Castillo de San Marcos	83
31.	Projected sea level rise in St. Augustine by 2050	85
32.	Projected sea level rise in St. Augustine by 2100	87
33.	Marine Street	88
34.	Gonzalez-Alvarez House	89
35.	Houses in Lincolnville Historic District	90
36.	Office building in Model Land Company Historic District	91
37.	Houses in Abbott Street Historic District	92
38.	Houses in Nelmar Terrace Historic District	92

39.	Houses in Fullerwood Park Historic District	93
40.	Historic seawall bordering Castillo de San Marcos	94
41.	Rip-rap seawall near the Castillo de San Marcos	95
42.	Plan for the new St. Augustine seawall	97
43.	Elizabeth City, North Carolina, aerial view	109
44.	Elizabeth City town plat, 1832	109
45.	Elizabeth City historic districts' map	112
46.	Commercial buildings in Elizabeth City Historic District	113
47.	Houses in Elizabeth City Historic Expansion District	114
48.	Houses in the Shepard Street–South Road Historic District	115
49.	Houses in Northside Historic District	116
50.	Flood-damaged house in Shepard Street–South Road Historic District	122
51.	Projected sea level rise in Elizabeth City by 2050	125
52.	Projected sea level rise in Elizabeth City by 2100	126
53.	Stormwater system reconstruction in historic district	129
54.	Elevated home in Shepard Street–South Road Historic District	130
55.	Elevated home in Riverside Historic District	130
56.	Charles Creek Park wetlands restoration	131
57.	Alexandria, Virginia, aerial view	138
58.	Alexandria Town Plan, 1749	139
59.	Alexandria historic districts map	142
60.	Rowhouses in Alexandria Historic District	144
61.	Rowhouses in Alexandria Historic District	144
62.	Jones Point Lighthouse	145
63.	Torpedo Factory Arts Center, formerly the U. S. Naval Torpedo Station	148
64.	Projected sea level rise in Alexandria by 2050	153
65.	Fitzgerald's Warehouse	154
66.	101 King Street	154
67.	Projected sea level rise in Alexandria by 2100	155
68.	Projected sea level rise at Jones Point Park by 2050	156
69.	Projected sea level rise at Jones Point Park by 2100	157
70.	Sandbag protection at Fitzgerald's Warehouse	158
71.	Temporary floodgate at commercial building	159
72.	Flood resilient building materials in Torpedo Factory Arts Center	160
73.	Flood resilient building materials in Fitzgerald's Warehouse	160
74.	Earthen berm at Jones Point Park	161
75.	Seawall and rip-rap wall at Jones Point Park	161
76.	Seawall protection for historic boundary stone	162

CHAPTER I

INTRODUCTION

Statement and Discussion of Hypothesis

Few from the historic preservation community have connected the projections for global sea level rise with the devastating ways it may impact historic resources located on low-lying shorelines. Flooding, storm surge, and coastal erosion could severely compromise or even destroy the historic character and the longevity of these historic properties by 2100. The irreplaceable cultural heritage of the coastal United States is at stake unless the preservation community plans adaptation solutions to protect historic resources from the effects of sea level rise. My thesis research investigates the threats to historic districts and the methods used to preserve valued properties from this climate change threat.

My thesis question is: How can hard, soft, and non-structural adaptation methods be applied to protect the cultural heritage of National Register historic districts from global climate change impacts such as sea level rise? Many National Register properties are located within historic districts along tidal coasts affected by the increasing threat of sea level rise. These properties provide visual reminders of the nation's cultural and historic past. But without protection from sea level rise impacts, the cultural identity of the United States will be gradually destroyed, reducing the public's connection to the past.

Adaptation solutions, which are methods to minimize the effects of sea level rise,

must be applied to stall the deterioration of historically and culturally significant properties. My research analyzed four topic areas to answer the thesis question. First, the research evaluated sea level rise impacts on the National Register historic districts in St. Augustine, Florida; Elizabeth City, North Carolina; and Alexandria Virginia, all sited on low-lying lands along Atlantic Coast estuaries. Second, the research examined adaptation options that have been applied by the case study cities and by Galveston, Texas, and Norfolk, Virginia. Next, I analyzed the impact of adaptations applied by these historic cities on the integrity of historic resources. Last, the thesis analysis identified the decision-makers and stakeholders involved in adaptation planning.

Suppositions

Seven suppositions lay the foundation for the hypothesis analysis. First, global climate change is projected to continue since global carbon emissions are unlikely to be reduced in the near future. Even if global carbon emissions are stabilized at current high levels, sea levels would continue to rise due to previously released greenhouse gases warming the atmosphere and oceans, resulting in ongoing glacial and polar ice sheet melting.¹ Scientific assessments project a global sea level rise of 0.5 to 2 meters (1.6 to 6.6 feet) by 2100.² With continued warming, 4 to 6 meters (13.1 to 19.7 feet) of sea level rise is possible beyond 2100.³ Land subsidence for many regions, including the mid-Atlantic coastal area evaluated here, will further increase rates of projected global rise. These science-based projections for sea level rise establish the need for worldwide adaptation planning. My thesis analysis was based on sea level rise projections of one meter (3.3 feet) by 2100, judged to be a reasonable average value for planning purposes.

My second supposition examines the effects of projected sea level rise. Along low-lying tidal coasts, sea level rise will increase the likelihood of damaging floods and storm surge on the land. Intensified wave action, aggravated by severe storms, will increase land erosion. Along with eventual, permanent inundation, these impacts will cause significant alterations to the natural and built environments along the tidal coasts. Adaptations are needed immediately to protect essential infrastructure and critical facilities, such as roads, airports, schools, hospitals, and emergency shelters that are located in low-lying, coastal areas.

Although global averages are important, sea level rise has specific effects on local areas due to unique geophysical and oceanographic factors. A Coastal Vulnerability Index (CVI), composed of six interactive variables, can be used to project the effects of sea level rise along shorelines.⁴ Measures for tidal range, wave height, coastal slope, historic shoreline changes, geomorphology, and history of sea level rise must be calculated to accurately project an area's specific vulnerability to sea level rise.

Third, National Register historic districts along the Atlantic Coast's estuaries will be likely affected by sea level rise impacts. Many of these represent early European settlements. The new immigrants sought estuarial lands, providing a sheltered harbor, with locations close to the ocean for trade and transportation. The case study cities of St. Augustine, Florida; Elizabeth City, North Carolina; and Alexandria, Virginia, are examples of early Atlantic Coast communities with historic districts on low-lying shores. In addition to historic districts, National Register archaeological sites, cultural landscapes, and individual historic properties sited at low elevations are vulnerable to the

damaging effects of sea level rise. Left unchecked, sea level rise damage may affect the longevity of these historic resources.

The fourth supposition states that National Register listings exemplify the cultural heritage of the United States. The “National Register Criteria for Evaluation” establishes high standards for architectural, historical, cultural, archaeological, or engineering significance, which historic properties must meet to be listed in the National Register of Historic Places. The aspects of integrity—location, design, setting, materials, workmanship, feeling, and association—communicate and reinforce significance. The effects of sea level rise have the potential to weaken integrity and limit historic and cultural associations with the past. Further, National Register historic districts provide broad social, economic, and environmental benefits, contributing to a community’s unique sense of place. To maintain quality of life and cultural heritage, the preservation community must ensure the preservation and protection of the country’s historic resources from the threats posed by sea level rise.

The fifth supposition advances the thesis research through a discussion of adaptation strategies. Hard, soft, and non-structural adaptation measures have proven to minimize damage associated with flooding, storm surges, and erosion on tidal coasts. Sea level rise aggravates these natural hazards. A reduction in damage related to sea level rise translates to lower expenditures on post-disaster emergency and rehabilitation responses. The Federal Emergency Management Agency (FEMA) determined that “a dollar spent on [pre-disaster] mitigation saves society an average of \$4 in lower [post-disaster] damages.”⁵ In addition, communities that proactively apply adaptation solutions have

more flexibility to plan. Fewer options are available after disasters cause widespread property damage or destroy a community.⁶

Since sea level rise effects are specific to local areas, each community must develop an individual combination of protective adaptations. These adaptations are categorized as methods to accommodate, protect, or retreat. My thesis research evaluates the adaptation measures communities can employ to accommodate changes in local sea level and those used to protect the built environment, including historic resources. Accommodation and protection, however, serve as only temporary solutions and do not guarantee long-term preservation. As sea level rise inundates land area, retreat may be the only remaining option. This “last resort” response to sea level rise is outside the scope of my thesis analysis as it would abandon historic districts and accept their future destruction. Nonetheless, it will be necessary for at-risk communities to eventually plan for coastal retreat as shorelines shift to inland areas.

Sixth, adaptations have the potential to prolong the existence of at-risk National Register properties. The case study analyses illustrate the degree of protection offered by different adaptation solutions. Although critical for historic resource longevity, adaptations may compromise the integrity of National Register properties.

Last, the historic preservation community must fully participate as decision-makers and stakeholders to ensure adaptation solutions that protect historic resources and a community’s quality of life. It must join forces with residents, property owners, policy makers, planners, engineers, scientists, environmentalists, and disaster management and emergency management professionals to advocate for the protection of historic resources at risk and to compete for adaptation funding. Additionally, the perspectives of historic

preservation planners, citizen advocates, and historic property owners are essential to ensure that adaptation solutions do not adversely affect historic character.

Analytical Framework

My research analyzes the projected vulnerability of National Register properties to sea level rise, possible adaptation strategies for protection, and the role of the preservation community. The analysis considers scholarly literature addressing adaptation theory and research; general adaptation options; and, mitigation solutions specific to historic properties. Adaptation plans for Galveston, Texas, and Norfolk, Virginia, two cities with a history of implementing adaptations, provide additional perspectives.

To assess sea level rise risk, I identify historic properties and neighborhoods in the cases study cities potentially susceptible to this evolving hazard. Sea level rise inundation data projected to occur by years 2050 and 2100 are superimposed on historic district boundaries, indicating vulnerable properties and areas. Additionally, the vulnerability assessments include an analysis of current flood, erosion, and storm surge risks. The cities' proximity to water, land elevation, and history of tropical storms and hurricanes estimate the level of vulnerability. Furthermore, the thesis research analyzes the loss of social, economic, and environmental advantages that would negatively impact the communities if vulnerable historic properties remain unprotected.

I examine the benefits and drawbacks that hard, soft, and non-structural adaptations introduce when applied as protective strategies in historic cities. In addition, my analysis describes the characteristics of the local natural and built environments

influencing the selection of adaptations. Economic, social, and political perspectives also determine the development of local adaptation plans. My research identifies the multidisciplinary groups responsible for adaptation proposals and implementation in the case study cities.

Existing Literature

My thesis research references books, journal articles, and reports addressing sea level rise science, adaptation strategies, and adaptations designed for historic properties. The United States has only limited information on adaptation strategies for historic properties. Two United States' guides, *Disaster Mitigation for Historic Structures: Protection Strategies* and *Elevation Design Guidelines*, provide specific information on adaptation in response to flooding and storm surge.

By contrast, English Heritage produces extensive information on adaptation methods specific to historic buildings. Two of its reports, *Climate Change and the Historic Environment* and *Flooding and Historic Buildings*, illustrate adaptation options that safeguard historic buildings from the impacts of sea level rise, yet minimize the effects on integrity.

Collaborative Resilience: Moving Through Crisis to Opportunity, Adaptation to Climate Change: From Resilience to Transformation, and “Wicked Challenges at Land’s End: Managing Coastal Vulnerability Under Climate Change” contain information on adaptation theory and research that is relevant to my discussion on decision-makers and stakeholders.

Research Methods, Evaluation, and Data Collection

Historic districts are selected for analysis as opposed to individual historic properties because projections for sea level rise are more accurately estimated for large land areas. Historic areas broadly embody the social, economic, and environmental benefits of historic preservation as well. Widespread flooding, storm surge, or erosion damage in a historic district can also clearly illustrate the significant impacts of sea level rise on a number of properties and a community's quality of life. The case study cities, St. Augustine, Florida; Elizabeth City, North Carolina; and Alexandria, Virginia, provide appropriate settings for the thesis examination. The cities are located along Atlantic Coast estuaries and encompass at least one historic district on low-lying land. Each community currently faces flooding, storm surge, and coastal erosion hazards, resulting in the proposal and implementation of adaptation strategies. A comparison of the cities' historic districts, current natural hazards, sea level rise vulnerabilities, adaptation choices, and decision-maker and stakeholder groups contribute to the evaluation of my hypothesis

I collect research data from a wide range of resources, reflecting the multidisciplinary approach required for sea level rise adaptation planning. Books, journals, and newspaper articles provide extensive information on climate change, sea level rise, current natural hazards, adaptation theory and applications, and cultural history. The scientific research of federal agencies (National Oceanic and Atmospheric Administration, Environmental Protection Agency, and the United States Geological Survey) and academic institutions provide sea level rise data and adaptation analyses. Local and regional government reports and government employee interviews are critical to the evaluation of adaptation proposals and implementations. Historic district and sea

level rise inundation maps combine to create the projected 2050 and 2100 sea level rise scenarios. Personal visits to case study sites provide a clear, working knowledge of historic district characteristics, sea level rise vulnerabilities, and local adaptations.

Chapter Summaries

Chapter II discusses the first four suppositions, beginning with the scientific data supporting the cause and effects of global climate change. I investigate the sea level rise impacts on international and national coastlines, specifically on the Atlantic Coast. The section shifts to an analysis of National Register properties' susceptibility to sea level rise. The chapter concludes with an identification of the social, economic, and environmental benefits associated with historic districts and the impacts of their potential loss.

Chapter III delves into the three remaining suppositions. These address adaptation possibilities, adaptation protection of historic resources, and adaptation decision-makers and stakeholders. Five tables outline the benefits and disadvantages of hard, soft, and non-structural adaptations, accompanied by descriptions of each effort to minimize sea level rise impacts. An examination of Galveston, Texas, and Norfolk, Virginia, offers a historical interpretation of flooding, storm surge, and erosion adaptation. Impacted by ocean effects, both historic cities provide a forecast of the issues other shoreline communities may face if sea level rise intensifies as projected. An analysis of existing literature on adaptations benefitting historic properties and current adaptation theory and research concludes Chapter III.

Chapter IV presents the case study analyses. For each of the three selected cities,

this section identifies: 1) historic district characteristics and local contributions; 2) current natural hazards; 3) sea level rise projections and vulnerabilities by 2050 and 2100; 4) proposed and implemented adaptations; and, 5) decision-makers and stakeholders. These aspects are compared in Chapter V, an analysis of the case studies. My review of case study data and findings scrutinizes sea level rise vulnerabilities, historic district characteristics influencing adaptation implementation, and participation of decision-makers and stakeholders. Chapter VI provides the preservation community with findings and recommendations supporting the protection of historic properties from sea level rise.

CHAPTER II

A CHANGING CLIMATE THREATENS HISTORIC RESOURCES

Introduction

Climate on Earth has naturally fluctuated throughout history. Today, however, global apprehension grows as atmospheric warming has been increasing, due to rising carbon dioxide (CO₂) levels in the atmosphere, at a staggering rate over the last century. Numerous scientific analyses document that climate change is primarily a man-made phenomenon as carbon has been released into the atmosphere from the burning of fossil fuels. Without a reduction in greenhouse gas emissions, scientific projections call for an even greater acceleration of the warming rate. The impacts of climate change could significantly affect populations around the world. The devastating effect of sea level rise is projected to alter the natural and built environments, forever changing the daily lives of millions of coastal residents around the world. Understandably, concern for the future of critical infrastructure, emergency facilities, and transportation links is prominent in climate change mitigation discussions. Cultural heritage vulnerability, however, must not be overlooked. As visual communicators of cultural heritage, historic resources are also highly vulnerable to the devastating effects of sea level rise. They create a sense of place that is an essential component of quality of life. Without this, communities will lose their distinctive identities, critical to citizen resilience and well-being.

Global Climate Change

An abundance of scientific data has proven the warming of the earth's atmosphere. The Intergovernmental Panel on Climate Change (IPCC) asserts that higher air and ocean temperatures and rising seas indicate climate change.⁶ Eleven of the years between 1995 and 2006 registered as the warmest for global surface temperature since recorded measurements began in 1850. Air temperatures measured from 1956–2005 are double the temperatures gauged from 1906–2005. Warmer atmospheric temperatures have raised the average temperature of the Earth's oceans to depths of 3,000 meters (9,843 feet).⁷ Rising sea levels are the result of the melting of glaciers and the Greenland and Antarctica ice caps and ice sheets. The thermal expansion of the oceans and changes in ocean circulation patterns also contribute to rising seas. Globally, seas have risen between 0.1 to 0.2 meters (0.33 to 0.66 feet) over the past 100 years.⁸ Scientists claim this evidence does not indicate a long-term trend, although the thermal expansion of ocean waters, the global melting of snow and ice, and continued greenhouse gas emissions may supply future proof.⁹

Scientific data point to the increase in greenhouse gas emissions as the primary reason for the Earth's warming.¹⁰ (Fig. 1) Greenhouse gases are primarily composed of carbon dioxide. Evidence shows an increasing level present in the atmosphere since the Industrial Revolution. The burning of fossil fuels (coal, oil, and natural gas) increased dramatically with the rapid growth of the industrial and transportation economies beginning in the late nineteenth century. As those sectors grew and global population multiplied, atmospheric carbon dioxide has increased 30% since the late nineteenth century.¹¹ Greenhouse gases trap the Sun's radiant warmth in the atmosphere, leading to

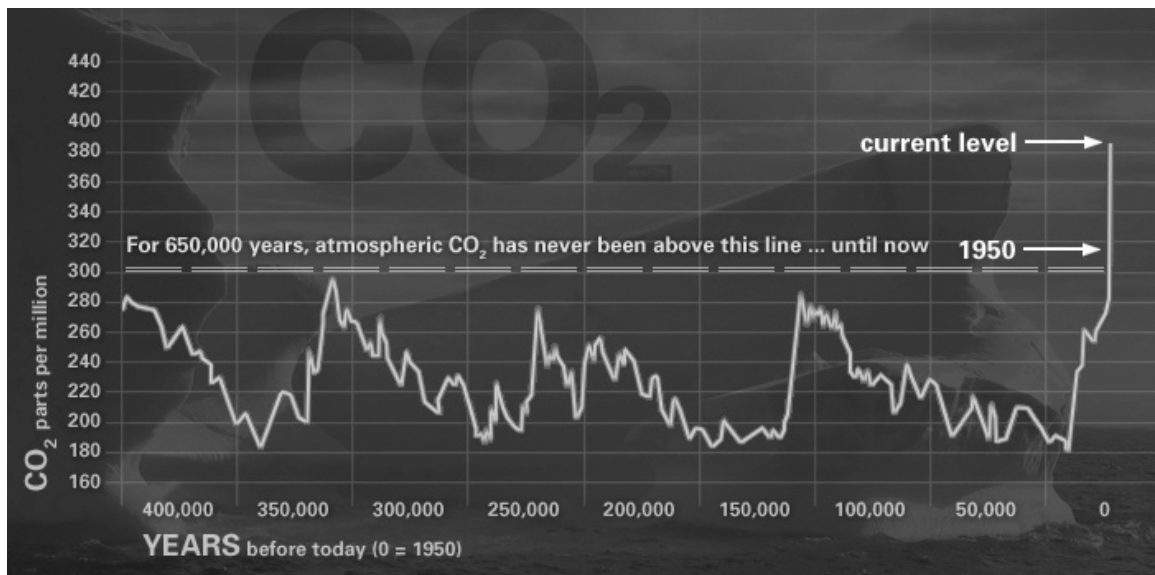


Fig. 1: The concentration of carbon dioxide in the atmosphere has exponentially increased since the mid-nineteenth century, causing global climate change. It is higher now than during the past 650,000 years. [National Aeronautics and Space Administration; atmospheric CO₂ graph, accessed May 28, 2013]

rising global temperatures. Scientific projections estimate global temperatures could rise as high as 11.5 degrees Fahrenheit (6.1 degrees Celsius) by 2100.¹² Rising temperatures and their effects will produce social, economic, environmental, and health challenges for the global population.

As a global problem, the international community has struggled to adopt a coordinated solution to reduce carbon emissions. In the absence of a global policy, a continued rise in global warming and its many impacts is projected.

Climate Change and Sea Level Rise Effects

The warming of the Earth affects its climate and weather patterns. Climate is defined as general weather patterns for an area over the long term, typically 30 years. Fewer winter snowstorms in the northeast or hotter summers in mid-Atlantic regions

reflect a change in climate. Weather indicates atmospheric conditions occurring over the short term, such as daily or seasonal thunderstorms, flooding, or wind patterns.¹³

The effects of climate change will continue to cause unusual and more highly variable weather patterns. Fewer cold days and nights are projected with heat waves becoming more frequent and prolonged. Increased rainfall in some areas and drought in other regions will result. The frequency of storms may remain the same, or even decrease, but the intensity—higher wind speeds, lower barometric pressure, and precipitation amounts—is expected to increase.¹⁴

Higher precipitation amounts and intense storm events combined with sea level rise will lead to an increased vulnerability to flooding, storm surges, coastal erosion, and inundation for areas at low-lying elevations. Additionally, twice-a-month spring tides will be higher when sea levels rise, resulting in more severe and frequent flooding.¹⁵ Repetitive or permanent flooding can lead to loss of life, immutable property damage, environmental degradation, and economic disruption along tidal shorelines.

The IPCC 2007 Assessment projects a global sea level rise of 0.75 to 1.9 meters (2.5 to 6.2 feet) by 2100¹⁶ (Fig. 2). Recent scientific projections update sea level rise to two meters (6.6 feet). With continued warming, sea level rise of four to six meters (13.1 to 19.7 feet) is possible beyond 2100.¹⁷ With ten percent of the global population residing on coasts that are less than ten meters (32.8 feet) above sea level, sea level rise will have debilitating effects on global stability and sustainability.

Sea level rise is projected to be greater than the global average along the Atlantic and the Gulf of Mexico coasts due to geologic subsidence. In California and in parts of Oregon, sea level rise is expected to remain near global projections. Only Washington

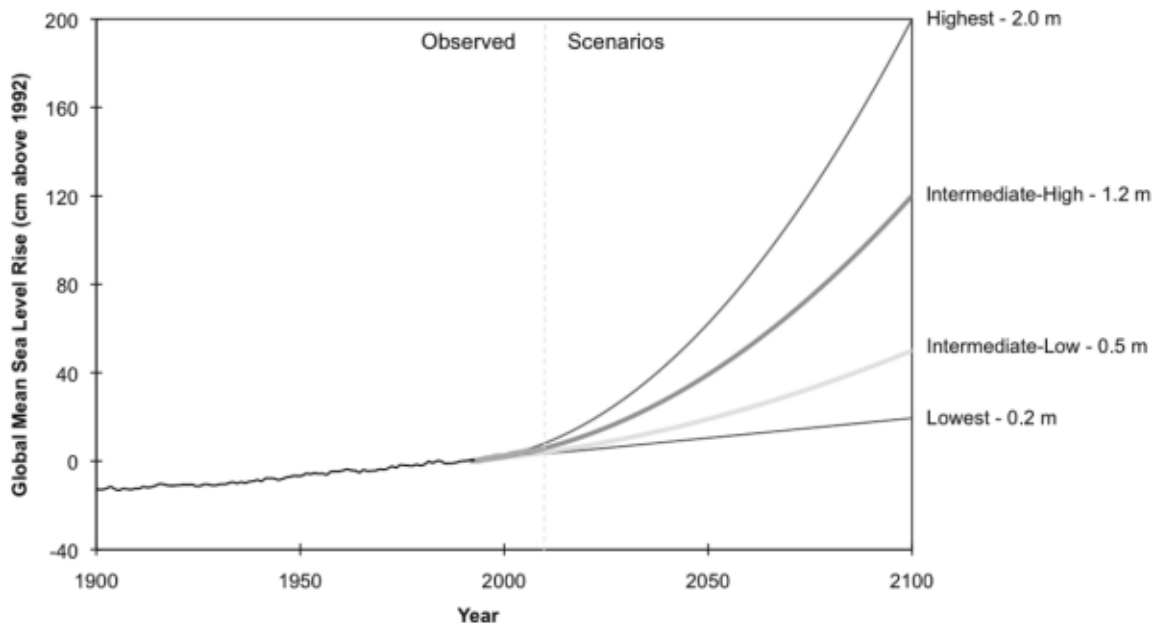


Fig. 2: The different sea level rise projections reflect the global scenarios that are possible. The lowest scenario at 0.2 meters illustrates historical sea level rise that does not take into account climate change. [National Oceanic and Atmospheric Administration; global sea level rise scenarios, December 6, 2012]

state and remaining segments of Oregon will experience a somewhat lower sea level rise due to geologic uplift.¹⁸ Sea level rise impacts have the potential to affect eighty-seven million people who reside along the contiguous United States coastlines.¹⁹

Climate change statistics are commonly communicated in global terms. To understand its effects on the Atlantic Coast, it is necessary to acknowledge that climate change impacts are specific to the regional and local level. Sea level rise cannot be uniformly projected due to six contributing and interactive variables: tidal range, wave height, coastal slope, historic shoreline changes, geomorphology, and history of sea level rise.²⁰ In the case of sea level rise, projections for the Atlantic Coast are projected to exceed the global average. Recently the United States Geological Survey (USGS) found that the rate of sea level rise from north of Boston, Massachusetts, to Cape Hatteras,

North Carolina, is increasing three to four times faster than the global rate. In this area, sea level could rise an additional 0.3 meters (one foot) beyond global projections by the year 2100. A decrease in the circulation of the Atlantic Ocean and land subsidence contributes to the higher rate of sea level rise on this shoreline.²¹ Climate change impacts will affect the lives of forty-one million people residing in communities located along the Atlantic Coast.²²

Historic and Cultural Resources at Risk

Properties listed in the National Register of Historic Places are part of the built and natural environment potentially affected by the impacts of climate change.²³ A division of the National Park Service (NPS), the National Register for Historic Places divides listed properties into five categories: buildings, historic districts, sites, landscapes, structures, and objects. Buildings are defined as individual property listings. Districts include properties that are typically groups of buildings or community plans. These historic resources consist of multiple properties linked by a common theme, such as neighborhoods, community areas, cemeteries, industrial complexes, cultural landscapes, and National Park Service units. Sites represent properties that are not associated with a building or structure such as archaeological areas, designed landscapes, and battlefields. Structures are man-made properties such as bridges, transportation vehicles, lighthouses, and forts. Last, objects commonly refer to monuments and outdoor sculpture.²⁴

National Register properties of exceptional national and historical significance are assigned an additional designation as National Historic Landmarks. These possess characteristics that are central to the understanding of the country's heritage. Within the

National Register, fewer than 2,500 properties are National Historic Landmarks, some of which may be impacted by sea level rise.²⁵

If located in low-lying elevations, National Register listings may be vulnerable to the effects of climate change. Sea level rise and higher temperatures threaten buildings, historic districts, sites, structures, and objects. Increases in flood frequency, storm surge, and water inundation can destroy or considerably damage all property types in the National Register. Intense storm events and storm surges contribute to coastal erosion that can damage all historic resource types including archaeological sites and cultural landscapes. Buried archaeology may also be harmed if the soil and water chemistry equilibrium that has preserved artifacts through time is disturbed by higher levels of polluted floodwater.²⁶ Higher temperatures, leading to a change in planting zones, will compromise the interpretation of historic cultural landscapes and designed gardens.²⁷ If left unchecked, these climate change impacts will significantly alter the historic and cultural record of the coastal United States.

Flooding, permanent inundation, storm surge, and erosion pose threats to historic buildings. In *Flooding and Historic Buildings*, English Heritage categorizes floodwater impacts as causing ‘primary’ or ‘secondary’ damage. Primary damage refers to direct water effects that are obvious on building materials “such as expansion or shrinkage, staining.” Secondary damage occurs after the flood event when residual moisture spreads through an improperly ventilated building and causes mold growth.²⁸ Mold can further damage buildings as well as cause health risks for residents.²⁹

Flooding below the first floor of a building rarely causes costly damage unless basements, a common feature in historic buildings, are part of the property. Foundation

walls are at risk of collapsing if floodwater in basements is pumped before external flooding recedes. In addition, utilities in a basement can be damaged by floodwater. Flooding above the first floor results in costly repairs, affecting interior finishes and walls and occasionally the building's structure.³⁰ Standing water, from flooding or permanent inundation, however, can gradually reduce the strength of walls, ceilings and floors.³¹

Storm surge and storm-induced erosion is more likely to create structural damage when the ground around supporting piers and foundations deteriorates due to the force of high energy water and waves. Leaning or sagging buildings, protruding or displaced masonry, cracks above doors and windows, and cracks larger than six millimeters (0.2 inches) may indicate foundation damage.³² Ultimately, a powerful storm surge can destroy buildings by washing them away.

Vulnerability Along the Atlantic Coast

In addition to historic properties representing all eras of development, the Atlantic shoreline is home to some of the earliest European settlements in the United States. Many have evolved into historic districts that reflect the culture of the first settlers. Emigrants from the Netherlands, England, and Spain sought to settle in the New World to claim territory, take advantage of plentiful natural resources, and to build a trade economy. Shoreline areas provided them with easy access to commercial ports, shipping routes, and food sources. Estuarial harbors were often selected as places of settlement for their sheltered locations and their proximity to the sea. Boston, New York City, and Baltimore are examples of existing American cities that were also successful as early trading ports along estuaries.³³

Additionally, prehistoric (associated with Native Americans) and historic sites on shorelines are endangered by sea level rise. Some of these are already submerged due to rising water levels and erosion. These represent many of the archaeological sites and cultural landscapes listed in the National Register. Examples are found in Maryland and Virginia along the Chesapeake Bay.

I estimated the number of National Register properties located on Atlantic Coast shorelines affected by sea level rise in a 2012 independent study.³⁴ By analyzing the number of historic properties for six states—Florida, Maryland, Massachusetts, New York, North Carolina, and Virginia—at elevations up to six meters (19.7 feet), I found that approximately 2,246 National Register listings or an average of 8.1% of the states' listings could be potentially impacted by sea level rise.³⁵ In Florida, almost half of the state's historic resources are within elevations up to six meters (19.7 feet). My findings indicated that about 3,096 Atlantic Coast properties could be affected by sea level rise.

Approximately 12.9% or 399 historic districts in the five state survey are potentially at risk from flooding, storm surge and shoreline erosion. Each of these historic districts incorporates multiple properties (from four to thousands) within their boundaries, exponentially increasing the total number of historic resources susceptible to sea level rise.

Cultural Heritage of the United States at Risk

A potential loss of National Register properties due to the effects of sea level rise would adversely affect the country's historic memory and cultural narrative. These non-renewable historic resources are:

“... symbols, products, and containers of the various cultures that value them. By culture we mean what people think, what they do, and the material products (and landscapes) they produce; culture is shared, learned, symbolic, cross-generational, adaptive, and integrated.”³⁶

National Register properties provide critically important tangible and symbolic connections to the past. Present and future generations can share the cultural heritage of an area with the everyday presence of historic resources.

Through listing in the National Register of Historic Places, historic resources have been validated as significant examples of the country’s past. The nomination process illustrates the rigorous requirements properties must satisfy to be considered worthy of inclusion in the National Register. The listing procedure begins with a detailed nomination addressing age, integrity, and significance. The age requirement of typically fifty years is one condition proving eligibility. A property that has remained relatively unchanged in “location, design, setting, materials, workmanship, feeling, and association” through time is in a strong position to satisfy the integrity provision.³⁷ With a high level of integrity, the property clearly illustrates a specific time and place in history. Historic districts endowed with the seven aspects of integrity create a distinctive sense of place within their communities.

Significance is met when at least one of four possible options from the National Register Criteria for Evaluation applies to the property. These are significance in associations with: events that reflect national history, notable historical people, a distinct architectural or construction style, or sites that have the potential to inform about pre-history or history.³⁸

The effects of sea level rise can potentially alter the integrity of a National

Register listed property. Flooding, storm surge, and erosion may undermine a property's location, design, setting, materials, workmanship, feeling, and association. For example, if a colonial era shipping warehouse was moved from its shoreline site, because of frequent flooding, to an inland twentieth century suburb, its integrity of location, setting, feeling, and association would diminish, misrepresenting the building's historical past and its level of significance.

National Register nominations are typically initiated at the local level with the support of community preservation groups or certified local governments. This is accomplished in cooperation with the State Historic Preservation Office (SHPO).³⁹ An advisory board of the SHPO reviews completed nominations. If approved, the application is forwarded to the Keeper of the National Register who accepts or denies listing in the national database as a National Register historic property.

Preserving Cultural Heritage to Sustain Quality of Life

Quality of life is composed of tangible and intangible attributes that are often measured by “physical well-being, material well-being, social well-being, emotional well-being, and development and activity.”⁴⁰ Within communities, social and economic vitality and environmental conservation create high quality places to live, work, and visit. Two analyses, *Contributions of Historic Preservation to the Quality of Life in Florida* published by the University of Florida and *Stewardship of the Built Environment: Sustainability, Preservation, and Reuse* by Robert A. Young, prove that the preservation of historic resources supports positive social, economic, and environmental outcomes, contributing to quality of life.

The University of Florida's study measures quality of life and its connection with historic preservation in economic, social, cultural, and environmental terms.⁴¹ This results in an overall assessment of an area's "collective values" interpreted as a measure of quality of life.³⁶ Likewise, Young establishes social, economic, and environmental connections with historic preservation to confirm that historic preservation is a sustainable practice.⁴² The University of Florida and Young include cultural benefits in their definitions of historic preservation's social benefits.

Social Benefits

The quality of life advantages associated with National Register historic districts are evident in the sense of place and community identity created by the districts. Differentiated development patterns, architectural aesthetics, local construction techniques, and building materials create a community character unlike any other place. Communities with distinct local identities become more revered as nationally standardized architectural designs replace unique regional building styles. Young confirms, "The mass replication of franchise architecture, suburban housing, and corporate office parks has created a less differentiated built environment nationwide that has contributed to a growing sense of placelessness."⁴³ The standardization of place threatens cultural heritage, causes "displacing tendencies," and a lack of social connections for a community's residents.⁴⁴

In their research, Jeremy J. Hess, Josephine N. Malilay, and Alan J. Parkinson determine the importance of sense of place to the quality of life. They find "a focus on place promotes resilience because identity and sense of place are central to community

resilience, public health, and well-being more generally.”⁴⁵ The Federal Emergency Management Agency (FEMA) backs this finding through observations published in a 2005 study. After a 2003 tornado devastated Pierce City, Missouri, residents mourned the loss of the historic downtown. Residents commented, “While most of the town survived, its heart has been damaged,” and “it was the prettiest little town in Missouri, but now it’s all gone, all the history, all its character—everything.”⁴⁶ FEMA discovered that populations faced with devastating property losses after a natural disaster were more resilient when historic places and local landmarks escaped severe damage. “The enduring qualities that root[ed] them in time and place” contributed to their emotional well-being when faced with an uncertain future.⁴⁷

The ability of historic districts to foster social connections and contribute to quality of life is evident in everyday life. National Register properties exhibit a feeling and association (elements of integrity) with previous times, providing a connection between past and present generations. The connections are cultivated when community members can access historic properties for housing, employment, education, and entertainment.

Economic Benefits

The material well-being, development, and economic activity of a community are enhanced through community reinvestment programs and initiatives applied in National Register historic districts. Preservation of the built environment supports these quality of life measures and contributes to stable property tax bases, the expansion of municipal

services, job creation, retail sales growth, and the development of a heritage tourism industry.

National Register designation of neighborhoods as historic districts has been found to stabilize real estate values, or even lead to increases at rates faster than the overall market area.⁴⁸ Unwavering or rising real estate assessments benefit local government tax revenues, supporting the development and expansion of programs and services advancing local public interests. Property tax revenue applied to infrastructure improvements, public transportation, public safety, schools, libraries, parks and recreation, cultural events, social services, and public building maintenance adds to a community's quality of life.⁴⁹

Additionally, historic districts are catalysts for community reinvestment and increased economic activity. The economic incentives and tools that encourage historic property rehabilitation lead to job opportunities (reducing governmental social service programs) and the growth of retail and service businesses. Reinvestment in the community through rehabilitation fulfills the potential of underused historic properties, adding property taxes to local government revenues for quality of life programs. Examples of federally funded economic incentive programs are: Historic Tax Credits (also available in some states), Low-Income Housing Tax Credits, New Market Tax Credits, and Community Development Block Grants (CDBG). Planning tools, such as Tax Increment Financing (TIF), tax abatements, Transfer of Development Rights (TDR), and Main Street Programs promote the rehabilitation of historic properties, resulting in community reinvestment.⁵⁰

When compared with new construction, five to nine new additional construction

jobs and \$107,000 more income is produced for every one million dollars spent on preservation-related work. Since these jobs usually are local, this translates to \$34,000 more in local retail sales. Furthermore, if 2–3% of existing buildings are rehabilitated each year, these new construction jobs are maintained.⁵¹ Additional jobs contribute to increased retail spending, higher state and federal income tax revenues, and less reliance on publicly funded social service programs.

Job creation, business development, and community reinvestment statistics from two historic preservation programs prove the economic contributions to quality of life. From 1980 to 2012, the National Trust for Historic Preservation’s Main Street Program generated 473,439 new jobs, rehabilitated 236,201 historic buildings, and created 109,664 new businesses. Community reinvestment amounted to \$55.7 billion. For every one dollar invested in a downtown revitalization program, eighteen dollars were reinvested in the community.⁵² A former federal initiative, the Save America’s Treasures grant program was responsible for the development of 16,012 jobs.⁵³

Additionally, heritage tourism contributes to economic vitality, inspires a community’s pride of place, and improves quality of life. Cultural heritage sites, many listed in the National Register, attract tourists who are likely to spend more on trips than other travellers. The United States Travel Association reported in 2010 on these comparisons. Cultural heritage visitors:

“Shop more (44 percent versus 33%);
Stay longer (4.7 nights versus 3.4 nights);
Stay in commercial accommodations more than with family
and friends (62 percent versus 56 percent);
Spend more per trip (\$623 versus \$457, excluding the cost
of transportation); and
Spend more per day (\$103.50 versus \$81.20).”⁵⁴

Increased expenditures generated by heritage tourism support businesses, create jobs, and boost sales tax revenues in historic communities.

National Heritage Areas (NHAs), designated by Congress and affiliated with the NPS, promote a characteristic regional theme through an area's cultural, architectural, and natural resources to build tourism. For example, eight Pennsylvania counties in The Rivers of Steel NHA address the area's industrial past with a particular focus on "Big Steel." The Erie Canalway NHA highlights the natural, cultural, and historic resources found along the 524-mile (843-kilometer) canal corridor in upstate New York. The fifty NHAs provide the framework that accounts for \$12.9 billion in annual economic activity and creates 148,000 jobs. Tax revenue resulting from NHA programs amounts to \$1.2 billion yearly.⁵⁵

Increased tourist activity also increases tax revenue in areas that add a supplemental tax on lodging and restaurant meals. While this additional tax improves quality of life for residents, it has been also used to supplement historic preservation activities in some areas. For instance, a number of innovative Florida counties designate between 8–60% of tourist "bed taxes" to be used specifically for historic preservation.⁵⁶

Environmental Benefits

Historic building rehabilitation is an environmentally sustainable practice that improves a community's quality of life. Life cycle analyses (LCA), determining the environmental impact of a product during its life cycle, reveal that the rehabilitation of historic buildings has less impact on the environment than demolition and building anew.⁵⁷ The National Trust for Historic Preservation's field office, the Preservation

Green Lab, conducted LCAs on a number of rehabilitated commercial, residential, and public buildings. The lab's findings confirmed:

“It takes between 10 to 80 years for a new building that is 30 percent more efficient than an average performing existing building to overcome, through efficient operations, the negative climate change impacts to the construction process.”⁵⁸

Reusing and rehabilitating historic buildings is inherently more sustainable than abandoning older properties and replacing them with new structures.

The rehabilitation or relocation of historic buildings, rather than their demolition, reduces the amount of construction material in landfills. The Environmental Protection Agency (EPA) has found that one third of all landfill debris results from construction refuse.⁵⁹ Additionally, new construction calls for the harvesting of raw materials and the expenditure of energy to transform these materials into finished building components. Raw materials are preserved and energy use decreases with the reuse of a historic building. If a historic building must be demolished, its historic construction materials and architectural features can be recycled for use on other historic properties. This, too limits landfill waste.⁶⁰

Historic building techniques and development patterns reflected local climate conditions, resulting in natural and sustainable methods of temperature control and lighting. Often, historic buildings require less energy for heating, ventilation, and air conditioning (HVAC) and lighting systems, contributing to a sustainable environment and quality of life.⁶¹

In cold climates, historic buildings tend to be smaller, requiring less energy to provide warmth. Heating is also more efficient in historic buildings constructed close

together or in properties that share walls. Small windows, applied sparingly, reduce heat loss. Solid paneled shutters minimize cold drafts when closed.

Conversely, in warmer climates, historic buildings are designed to maximize ventilation and allow for shade. High ceilings and expansive windows in large buildings promote air circulation. Landscaping and roof eaves shade smaller properties. In addition, porches, balconies, loggias, and louvered shutters ventilate and shade historic buildings in warm and humid areas. Building materials, such as adobe, stone, and brick, moderate hot and cold temperatures, providing comfortable interior spaces.

The siting of historic properties controls lighting and solar temperatures, reducing the need for artificial lighting and temperature control. Positioning the long sides of properties to face east and west provides for the optimum sunlight, although westerly elevations are warm in hot summer climates. A north and south siting moderates interior temperatures in warmer areas.⁶²

Dense and mixed-use historic districts also contribute to environmental sustainability and quality of life. Nearby locations for work, school, housing, and entertainment encourage walking, biking, and the use of public transportation. This reduces the need for automobile travel, limits dependency on oil, and improves air quality.

Conclusion

Based on current sea level rise projections, National Register listings and the cultural heritage they represent are at risk. Quality of life is also vulnerable in shoreline communities due to the impact historic properties have on a community's social,

economic, and environmental attributes. The case study analyses in Chapter IV will provide further proof of historic resource vulnerability to sea level rise and the value of historic districts to quality of life.

CHAPTER III

ADAPTING HISTORIC RESOURCES TO THE CHANGING CLIMATE

Introduction to Adaptation

A result of climate change, sea level rise is altering shorelines with more intensity and at an accelerated pace. The damage inflicted even today by increasingly severe storms and storm surges and by accelerating erosion provides evidence that adaptation actions are needed now as well as in the future. Sea level rise impacts will likely alter the social, economic, and environmental characteristics of many coastal communities, negatively affecting their quality of life.

Climate change responses occasionally use the terms adaptation and mitigation interchangeably. Although both address human responses to the impacts of climate change, they differ in approach. Mitigation measures slow the climate change process through the reduction of greenhouse gas emissions and the development of sinks to capture excess emissions. An example of a reduction effort is shifting energy production from fossil fuel to clean energy sources. Sinks, such as increased forest coverage, encourage the absorption of excess carbon dioxide from the atmosphere. While state and local governments and organizations have implemented mitigation programs, national and international mitigation policies have the greatest impact on slowing global climate change.⁶³

By contrast, adaptation methods minimize climate change effects or create situations where areas benefit from changing climate.⁶⁴ The primary adaptation responses

to sea level rise, examined in this research, are to accommodate and protect the built and natural environments from flooding, storm surge, and inundation. Adaptation responses are temporary solutions. As sea level rise continues over time, methods will require revision to protect historic districts as well as other aspects of the built environment. For some districts, a point may be reached when adaptations to protect and accommodate will no longer preserve buildings within their boundaries. Retreating from the coast will then be the last possible adaptation. This is considered a land management adaptation that involves the acquisition and demolition or relocation of property that is vulnerable to repeated damage from the sea. Nevertheless, the goal of my analysis is to recommend ways to extend the life of properties within historic districts, not to retreat through demolition.

Retreat through property relocation has been successfully applied to historic properties in the past, such as the Cape Hatteras Lighthouse, a National Park Service (NPS) property in North Carolina. As the sea eroded the shoreline, the NPS applied adaptation strategies—beach nourishment, jetties, and plastic seaweed—to protect the lighthouse in the 1960s and 1970s. These adaptation efforts only resulted in short-term protection. The NPS recognized that a more permanent solution was required to save the lighthouse.⁶⁵ In its 1988 report, *Saving Cape Hattaras from the Sea: Options and Policy Implications*, the National Academy of Sciences recommended the relocation of the historic lighthouse. This solution protected the historic resource and allowed for the beach erosion process to naturally continue without the interference of adaptation methods.⁶⁶ The Cape Hattaras Lighthouse was moved inland 2,900 feet (885 meters) in 1999, preserving the historic property for an additional 100 to 150 years. It is important

to note that it took nearly eleven years to coordinate public support and funding to apply this adaptation and only three weeks to physically move the lighthouse.⁶⁷

This method of retreat suits the preservation of individual historic properties that face destruction by the sea. Historic districts cannot be relocated due to the multiple properties involved. For this reason, retreat through relocation is outside the scope of this thesis research.

The November 2012 decision to build a \$4.2 million jetty to protect the historic harbor of Tangier Island, Virginia, in the Chesapeake Bay illustrates adapting to protect quality of life. Further, the example provides evidence of present-day sea level rise effects and the temporary nature of adaptation strategies. Due to the island's isolation, a characteristic culture and lifestyle has been maintained for over two centuries.⁶⁸ Currently, the 535 current inhabitants still work as watermen, speak a dialect unique to the island, and interact daily in a close-knit community. A low-lying, marshy island of erodible silt, Tangier Island is disappearing due to the effects of sea level rise and to subsidence, threatening the settlement's sense of place and history.

The jetty will reduce the sedimentation of the harbor, maintaining a navigable waterway and the island's economy. It extends the time the island can remain inhabitable. This protective measure, however, will only offer temporary protection, since two sides of the island continue losing up to 19 feet (5.8 meters) of shoreline a year. Proudful residents are hopeful that the jetty will prolong their culture for the benefit of present and future generations.⁶⁹ A project of the Army Corps of Engineers, the jetty may extend the harbor's functionality for an additional fifty years. After that, it is inevitable that the sea will eventually inundate the island as sea level rise increases.⁷⁰

Adaptations Accommodate and Protect

Because each tidal shoreline is influenced by sea level rise in different ways, a variety of adaptation methods have evolved to satisfy different conditions. The expertise of coastal engineers, scientists, planners, and community leaders is applied to determine the best possible solution based on economic, political, social, and environmental factors.

Methods to accommodate sea level rise and protect the built environment are categorized as hard, soft, and non-structural adaptations. Hard adaptations are engineered, technical solutions that are generally large scale and expensive projects. (Table 1) Most provide protection for large areas of land. Seawalls, floodgates, and jetties are examples of hard adaptations. Soft adaptations incorporate the use of natural materials in their engineered construction. (Table 2) Examples of soft adaptations are beach nourishment, dune building, and wetlands reclamation. Additionally, non-structural adaptations involve organizational policies and strategies that offer smaller scale solutions accommodating sea level rise. (Tables 3, 4, 5) These include zoning ordinances, building retrofit programs, and the elevation of buildings.⁷¹

Each form of adaptation has benefits and disadvantages for abating the effects of sea level rise. Hard adaptations sustain protection from flooding, storm surge, and inundation for expansive areas of land. These methods indiscriminately safeguard all categories of property, not only those of high economic value. In spite of these broad advantages, hard adaptations are expensive and often damage the natural environment.⁷² (Fig. 3) In addition, the barrier approach often provides a false sense of security for residents it is temporarily protecting.

	Benefits:	Disadvantages:
Hard Adaptations:	Equitable protection for large areas and populations.	Expensive. Damage the environment. Public safety and the built environment are at risk if structures fail.
Seawalls	Deflect severe waves and storm surge. Maintains existing shoreline.	Erodes adjacent shorelines.
Revetments/Rip-Rap Walls	Protects base of seawalls from erosion and structural failure. Minimal impact on beach erosion. More resilient to failure than seawalls. Maintains existing shoreline.	Lack of protection from severe storms.
Breakwaters	Less expensive than seawalls.	Deteriorate downdrift beaches.
Groins/Jetties	Builds updrift beaches and limits erosion.	Limited protection against severe waves. Erodes adjacent shorelines.
Bulkheads	Less expensive and smaller than seawalls. Maintains existing shoreline	Erodes adjacent shorelines.
Floodgates	Flexible barrier to hold back flood waters. Keep water channels open for water travel.	Will need to be closed more frequently when sea level rise intensifies. Erodes adjacent shorelines.
Water Storage Areas	Captures excess water, gradually releasing it. Decreases need for costly pumping facilities.	Reduces areas of developable land.

Table 1. Hard Adaptations. “Types of Coastal Structures,” United States Army Corps of Engineers, n.d.; Coastal Sensitivity to Sea Level Rise, James G. Titus and Michael Craghan, 2009; “Netherlands flood prevention presentation,” City of Norfolk, Virginia, 2012]

	Benefits:	Disadvantages:
Soft Adaptations:	Use of natural building materials to absorb and reduce floodwater or storm surge impacts.	Regular maintenance is time intensive and costly.
Green Infrastructure	Reduces flooding by absorbing excess water. Replenishes groundwater, filters sediments and creates wildlife habitats. Less expensive than other soft adaptations to maintain.	
Berms	Less expensive barrier method.	Cause flooding because difficult to drain during intense storms.
Dikes	Protect interior lowland areas from flooding. Less expensive barrier method. Water storage capability reduces reliance on pumping facilities.	
Beach/Dune Replenishment	Temporary protection from inland flooding. Creates wildlife habitats, open space, recreation areas.	Major repairs required after severe storms. Large land areas required to be effective.
Wetland Reclamation	Buffers storm surge force and absorbs floodwater. Mitigates water pollution and augments groundwater supply. Creates wildlife habitats, open space, recreation areas.	Large land areas required to be effective.

Table 2. Soft Adaptations. [“Types of Coastal Structures,” United States Army Corps of Engineers, n.d.; Coastal Sensitivity to Sea Level Rise, James G. Titus and Michael Craghan, 2009; Recurrent Flood Study, Center for Coastal Resources]

Non-Structural Adaptations:	Benefits:	Disadvantages:
Infrastructure	Improvements can minimize flooding in a local area.	Benefits may not be equitably distributed among neighborhoods.
Stormwater Management	Limits flooding.	Costly to construct and update.
Raise Roads, Sidewalks	Added height eliminates flooding on these surfaces.	May compromise integrity of setting in historic districts.
Permeable Surfaces	Drains rain and flood water to ground soil.	
Elevating Buildings	Prevents intrusion of floodwater inside building, limiting property damage.	May compromise integrity of design and setting in historic districts. Wood, masonry, and brick piers are susceptible to deterioration from frequent flooding.
Limited Elevation Change	Limited alteration of historic building	
Significant Elevation Change	Protects building from high flood levels.	
Elevating Land	Reduces flood risk	Expensive. Implementation difficult.
Local Zoning, Building Codes	Implement adaptations fairly across a broad area. Inexpensive for local government. Adaptations specific to historic design can be legislated.	Time consuming for historic property owners to implement due to required municipal approvals.

Table 3. Non-structural Adaptations: infrastructure, elevating buildings and land, zoning and buildings codes. [Center for Coastal Resources Management, "Recurrent Flood Study," 2012; Mississippi Development Authority, "Elevation Design Guidelines," n.d.; "Permeable vs. Impermeable Surfaces," University of Delaware, Cooperative Extension, 2009]

	Benefits:	Disadvantages:
Non-Structural Adaptations: Building Retrofits	Cost effective to implement for a specific building.	Insufficient protection for permanent and severe flooding.
Floodproofing:	Relatively inexpensive to implement. Improves flood protection for individual buildings. Flexibility for design since individually developed for each property. Provides protection up to flood heights of one meter.	Floodwater in excess of one meter should not be held back from building; may be harmful to structural framework. Wood-frame or brick properties can be damaged at lower flood heights. Permanent solutions may affect integrity. Temporary methods may be difficult to set up before sudden flooding. Some adaptations provide only a few hours of protection.
Building maintenance	Cost effective	
Sandbag barriers	Temporary solution that does not affect long-term integrity.	Appropriate for minor flooding only. Heavy to move and stack. Floodwaters cause contamination.
Air vent covers	Temporary solution that does not affect long-term integrity.	Keeps flood water away from building for 20-60 minutes.
Drainage ditches and earthen berms	Permanent barriers; natural materials absorb water.	May compromise integrity of the landscape.
Floodgates or shields	Prevents water entry through windows and doors for extended periods.	Permanent methods may affect integrity.
Connect walls to foundations	Protects building from collapse or shifting due to storm surge.	Building may become more vulnerable to flooding and storm surge by making it less able to slightly shift and reduce pressure.

Table 4. Non-structural Adaptations: building retrofits, flood proofing. ["Disaster Mitigation for Historic Structures," 1000 Friends of Florida et al., n.d.; "Flooding and Historic Buildings," English Heritage, 2010]

	Benefits:	Disadvantages:
Non-Structural:	Temporary solutions with limited affect on long-term integrity.	
<p>Flood Resilience</p> <p>Move utilities to upper floors (electric circuits, fuse boxes, meters, and furnaces) and electrical appliances</p> <p>Sump pump in basement</p> <p>Add backflow valves to plumbing</p> <p>Reduce hard surfaces around property; replace with landscaping</p> <p>Wood or lime concrete for flood-prone first floor</p> <p>Construct with natural building materials</p>	<p>Minimizes damage from flooding. Relatively inexpensive to implement.</p> <p>Pumps floodwater out of building</p> <p>Keeps sewage from stormwater drains and sewers from entering building.</p> <p>Drains absorbs floodwater and rain.</p> <p>Drains water to ground soil; concrete floors retain water</p> <p>More resilient to water; synthetic building materials are usually irretrievably damaged.</p>	<p>Salt water deposits deteriorate concrete and lime mortars after floodwaters recede.</p> <p>Wood floors can be damaged by floods</p>

Table 5. Non-structural adaptations: flood resilience. [English Heritage, "Flooding and Historic Buildings," 2010]



Fig. 3: Beach eroded 114 meters (374 feet) in 30 years as a result of groins (bottom) and stone revetments (middle and top) in Northumberland County, Virginia [Hardaway and Byrne; *Shoreline Management in Chesapeake Bay*, 1999]

Soft adaptations benefit a shoreline area by minimizing the flood and storm surge effects of sea level rise. The natural materials—soil, sand, and vegetation—comprising soft adaptations absorb intense rainfall and storm surge that non-porous and hard surfaces characteristic of developed areas cannot. Other advantages of soft adaptations are habitat creation and the development of open space and recreational areas. Environmental benefits include water pollution abatement and the absorption of additional groundwater. Large swaths of land, however, are required to benefit the adjacent, built environment.

Near urban areas, land to accommodate soft adaptations is not always available.

Moreover, soft adaptations require frequent and costly maintenance as erosion can break down the defenses over time, particularly after intense storm events.⁷³

Non-structural adaptations directly benefit specific properties or portions of a community by accommodating the built environment to sea level rise. Adaptations at the individual property level that minimize flood damage and storm surge include building elevation, building retrofits, and temporary sandbag barriers. Property owners of vulnerable buildings typically cover the expense of non-structural adaptations, but are occasionally reimbursed through public funding programs. Adaptations protecting one building may contribute to inconsistent protection throughout a historic district. Property owners who are unwilling to apply adaptations or unable to pay for them may contribute to the deterioration of an entire historic neighborhood.

Segments of cities and towns can accommodate flooding effects through zoning and building codes, stormwater management programs, and the raising of sidewalks and roads. These non-structural adaptations are planned and paid for at the local level. While the implementation of zoning and building codes is not cost prohibitive, the improvement of stormwater management systems and the raising of sidewalks and roads can be a substantial expense for cities and towns. Another drawback of neighborhood-based adaptation is that it can be inequitably applied across a city or town. Those with political, economic, and social influence within a community can successfully advocate for accommodations to their specific areas, leaving less-represented neighborhoods unprotected.

Adaptation Methods Benefitting Historic Resources

Just as adaptation methods offer protection to localities and regions, the strategies also safeguard the historic properties within these areas. The lifetime of entire historic districts can be extended through hard and soft adaptations that are designed to protect large areas of land. Non-structural methods minimize damage to individual historic properties and infrastructure within historic districts. By abating the effects of sea level rise, adaptations prolong the historical record and the cultural heritage for future generations. Quality of life for current residents is maintained. Adaptations, however, cannot save historic buildings and places forever. The alternative, to do nothing, shortens the time historic resources are in existence before coastal retreat is necessary.

Galveston, Texas

In Galveston, Texas, the early decision to adapt to the effects of ocean storms preserved historic neighborhoods and individual properties that remain historically and culturally significant today. The city's adaptations have protected its primary economic attractions: tourism, beaches, historic districts, and the shipping port.⁷⁴ The city of 48,000 people has four National Register historic districts, two National Historic Landmark Districts, and five local historic districts protected by a local ordinance. (Fig. 4) Most of the city is protected with historic district designation. Despite vulnerability to hurricanes, the continued existence of these historic neighborhoods confirms the success of adaptations implemented by the city.

Adaptation to ocean effects began around the time Galveston was founded in 1838. A local carpenter suggested raising buildings on "stilts" to withstand flooding from

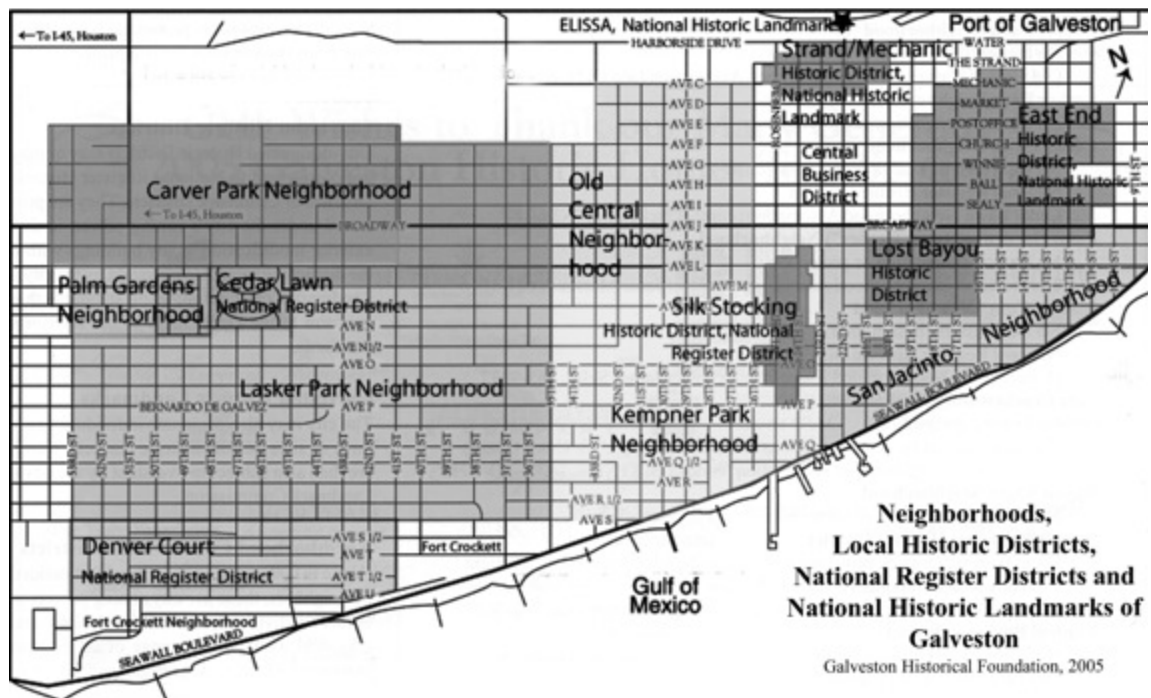


Fig. 4: Local, National Register, and National Historic Landmarks Historic Districts in Galveston, Texas are bordered on the south by the seawall. [Galveston Historical Foundation Preservation Resource Center; Galveston Historic Districts, 2005]

storms. After damage from an 1875 hurricane, the city petitioned the state to build a breakwater but the state declined. In its place, the city resorted to a soft adaptation—planting trees along the top of sand dunes and raising other areas with sand.⁷⁵

A critical demand for protection resulted after a hurricane in 1900 destroyed 3,600 buildings and took the lives of 8,000 residents. The estimated cost of damage was \$20 million (\$700 million today). The 1900 Galveston hurricane remains the deadliest natural disaster in the history of the United States.⁷⁶ The city was faced with a decision to retreat from the barrier island or rebuild. It chose the latter, initiating a massive engineering project to protect itself from future storms. A seawall, three miles (4.8 kilometers) long and 17 feet (5.2 meters) high with a rip-rap base, was built to protect the densely developed residential and commercial neighborhoods on the island. (Fig. 5)



Fig. 5: Galveston Seawall circa 1910–1920. [Library of Congress Prints and Photographs; Seawall and Beach, Galveston, Texas, circa 1910–1920]

In addition, the ground level was sloped from the top of the seawall on the south shore downward to the northern side of the island. If water overtopped the wall, it would flow out to sea at the north shore. Buildings were jacked up, at the property owners' expense, and slurry was pumped below them, raising the ground level up to 17 feet.⁷⁷ (Fig. 6)

Owners who could not afford to raise their buildings lost either their first floors or their entire buildings. The adaptations took seven years and \$1.6 million (over \$39 million today) to complete.⁷⁸ Galveston County funded the adaptations. The seawall and raised slope of the island proved successful when a hurricane in 1915, as severe as the last, led to only eight deaths.⁷⁹ Still, the 1915 storm flooded downtown Galveston with six feet (1.8 meters) of water. A storm surge of 16 feet (4.9 meters) crashed into the city. Because damage was greater outside of the seawall-protected area, city residents believed



Fig. 6: Galveston homes were raised to accommodate the landfill required to elevate the island and build the seawall. [courtesy of Ellen Beasley and Billy Phillips; *The Alleys and Back Buildings of Galveston*, 1997]

the hurricane's toll would have been worse without the engineered adaptations in place.⁸⁰

Federal funds paid for a seawall extension in 1904 and 1905 to protect Fort Crockett, west of the historic districts. Today's 9.9 mile (16 kilometer) long seawall resulted from additions to its length in 1927 and 1963.⁸¹ Although the city has suffered subsequent hurricane damage through the years, Galveston had been largely spared until Hurricane Ike in 2008. Hurricane Ike caused heavy damage to the Port of Galveston, infrastructure, housing, and a research hospital. The city requested \$2.2 billion in disaster relief from Congress.⁸² Hurricane forces compromised the stability of the seawall, leading to an \$18 million repair by the Army Corps of Engineers in 2010.⁸³

Recognizing the need for more protection, the Houston and Galveston communities have proposed construction of the "Ike Dike," based on sea barriers used in the Netherlands. The estimated cost is \$6.6 billion. (Fig. 7) Sea gates—to protect the shipping, chemical and industrial concerns of the Galveston and Houston harbors—are a less costly alternative at \$1 billion. (Fig. 8) Both proposals are under consideration.⁸⁴



Fig. 7: The Maeslant Barrier floodgate, near Rotterdam, Netherlands, is similar to the floodgate proposed for Galveston and Houston. [European Press Agency/Cor Mulder; “Planning the ‘Ike Dike’ Defense, June 4, 2009]

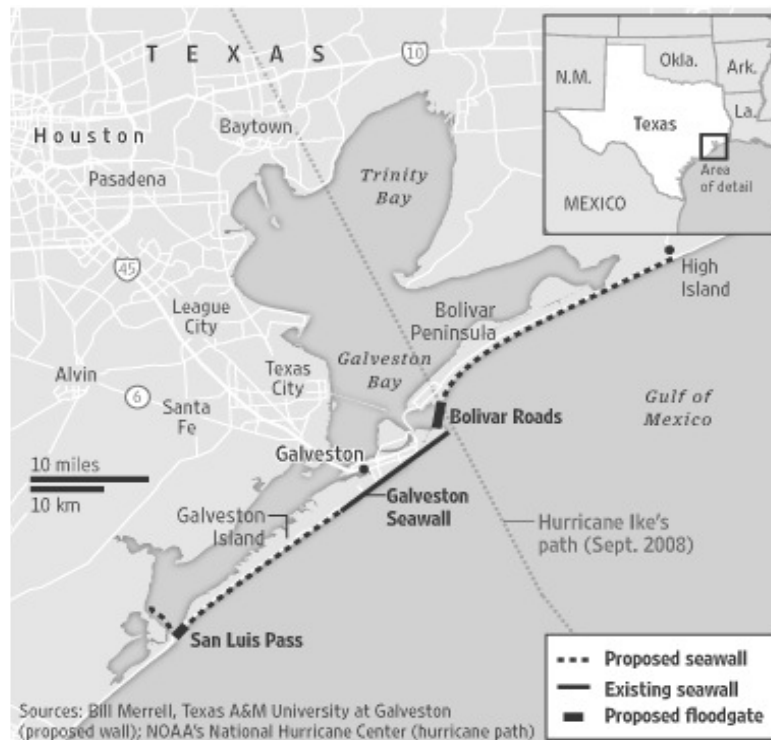


Fig. 8: Proposal for the “Ike Dike” to protect the Galveston and Houston harbors. [Bill Merrell; “Planning the ‘Ike Dike’ Defense,” June 4, 2009]

Norfolk, Virginia

Established in 1680, Norfolk, Virginia, is home to 1.7 million people. It holds claim to the Atlantic Coast's deepest shipping channels and is a major base for the United States Navy. Norfolk has a fifty-year history of adapting to life along the tidal shoreline. The city's location at the confluence of the estuarial Elizabeth and James Rivers limits its exposure to direct ocean effects. While Categories 2 and 3 hurricanes could cause severe storm surge damage, nuisance flooding impacts the city on a monthly basis. Common rainstorms, high tides, and spring tides provoke frequent floods, resulting in property damage and impassable transportation routes.

Of the twelve National Register historic districts in Norfolk, the Ghent, Colonial Place, Freemason, and Downtown neighborhoods are located in low-lying, flood-prone areas. The Berkley North and Riverview historic districts are partially prone to flooding. All historic districts are in hurricane evacuation zones.⁸⁵ (Fig. 9)

Norfolk's vulnerability to sea level rise is attributed to its low elevation, measuring no higher than ten meters (32 feet) above sea level, and to land subsidence. Since 1930, local sea levels have risen 0.36 meters (1.2 feet), double the global average. Norfolk has been subsiding at an accelerated rate because the city was built on marshes and tidal creeks.⁸⁶ The current flood frequency in Norfolk forecasts the types of sea level rise issues shoreline communities will face in the future.

Norfolk constructed its first adaptation—a three to six meter (9.8 to 19.7 feet) rock and concrete seawall—in the 1960s to protect the downtown area. As flooding became increasingly frequent, the city implemented steps to safeguard residents and their properties. Because of its long-term record of adaptations, a Public Broadcasting System



Figure 9. Six of Norfolk's twelve National Register Historic Districts are located in flood-prone areas. [City of Norfolk; National Register Historic Districts, n.d.]

(PBS) report stated the city is “way ahead of the curve when it comes to flood protection.”⁸⁷

After a 2003 storm, the Federal Emergency Management Agency (FEMA) paid over \$100,000 per house to elevate twenty homes.⁸⁸ Some property owners implemented their own adaptation methods by moving air conditioning units to roofs and raising their electric and gas utilities to higher floors. One Colonial Place homeowner, claiming a historic Tudor home would look “stupid and ugly” if elevated, constructed a berm around his property. The \$159,000 project also included the installation of a pump and drainage system and decorative plantings to blend the berm into the landscape.⁸⁹ (Fig. 10) The city



Fig. 10: A professionally landscaped earthen berm protects a home in Norfolk's Colonial Place National Register Historic District. [*The Virginian-Pilot*; "Norfolk Resident Builds Berm to Protect Home from Floods," April 19, 2009]

further funded the raising of roads by 1.6 feet (0.5 meters) in chronically flooded areas. Yearly upgrades to the drainage system—sewage pipes and stormwater pumping facilities—cost Norfolk \$6 million annually. Currently, the city is constructing additional stormwater pumps and elevating public buildings.⁹⁰ Conditions in some areas have improved during regular rain events, but widespread flooding still occurs during heavy storms.⁹¹

Projections for sea level rise to reach 1.74 meters (5.7 feet) by 2100 indicate a need for additional adaptations in the future.⁹² To plan ahead, Norfolk asked the Dutch coastal engineering firm, Frugro, for suggestions on how the city could adapt to sea level rise. Frugro recommended the construction of long floodwalls at strategic points around the city. The construction of additional culverts, drainage ditches, and pumping stations

would protect the entire city. The complete plan would cost over \$1 billion. A localized plan to manage chronic flooding of the Hague, an inlet bordering the Ghent National Register Historic District, was also proposed. This entails building a floodgate that could be closed to protect from storm surge. The estimated cost to protect the Ghent neighborhood alone is \$60 million.⁹³

In June 2012, Dutch planners proposed an alternative long-term solution for Norfolk based on successes in the Netherlands. They suggested diverting excess rainwater to urban water storage areas, away from buildings and infrastructure. New Orleans is also considering this strategy. Water storage areas reduce nuisance flooding and repetitive flood costs from intense rain events. In addition, they can minimize flood damage caused by hurricanes. The water storage basins are designed as attractive, urban water features constructed in locations that have been abandoned due to flooding. If constructed, the Dutch planners maintained that hard adaptation barriers around the city's perimeter are still required to protect the area from high waves and storm surge. Because water storage areas are gradually drained, expensive and fossil fuel-dependent pumping facilities are not required.⁹⁴

Despite the prospects for added protection, Mayor Paul Fraim was hesitant about the prospects for a flood-free Norfolk during a 2012 interview. He stressed that the city could not maintain the financial expenditures for updated adaptation methods as sea level rise vulnerability increases. It required the federal government to assist in funding.⁹⁵ Even with additional adaptation strategies, Fraim conceded that Norfolk may have to consider retreat zones within twenty to thirty years.⁹⁶

Involvement of the Historic Preservation Community in Adaptation

The published literature regarding adaptations to sea level rise primarily addresses the benefits to entire municipal areas. Few historic preservation organizations, however, provide adaptation guides specific to historic districts or to individual properties. The exceptions are English Heritage in England, the British National Trust, the 1000 Friends of Florida, and the Mississippi Development Authority.

English Heritage and the British National Trust

Adaptation policy in England has shifted from a tradition of hard barriers to a preference for soft or non-structural strategies. Seawalls and other hard adaptations have been used to hold back the sea for centuries in England. As a result, the country recognizes the harmful effects of these methods on the environment. The House of Commons Select Committee on Agriculture stated in its 1998 Flood and Coastal Defence report “that coastal defence could no longer be wholly dependent on traditional ‘hard’ defence works and called for a radical change in policy.”⁹⁷ The revised policy recommended that adaptations should be environmentally “sustainable and economically viable in the long term.”⁹⁸ Additionally, a need for the coordination of adaptation efforts among localities was stressed.

In England, the national government plays a central role in the management of its coasts. The Department for Environment, Food and Rural Affairs (Defra) oversees the program. Defra provides grants for adaptation to the national Environment Agency and Internal Drainage Boards. Local areas also are eligible to receive grants after fulfilling Defra’s technical, environmental, and economic requirements. One requirement directs

the national or local group to assess the impact of proposed adaptations on both the natural and historic environments.⁹⁹

Under the National Heritage Act of 1983, English Heritage was established as a governmental organization operating under the Department of Culture, Media and Sport. The organization advises the government on issues related to historic resources, manages historic properties, and maintains the National Heritage List for England (NHLE). This list is comparable to the National Register of Historic Places. As part of its advisory responsibilities, English Heritage informs the government on the impacts of sea level rise and coastal change on historic resources. Its four publications on this topic cover shoreline management, climate change, adaptation, and flooding.

Climate Change and the Historic Environment echoes the national policy to avoid the use of hard adaptations due to harmful environmental effects. *Flooding and Historic Buildings* contains non-structural adaptation suggestions specific to individual historic properties. Adaptations are divided into two categories: flood proofing works and flood resilient works. The former holds water back from the property. Flood proofing through regular maintenance protects buildings from water entering through cracks in mortar, masonry, walls, vents, and through spaces around windows, doors, and pipes. Floodgates at doors and windows are additional examples of flood proofing. (Figs. 11, 12) Flood resilient adaptation methods, such as the relocation of utilities to upper floors and constructing with natural materials, limit damage to the building's interior.¹⁰⁰

The British National Trust follows the English preference to employ soft adaptations for its coastal properties. This membership organization owns and manages historic properties, landscapes, and wildlife habitats throughout the United



Fig. 11: Floodgate at historic home near the River Thames. [Douglas Kent for English Heritage; *Flooding and Historic Buildings*, April 2010]



Fig. 12: Temporary flood barriers, hidden within slots at base of windows, can be raised in case of flood. [John Fidler for English Heritage; *Flooding and Historic Buildings*, April 2010]

Kingdom. The organization's philosophy is to protect historic properties as long as possible, realizing that retreat from the coast is inevitable as sea level rise increases.

At South Milton in Devon, the National Trust rebuilt dunes as a soft adaptation strategy. The British National Trust's choice of adaptation methods reflects their intention to "work with nature, not against it."¹⁰¹

The 1000 Friends of Florida

In the United States, the 1000 Friends of Florida, Florida Department of State, Florida Division of Historical Resources, and the Florida Division of Emergency Management have developed additional non-structural adaptation recommendations in *Disaster Mitigation for Historic Structures: Protection Strategies*. The 1000 Friends of Florida, a non-profit organization, preserves and promotes quality of life in the state. Its publication guides historic property owners in the care of specific historic building components as they prepare for hurricane wind, rain, and flooding. Roof, window, door, garage door, porch, wall, and foundation adaptations that maintain the property and its historical significance are stressed.

The guide points out that windows and doors are the weakest points of a building. Keeping them in good repair will mitigate cracks and spaces where floodwater can enter a building. Regular cleaning, painting, and the replacement of glazing putty and weather stripping will improve the watertight quality of windows. Weather stripping on historic doors and garage doors can also minimize floodwater inundation inside a building.¹⁰² Maintenance of building materials used for foundation piers prevents floodwater intrusion and assists in withstanding storm surge. This includes replacement of wood that

has rotted and repointing of mortar.¹⁰³

Additionally, foundations and walls are vulnerable to storm surge. To withstand storm surge, appropriate connections must be constructed between walls and foundations. Brackets, clip, and straps, connecting the wall framing to the foundation, enhance vertical building stability, but do not guarantee protection from storm surges.¹⁰⁴ (Fig. 13)



Fig. 13: Masonry piers have been replaced at the Maddox House at Port St. Joe, Florida. Metal brackets (upper right) connect floor foundation to piers, supplementing vertical building strength. [1000 Friends of Florida, et al.; *Disaster Mitigation for Historic Structures: Protection Strategies*, 2008]

Mississippi Development Authority

Mississippi communities along the Gulf Coast lost between 6% to 95% of their historic properties due to Hurricane Katrina.¹⁰⁵ In response, the Mississippi Development Authority (MDA) has developed a grant and loan program to fund the elevation of coastal historic properties and districts vulnerable to flood damage and storm surge. Grants and

loans are funded by the United States Department of Housing and Urban Development (HUD). Design guidelines accompany the elevation program to ensure that significance and integrity are not compromised. These are based on revised FEMA and National Flood Insurance Program (NFIP) guidelines with design assistance from the Mississippi State Historic Preservation Office (SHPO) and local and national preservation organizations. To elevate historic buildings and receive a grant or loan, property owners must propose an elevation plan that is approved by MDA and the SHPO. It must adhere to local floodplain ordinances, building permit rules, and historic design guidelines.¹⁰⁶

FEMA flood elevation maps determine the height of a building's elevation based on the level of flood risk. To maintain historic significance, evaluations regarding site, architecture, foundation, and elevation design are outlined in the guidelines and must be addressed before this non-structural adaptation is applied to a historic property. All relate to maintaining the integrity of the historic building.¹⁰⁷ (Fig. 14, 15)

The raising of a property considerably changes its scale, mass, and setting. The guidelines recommend that the elevated building not interrupt the characteristic context and rhythm of the historic district. Historic districts maintain an appropriate design aesthetic when building elevations are consistent and heights and setbacks are the same depth. Additionally, the integrity of the setting must be addressed in proposals to elevate. This entails allowing space for established sidewalks, walkways, and driveways. Spacing between historic properties should be also maintained. In addition, historic landscaping defines the contextual setting in historic districts. Proposals should limit the removal of existing landscape elements. It is suggested to use plants to screen the piers that elevate the properties. (Fig. 16) Last, the architectural design and materials of the



Fig. 14: Setback, height, and compatible porch design are consistent in this historic district of elevated homes. [Mississippi Development Authority; *Elevation Design Guidelines*, n.d.]



Fig. 15: Raised foundation is decorated with an architectural grid pattern that coordinates with porch railing and window mullions. [Mississippi Development Authority; *Elevation Design Guidelines*, n.d.]



Fig. 16: Landscaping screens the piers that elevate the historic property and visually reduces the heightened scale of the adaptation. [Mississippi Development Authority; *Elevation Design Guidelines*, n.d.]

elevation components must be compatible with the existing historical style and materials of the property. The character and feeling of the building and the historic district is preserved with the application of the elevation design guidelines.¹⁰⁸

Obstacles to historic property elevation may interfere with the application of this adaptation solution. Residential property owners may find raising a home is cost prohibitive. Construction and engineering fees can range from \$30,000 to over \$100,000 per property.¹⁰⁹ Historic integrity can diminish when all property owners within a neighborhood cannot afford to elevate their properties. Additionally, elevating water, sewer, and gas utility lines is a major undertaking. Accommodating access for the elderly and disabled adds another impediment to building elevation.

Potential for Compromised Historic Integrity

Adaptation methods can alter the built environment even as they protect it. In

historic districts significance may be compromised if any of the seven aspects of integrity—location, design, setting, materials, workmanship, feeling, and association—are changed. Hard and soft adaptations can affect location due to the coastal erosion that results. Land from under historic properties can gradually disappear, causing destruction or relocation of the property. Also, adaptations with high barriers like seawalls affect location and setting by removing the landscape context in which a historic district was built. Non-structural adaptations such as property elevations, wall to foundation connection brackets, and flood barriers for windows and doors have the potential to affect the architectural integrity of a building. This impacts the overall character or feeling of the historic district. Materials and workmanship will be affected when new or incompatible materials are used to adapt windows, doors, or foundations to sea level rise impacts. The final element of integrity, association, is compromised when the other six are altered. In summary, significance diminishes when the overall character of a place or its association with its historical past is altered. A dramatic degradation of historical integrity can lead to the de-listing of National Register properties.

Adaptation Decision-makers and Stakeholders

Recent theoretical analyses and research studies identify ways communities can become resilient to the effects of climate change. Resilience theory focuses on “the ability of a system not only to ‘bounce back’ following a crisis, but also to learn and adapt so as to reduce future vulnerabilities.”¹¹⁰ This discipline includes analyses of how communities adapt to climate change through social and political collaboration among decision-makers and stakeholders. The historic preservation community may find it

advantageous to apply recommendations from this literature to further adaptation planning for historic resources. Theories and research in the study of resilient communities are published in *Adaptation to Climate Change* by Mark Pelling and in *Collaborative Resilience: Moving Through Crisis to Opportunity* edited by Bruce Evan Goldstein. “Wicked Challenges at Land’s End: Managing Coastal Vulnerability Under Climate Change,” by Susanne Moser, S. Jeffress Williams, and Donald F. Boesch provides insight into the adaptation decision-making process and the stakeholders involved in adaptation planning.

This resource information overlaps in two areas. First, the theories and research state the importance of educating the public—stakeholders in adaptation—on the local science of sea level rise. An informed public will more likely support the adaptation efforts of the local government. Through education, established values and activities can be potentially altered, limiting the barriers to adapt to sea level rise. Secondly, the theories and research findings confirm the need for collaboration among multidisciplinary groups in the adaptation planning process. Intergovernmental public works, planning and emergency management departments and policymakers must collaborate with the public, property owners, environmentalists, and the scientific community to create adaptation solutions.

Different points of view are evident in the literature on the subject of state and federal government adaptation intervention. Mark Pelling asserts that adaptation strategies cannot be implemented without the support of higher levels (state and federal) of government.¹¹¹ Moser, Williams, and Boesch state that strong leadership beyond the local government level can further adaptation planning, however, it has the potential to

mute local public opinion and interests.¹¹² *Collaborative Resilience* authors John Randolph and Edward Weber also stress the importance of local decision-making in adaptation planning. They say state and federal governments should respect community values, opinions, and adaptation plans rather than imposing solutions without local input. Randolph suggests that state and the federal governments should limit their roles in adaptation planning by providing technology and scientific data assistance to communities.¹¹³

Moser, Williams, and Boesch insist that all decision-makers and stakeholders involved in adaptation planning must continually access the latest scientific data on sea level rise.¹¹⁴ Sea level projections will be likely adjusted as climate change conditions evolve, altering the types of adaptations that will protect a community. Local, state, and national governments must include the scientific community in local adaptation planning decisions for the implementation of successful and relevant adaptation strategies.

As attempts to plan for adaptation advance, obstacles will arise along the way. The involvement of diverse groups in adaptation planning also creates barriers to adaptation implementation. Moser and her colleagues write, “challenges repeatedly found are intra- and cross institutional or governance barriers” where “[i]nformational, communicational, political, and public support barriers also play important roles.” Additionally, at the government employee level, barriers arise due to lack of human resources, sufficient financing, and education on sea level rise science. “Attitudes, worldviews, cultural norms, place attachment, historical investments, and available adaptation options” impede adaptation implementation at the local level.¹¹⁵

Pelling concurs, stating that adaptations are a challenge to plan and implement

because different groups have different perspectives on ways to adapt. Consensus is difficult to reach.¹¹⁶ He identifies the existence of “rigidity traps” when the public and organizations decline opportunities to adapt even when it is clear that environmental conditions are changing. These traps occur in the absence of government policy and financial support for adaptation and in a lack of innovative solutions proposed by organized interest groups.¹¹⁷

It is necessary for the historic preservation community to understand sea level rise science and become a part of the adaptation decision-making process. No other decision-maker or stakeholder group is solely committed to the protection of historic resources. As sea level rise threatens, historic preservation planners, advocates, and owners of historic properties must collaborate with adaptation planning groups to safeguard historic resources and cultural heritage.

Conclusion

A number of adaptation methods have been developed to protect the built environment, including National Register properties. Benefits, however, are often temporary, with different adaptation solutions applied as conditions change. Nonetheless, adaptation methods are available to prolong the lifespan of National Register properties that are vulnerable to sea level rise. Historic resources and their cultural associations are irreplaceable. Adaptation methods extend the unique cultural experience that defines an area for present and future generations. An area’s quality of life and characteristic sense of place will continue on, enhancing an area’s social, environmental, and economic well-being. The historic preservation community must stress these benefits when advocating

for the protection of historic resources from sea level rise as decision-makers and stakeholders in the adaptation planning process. In addition, developing relationships with other groups concerned with sea level rise will advance the profile for historic property adaptation in the social, economic, and political arena.

Chapter IV reveals adaptation solutions that have been proposed or applied in the case study cities. Many of the strategies protect historic districts from the effects of sea level rise; some negatively impact integrity. The upcoming section also identifies adaptation decision-makers and stakeholders.

CHAPTER IV ATLANTIC COAST CASE STUDIES

Introduction to the Case Studies

To varying degrees, each of the case study cities—St. Augustine, Florida; Elizabeth City, North Carolina; and, Alexandria, Virginia—currently apply adaptations to mitigate flooding, erosion, and storm surges. Due to low-lying locations along Atlantic Coast estuaries, they are vulnerable to the projected effects of sea level rise. The natural hazards these cities face today will worsen as sea level rise incrementally reaches one meter (3.3 feet) by 2100.

As some of the earliest settlements along the Atlantic Coast, the case study sites include historically and culturally significant properties representing early development in the United States. Historic districts have been documented in each city and are listed in the National Register of Historic Places. All representative historic districts prominently define the areas' characters, contributing to quality of life.

I document the development history of each case study city and describe the character of the historic districts. The chapter continues with an analysis of current risks that impact the historic districts. Projected, future risks to the historic districts are mapped for 2050 at approximately 42 centimeters (1.4 feet) and for 2100 at one meter (3.3 meters). Each case study evaluation concludes with an examination of implemented and proposed adaptations and the decision-makers and stakeholders involved.

St. Augustine, Florida

St. Augustine, Florida is the oldest, continuously occupied European settlement in the country. The city is located on a peninsula on the northeast shore of Florida in St. Johns County, between Jacksonville and Daytona Beach. The Spanish settled on the western shore of the tidal Matanzas River in 1565, partially sheltered from the open ocean by the Anastasia Island barrier beach. (Fig. 17) The tidal San Sebastian River



Fig. 17: Looking westward at St. Augustine, Florida. The star-shaped structure on right is the Castillo de San Marcos. The historic Bridge of Lions in the center crosses the Matanzas River, connecting to St. Augustine to Anastasia Island. Maria Sanchez Lake is on the right in the middle of the peninsula. [Google Earth; St. Augustine aerial photograph, December 17, 2011]

borders the city to the west. The city is exposed to frequent flooding, storm surges, and coastal erosion due to its low-lying elevation and proximity to tidal rivers. Sea level rise will intensify these tidal effects. Seven historic districts are located within the city limits, all potentially susceptible to sea level rise.

The history of St. Augustine is divided into four eras, referring to the countries

that governed the city through the years. These periods are the Spanish Colonial, the English, the second Spanish, and the American. The people of each country, joined by immigrants from Europe and Africa, left their cultural marks on the community, creating a cosmopolitan city by the end of the second Spanish era in 1821.¹¹⁸

The Spanish Colonial period begins with Pedro Menendez de Aviles leading a Spanish fleet to the New World and establishing St. Augustine as a military base in 1565. The city was strategically placed to defend Spain's southern territories from the British who had settled to the north.¹¹⁹ In addition to being a strategic military location, the city was founded as a trading center and a mission.

Free blacks settled at Fort Mose, northwest of St. Augustine's colonial city, during the sixteenth, seventeenth, and eighteenth centuries. Spain acknowledged their freedom as long as they joined the Catholic Church.¹²⁰ Fort Mose was the first legal African American settlement in the United States.¹²¹ (Fig. 18)

Between 1573 and 1586, St. Augustine's colonial city was designed according to guidelines established by the Laws of the Indies, a Spanish planning code derived from Roman principles. A centrally located rectangular plaza emanated from four major, corner streets. The plaza was the center of all community activities. Civic and religious institutions bordered the plaza enclosed by King and Cathedral streets. The plan was flexible for growth, allowing for expansion from the central plaza.

Because of its geographic location, St. Augustine did not measurably expand and prosper. Development was confined to the narrow parameters of the peninsula and to the town plan. The placement of the Castillo de San Marcos to the north and the monastery

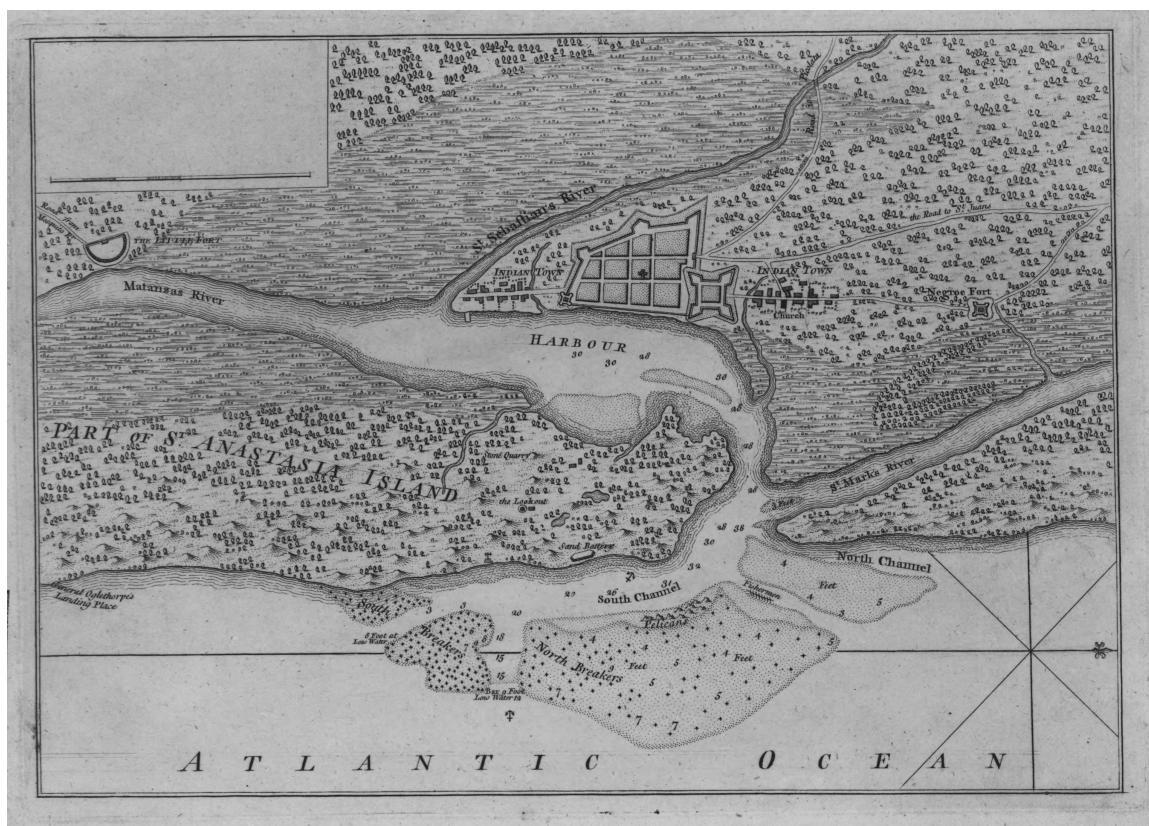


Fig. 18: The walled St. Augustine Town Plan District, a National Historic Landmark, represents the city's colonial heritage. The monastery, now St. Francis Barracks, is located at the southeast corner with the star-shaped Castillo de San Marcos at the northeast corner. The African American settlement, Fort Mose, is labeled as "Negro Fort" to the city's north. [Thomas Jeffery, Library of Congress Geography and Map Division; plan of the town and harbor of St. Augustine, circa 1762]

to the south created obstacles to development. (Figs. 19, 20) The shallow harbor and shifting barrier beaches made the harbor difficult to navigate for trading ships.

Consequently, the success of a port economy eluded the city, forcing the Spanish to subsidize the settlement.¹²²

The colonial years were marked by frequent conflicts between warring colonizers wishing to expand territorial command in the New World. The British and Native Americans fought with the Spanish settlers, periodically attacking the town. As the Carolina colonies strengthened under British rule, the Spanish fortified St. Augustine's



Fig. 19: The Castillo de San Marcos, a NPS site, is located at the northern border of the St. Augustine Town Plan Historic District, overlooking Matanzas Bay. [Ann Horowitz; photograph, January 2013]



Fig. 20: A monastery and missionary first occupied this site in 1577. St. Francis Barracks was constructed between 1724-1755. It faces the Matanzas River at the southern end of the St. Augustine Town Plan Historic District. Since the British period, the building has been used for military purposes. The Florida National Guard is stationed here today. [Google Earth; street view photograph, 2013]

military strength by building a massive coquina stone fort, the Castillo de San Marcos, beginning in 1672. After the British destroyed the city in 1702, the settlement was walled to the north, west, and south.¹²³

The Spanish recognized the need for protection from the sea as early as 1599 when a severe storm damaged the early settlement. The first seawall was constructed between 1596 and 1602 of wooden trees that were three-inches (7.6 centimeters) in diameter.¹²⁴ After that deteriorated, Florida governor Don Diego de Quiroga y Losada wrote to the King of Spain in 1690 requesting funding for a new seawall. He proposed “building a wall the whole length of the City along the sea, seeing the danger in which it now is of being ruined by floods from the sea (which already comes up to the houses) when we have the slightest storm.”¹²⁵ Spain financed the second seawall, constructed of coquina stone between 1694 and 1705. As this seawall decayed, the United States government funded a replacement built from 1836 to 1842.¹²⁶ (Fig. 21) Currently, the rehabilitation of the nineteenth century seawall is under construction.

After the Seven Years’ War in 1763, the Spanish traded Florida for Cuba with the British.¹²⁷ The British period in St. Augustine lasted until 1784 when the British traded the city again with Spain for the Bahamas. The second Spanish period lasted until 1821 when Spain ceded Florida to the United States in 1821. Florida became a state in 1845.¹²⁸

As part of the United States, St. Augustine gradually attracted tourists from the north due to its mild weather and unique European character. The Union Army enlisted the Castillo as a military base during the Civil War, renaming it Fort Marion. After the war, land was slowly developed outside the city’s colonial boundaries. African

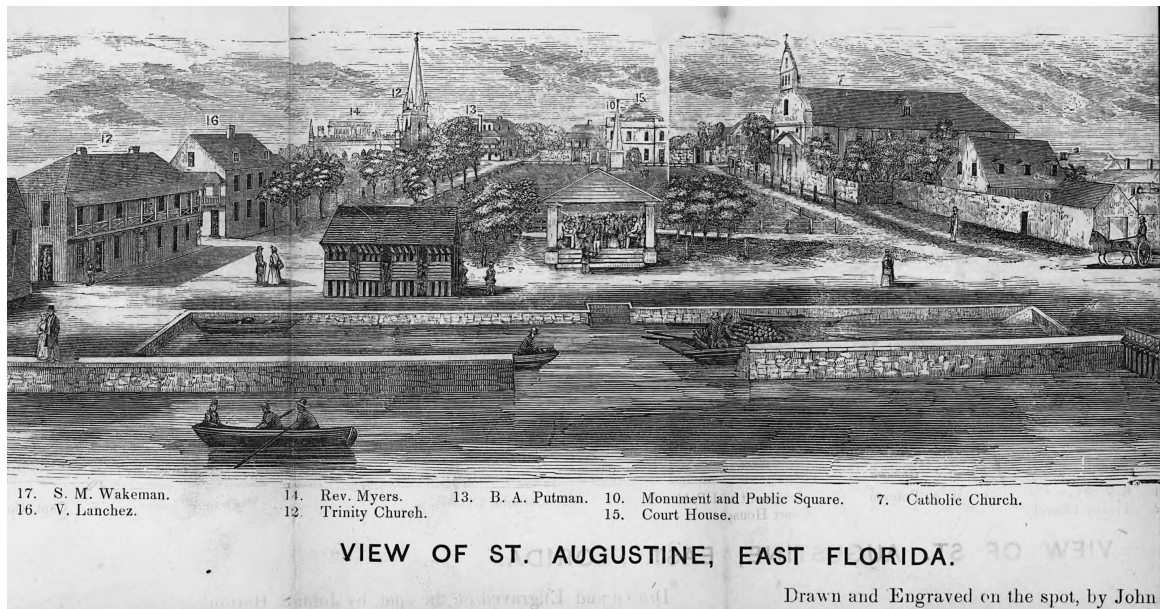


Fig. 21: The plaza was the center of the original town plan, protected from storms by the city's third reconstructed seawall. King Street is to the left of the square; Cathedral Street is on the right. [John S. Horton, Library of Congress Geography and Map Division; View of St. Augustine, East Florida, 1855]

Americans settled southwest of the historic city in Lincolnville; the Abbott Tract neighborhood grew to the north.

In 1883, Henry Flagler, John D. Rockefeller's co-partner in Standard Oil, believed the city could rival Newport, Rhode Island as a tourist destination.¹²⁹ He purchased the railroad and land west of the city wall to build the Ponce de Leon and the Alcazar Hotels. With partner Heth Canfield, Flagler filled part of the Maria Sanchez Creek, a saltwater tributary of the Matanzas River, to create additional land for his tourist hotels.¹³⁰ The creek became Maria Sanchez Lake, south of the city plaza and east of Lincolnville.

Henry Flagler continued to build within the community. West of his hotels, he developed the Model Land Corporation neighborhood near his railroad station. The

Flagler era in St. Augustine, however, quickly came to an end in the late 1890s when Flagler decided to develop in southern Florida's warmer climates.¹³¹

Since the early twentieth century, tourism in St. Augustine has remained one of its primary industries. The National Park Service took over the Castillo de San Marcos in 1924, opening it to the public for tours. Inspired by Colonial Williamsburg, the St. Augustine Historical Society in conjunction with the Carnegie Institute began preservation efforts in 1937. Their goal was to preserve, restore, and reconstruct the city's architectural past to reflect the first Spanish era. The group created a "living museum," along St. George Street, highlighting the area's unique Spanish heritage.¹³² (Fig. 22) The



Fig. 22: St. George Street has evolved from a "living museum" into an area of tourists' shops. The street features many building reconstructions. [Ann Horowitz; photograph, January 2013]

University of Florida Historic St. Augustine, Inc. (UFHSA) currently owns, leases, preserves, and interprets sixteen buildings on St. George Street in addition to 45 others within the original colonial city.¹³³

The Flagler Hotels were adapted to contemporary uses. City government offices and the Lightner Museum moved into the rehabilitated Alcazar Hotel in the 1960s. In 1968, Flagler College purchased the Ponce de Leon Hotel for its campus.¹³⁴

Government, religious, and educational institutions own 51% of the city's property, limiting the amount of property taxes St. Augustine can collect from its property owners. For this reason, the city relies on sales and room taxes generated by tourism to fund the city budget. The economic base has diversified in recent years with the addition of light industries and service businesses in the area.¹³⁵

The population in 2011 was estimated at 13,336. Median household income for city residents is \$38,325, \$9,502 less than the state average. Twenty-two percent live below the poverty line, compared to 14.7% for the state. The land area measures 9.43 square miles with 1,376.2 persons per square mile.¹³⁶

National Register Historic Districts

St. Augustine has emphasized its architectural and cultural past through its commitment to historic preservation. In addition, support of historic preservation is indicated in the city's Comprehensive Plan, recommending the nomination of neighborhoods to the National Register. Seven National Register historic districts have been listed. These illustrate the historical periods of St. Augustine. They are: the City of St. Augustine Town Plan, Abbott Tract, Model Land Company, Lincolnville, North City,

Fullerwood Park, and Nelmar Terrace. (Fig. 23) Historic districts encompass 159 blocks with 1,711 buildings.

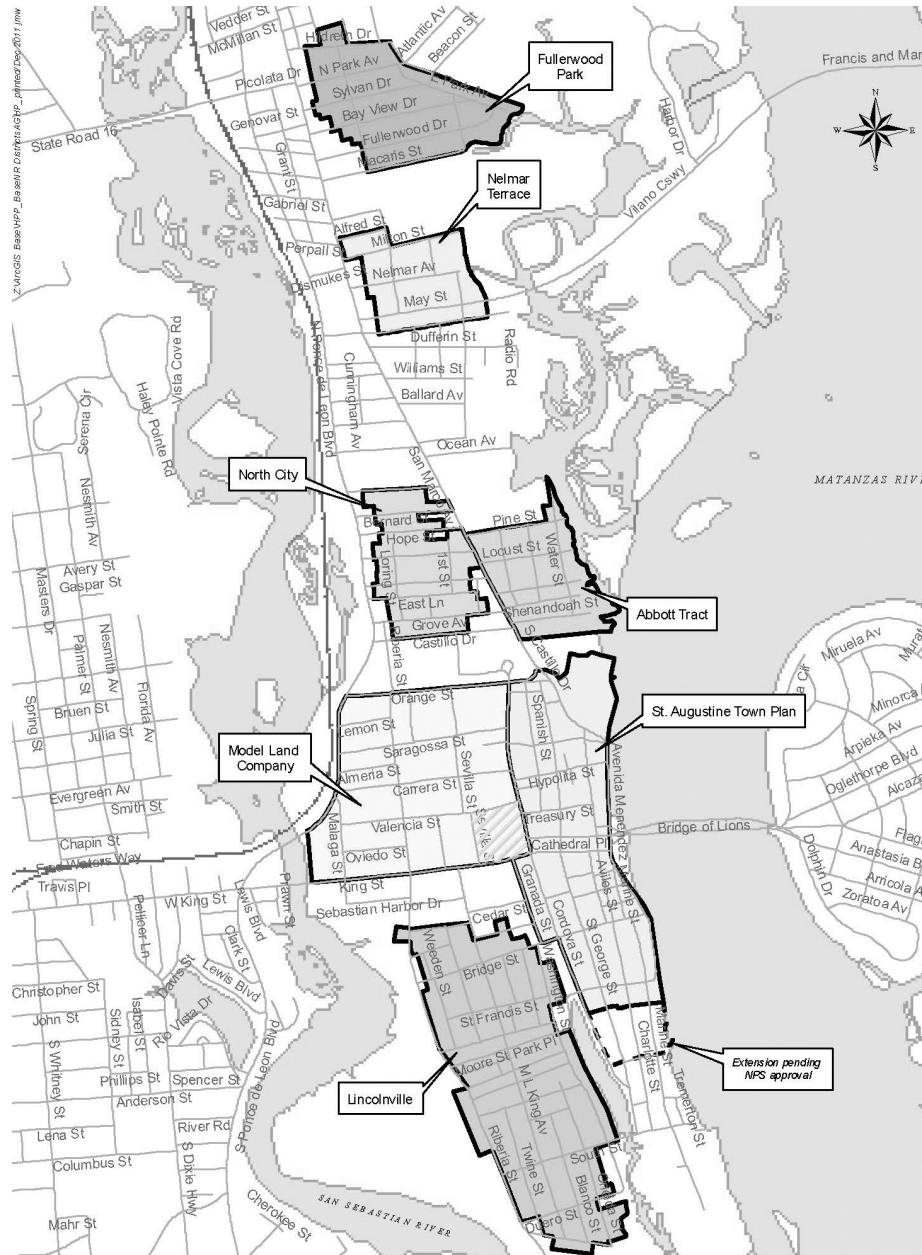


Fig. 23: The seven historic districts of St. Augustine are sited at low-lying elevations near rivers and wetlands. [City of St. Augustine “Architectural Guidelines for Historic Preservation, p. 22; Historic districts of St. Augustine, October 2011]

The Historic Architectural Review Board reviews proposals for alterations and new construction according to guidelines specified for five historic preservation zones. The St. Augustine Town Plan and Abbott Tracts areas are the only districts comprehensively regulated by historic preservation zones. Limited sections of the North City, Model Land Corporation, and Lincolnville districts are subject to design review. Alteration and new construction reviews are not required in the Fullerwood Park and Nelmar Terrace districts.¹³⁷

The St. Augustine Town Plan Historic District is a 22-block area characterized by Colonial era development from 1565–1821. The 394 contributing buildings are located within the “Old Walled City.”¹³⁸ In addition to Spanish and British Colonial architecture, styles from the American period—Gothic Revival, Queen Anne, and Colonial Revival—add character to the district. Vernacular bungalows were constructed during the early twentieth century. (Fig. 24) Spanish and British reconstructions were created on St. George Street to form the “living museum.”¹³⁹



Fig. 24: The Joaneda House was erected during the British period, circa 1806. [Google Earth; street view photograph, 2013]

The district is also listed as a National Historic Landmark for its extraordinary example of early town planning and its collection of colonial architecture. Spain's Laws of the Indies were the basis for the development of St. Augustine. In 1573, King Phillip II compiled the urban planning guidelines for the country's colonies. Settlements were to be placed in areas with good sea and land access for commercial prosperity and for defense. Towns were to be sited on a northern or eastern shore. The plaza was the social, political, and economic center of the town, where eight roads extended from it to the settlement's borders. If a town was walled, it was densely built.¹⁴⁰

Four other buildings inside the district are also National Historic Landmarks. These are: the Cathedral of St. Augustine, the Gonzalez-Alvarez House, the Hotel Ponce De Leon, the Ximenez-Fatio House, and the Llambias House.¹⁴¹ (Figs. 25, 26)



Figs. 25 and 26: The Ximenez-Fatio House (left), constructed in 1807 exemplifies the second Spanish period. The Llambias House (right) represents the first Spanish period and was built around 1763. [Frances Benjamin Johnston, Library of Congress Prints and Photographs Division; photographs, circa 1936]

The Castillo de San Marcos is included in the St. Augustine historic district. The fort was constructed between 1672 and 1695 as a military warehouse and a fortress to house residents when the town was under attack. The Castillo is the last remaining seventeenth century fort in the United States and one of two military installations constructed of coquina.¹⁴² The porous and lightweight stone is a natural composite of quartz, sand, and fragmented shells found in most of Florida and in North Carolina.¹⁴³ Coquina was quarried on Anastasia Island and cut into blocks for construction use. The porosity of coquina is vulnerable to deterioration when exposed to the elements. The native stone, however, proved to be well suited for military defense since cannonballs compressed the building material rather than cracking it. The thick, porous walls absorbed the projectile force or deflected it.¹⁴⁴

The Abbott Tract Historic District is composed of 124 contributing buildings on 17 blocks located north of the St. Augustine Town Plan Historic District.¹⁴⁵ The Matanzas River borders the district on the east. A pond and an inlet form the northern border. As the first area constructed outside of the original city limits, the district represents the highest concentration of nineteenth century buildings in St. Augustine. Queen Anne, Colonial Revival, Mediterranean styles of frame and masonry construction are featured in the district.¹⁴⁶

The Model Land Company Historic District is a 245 building, 19-block residential and commercial area developed during the late nineteenth and twentieth centuries under the guidance of Henry Flagler.¹⁴⁷ The St. Augustine Town Plan Historic District is to the west of the district; the San Sebastian River borders the area on the west.

The Ponce de Leon (1888) and Alcazar Hotels (1889) are included in the district.

Both were designed by architects John Carrere and Thomas Hastings to harmonize with the city's Spanish Colonial architecture.¹⁴⁸ The Ponce de Leon Hotel was the more luxurious and elaborate of the two. (Fig. 27) Louis Comfort Tiffany designed stain



Fig. 27: Henry Flagler built the exclusive Ponce de Leon Hotel in 1888. Flagler College now uses the former hotel as its campus. [Ann Horowitz; photograph, January 2013]

glass, murals, and mosaics decorating the Gilded Age interior. Indoor plumbing and electricity, rarities for hotels at the time, accommodated wealthy tourists.¹⁴⁹ The Alcazar Hotel held claim to the first indoor swimming pool in Florida and to a casino on the premises. (Fig. 28) Italianate, Queen Anne, Romanesque Revival, and Colonial Revival, and Mediterranean architectural styles are incorporated in the neighborhood. Bungalow and vernacular residences from the twentieth century add to the district's character. Frame and masonry building materials were used in construction. Architects Carrere and



Fig. 28: The Alcazar Hotel pool was drained and is now a restaurant. [Detroit Photographic Co., State Archives of Florida; Alcazar hotel casino pool in Saint Augustine, Florida, circa 1905]

Hastings designed additional buildings in the district.¹⁵⁰

The Lincolnville Historic District of 45 blocks and 548 contributing buildings, constructed from 1870 to 1930, represents the history of an African American settlement developed after the Civil War.¹⁵¹ The district is southwest of the colonial city, located to the east of Maria Sanchez Lake. During the civil rights era, the neighborhood hosted Martin Luther King and the Southern Christian Leadership Conference. African American builders and craftsmen constructed many of the residential and commercial buildings in the district. Frame buildings, some with coquina foundations, characterize the area, featuring Mediterranean Revival architectural styles, bungalows, and vernacular buildings.¹⁵² The neighborhood, however, is currently at risk due to deteriorating and abandoned buildings. To improve conditions, the city is considering a Community Redevelopment Area designation for the neighborhood.¹⁵³

The North City Historic District is a collection of subdivisions developed between 1879 and 1935. Twenty-four blocks with 235 contributing buildings are located northwest of the St. Augustine Historic District.¹⁵⁴ Residential buildings are commonly frame construction. Commercial buildings display the early use of concrete block and poured concrete.¹⁵⁵

The Fullerwood Park Historic district is the northernmost historic district that was originally developed as a streetcar suburb beginning in 1914. Construction in the neighborhood continued until 1964. The district is laid out on 13 blocks and portrays 65 contributing examples of frame styles popular during the early to mid-twentieth century in St. Augustine.¹⁵⁶

The nine-block Nelmar Terrace Historic District, featuring 100 contributing buildings, is located in the area north of the original platted city.¹⁵⁷ Construction of the subdivision began in 1913, accelerating during the 1920s Florida Land Boom and after World War II. The result is a residential neighborhood of varied architectural styles such as Colonial Revival, Mediterranean, and Tudor. Bungalows are scattered throughout as in many sections of St. Augustine. The majority of homes are frame construction.¹⁵⁸

Social, Economic, and Environmental Benefits of the Historic Districts

Social, economic, and environmental factors inherent in the historic districts benefit the area's quality of life. As sea level rise increases, flooding, storm surge, and erosion may diminish the value of the historic resources over time unless adaptations are applied. The city and its residents recognize the positive impact of their historic environment. Nancy Sikes-Kline, a city commissioner and member of the Citizens for the

Preservation of St. Augustine, stated, "Our historic buildings are a core value to our city. It's why a lot of people move here. I think that gives people security in knowing that their neighborhood is going to increase in value and remain stable. It's also a quality of life issue. Everything will be well maintained."¹⁵⁹

The popular press has acknowledged the city's characteristic sense of place with recent accolades. Most recently, Forbes Magazine named St. Augustine to its ten top prettiest cities in the United States. The ranking took into account natural beauty and a unique identity. In early 2012, TripAdvisor listed it as one of the top 15 tourist locations. Glen Hastings, Executive Director of the St. Johns County Tourist Development Council, noted, "In past years, St. Augustine was named among the most walkable cities and the best place to feel like you're in Europe even though you're stateside."¹⁶⁰ Each honor was bestowed due to the city's unique qualities, all resulting from its preserved and maintained historic districts.

Of the seven districts, the St. Augustine Town Plan Historic District most clearly demonstrates the benefits of historic settlements and their contribution to creating quality of life. The densely developed area fosters social interaction since walking is the most efficient way to navigate the narrow streets. The densely developed residential and commercial district make destinations easily accessed on foot. The central plaza promotes social interaction through farmers' markets and civic events.

A distinct sense of place is evident in the St. Augustine district, strengthening the social and cultural ties to the area. The blend of colonial Spanish and British architecture, uncommon in the United States, and the use of native coquina and tabby create an image unique only to St. Augustine.¹⁶¹ Pride of place, generated by these architectural

characteristics, has drawn residents and politicians together to preserve the cultural legacy.

The six other historic districts convey unique historical legacies of their own. Lincolnville portrays the post-Civil War African American experience in St. Augustine as it developed around a former plantation. Flagler's enthusiasm for St. Augustine is displayed in The Model Land Corporation. The suburban Abbott Tract, North City, Nelmar Terrace, and Fullerwood Park reflect a diversity of aesthetic tastes, representative of national architectural styles popular during the period.

Economically, local property tax abatements for certified rehabilitation work benefit residents who own historic property in the historic preservation zones. Additionally, this incentive supports local construction jobs that require expertise in repairing buildings unique to St. Augustine. Increased employment and wages not only add to personal and business income, but also to city tax revenues.

Heritage tourism contributes substantially to the economic well-being of St. Augustine. The industry attracts 6.2 million visitors a year.¹⁶² The National Trust for Historic Preservation conducted a survey in 2002, assessing the impacts of heritage tourism on St. Augustine. The study found that 80 percent of tourists came to the city to visit historic sites.¹⁶³ At the Castillo de San Marcos, 750,000 people visit every year.¹⁶⁴ St. Johns County reported that \$712 million tourist dollars were spent in 2012. The sales tax revenue from tourism in 2008 registered at \$42 million. Tourism-related jobs employ 12,000 in the county.¹⁶⁵

Town planning guidelines from the Laws of the Indies adapted to environmental conditions. These considerations have contributed to the long-term sustainability of St.

Augustine. In St. Augustine, the town is sited on the eastern shore of the peninsula. The city receives morning sun and opens up to the river, naturally cooling the area with ocean breezes. This setting contributes to a reduced need for air conditioning. Additionally, the density of the walled city created an urban plan that was not car-dependent, reducing carbon emissions and improving energy efficiency and air quality.¹⁶⁶

The first Spanish period features building design and materials that have proven to be environmentally advantageous. After the British destroyed the city by fire in 1702, residents rebuilt their homes from fire-resistant coquina and tabby. Their homes were based on designs from Santanderina in Northern Spain, a place similar in climate to St. Augustine.¹⁶⁷ A sheltered porch or loggia was placed in the rear of the residence, opening to a yard. (Fig. 29) The loggia shielded wind in the cold winter months, but let in the



Fig. 29: The first floor loggia at the Gonzalez-Alvarez House, built circa 1720, on St. Francis Street represents a common St. Augustine building feature that began with the first Spanish period. The open, yet shielded, porch is designed to be warm in the winter and cool in the summer. [Historic American Building Survey, Library of Congress Prints and Photographs Division; photograph, February 1965]

warm sun. In the summer the loggia allowed for the free flow of summer breezes, while shielding the porch from the hot sun.¹⁶⁸ Second floor street balconies circulated air, cooling the upper floors in warm weather. The thick masonry walls cooled the buildings. Early Spanish building techniques reduce the reliance on energy consumptive air conditioning.

Natural materials also protected building longevity. The addition of tabby to a coquina exterior made the building watertight. Coats of lime plaster were also painted on the tabby and coquina exterior walls to prevent mold growth, a product of flooding and high humidity.¹⁶⁹

Natural Hazard Risks

Close to tidal waters at a low-lying elevation, St. Augustine is currently susceptible to flooding, storm surge, and erosion. Elevations throughout St. Augustine range between one to two meters.¹⁷⁰ After rainstorms, nuisance flooding over one inch (2.5 centimeters) occurs on a regular basis in the St. Augustine Town Plan and Lincolnville historic districts. Martha Graham, St. Augustine's Public Works Director stated on February 1, 2013 that nuisance flooding will regularly close streets.¹⁷¹ The parking lot at the Castillo de San Marcos floods several times a year in an area that was landfilled by the NPS to create the parking lot.¹⁷² (Fig. 30)

Barrier beaches and wetlands near the St. Augustine peninsula absorb some of the wave action during storms. The St. Augustine historic district, however, is sited due west of an inlet that opens directly to the Atlantic Ocean. Due to this vulnerability, tropical storms, hurricanes, and nor'easters can generate storm surges and waves that overtop the



Fig. 30: The parking lot at the Castillo de San Marcos floods several times a year. [National Park Service; photograph, November 17, 2012]

current seawall. During the 2004 hurricane season, forecasters predicted the possibility of 10-foot (three meter) storm surges. In addition, heavy wave action has eroded the shoreline and the seawall.¹⁷³

Tropical storms and hurricanes are the most damaging and costly of all natural disasters to strike in Florida. Eighteen hurricanes have passed within range of St. Augustine since 1886. Hurricane Dora was the last hurricane to directly hit St. Augustine. In 1964, it came ashore with winds of 115 miles (185 kilometers) per hour, causing widespread damage.¹⁷⁴ More recently, storm surges from Tropical Storm Gabrielle in 2001 and Tropical Storm Faye in 2008 overtopped the floodwall, significantly damaging historic properties along the Avenida Menendez, the shoreline street.¹⁷⁵ Rainfall from Gabrielle measured 6.51 inches (16.6 centimeters).¹⁷⁶ During Tropical Storm Debby in 2012, the Abbott Tract Historic District flooded from 7.7 inches (19.6 centimeters) of

rain.¹⁷⁷ With climate change, projections for higher intensity hurricanes and rain events will impact Florida. Storm surge and flooding will be exacerbated.¹⁷⁸

Past hurricanes have damaged historic resources in the St. Augustine Historic district. The Ximenez-Fatio House, a National Historic Landmark in the St. Augustine district, three blocks inland, was affected by numerous storms. A Save America's Treasures grant of \$200,000 was awarded in 2004 to repair the storm damage and problems from previous repair work.¹⁷⁹ Additionally, the historic coquina seawall, a contributing element in the St. Augustine district, has eroded and collapsed in places after recent tropical storms and hurricanes.¹⁸⁰

Projected risks: 2050 and 2100

The sea level rise projections for Northeast Florida are nearly consistent with global projections. The global average for sea level rise is 2 millimeters (0.08 inches) per year; the closest tide gage at Mayport, Florida registers 2.2 mm (0.09 inches) per year.¹⁸¹ For the year 2050, this study maps sea level rise as 42 centimeters (one foot) and nearly one meter (three feet) in 2100 for all case study cities. As the sea level rise incrementally increases, St. Augustine's historic districts will be placed at greater risk. Historic buildings that are flooded will lead to irreparable damage. Significant buildings close to the inundation areas will also become more vulnerable to flooding, storm surge, and land erosion risks. In addition, nearby wetlands are likely to gradually migrate inland, compromising the land where historic districts are located.¹⁸²

In 2050, sea level rise of 42 centimeters (one foot) will impact the historic districts, although few historic properties will be permanently inundated. (Fig. 31) The

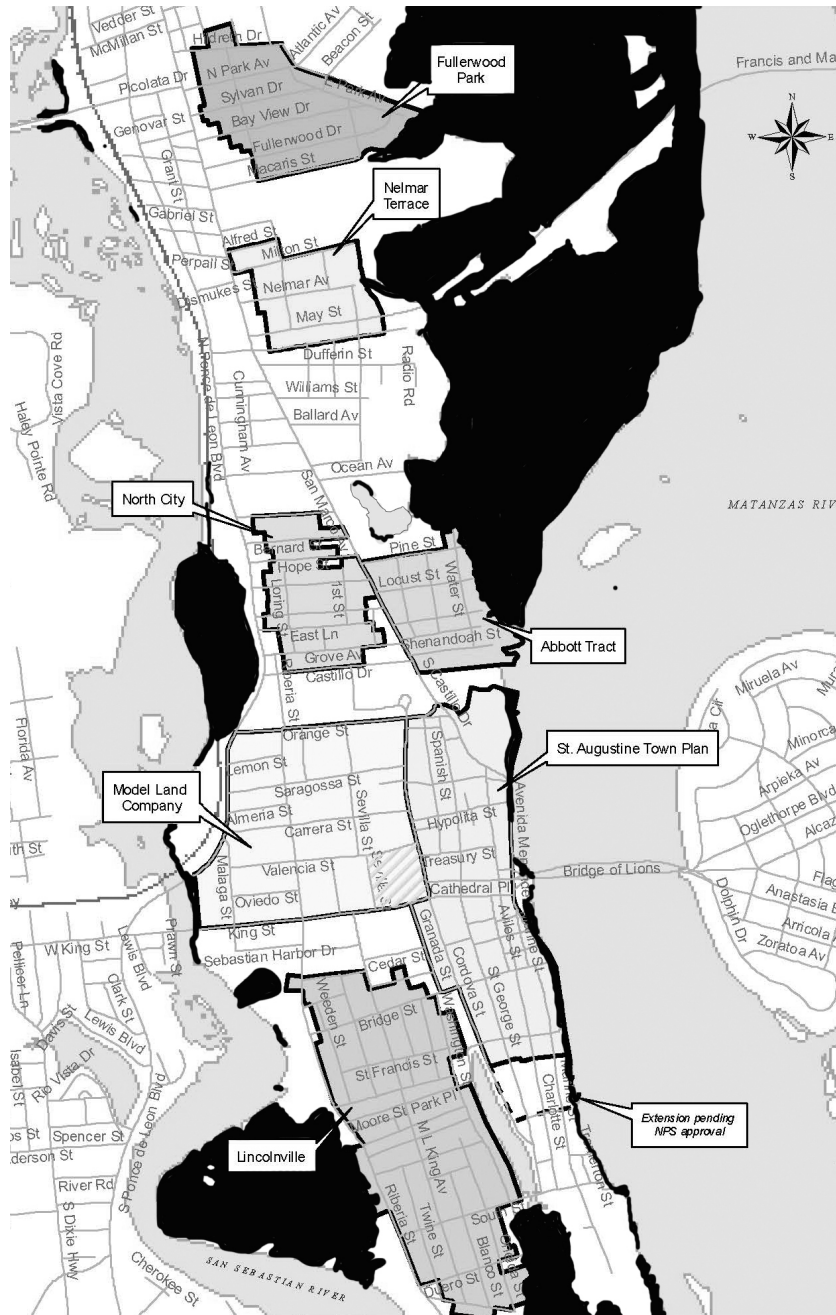


Fig. 31: In 2050, 42 centimeters (one foot) of sea level rise is projected. Flooded areas are illustrated in black. The wetlands, north and south of the colonial city, and a sliver of the Matanzas River shoreline will be flooded. Shorelines will encroach on historic districts borders, although few properties will be flooded. [City of St. Augustine; historic district base map, October 2011. National Oceanic and Atmospheric Administration; sea level rise and coastal flooding impacts one foot overlay, n.d.]

encroachment of shorelines near all districts, except for the North City Historic District, will heighten the areas' vulnerabilities to sea level rise impacts. As sea level rises to 0.5 meters, floods are projected to last 37 days a year, straining historic properties beyond present day conditions.¹⁸³ Additionally, the wetland areas north and south of the St. Augustine district and around Maria Sanchez Lake will be permanently flooded in 2050. This will raise the possibility of marsh-like conditions moving into the Lincolnville, Abbott, Nelmar Terrace, and Fullerwood Park districts. Since wetlands cannot support buildings, the historic properties in these areas will eventually collapse.

By 2100, a one meter (three feet) of sea level rise is likely to affect a large number of properties in the historic districts. (Fig. 32) The shoreline will move farther inland, permanently inundating historic properties in all of the districts except for the North City area. Storm surge and land erosion will have a greater effect on more buildings. Further, more land area could convert to wetlands. At one meter of sea level rise, the duration of floods is projected to last 149 days a year.¹⁸⁴

The integrity of the historic districts will be dramatically altered by 2100. In the St. Augustine Historic District, the areas most affected are along the Matanzas River shoreline and the former Maria Sanchez Creek. The colonial town, representing some of the oldest and most unique buildings on the Atlantic Coast, will be greatly impacted. Examples of a distinct history and identity may be damaged or greatly altered unless carefully planned methods to adapt to sea level rise are applied.

Properties constructed of lime-based materials—coquina and tabby—face an additional threat due to climate change. The rising acidity of ocean and rainwaters from carbonic acid, a result of carbon dioxide in the atmosphere, will hasten the dissolution

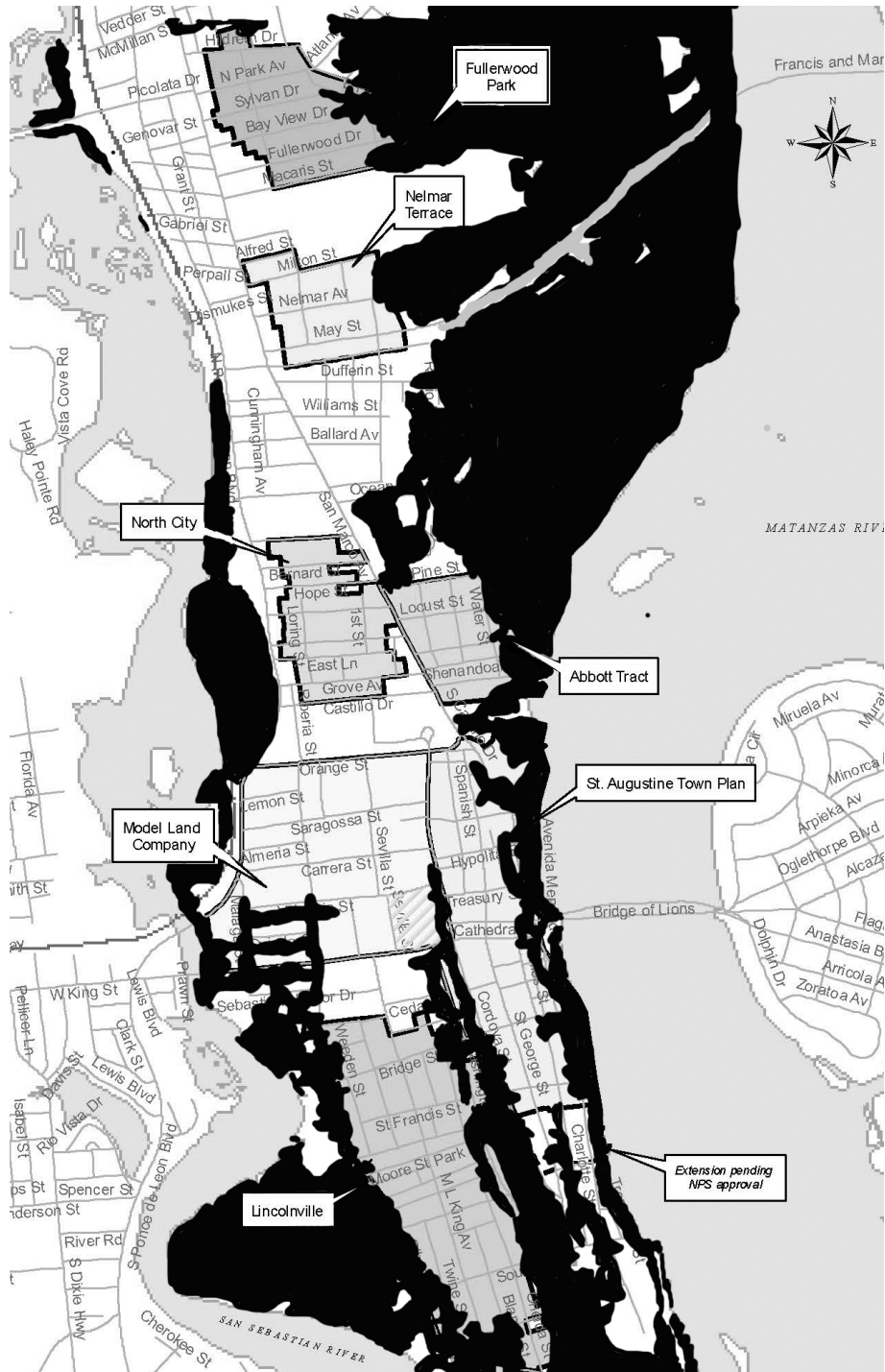


Fig. 32: With a one meter (three feet) of sea level rise by 2100, a substantial portion of the city is likely to be affected. Inundated areas are illustrated in black. All historic districts will be impacted by sea level rise to some degree. [City of St. Augustine; historic district base map, October 2011. National Oceanic and Atmospheric Administration; sea level rise and coastal flooding impacts three feet rise overlay, n.d.]

of lime based stone like coquina and tabby.¹⁸⁵ If submerged in highly acidic water, the earliest buildings, portraying the city's Spanish roots will eventually decompose and cease to exist.

Sea level rise will not only impact the St. Augustine district's characteristic streetscapes, but also highly significant individual historic properties. (Fig. 33) Buildings



Fig. 33: Marine Street portrays a characteristic St. Augustine streetscape. Second period Spanish buildings of coquina and tabby are interspersed with American era Victorian styles and bungalow frame architecture. The street will be inundated by sea level rise by 2100 unless adaptation measures are taken. [Google Earth; street view photograph, 2013]

along the Avenida Menendez, the street parallel to the Matanzas River, will be flooded.

This includes the historic Castillo and the St. Francis Barracks. Six original colonial buildings are located between these distinctive landmarks on the Avenida Menendez.¹⁸⁶

The Castillo de San Marcos will suffer structural damage if the dry moat is permanently inundated. In the 1930's, the NPS permanently flooded the dry moat. This caused the walls and foundation to crack and erode. Numerous repairs were required

through the years to restore the coquina and mortar. By 1996, the NPS restored the dry moat and constructed a French Drain to maintain the dry conditions.¹⁸⁷ Permanent inundation from sea level rise could further compromise the foundation of the Castillo, threatening its future. The Gonzalez-Alvarez House on St. Francis Street, a National Historic Landmark, will also be flooded. (Fig. 34)



Fig. 34: The Gonzalez-Alvarez or Oldest House is the earliest residential building in the city. It was constructed in the early 1700s of coquina and tabby. The building will be flooded by 2100. [Daniel Horowitz; photograph, January 2013]

The land where Maria Sanchez creek once flowed, along Cordova and Granada Streets, will be inundated. In this area, the former Alcazar Hotel, constructed by Henry Flagler of rusticated stone, and its landscaped grounds will be flooded. South of the hotel, a neighborhood of frame Queen Anne and Victorian residences will also be permanently flooded. The Dow museum, a collection of nine coquina, tabby, and frame

buildings constructed between 1790 and 1910, is located on one city block in this area of projected inundation.

The Lincolnville Historic District, portraying the history of African Americans in St. Augustine, will be inundated on its south, east and west. (Fig. 35) The majority of



Fig. 35: Vernacular frame houses in the Lincolnville district were originally constructed on block piers, some coquina. The added height currently protects from repetitive flooding in the area. This area on Duero Street, the district's western border, is likely to be flooded by 2100. [Google Earth; street view photograph, 2013]

residences in the district are frame homes that were elevated on blocks, some coquina, when constructed. The elevation may protect some properties from periodic floods.

Coquina blocks, however, will deteriorate if submerged in seawater acidified by carbonic acid, a result of the increased carbon dioxide in the atmosphere.

Permanent flooding will occur in the Model Land Corporation Historic District, eliminating the visible history associated with the Flagler era. Portions of Flagler College, a building of rusticated stone, will be partially inundated. Three office buildings on Riberia Street, erected between 1922 and 1926, housed the offices for Flagler's Florida

East Coast Railway until 2006.¹⁸⁸ (Fig. 36) Flagler College now uses the buildings for dormitories and administrative offices. Residential properties, primarily of frame construction, along Valencia, Oviedo, and King Streets will also be flooded.



Fig. 36: Formerly the headquarters for Florida East Coast Railway, the Flagler College building is part of the Model Land Company Historic District. The masonry buildings will be permanently flooded by 2100. [Google Earth; street view photograph, 2013]

The integrity of the three remaining districts is also at risk by 2100. The Abbott Tract Historic District and its collection of nineteenth century architecture, mainly frame buildings, will be threatened by 2100. Areas near the Matanzas River will be affected as well as properties near the inland pond on the district's northern border. (Fig. 37) Additionally, permanent inundation will affect the twentieth century residences in the Nelmar Terrace and Fullerwood Park districts. (Figs. 38, 39) The longevity of these mostly frame properties will be in question as one meter of sea level rise affects St. Augustine by 2100.



Fig. 37: Frame residences in the Abbott Street Historic District along Pine Street are projected to be flooded by nearly one meter of sea level rise by 2100. Pine Street houses facing an inland pond are currently elevated approximately two feet from the ground. [Google Earth; street view photograph, 2013]



Fig. 38: Early twentieth century frame residences on Nelmar Avenue in the Nelmar Terrace Historic District are located on low-lying elevations susceptible to flooding from sea level rise by 2100. [Google Earth; street view photograph, 2013]



Fig. 39: Vernacular frame homes from the twentieth century on East Park Avenue in the Fullerwood Park Historic District are projected to be flooded by sea level rise of approximately one meter by 2100. [Google Earth; street view photograph, 2013]

Implemented Adaptations

Adaptation methods to minimize flooding have been implemented in the St. Augustine environs due to the area's proximity to the Atlantic Ocean and its low elevation. These adaptations may prove to mitigate the impacts for future sea level rise, although planning efforts considered only current flooding conditions and did not incorporate projections for sea level rise. In addition, adaptations have not yet been proposed that include data for projected sea level rise.

The earliest of these implemented adaptations is the St. Augustine seawall, a prominent historic feature in the colonial district. The coquina seawall, constructed between 1836 and 1842, originally extended from the Castillo southward along the Matanzas River. In the 1950s, this seawall was buried with the widening of the Avenida Menendez between the Bridge of Lions (the bridge intersects with the Plaza) and the Castillo. The historic seawall, integral to the city's identity, remains at the Castillo and

south of the Bridge of Lions. Due to tropical storm and hurricane impacts, the seawall's condition has severely deteriorated. At the Castillo, the seawall shows signs of erosion. (Fig. 40) The 6.5 foot (two meter) structure no longer protects the city from Category 1



Fig. 40: Part of the nineteenth century seawall borders the Castillo. At low tide, the deterioration from wave action and dissolution is evident on the coquina wall. [Ann Horowitz; photograph, January 2013]

storm surges of 7.4 feet (2.3 meters) south of the Bridge of Lions. Even high tides have the potential to overtop the wall at this location, flooding the historic properties sited inland.¹⁸⁹

The National Park Service (NPS) constructed a “living” seawall of rip-rap design in 2011 to minimize erosion of the historic seawall and provide some environmental

benefit. (Fig. 41) The hard adaptation, composed of loosely piled stones is designed to protect the coquina seawall and to provide a habitat for river species.¹⁹⁰ The water level at



Fig. 41: The rip-rap seawall, as seen at low tide, was constructed by the NPS to reduce erosion on the historic seawall and to create a natural habitat. [Ann Horowitz; photograph, January 2013]

high tide nearly reaches the top of the rip-rap wall. The protective benefits of this adaptation have not been yet evaluated, although the rip-rap wall does not negatively impact integrity. Jon Burpee, Chief of Interpretation and Education at the Castillo stated that the local NPS staff at the Castillo site has not considered future implications of sea level rise in park plans as of March 2013.¹⁹¹

During Hurricane Floyd in 1999, a 7.7 foot (2.3 meter) crest overtopped the seawall south of the Bridge of Lions, transforming the Avenida Menendez into a river.¹⁹² The next year, the city commissioned an engineering report to assess the seawall

condition. The report found that the granite blocks on top of the wall were falling toward the river at a rate of 1/8 inch (0.32 centimeters) per month. Furthermore, soil behind the wall was filtering through cracks in the wall into the Matanzas River. The engineer informed the city's Port Board in 2000 that, "The [wall's] blocks are deteriorating. That's going to continue. Digging out the fill, repairing the wall and putting in new fill may extend its life, but won't reverse the process."¹⁹³

The city considered repairing the wall or replacing it in 2000 after receiving the engineer's evaluation. Repairing the wall would provide a temporary solution. Replacement of the damaged section was the most desirable but costly option. The project's estimate was \$700,000–\$900,000 with the Federal Emergency Management Agency (FEMA) contributing \$180,000. Because of the funding shortfall, the project was not initiated.¹⁹⁴

Storms continued to damage the seawall, diminishing all aspects of its integrity. Tropical Storm Gabrielle caused a 100-foot (30.5 meters) section of the wall to collapse in 2001. Hurricanes Frances and Jeanne inflicted \$60,000 of damage in 2004.¹⁹⁵ The city decided to move forward to rehabilitate the entire length of seawall south of the Bridge of Lions to the St. Francis Barracks. From 2002 to 2003, the city conducted five public sessions to distribute information on the seawall resolution and to collect resident feedback. A cost-benefit analysis indicated 428 properties would be protected and \$15.6 million in property damages would be saved with a new seawall.¹⁹⁶ In 2004, the city received a \$750,000 CDBG grant to replace the seawall south of the Bridge of Lions.

Between 2004 and 2005, the city archaeologist and the SHPO worked with the city to develop an option that would preserve an aspect of the historic seawall behind a

new higher seawall. A Section 106 Report was required because federal funds would partially finance the new seawall. The report was completed on January 10, 2005. The SHPO approved the option to build a new, higher, 8.7-foot (2.7-meter) seawall into the river, leaving a portion of the lower, 6.5-foot (two-meter) historic seawall visible behind it. A 12-foot (3.7-meter) wide pedestrian path would be placed between the two seawalls. (Fig. 42) The St. Augustine Historic Architectural Review Board (HARB) authorized the project, issuing a Certificate of Appropriateness in 2006.

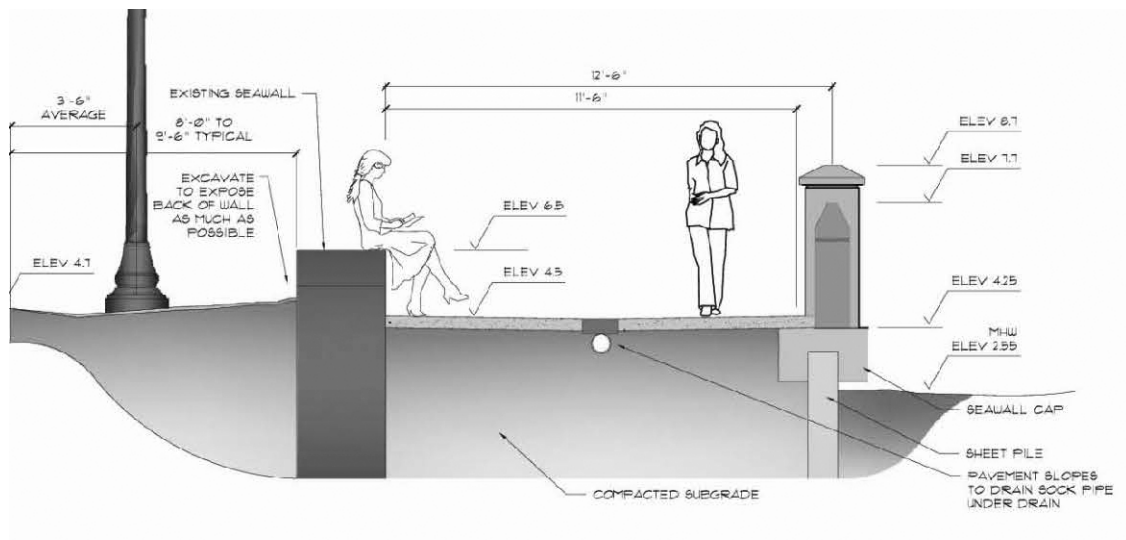


Fig. 42: The section of the current St. Augustine Seawall project illustrates the historic seawall on the left with the new, higher seawall on the right. Approximately two feet (61 centimeters) of the coquina seawall will be visible. This illustration does not depict the six-inch (15-centimeters) height increase for the new seawall and pedestrian path applied after severe flooding in November 2012. [City of St. Augustine; St. Augustine Seawall Flood Mitigation Project, August 22, 2011]

When Tropical Storm Faye caused a 150-foot (45.7 meters) breach in the seawall in August 2008, the city then qualified for a FEMA grant to assist in replacing the entire seawall south of the Bridge of Lions to the St. Francis Barracks.¹⁹⁷ The \$4.7 million grant was awarded in August 2011 to contribute to the \$6.35 million project. The FEMA

Regional Administrator, Phil May explained the reasons for funding the seawall rehabilitation: “The goals are to protect lives, prevent property damage and save money for all in the long run. In the future, there likely will be less damage, due to storm surge and associated flooding, to our historic treasures in the nation's oldest city.” The city funded the remaining portion through the city’s general fund and by increasing the parking fees at the city parking garage.¹⁹⁸

In April 2012, construction began on the new Avenida Menendez seawall. Expected completion is in April 2013. Mayor Joe Boles referred to the seawall rehabilitation as a “legacy project,” stating, “If we don’t leave some infrastructure here for the 450th [anniversary in 2015], then the celebrations won’t have meant a lot.”¹⁹⁹

The planned height of the new seawall and the pedestrian path were raised six inches after a severe November 2012 rainstorm, occurring at high tide, caused flooding in the colonial city district. The finished height of the seawall will be 9.1 feet (2.8 meters)

The higher seawall is projected to hold back Category 1 storm surges and high tides in the short term. By 2050, however, a storm surge during a spring tide could flood the seawall. By 2100, with a sea level rise of one meter (three feet), the sea wall will no longer be high enough to protect the city from storm surges.²⁰⁰

The city of St. Augustine has implemented two non-structural adaptations to improve chronic flooding in historic districts. The Maria Sanchez Lake Weir Gate Installation Project has been completed and the installation of the upgraded Riberia Street stormwater management system is underway. The weir gate project was undertaken to minimize flooding along Cordova and Granada Streets on the western border of the St. Augustine district. Due to inoperable valves, excess rainwater would overtop the weir and

flood. By replacing the valves and the installing of a new weir gate system, the level of the water in the weir can be controlled. If the level gets too high, the weir is drained to marshy sections of the nearby creek. Historic integrity was not affected by the weir gate project.

The Lincolnville Historic District has benefitted from the first phase of the new Riberia Street stormwater management system, part of the larger Riberia Street Redevelopment project. Larger storm drain pipes and check valves have been installed while more are currently being added. Integrity within the Lincolnville Historic District was not impacted by the stormwater system upgrades. After a nor'easter affected the area during high tide in November 2012, the Lincolnville area did not flood.²⁰¹

The local adaptations—the seawall, weir gate, and stormwater improvements—are expected to mitigate flood conditions in the Lincolnville and St. Augustine historic districts. These adaptations may reduce the number of areas projected to be inundated on this study's maps. Other areas, however, remain vulnerable to flooding. Public Works Director Martha Graham reported in 2012 that pumping facilities were the only other option to address chronic nuisance flooding. The city has not committed to installing the costly pumping stations at this time.²⁰²

A non-structural adaptation, St. Augustine's zoning ordinance, Article V-Floodplain Management, Sections 8-422-424, mandate the elevation of new construction or buildings undergoing a major reconstruction. The lowest floors, including basements, are to be elevated above the base flood elevation as determined by FEMA. If elevations are solid foundations, openings on either side must be included in the design to promote the equalization of hydrostatic forces caused by flooding. Floors may be constructed

below the base flood elevation if designated for parking, storage, or access. Historic properties are exempt from these regulations unless historic character has been previously altered. This leaves historic properties with intact integrity vulnerable to flooding and storm surge.²⁰³ New infill in the districts, subject to the elevation ordinance, could alter the integrity of the historic neighborhoods unless design guidelines are developed similar to the Mississippi Development Authority's *Elevation Design Guidelines*.

At the county level, the Land Development Code Article IV, Sec. 4.01.06 requires the maintenance of a 25-foot (7.6 meter) vegetative buffer between new development and wetlands. A 50-foot (15 meter) buffer must be set aside along riverbanks. This non-structural adaptive regulation minimizes flood conditions in adjacent areas, does not affect historic integrity, and improves environmental quality.

The "St. Johns County Flood Facts" brochure informs property owners of hard, soft, and non-structural adaptations they can apply on an individual basis to avoid flood damage. The county recommends: floodwalls, berms, building elevation, flood proofing, sandbag barriers, elevating furniture, sewer line backup valves, and floodwater openings in floors below base flood levels.²⁰⁴ In *Flooding and Historic Buildings*, English Heritage recommends many of these adaptations that maintain integrity.

Regionally, two organizations are providing studies that will be useful for future adaptation planning. The Northeast Florida Regional Council (NEFRC) is a consortium of six counties, including St. Johns, that plans and advocates for the social, economic, and environmental issues that make up the region's quality of life. The organization recently received a grant from the Environmental Protection Agency (EPA) to study the vulnerability and adaptations to sea level rise for natural resource management and to

address inundation and erosion impacts on the built environment. NEFRC plans to develop sea level rise vulnerability maps for local governments.²⁰⁵

In addition, the University of Florida and the Guana Tolomato Matanzas National Estuarine Research Reserve provide sea level rise data analyses to communities in the St. Augustine area. The National Estuarine Research Reserve System Science Collaborative, a partnership of NOAA and coastal states, funds the group's collaboration on "Planning for Sea Level Rise in the Matanzas Bay." In December 2012, this planning group presented Resident Workshops in St. Augustine informing citizens of projected sea level rise. In Spring 2013, they will hold additional workshop sessions for St. Augustine public officials on the development of adaptation policies.

At the state level, Florida is fully engaged in supporting adaptation planning for its communities. Climate change induced sea level rise and increased hurricane intensity will significantly impact the low-lying state. At his 2007 State of the State address, Governor Charlie Crist announced, "Florida is more vulnerable to rising ocean levels and violent weather than any other state."²⁰⁶ The governor moved the climate discussion forward by creating the Governor's Action Team on Energy and Climate Change. A Technical Work Group for Adaptation was one of the teams formed to address climate change impacts on Florida. To prepare for statewide adaptation, the work group outlined initiatives to begin planning adaptations. These are to support: scientific research and analysis; local and state government planning; development of policies balancing private property rights with municipality protection; safeguarding environmental health; beach retention; revising the state building code; and, public education.²⁰⁷

Consequently, Florida is at the forefront of adaptation planning. The Technical

Work Group's recommendations have led to legislative support for adaptive solutions. In 2011 two additional programs, backed by the legislature, encouraged adaptation planning at the state and local levels. One is the Community Planning Act enabling and encouraging local communities to include adaptation planning, termed as Adaptation Action Areas, in their comprehensive plans. The second initiative, *Community Resiliency: Planning for Sea Level Rise*, is a five-year project of the Florida Department of Economic Opportunity (DEO). This will also determine ways to coordinate local adaptation activities. Fort Lauderdale will serve as a pilot program to test adaptation responses. Findings are intended to stimulate additional legislative action.²⁰⁸

The state has almost finished a \$24.5 million LiDAR elevation study of its coastline.²⁰⁹ Light detection and range (LiDAR) mapping offers the most accurate and precise method to measure elevation on the Earth's surface. LiDAR data is combined with sea level rise projections to determine future potential inundation of the land. With precise LiDAR information, Florida will be able to identify coastline areas, as well as specific historic districts, that are vulnerable to sea level rise.²¹⁰

Prior to considering the impacts of sea level rise, Florida had implemented soft adaptation programs to protect its beaches and dunes. The state recognized the importance of these sand features in maintaining the quality of natural and built environments. Beach nourishment does not impact historic integrity, however, the creation of dunes have the potential to block a historic district's waterfront view. This does not apply to the St. Augustine case study because dunes are located on the outlying barrier islands.

Beaches and dunes are critical as buffers, protecting inland areas from flooding,

storm surge, and erosion aggravated by sea level rise. The Beach Erosion Control Program (BECF), authorized through the Florida Beach and Shore Preservation Act, provides federal, state, and local financial assistance to communities for the protection and preservation of its shoreline resources. Beach restoration and nourishment are eligible expenditures. Also under the act, the Strategic Beach Management Plan (SBMP) applies to the restoration of beaches. The St. Augustine Beach, Anastasia Recreation area, and Matanzas Inlet, barrier beaches that may minimize ocean impacts on St. Augustine, are regularly restored with this program. Other state beach nourishment and protection initiatives are the Coastal Construction Control Line Program and the Coastal Building Zone Program.²¹¹

At the federal level, the Coastal Barrier Resources Act (CoBRA) of 1982 has protected barrier islands by limiting development in high risk areas in St. Johns County. Although CoBRA was not intentionally established as an adaptation to sea level rise, its programs lessen the impact of flooding, storm surge, and erosion on inland shoreline communities. The preservation of Guana River, Usinas Beach, and Conch Island through CoBRA will minimize the effects of sea level rise on the St. Augustine peninsula.²¹²

Decision-makers and Stakeholders

Adapting to increased flooding from higher tides and Category 1 hurricanes through the construction of a new seawall involved a broad-based group of decision-makers and stakeholders. At the local level, the Public Works department observed the need for a new seawall and elicited support from its citizen commission, city commissioners, and the mayor. The state was involved with the granting of the initial

CDBG grant. The federal government became engaged in the project with the Section 106 Report and later with the FEMA award that made the new seawall possible. The State Historic Preservation Office represented the preservation community in a planning and an advisory role during the Section 106 review, part of the decision-making process. The local Historic Architectural Review Board, a division of the city's Planning and Building Department, reviewed the Section 106 proposal, approving it with a Certificate of Appropriateness before construction on the project could begin. United States Representative John Mica advocated for the city to secure the FEMA grant.

The weir and stormwater system installations required decisions made by the Public Works department, its citizen commission, city commissioners, and mayor to implement the projects.

Prior to each local adaption, the St. Augustine city employees held public meetings at the proposal, design, implementation, and ribbon-cutting stages of the projects to involve citizen stakeholders.

Although the Public Works Director Martha Graham stated on February 1, 2013, that the city was not considering future sea level rise in its current planning efforts, the state's steadfast support for adaptation may contribute to a shift in local perspective.²¹³ When that time comes, the list of decision-makers will expand beyond the local groups included with the Avenida Menendez Seawall.

The local staff of the National Park Service has a stakeholder position in how the city plans for adaptation. In addition, the St. Johns County Emergency Management, Environmental, Engineering, Land Management Systems, Planning and Zoning, Public Works, Tourism Development Council, and Transportation Planning divisions will

become involved in the adaptation planning process.

Regional guidance on sea level rise vulnerability and its effects on the built environment will be available through the Northeast Florida Regional Council and the University of Florida and the Guana Tolomato Matanzas National Estuarine Research Reserve. All are stakeholders in the adaptation discussion.

As a stakeholder, the state of Florida will assist St. Augustine with the formulation of its future adaptation plans. The technical information and policy support under development will benefit the city of St. Augustine when it plans adaptation solutions specific to its geography, sea level vulnerability level, and man-made environmental needs.

Aside from the mandatory state and local historic preservation reviews for the new Avenidas Menendez seawall, the preservation community in the city has not addressed the implications of sea level rise on historic properties. On February 1, 2013, Kathryn Frank, a professor at the University of Florida, stated that the University of Florida Historic St. Augustine organization plans to analyze the risk of sea level rise on the properties it owns in the city.²¹⁴

Summary of Findings: St. Augustine, Florida

St. Augustine responds to present day flood conditions by applying adaptations, but has not preemptively planned adaptation solutions by considering sea level rise science. Both the City of St. Augustine Public Works Director and the NPS Chief of Interpretation and Education at the Castillo de San Marcos state that their employers have no immediate plans to assume a preemptive adaptation planning approach in the future.

This strategy leaves the city and its historic districts vulnerable to damage associated with sea level rise.

Nonetheless, the city provides protection for the St. Augustine Town Plan, Model Land Company, and Lincolnville historic districts due to chronic flooding in those areas. The largest and most costly adaptation project, the Avenida Menendez Seawall, illustrates the challenges of adaptation planning and implementation. As the historic seawall deteriorated after each storm, it was not until the wall was almost destroyed that federal funding became available for mitigation. Twelve years of community discussions, political approvals, and funding requests occurred before work could begin on the new seawall. Project construction was estimated to be one year. Like the Cape Hattaras Lighthouse relocation, the construction of the new seawall can be achieved in less time than the approval and funding process.

A multidisciplinary group of decision-makers and stakeholders contributed to the seawall project, a critical factor for success according to adaptation theorists and researchers. The city archaeologist, SHPO, and St. Augustine Historic Architectural Review Board represented the historic preservation community at the advisory and approval stages. The SHPO's and review board's endorsements for the new wall indicate the importance they placed on maintaining a remnant of the historic wall rather than lose it entirely to the impacts of the sea. The city included the community as an active participant in the seawall discussion. Theory and research from literature reveal that the involvement of the community in adaptation planning is necessary to establish local support for a project and ensures that residents' concerns are addressed in the final plan.

Although the Avenida Menendez seawall impacts all aspects of the historic

seawall's integrity, other adaptations applied in St. Augustine do not affect historic district character. The stormwater management improvements, weir gates project, rip-rap wall at the Castillo, vegetative buffer zones, flood proofing, and flood resilience options for individual buildings protect historic districts from flooding without impacting integrity.

The University of Florida (UF), the Guana Tolomato Matanzas National Estuarine Research Reserve (GTM NERR), and the state of Florida may eventually persuade the city of St. Augustine to preemptively plan for the effects of sea level rise. The UF and GTM NERR collaborative continues to educate the public and city government employees on sea level rise science and adaptation. As a leader in sea level rise policy, Florida's legislature encourages local communities to incorporate adaptation strategies into comprehensive plans. Additionally, the state offers scientific and technical support to communities, a practice endorsed by John Randolph in *Collaborative Resilience*.

Florida's gubernatorial and legislative acknowledgement of climate change and eagerness to develop adaptation programs will benefit St. Augustine's future adaptation needs. An active state that voices the need to adapt will attract federal attention in the quest for adaptation funding. The state level endorsement of Adaptation Action Areas within a city's comprehensive plan should encourage St. Augustine to consider the effects of sea level rise on its shoreline. The scientific data and planning information generated by the state will provide a framework for city employees to plan adaptively. The Fort Lauderdale pilot program should also assist St. Augustine in visualizing an adaptation plan that can be tailored to the city's unique characteristics.

Elizabeth City, North Carolina

Elizabeth City, North Carolina, was founded in 1793 along the banks of the Albemarle Sound, a tidal estuary sheltered from the Atlantic Ocean by the Outer Banks barrier islands. The city is the county seat for Pasquotank County and is located at the “Narrows” of the Pasquotank River. (Fig. 43) Sea level rise is projected to have an effect on the city since it is sited at elevations ranging from three to twelve meters (9.8 to 39.4 feet) above sea level.²¹⁵ Six National Register historic districts are located in close proximity to each other within the densely developed city.

Lush forests and fertile agricultural land drew lumbermen and farmers to the Elizabeth City area in early colonial times. The city was incorporated as the town of Redding in 1793 when construction began on the Great Dismal Swamp Canal. The town was renamed Elizabeth City in 1801 and was formally platted in 1830 to 1831. (Fig. 44) It has served as the county seat since 1800.²¹⁶ The development of the Great Dismal Swamp Canal influenced periods of rapid growth in Elizabeth City from its inception until the 1920s.²¹⁷ Because the city’s geography is dominated by water, the area lacked surface roads to northern trade markets. The city’s harbor and the Pasquotank River, however, were too shallow to accommodate large trading ships. Smaller ships could travel in the river to the Albemarle Sound, but then encountered the treacherous waters along the Outer Banks. The profitability of the agriculture and lumber industries was stifled by the lack of access to other regions.

Trading routes opened when the Great Dismal Swamp Canal was constructed to connect the Albemarle Sound with the Chesapeake Bay at Norfolk, Virginia. From the deep-water harbor at Norfolk, products from Elizabeth City were transported to



Fig. 43: Low-lying Elizabeth City, North Carolina, is sited at the “Narrows” of the Pasquotank River. Pasquotank County’s population and building density are highest in Elizabeth City. Wetlands, forests, and agricultural land dominate the landscape. [City of Elizabeth City, North Carolina; Elizabeth City aerial photograph, August 12, 2003]

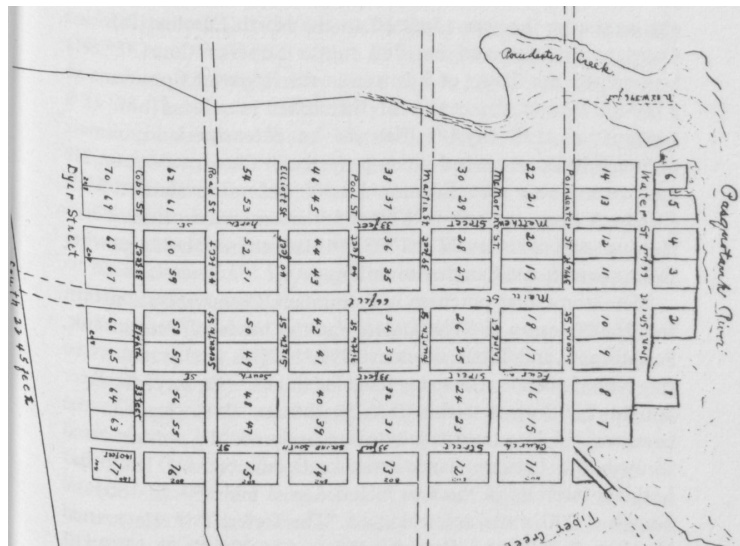


Fig. 44: The town of Elizabeth City, was platted as a grid between 1830 to 1831 on the Pasquotank River. This area remains the downtown center. [Exum Newby; Elizabeth City town plan, December 10, 1832]

Charleston, South Carolina; New York; and New England. England and the West Indies also became destinations for goods produced in Pasquotank County.

The founding of Elizabeth City coincided with the year construction began on the Great Dismal Swamp Canal. With each canal improvement, the population increased, buildings were constructed, and commercial prosperity grew. The city emerged as the region's trade center after completion of the canal in 1805.²¹⁸ Stagecoach, steamboat, and rail lines advanced the city's position as a regional hub for social, political, and economic activity. Economic diversification and prosperity led residents to boast that Elizabeth City was the "Eastern Emporium of North Carolina, where . . . [purchasers] can be suited with a cambric needle to a sheet anchor."²¹⁹ Industry and manufacturing developed in areas associated with fishing, shipping, and lumbering. Retail establishments opened to accommodate the rise in local incomes.²²⁰

Elizabeth City's economy stagnated during the Civil War and the post war period of Reconstruction. Recovery came in 1881 when the Norfolk and Elizabeth City Railroad took the place of the canal as a means of commercial transportation connecting to northern routes.²²¹ At the same time, Daniel S. Kramer, a lumberman from Pennsylvania, formed a successful lumber and construction company that evolved into a major industrial employer.²²² Rapid growth occurred up to the 1920s, with the population tripling between 1880 and 1900. Adjacent land was annexed for neighborhoods and for commercial and industrial enterprises.²²³ The present day city structure reflects Elizabeth City during the 1920s when it was the region's commercial and social center.²²⁴

Since then, the city gained new institutions and businesses that remain prominent employers today. The Coast Guard established a major base in 1938. Elizabeth City State

University, College of the Albemarle, and Roanoke Bible College are located within the city. Service, government, and agriculture are the city's dominant economic sectors. The city aims to develop its tourism potential by showcasing the area's natural, cultural, and historic resources.²²⁵

The city's population is 18,597 with 40,438 residing in Pasquotank County. The city is 11.63 square miles and is densely settled with 1,607 people per square mile. In comparison, rural Pasquotank County has 179 people per square mile. The city's median household income is \$32,303, almost \$14,000 below the state average. Approximately 32% of city residents live below the poverty level, double the state average.²²⁶

National Register Historic Districts

Elizabeth City's six historic districts, consisting of 1,248 buildings, are evidence of the major growth periods from 1793 to the 1920s. (Fig. 45) The districts are located in close proximity to each other with individual buildings constructed on narrow lots. This development pattern illustrates the unique dense, urban nature of the city, uncharacteristic of southern coastal communities.²²⁷

Each district displays a variety of architectural styles. Residential neighborhoods include homes for all income levels. Rather than featuring one distinct building design, the historic districts portray an array of architectural trends popular during the time of development. This heterogeneous mix of styles and building size provide Elizabeth City with a distinct sense of place. The antebellum styles of Federal, Greek Revival, Gothic Revival, and Italianate are present in districts constructed during years when the Great Dismal Swamp Canal brought prosperity to the city. During the city's most robust period

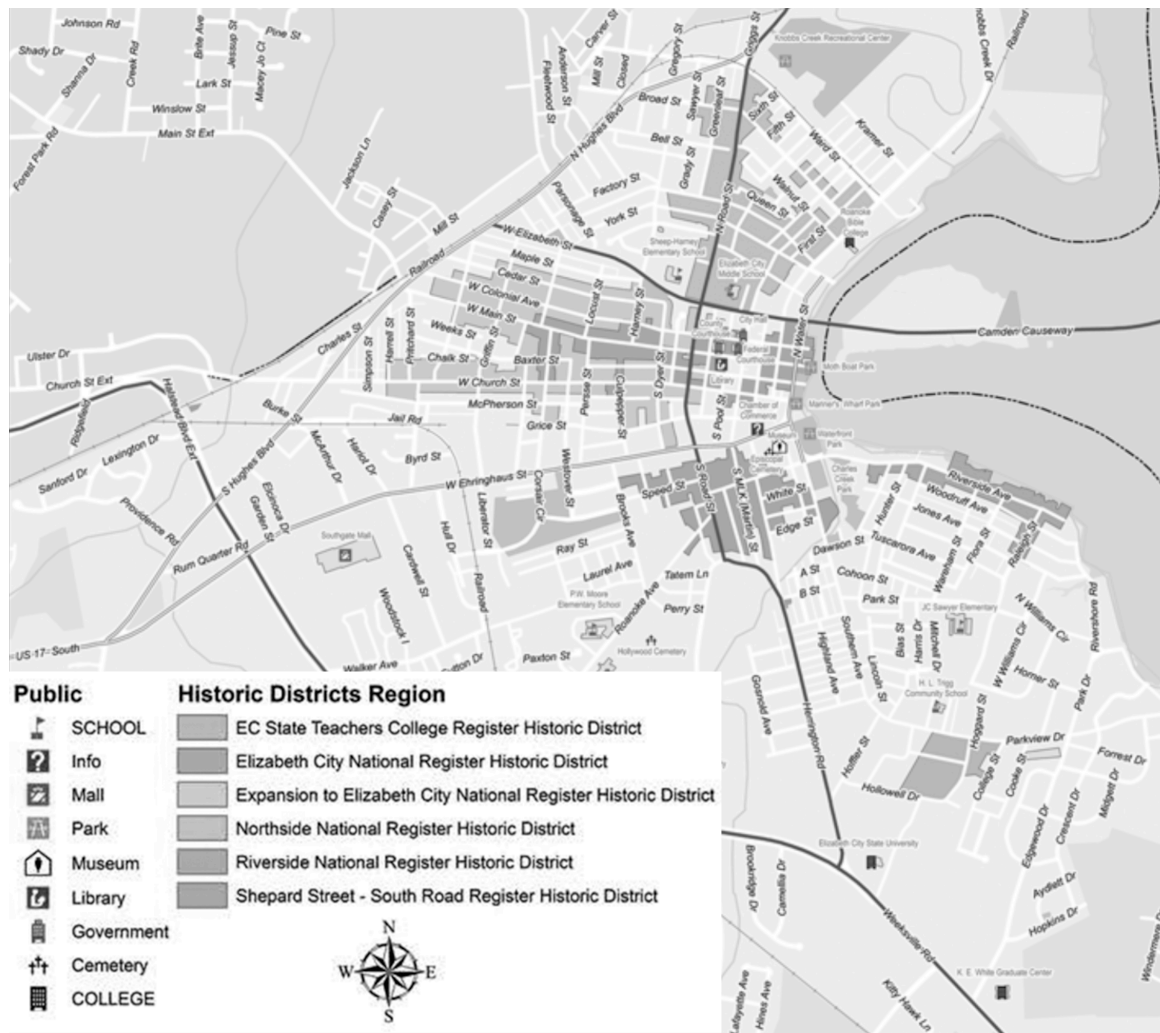


Fig. 45: Elizabeth City's six National Register Historic Districts reflect the area's development patterns from the nineteenth and early twentieth centuries. The uncommon density of historic districts provides the city with its unique sense of place. [Elizabeth City Historic Neighborhood Association; Elizabeth City historic districts map, 2012]

of growth between 1880–1920, examples of Queen Anne, Eastlake, Craftsman Bungalow, American Foursquare, Neo-classical Revival, and Colonial Revival buildings, are prevalent in the districts. Victorian millwork details are common characteristics adorning buildings throughout all the historic districts.

The Elizabeth City Historic District is the city's first National Register listed historic district. (Fig. 46) This 30-block area incorporates the earliest settled area in



Fig. 46: Main Street in Elizabeth City Historic District is part of Elizabeth City Downtown, Inc. The former Chesson's Department Store is now an arts center and tourist destination. The Chesson Building suffered wind and flood damage after Hurricanes Floyd and Isabel. [Ann Horowitz; photograph, January 2013]

Elizabeth City. The Pasquotank River borders the 190-building district on the east. Brick and masonry (stone and brick) commercial buildings are concentrated in the center of the district along Main Street. Residential buildings, primarily wood frame, emanate from Main Street. The developed area reflects the nineteenth century architectural styles that were popular during the Great Dismal Swamp Canal era. Only two Federal period buildings remain from the city's original settlement, platted in 1793. Antebellum properties are prominent, comprising the largest collection in the state. The majority of these buildings were constructed after the Great Dismal Swamp Canal expanded in 1828.²²⁸ As of January 2013, many commercial buildings are vacant and underused in the historic district.

In 1994, the Elizabeth City Historic District was expanded to the north, south, and west, adding 423 buildings and one site to the National Register. (Fig. 47) The expansion



Fig. 47: Elizabeth City Historic Expansion District features residential architectural design from the nineteenth and twentieth centuries. Elizabeth City's characteristic building density is evident in this neighborhood. [Ann Horowitz; photograph, January 2013]

district represents the first suburban development in the city. Originally farmland, the area was developed as residences when the city economically thrived in the nineteenth and early twentieth centuries.

South of the Elizabeth City district is the Shepard Street–South Road Historic District. (Fig. 48) One hundred and sixty-one buildings contribute to the historic district. Residences are mainly wood frame buildings while institutional buildings are brick. It encompasses the neighborhood representing the African American social and cultural center. Originally farmland, the Shepard Street–South Road Historic District was the first area developed outside the original city limits. It grew in the mid-1850s, rapidly



Fig. 48: The Shepard Street–South Road Historic District represents the city’s first African American neighborhood listed in 1994. [Ann Horowitz; photograph, January 2013]

expanding through the late nineteenth and early twentieth centuries. A self-sufficient neighborhood of modest homes emerged with six churches, three schools, and commercial, fraternal, and entertainment establishments.²²⁹

In the antebellum era, both freed blacks and slaves lived in the area. By 1860, 34% of the African Americans in Elizabeth City were free. This unusually high number for the region has been attributed to the employment opportunities for laborers and to the anti-slavery beliefs established by early Quaker settlers.²³⁰ After the Civil War, African Americans were drawn to the district for the access to schools and religious institutions the neighborhood provided. In 1892, one of the earliest colleges for African Americans in the state opened in the district. The State Colored Normal School educated African Americans to become teachers for segregated schools. Due to its success, the college expanded, was renamed the Elizabeth City State Teachers College, and moved south of the district in 1910. It became Elizabeth City State University in 1969, representing

another National Register Historic District.²³¹ Many buildings in the Shepard Street–South Road Historic District exhibit signs of deferred maintenance; some are marked with “No Trespassing” signs indicating a vacant property. This limits the district’s integrity of design, materials, workmanship, and feeling.

The Elizabeth City State Teachers College Historic District is a visual reminder of the educational opportunities made available to African Americans in the early twentieth century. In addition to being a teachers college, the institution granted high school diplomas to African American students when no other county in the region provided this opportunity. Six buildings and one structure comprise the 19-acre district. With the exception of one frame Craftsman Bungalow, the remaining buildings are frame or brick Colonial Revival properties.²³²

On the opposite side of the city, the arrival of the railroad shaped the development of the suburban Northside Historic District. (Fig. 49) For years, Poindexter Creek to the



Fig. 49: The Northside Historic District illustrates early suburban development patterns. Decorative millwork, a distinguishing building feature throughout Elizabeth City, enhances front porches in this neighborhood. [Ann Horowitz; photograph, January 2013]

south had separated the area from the original city district. The neighborhood is composed of 398 buildings, primarily of wood frame construction. Rapid growth occurred between 1890–1910, resulting in orderly rows of wood frame houses. Descendants of the lumberman Daniel Kramer constructed many of the houses in this neighborhood. Residents worked in the nearby Kramer mills or were commercial and professional leaders in the city. Today, the city schools are centered in the district.²³³ Some of the historic homes in the Northside Historic District are neglected and vacant, reducing the integrity of design, materials, and workmanship and feeling in the neighborhood.

The most recently developed district is the Riverside Historic District. Located along the southern shore of the Pasquotank River east of the original city limits, the area was settled by farmers in the late 17th century and remained as farmland until 1893. The residential district, constructed between 1894 and 1942, consists of 68 brick and wood frame buildings and one structure. In addition to the architectural styles popular in Elizabeth City, Tudor Revival homes were constructed here in the 1930s. Homes of a grand scale, built by the city's industrialists, are located along the river while more modest homes of city professionals and small shop owners are sited on the district's south side.

Two local historic districts include properties in the National Register Elizabeth City and the Expansion districts. A local historic preservation commission rules on proposals for property alterations and demolitions in these areas, leaving the integrity of the remaining four historic districts vulnerable to inappropriate changes. Residents of these four districts may perceive that their neighborhoods are often overlooked. A

resident of the Northside Historic District wrote to the editor of the *Daily Advance*, Elizabeth City's newspaper, "Although we are often looked at in a negative way, many of our homes have the beauty and grace that the Main Street Historic District [Elizabeth City and the Expansion districts] has to offer."²³⁴

Social, Economic, and Environmental Benefits of Historic Districts

The city of Elizabeth City and its preservation organizations support the preservation of the area's historic resources. In the *2004 Advanced Core Land Use Plan for Pasquotank County and Elizabeth City*, the city clearly acknowledges the economic, social, and environmental benefits of historic preservation. Historic preservation is cited as an integral part of the downtown, waterfront, housing, and economic revitalization goals. The city values its collaborative programs with the Historic District Commission; the Elizabeth City Historic Neighborhood Association; Elizabeth City Downtown, Inc.; Museum of the Albemarle; and Preservation North Carolina.²³⁵

Economically, the city recognizes that historic districts can stabilize property values and spur reinvestment in existing, historic neighborhoods.²³⁶ Elizabeth City Downtown, Inc., the city's Main Street Program, is responsible for downtown reinvestment projects that rehabilitate vacant buildings in the Elizabeth City Historic District.²³⁷ For 2011–2012, public and private reinvestment in the downtown area was \$4,754,308. This figure accounts for six new businesses, eight façade renovations, nine building renovations, and four business expansions. Thirteen new jobs were created as a result of the reinvestment in downtown Elizabeth City.²³⁸

Expanding the city's tourism industry is another economic recovery program

outlined in the land use plan. As a result, tourist spending increased 5% in the county from 2010 to 2011. Part of the increased tourism is linked to the city's historic districts. Historic district walking tours, the Historic Ghost Walk, the North Carolina Potato Festival, and the recent commemoration of the Civil War Sesquicentennial drew tourists to the historic districts in record numbers. The Historic Ghost Walk, a yearly event sponsored by Elizabeth City Historic Neighborhood Association, attracted 1,400 people in 2012, earning it a North Carolina Main Street Award for best downtown special event. The Potato Festival brought 30,000 tourists to the Elizabeth City Historic District in 2011.²³⁹

The city's plan to incorporate the historic districts in its waterfront development goals, part of the *2004 Advanced Core Land Use Plan*, indicates additional support for heritage tourism.²⁴⁰ North Carolina's Secretary of Cultural Resources, Linda Carlisle, recently recognized the city's commitment to heritage tourism. At the annual meeting of the Chamber of Commerce, she said, "I see a community that values what they have, that are exploring and exposing what they have to the greater community, who are building on those assets."²⁴¹

The closely grouped and densely developed historic districts have strengthened social ties by bringing together city residents in support of preservation. The Elizabeth City Historic Neighborhood Association, formed in 1985, raises funds through events and programs, such as the Historic Ghost Walk, to fund preservation grant programs. Nine preservation projects within the historic districts have been completed using grant funds. In addition, the group funds a college scholarship to promote preservation education among young residents.²⁴² Civic support for historic preservation also thrives among

volunteers in Elizabeth City Downtown, Inc. From 2011 to 2012, some 1,610 volunteer hours were donated at a value of \$30,268.²⁴³

The city acknowledges the environmental importance of “‘recycling’ or otherwise maintaining the existing usable housing stock, especially historically significant structures.”²⁴⁴ Rehabilitating vacant residences in the historic districts, instead of demolishing them, will “reuse” quality building materials and maintain the cohesive and compact character of the neighborhood.

Before a historic property is demolished, the property owner may contact the Elizabeth City Historic Neighborhood Association (ECHNA) which deconstructs, salvages, and resells building materials. Rather than adding to overused landfills, the building materials are recycled for construction or rehabilitation projects. ECHNA’s resale store profits contribute to the organization’s preservation grant program.

While these practices benefit the environment, they also contribute to sustainability. The city as a sustainable community is evident in the attributes of its neighborhoods. The characteristic dense building pattern in Elizabeth City reduces heat loss in buildings while the ubiquitous porches provide shade during the hot summers.²⁴⁵

Natural Hazard Risks

The location of Elizabeth City on the tidal Pasquotank River and its proximity to water within its boundaries contributes to its flooding, storm surge, and erosion vulnerability. Thirty-three percent of the county’s land area is water.²⁴⁶ Combined with the city’s low elevation, 46% of the county’s land area is susceptible to flooding and storm surge.²⁴⁷ The Stormwater Advisory Task Force reported that “the city's flat

topography ‘is further exacerbated by the fact that much of the city was built on top of the natural creeks and swamp land adjacent or tributary to Poindexter Creek (now Elizabeth Street) and Tiber Creek (now Grice Street).’”²⁴⁸ The Pasquotank County Multi-Jurisdictional Hazard Mitigation Plan categorizes flooding as a “significant threat” in Elizabeth City.²⁴⁹

As of 2013, neighborhoods in Elizabeth City adjacent to bodies of water or built on landfill experience nuisance flooding during short periods of heavy rainfall.²⁵⁰ The Shepard Street–South Road and Riverside historic districts encounter the most frequent flooding. Street signs warning of “High Water” are permanently placed in these neighborhoods. Wood frame buildings without raised foundations show water damage, decreasing the level of integrity for materials, workmanship, and feeling. (Fig. 50) East Elizabeth Street, built over Poindexter Creek, now separates the Elizabeth City Historic District from the Northside neighborhood.²⁵¹ The southern and northern sections of the Northside Historic District regularly flood near East Elizabeth Street and Knobbs Creek. Summer hurricanes and winter nor’easters cause flooding, erosion, and storm damage that have impacted North Carolina between 1851 and 2012. Tropical storms affect North Carolina on average every 1.72 years.²⁵² Hurricanes pose a moderate threat to Elizabeth City.²⁵³ Although tropical storms can be severe in the city, the impacts are not as harsh as those experienced directly on the North Carolina coast. In recent years, Hurricane Floyd (1999) and Hurricane Isabel (2003) caused significant damage throughout North Carolina. Hurricane Floyd generated winds reaching 120 miles (193 kilometers) per hour and 2.7 to 3 meter (8.9 to 26.2 foot) storm surges along the coast. Rainfall amounts ranged from 9.8 to 18.9 inches (25 to 48 centimeters). In Elizabeth City, wind gusts of 64



Fig. 50: A water line, approximately three feet (one meter) above the foundation, on a historic residence in Shepard Street–South Road Historic District indicates the possibility of a past flood. Additional properties in the district exhibit possible signs of water damage around the foundations. Permanent “High Water” street signs in the district provide further evidence of frequent flooding. [Ann Horowitz; photograph, January 2013]

miles (103 kilometers) per hour and rainfall of 2.6 inches (6.7 centimeters) were reported.²⁵⁴ The storm surge left residual water lines of nearly three feet (one meter) high, indicating flooding, in commercial businesses along the Pasquotonk.²⁵⁵ The North Carolina State Historic Preservation Office reported on building devastation and flooding in Elizabeth City. In the Elizabeth City Historic District, the Carolina Theater (1945) was severely damaged and the 1897 Chesson Building’s roof was destroyed.²⁵⁶

The North Carolina State Historic Preservation Office (SHPO) documented damage again in Elizabeth City when Hurricane Isabel struck the mid-Atlantic Coast in

2003. Storm surges were 6 to 8 feet (1.8 to 2.4 meters) along the North Carolina coast with 4 to 7 inches (10-18 centimeters) of rain. In Elizabeth City, the storm surge measured five feet (1.5 meters) with rainfall of 4.7 inches (12 centimeters).²⁵⁷ Wind gusts were reported up to 92 miles (148 kilometers) per hour.²⁵⁸ Wind and flooding damaged buildings in the city's historic districts. Roof, door, and window damage due to high winds was recorded for numerous historic properties. The Antioch Presbyterian Church, a Gothic Revival wood frame building built in the mid-nineteenth century, collapsed. The Chesson Building once again suffered roof damage.²⁵⁹

Near waterways and exposed to severe storms, Elizabeth City is also vulnerable to the impacts of sea level rise due to its elevation at three to twelve meters (9.8 to 39.4 feet). The low-lying Albemarle and Pamlico Sounds are projected to be one of the three areas in the United States most impacted by sea level rise.²⁶⁰ Although within the highly susceptible Albemarle Sound, Elizabeth City's sea level rise projections are more optimistic than surrounding cities and towns. Its elevation is comparably higher than many North Carolina coastal areas, which commonly have land elevations of less than one meter.²⁶¹

Based on NOAA tide data collected at Duck, North Carolina, the mean tide range in Elizabeth City is 3.2 feet; the spring tide range is 3.69 feet. Sea level rise effects will be most acutely felt during the high spring tides that occur twice a month during the full and new moons.²⁶²

Projected risks: 2050 and 2100

If sea level rise intensifies as projected, the risks for flooding, storm surge and

erosion would incrementally increase in Elizabeth City, where the land elevation ranges between three and twelve meters (9.8 to 39.4 feet). Based on a one-meter (3.3-feet) sea level rise projected for 2100, a 42-centimeter (1.4-feet) rise is expected by 2050.²⁶³ (Fig. 51) By 2050, some city land areas are likely to be permanently inundated by water. Land surrounding Knobbs Creek, northeast of the Northside Historic District, is extensively impacted. Riverfront areas east of the Northside and Shepard Street–South Road historic districts would be permanently flooded. Portions of the Elizabeth City and Riverside historic districts could be also inundated.

With a one-meter (3.3-feet) sea level rise, the projected effects of sea level rise become more expansive by 2100. (Fig. 53) Water inundation is likely on the land around Knobbs Creek, directly impacting the northern portion of the Northside Historic District. Inundation to the south of the Northside Historic District is likely to extend westward from the river, permanently flooding the southern section of the Northside neighborhood.

The Elizabeth City Expansion District land area would be likely inundated, less than a block from the original city settlement. Without adaptation, permanently flooded historic properties could be threatened with demolition or relocation.

Further, sea level rise impacts extend beyond the areas shaded in black on the 2050 and 2100 maps (Figs. 51, 52). As land becomes permanently inundated, the effects of sea level rise move farther inland. The vulnerability to flooding, storm surge, and land erosion increases on historic properties located near the inundated land, threatening the historic character of the neighborhoods.

Scientists at Climate Central, an independent organization studying climate change, analyze storm surge impacts and probabilities for coastal cities and counties.

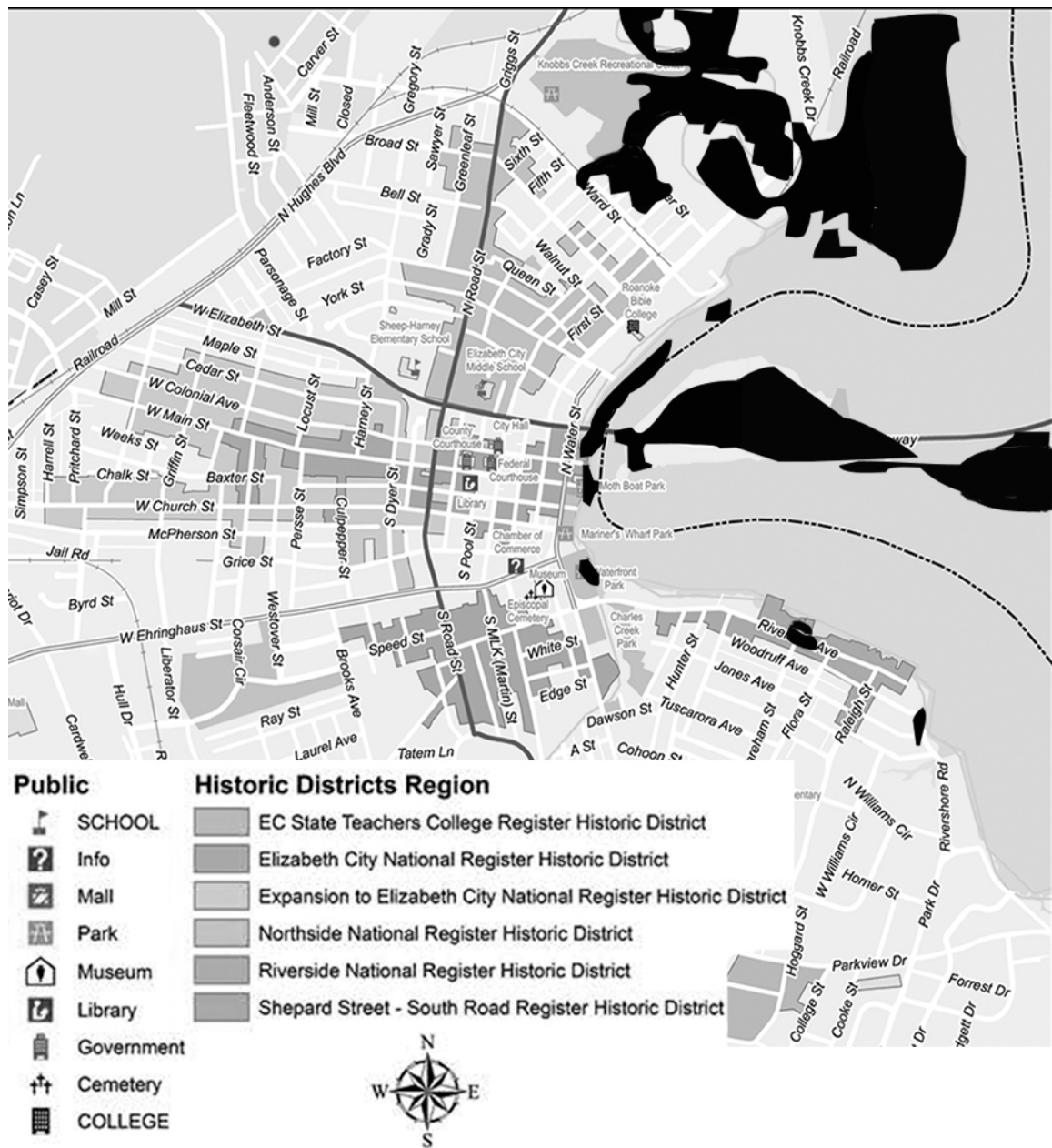


Fig. 51: Sea level rise is projected to be 42 centimeters (1.4 feet) in Elizabeth City by 2050. The nearest data figure available is 40 centimeters (1.3 feet), reflected on the map. Solid black shapes indicate land areas in Elizabeth City likely inundated by a 40 cm sea level rise. [North Carolina Coastal Atlas, East Carolina University; sea level rise map data, 2009 and Elizabeth City Historic Neighborhood Association; Elizabeth City historic districts map, 2012]

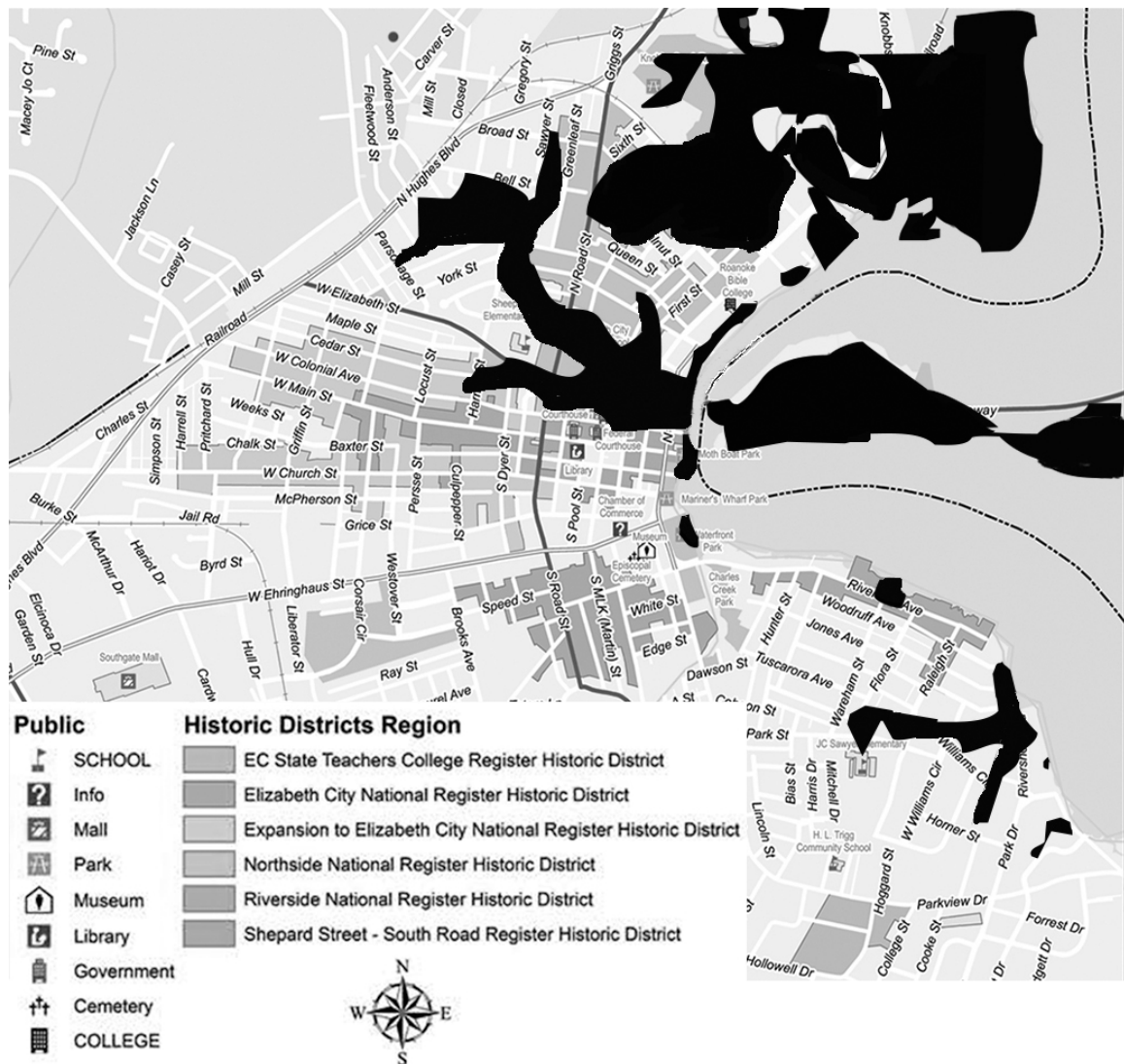


Fig. 52: Sea level rise is projected to be one meter (3.3 feet) in Elizabeth City by 2100. Solid black shapes indicate land areas in Elizabeth City likely inundated by this change in water level. [North Carolina Coastal Atlas, East Carolina University; sea level rise map data, 2009 and Elizabeth City Historic Neighborhood Association; Elizabeth City historic districts map, 2012]

Their data indicate a 16% chance by 2030 that sea level rise, a storm surge, and a high tide will converge to create five-foot (1.5 meter) water levels in Elizabeth City. At this water height, all of the city's historic districts will be temporarily flooded by water. Thirty-two percent of the city's acreage will be impacted. This encompasses 40% of the population and 46% of the homes in the city.²⁶⁴

Adaptations Implemented and Proposed

Elizabeth City and Pasquotank County have planned and implemented projects to minimize flooding, storm surge risks, and erosion. These non-structural and soft adaptation projects, many from the *2004 Advanced Core Land Use Plan*, were planned with sea level rise in mind.²⁶⁵ To reduce flooding, the city has relied on extensive improvements to the previously “poorly designed, poorly documented, and poorly maintained” stormwater management system. Tony Stimatz, City Councilor and chairman of the Stormwater Advisory Task Force, stressed that “We cannot afford to prevent all flooding, but we can intervene to mitigate impacts [through stormwater management]. It will be an ongoing process and will take time.”²⁶⁶ A pumping station in the Elizabeth City Historic District area is designed to augment the natural drainage of floodwaters, but fails to keep up with short, intense rainfalls.²⁶⁷ As of January 2013, sewer and stormwater drainage lines were being replaced along Elizabeth Street to minimize flooding. The construction work was occurring between the Elizabeth City Expansion and the Northside historic districts.

Elizabeth City's Stormwater Management Ordinance is another non-structural adaptation designed to manage and control the runoff from storms. Runoff can

compromise water quality and cause erosion. Before the city grants approval for new subdivision construction, a stormwater management plan, accompanied by a landscape plan, must be submitted and approved before a building permit is granted. The importance of vegetation in the surrounding landscape to control erosion, sediment and water quality is acknowledged in the ordinance. A stormwater management proposal may include storm water detention and retention structures.²⁶⁸

In addition, the land use plan establishes further goals to improve the stormwater management system. It calls for limiting impervious surfaces to promote the drainage of rainwater, reducing the excess water processed by stormwater systems. Sewer and water system upgrades will be also designed to function adequately under more frequent and intense flood conditions.²⁶⁹

The stormwater management system improvements in Elizabeth City will mitigate flooding in the historic districts while maintaining the integrity of the historic districts. Integrity of feeling and setting, however, could be affected temporarily during the construction phase. In January 2013, these temporary affects on integrity are evident on the north side of the Elizabeth City Historic District. (Fig. 53)

As directed by the land use plan, the city has incorporated flood mitigation into its zoning ordinances. The Elizabeth City Flood Hazard District Overlay, a non-structural adaptation, requires that new development in flood-prone areas adhere to strict flood mitigation standards. Within flood hazard areas, the lowest floor of new construction must be elevated at least one foot (30.5 centimeters) above base flood elevation or flood proofed so the foundation is watertight.²⁷⁰ Historic properties are exempt from this mandate as long as the building maintains historic integrity. In addition, the ordinance



Fig. 53: The stormwater system improvement project on Elizabeth Street temporarily detracts from the integrity of the Elizabeth City Historic District. [Ann Horowitz; photograph, January 2013]

disallows the construction of new buildings in floodways or along bodies of water. New or replacement water and sewer systems must perform as intended under flood conditions.²⁷¹

Historic properties are more vulnerable to flooding because they are not included in the city's elevation zoning ordinance. In addition, newly elevated infill in the districts may be incompatible with the historic character of the districts. Some wood frame buildings in Elizabeth City's historic districts could be elevated. (Figs. 54, 55) Local design guidelines for infill and historic properties, based on the recommendations from *Elevation Design Guidelines* by the Mississippi Development Authority, would be helpful to ensure the integrity of the districts. The Mississippi guide evaluates design, setting, materials, workmanship, feeling, and association considerations when elevating properties within historic districts.



Figs. 54, 55: The Shepard Street–South Road historic district home (left) may have been originally constructed without a basement, nonetheless, its elevation may offer protection from flooding. The Beveridge House (right) in the Riverside Historic District was constructed in 1926 as an elevated home. According to local legend, Mr. Beveridge commissioned an architect to design the house to be raised over water so he did not have to mow a lawn. Regardless, the home’s elevation has likely provided structural protection in the frequently flooded historic neighborhood. [Ann Horowitz; photographs, January 2013]

The city’s public works department presided over the elevation of an intersection located between the Elizabeth City and the Shepard Street–South Road historic districts. Typically, the Water and Shepard Street intersection would flood with two feet (61 centimeters) of water after rainstorms, rendering the roads impassable. The City Council debated the design and the funding for three years. Ultimately, the city earmarked \$410,000 for the project; the state Department of Transportation contributed \$100,000. This non-structural adaptation to the city’s infrastructure was completed in March 2012 after seven months of construction.²⁷²

Public Works Director Paul Fredette warned that intense rainstorms could still impact the intersection with one foot (31 centimeters) of water, although the intersection would be closed fewer days per year. The frequently flooded roadways had also impacted the nearby Museum of the Albemarle. Spokesman Thomas Spagnol responded to the flood mitigation project by saying, “Anything that you can do to improve the general

look of the waterfront would be wonderful.”²⁷³ Improvements to the waterfront area also benefit the visual quality of the Elizabeth City and Shepard Street–South Road historic districts.

The elevation of the Water and Shepard Street intersection does not affect the integrity of the Elizabeth City and the Shepard Street–South Road historic districts because the districts are located beyond the reconstructed roads. If historic properties had been along the elevated roads, floodwater may have flowed away from the intersection and toward the properties. This scenario could have affected all the aspects of integrity.

Wetlands preservation and restoration, a soft adaptation, is a priority in the land use plan. To minimize urban flooding and protect water quality, the Charles Creek Park Wetlands were reconstructed in 2007.²⁷⁴ (Fig. 56) Owned by the city, the original wetlands had been filled to create a city park “an unknown number of years ago.” The area is east of the Elizabeth City and Shepard Street–South Road historic districts.



Fig. 56: Charles Creek Park, site of the wetlands restoration project, is in downtown Elizabeth City. The Shepard Street–South Road Historic District is located across the street from the park. [Ann Horowitz; photograph, January 2013]

To construct the soft adaptation, fill was removed and native vegetation was restored to the 1.93-acre site. The restored area was found to be functioning appropriately as a wetland in a 2008 assessment.²⁷⁵ It is unclear if the restored wetland has minimized flooding in the Shepard Street–South Road neighborhood.

The Charles Creek Park Wetlands restoration supports the integrity of the setting for the Elizabeth City and Shepard Street–South Road historic districts. Through history, each neighborhood looked upon the wetlands as part of the landscape. A more accurate representation of the original viewshed has been restored to complement the historic districts' setting.

Further adaptation proposals are included in the city's land use plan, although not yet executed in 2013. These also focus on soft and non-structural adaptations and include wetlands preservation and restoration, open space acquisition, and vegetative buffers along bodies of water.²⁷⁶ As part of the land use plan, the waterfront plan incorporates the development of a canal to collect and divert floodwater. This soft adaptation will also benefit the community and the Elizabeth City Historic District as an outdoor recreational amenity.²⁷⁷ These adaptation strategies would have little effect on historic districts since they do not disturb historic properties or significantly alter the historic landscape.

In addition to adaptations outlined in the land use plan, Elizabeth City citizens proposed methods to minimize the effects of sea level rise at one of the *Public Listening Sessions: Sea Level Rise and Population Growth* meetings. One of seven, the event was co-sponsored by the Albemarle-Pamlico Conservation and Communities Collaborative (AP3C) and the Albemarle-Pamlico National Estuary Program (APNEP) in 2008. AP3C is an association of government and environmental groups fostering economic and

environmental resilience and sustainability in the Albemarle-Pamlico region.²⁷⁸ Climate change is one of the AP3C's study areas. The APNEP is a collaborative project of the North Carolina Department of Environment and Natural Resources, the North Carolina Environmental Protection Agency, and the Virginia Department of Conservation and Recreation. The APNEP's goal is to encourage local communities to develop environmental preservation and rehabilitation programs. Assisting municipalities with the development of adaptations in response to sea level rise is one of the organization's goals.

The purpose of the public listening sessions was to inform residents about local sea level rise projections and population growth forecasts and to collect relevant opinions at the grassroots level. Residents at the Elizabeth City sessions expressed their interest in learning more about sea level rise impacts projected for their area. Program participants recognized that sea level rise adaptation planning required “many departments to try and view the possible solutions to this problem” and “more participation by our local elected officials.”²⁷⁹

From the public listening sessions, citizen suggestions for adaptations reflected the natural hazard and environmental protection goals in Elizabeth City's land use plan. They favored soft adaptation and non-structural solutions or “nature-based solutions.”²⁸⁰ Specifically, the preferred adaptations included additional vegetation bordering waterways, restored and preserved wetlands, and the cultivation of oyster beds to buffer wave effects during storms. Hard adaptation solutions were unpopular. Participants believed hard adaptations were poor investments, providing only short-term benefits.²⁸¹

Decision-makers and Stakeholders

A broad-based group of local Elizabeth City individuals were involved as decision-makers and stakeholders in the development of adaptations. Led by the Elizabeth City planning department, elected leaders, city employees, and citizen representatives were responsible for the strategies outlined in the *2004 Advanced Core Land Use Plan*. Ultimately, the Pasquotank County Board of Commissioners and the Elizabeth City Council adopted the plan on January 9, 2012.²⁸²

Presently, the city's historic preservation community—the city's Historic Preservation Division, the Main Street Program, and the Elizabeth City Historic Neighborhood Association—has not become involved in adaptation planning. Senior Planner Angela Cole stated that the city's preservation planning office “do[es] not track historic flood events, their effects, or future mitigation.”²⁸³ The Public Works department monitors flood events and plans for mitigation while the Building Inspections department presides over the elevation zoning ordinance. A cross-department planning group does not assess the effects of sea level rise or adaptation options.

Pasquotank County assists Elizabeth City with emergency management issues and Federal Emergency Management Agency (FEMA) requirements. The county's involvement, however, is limited to post disaster mitigation rather than to preemptive adaptation planning to reduce property damage.

At the state level, North Carolina has prohibited the use of science driven sea level rise projections to be included in the state's regulatory process until 2016. Historic sea level rise rates, substantially lower than global projections, can only be considered by North Carolina's agencies. Municipalities, however, are free to plan according to sea

level rise projections supported by the local government.²⁸⁴

The NC DENR and its APNEP division have established programs to educate the public on sea level rise science and adaptation strategies despite the state legislature's lack of support. The public listening sessions and additional APNEP educational programs held in Spring 2013 are examples of these educational efforts. The distribution of information cultivates adaptation planning expertise within local communities.

Historic preservation support at the state level is limited to the North Carolina State Preservation Office's (NC SHPO) tracking of hurricane damage to historic properties. It offers exceptional advice for hurricane preparedness and disaster recovery. The NC SHPO, however, does not offer suggestions for preemptive planning or adaptation solutions to protect historic properties from the effects of sea level rise.²⁸⁵

Academic institutions and environmental groups represent additional stakeholders interested in protecting the North Carolina coastline from sea level rise impacts. Many are participants in the AP3C group. East Carolina University has created an interactive map of the North Carolina coast, depicting land inundation at incremental stages of sea level rise. Municipalities can view projected inundation at the street level to determine specific properties that may be flooded. I applied East Carolina University's information to identify sea level rise vulnerability in Elizabeth City's historic districts.

Summary of Findings: Elizabeth City, North Carolina

Elizabeth City's local government and preservation community acknowledged the benefits of the city's historic resources to quality of life in the *2004 Advanced Core Land Use Plan* and through area programs. Despite valuing historic resources, the groups have

not connected the increasing effects of sea level rise with the protection of historic properties at risk. The absence of adaptation plans to minimize the historic property flood damage evident in the Shepard Street–South Road Historic District confirms this observation. Senior Planner Angela Cole’s commented that the public works and building inspection departments, not preservation planning, plan and monitor adaptation strategies. This indicates the lack of cross-departmental collaboration. The effects of sea level rise and the application of future adaptation strategies may lead to a loss of historic district integrity if the preservation community remains disengaged in Elizabeth City. Preservation planners along with citizen advocates and owners of historic property must advocate for adaptation protection while safeguarding historic character and integrity.

The adaptation theory and research detailed in Chapter III stress the importance of cross-departmental participation within local governments to successfully plan for adaptation. As of February 2013, Elizabeth City’s governmental departments operated independently, providing adaptation solutions that were developed from one point of view. The compartmentalized approach will not benefit historic district properties as the impacts of sea level rise intensify.

Frequently flooded roads motivated the city to adapt thorough stormwater management improvements. Additionally, the city has applied and proposed soft adaptations that incorporated the use of existing wetlands and open space to mitigate flooding, storm surge, and erosion. These adaptations contributed to protecting adjacent at-risk historic districts; however, the soft adaptations alone will not protect historic properties from the impacts of sea level rise.

The *2004 Advanced Core Land Use Plan* illustrates that local governments in

North Carolina can incorporate sea level rise adaptation into their goals without state legislative support. State sanctioning of climate change and adaptation, however, is essential to implementing a comprehensive, local adaptation plan. Without state support, Elizabeth City very likely does not have the expertise at the local level to collect information on sea level rise science and its potential impacts. AP3C, APNEP, and East Carolina University have provided some sea level rise data, but it is not the high resolution LiDAR information necessary for accurate planning. Additionally, it would be unlikely that the small and economically challenged city could secure federal funding for extensive adaptation projects in the absence of a state intermediary. Fortunately, AP3C and APNEP have stepped in to provide public education on sea level rise science, impacts, and adaptation strategies, an activity typically funded and organized at the state level.

Elizabeth City's intentions to adapt to sea level rise and to preserve its historic districts are commendable. Nevertheless, lack of cross-departmental and state participation in sea level rise planning may limit the city from implementing a multi-dimensional effort to safeguard its shores from sea level rise.

Alexandria, Virginia

The area established in 1749 as Alexandria, Virginia, was first settled on the western shore of the Potomac River, a tidal estuary approximately 250 miles north of the Atlantic Ocean. Alexandria is six miles south of Washington, D.C. George Washington's home, Mount Vernon, is nine miles to the south. As the city grew, it developed westward on higher ground. (Fig. 57) Consequently, the city's low-lying waterfront is the area most



Fig. 57: Aerial view of the Alexandria Historic District on the Potomac River looking westward. Jones Point Park is located on the peninsula, south of the commercial and residential areas. [Google Earth; aerial photograph, 2007]

prone to flooding, storm surges, and erosion. The waterfront forms the eastern border of the Alexandria Historic District, known as Old Town. The district was designated as a National Historic Landmark because it represents a relatively intact example of an early Atlantic Coast seaport and commercial area. Colonial and Federal style residences, churches, and public buildings contribute to the district's significance.

Alexandria's position on the Potomac River with its connection to interior farmlands shaped the city's early development. European settlement began in the 1730s with a few warehouses, an inspection station, and a ferry to export Virginia-grown tobacco.²⁸⁶ Due to its strategic Potomac River site, the Virginia Assembly formally established the town in 1749.

Surveyor John West, Jr., assisted by a young George Washington prepared an official map of the newly formed town. The settlement was laid out as a grid containing 84 buildable lots bounded on the east by the Potomac River. (Fig. 58) Lots were sold to individuals agreeing to establish permanent homes and businesses.²⁸⁷



Fig. 58: The original town map was used to plat Alexandria in 1749. The cove was landfilled sometime before 1799 to accommodate wharves extending into deeper waters. [Theodor Horydczak, Library of Congress Prints and Photographs Online Catalog; photograph, 1920]

Maps between 1749 to 1799 indicate landfill was added at the base of Water Street, (now Lee Street), expanding the wharf two additional blocks into deeper waters.²⁸⁸ By the Revolutionary War, Alexandria was a major port on the Potomac River, ranking seventh largest in the United States.²⁸⁹ Rapid growth occurred until the late 18th century. Ocean-going ships arrived in Alexandria to export animal feed, grains, and tobacco to Atlantic coastal and international cities. Retail businesses developed westward along King Street; warehouses were constructed along the infill portion of the waterfront.²⁹⁰ Residential neighborhoods of brick and frame rowhouses emerged to the north and south of King Street.²⁹¹

As the closest city to Mount Vernon, Alexandria became George Washington's business and social base. Through the years, the city was proud of its connection with the country's first president. Such was the area's prestige and sophistication in 1796, that a

visitor deemed Alexandria as “beyond all comparison the handsomest town in Virginia—indeed [it] is among the finest in the United States.”²⁹²

Baltimore and Richmond overtook Alexandria’s position as a prominent seaport in the early nineteenth century. During that time, the city became part of the District of Columbia between 1801 to 1846 and the Embargo Act of 1807 hindered port activity. These events coincided with an economic collapse of the Virginia farm economy, reducing the port’s customer base.²⁹³ Despite its diminished importance, the port accommodated the city’s slave traders as they shipped slaves to New Orleans. Slave trading businesses operated in Alexandria until the Civil War.²⁹⁴

Alexandria escaped the destruction that other southern cities encountered during the Civil War due to the Union Army’s occupation. The city became a safe haven for African Americans fleeing slavery during wartime. Contraband and free African Americans settled in four neighborhoods around the city center. Because no battles were fought on Alexandria soil, the architectural core of the city was preserved, although well worn, at the conclusion of the war.

A tourism industry began after the Civil War. It was successfully built upon the town’s George Washington connection and its colonial architecture, an early example of heritage tourism. As a mid-point between Washington, D.C., and Mount Vernon, Alexandria was a convenient stop on a tourist’s route.²⁹⁵

In addition to the growing tourist trade, the arrival of the railroads in the mid-nineteenth century contributed to economic recovery after the Civil War. Rail lines, running through the city and along the waterfront, connected Alexandria to the north through Washington, D.C., as well as to southern markets. Between 1899 and 1915, the

industrial sector grew rapidly on the waterfront. By 1909, 54 industries employed 1,173 people.²⁹⁶ With the growth of the federal government during the Great Depression, federal workers began moving to the area in the 1930s. Alexandria began to take shape as a “bedroom” community.²⁹⁷

Alexandria was home to the defense industry during World Wars I and II. A shipbuilding company and a torpedo manufacturing plant opened on the waterfront. South of the original platted city, the peninsula at Jones Point was filled to create land for the Virginia Shipbuilding Corporation. Merchant ships for World War I were constructed at this location. The United States Naval Torpedo Station, constructed on landfill, manufactured torpedoes during World War II.

From the 1950s to the present, Alexandria has gradually shifted away from its maritime and industrial roots, becoming a suburb of Washington, D.C., with a service-based economy. Industrial waterfront properties have been replaced with residential, office, and retail construction. Public parks have been created through landfill where commercial docks once were located. Recreational boat docks have replaced the wharves that had hosted commercial seafaring ships. The city’s historic character, its accessibility to Washington, D.C., and its proximity to nearby employment centers attract residents and businesses. Alexandria’s estimated 2011 population is 144,301. The city is densely developed on 15.03 square miles with 9,314.3 persons per square mile. Median household income is \$82,889, \$19,597 higher than the state average. The percentage of people living below the poverty line is 7.8%, lower than the state average of 10.7%.²⁹⁸

Alexandria National Register Historic District

In addition to the Alexandria Historic District, four other National Register historic districts contribute to the city's historical narrative. They are the Parker-Gray, Rosemont, Town of Potomac, Fairlington, and Parkfairfax historic districts. (Fig. 59) The Parker-Gray neighborhood was an early African American settlement. Rosemont

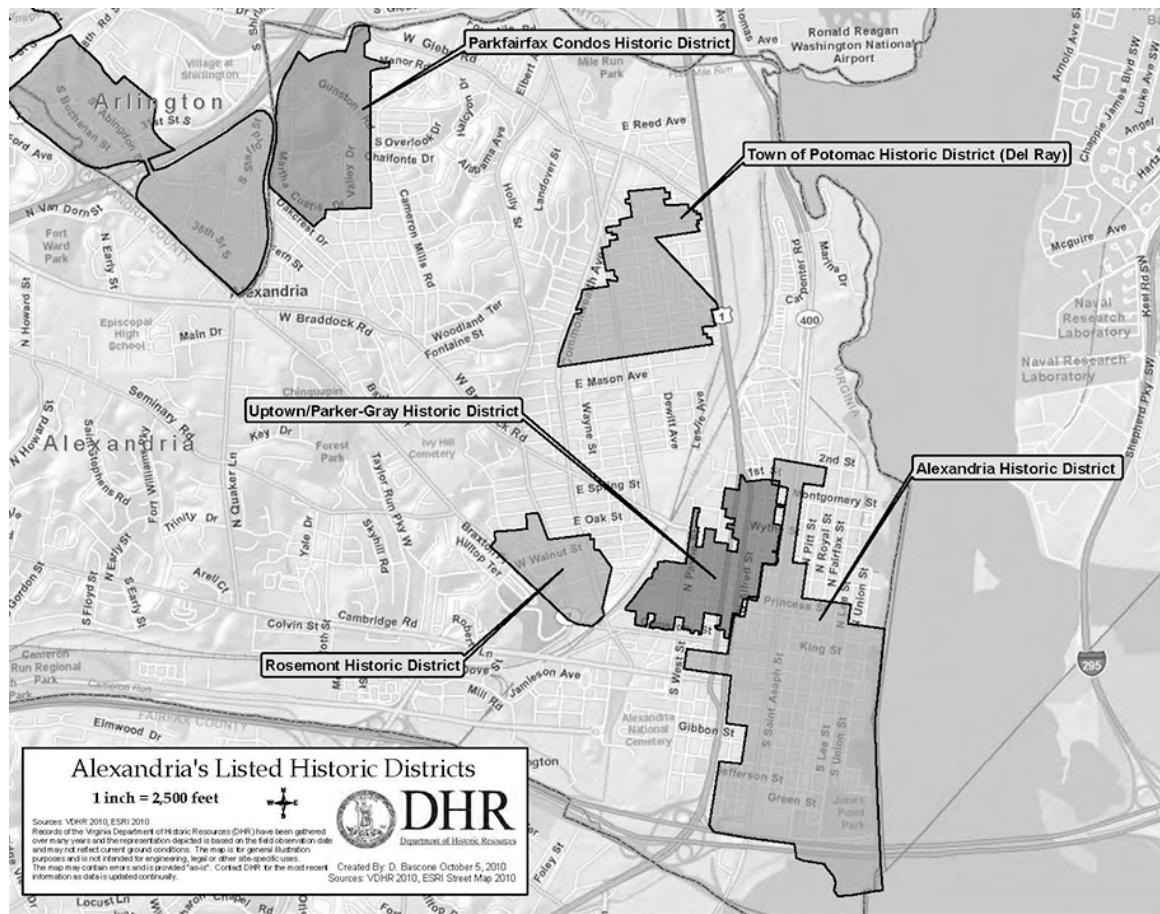


Fig. 59: The six National Register Districts in Alexandria represent different periods of the city's development history. The Alexandria Historic District is the only district projected to be affected by sea level rise. [D. Bascone for the Virginia Department of Historic Resources; Alexandria's Listed Historic Districts, October 5, 2010]

and Potomac developed as early suburbs in response to rail line connections to Washington, D.C. Fairlington and Parkfairfax were planned communities created in the

mid-twentieth century to reduce the area's housing shortage, resulting from the federal government's expansion. Only the Alexandria Historic District is vulnerable to sea level rise due to its Potomac River location.

The original city grid plan from 1749 forms the core of the Alexandria Historic District. Beyond the 1749 plan, the district boundaries expand to the north, south and west. This larger area encompasses buildings included in a locally designated historic district, the Old and Historic Alexandria District.

Old Town is characteristic of a "Walking City," a trait common to early nineteenth century cities.²⁹⁹ Commercial, industrial, and residential building types were constructed adjacent to each other in a dense pattern. Residential areas included people of mixed economic backgrounds. A higher concentration of wealthy homeowners, however, lived at the district's higher elevations.

Approximately 200 contributing buildings are included in the Alexandria Historic District. The area is best known for its Federal-style architecture, although examples of other late eighteenth and nineteenth century styles also appear in the district.³⁰⁰ The two and three story buildings are commonly constructed of brick with a scattered representation of frame residences throughout the district.

Additionally, the contiguous blocks of rowhouses provide Old Town with its unique character. Soon after the town was established, the governing trustees formulated strict rules for residential real estate development on the lots; one pre-determined the rowhouse building pattern. This stipulation required that "all dwelling houses not begun or to be built hereafter...to be in line with the street as chief of the houses now are, and that no gable or end of such house be on or next to the street."³⁰¹ When building began in

the new town, rowhouses were constructed along the streets. Later development continued to emulate this building pattern. (Figs. 60, 61)



Fig. 60: Early Federal style residential buildings were constructed on the highest ground along Lee Street, formerly Water Street, overlooking the Potomac River. In the late eighteenth century, land was filled below Lee Street to expand the Alexandria harbor. [Ann Horowitz; photograph, February 2013]



Fig. 61: Frame and brick rowhouses of varying sizes were developed along Lee Street. [Ann Horowitz; photograph, February 2013]

Jones Point Park is included in the Old and Historic Alexandria District. As a natural area defined by open space, woodland, and marsh, it contrasts with the dense urban environment of Old Town. A lighthouse, constructed in 1855, sited at the river's edge, is the only building on the property. (Fig. 62) It is an early example of a lighthouse



Fig. 62: The Jones Point Lighthouse guided ships along the Potomac River until 1925. The National Park Service plans to restore the building's interior and open it to the public. [Ann Horowitz; photograph, February 2013]

constructed along an inland river. A National Register object, the southern and first cornerstone marking the District of Columbia boundary, was placed between the lighthouse and the river in 1791. It is the oldest object associated with the federal city. A series of boundary stones were positioned one mile apart to create the District of Columbia's 40-mile, diamond-shaped boundary from sections of Virginia and Maryland.³⁰² In 1846, Alexandria was retroceded back to Virginia, but the cornerstone remained.

Social, Economic, and Environmental Benefits of the Historic District

Throughout the region, the city of Alexandria is defined by its intact grouping of well-preserved historic buildings.³⁰³ Social, economic, and environmental factors combine to create a unique sense of place in the historic district. Because of its distinct character, people are drawn to the area for residential, entertainment, and business opportunities. The impact of Old Town's sense of place is well established in the region. When considering Alexandria's ability to attract new business in 1981, deputy city manager Clifford Rusch stated, "It's Old Town that gives this city an identity, a pizzazz the ordinary suburb doesn't have."³⁰⁴ Merrie Morris from the Alexandria Convention and Visitors Association recently said of Old Town, "There's no doubt we have a lot of unique qualities and have a unique charm, where no one in Northern Virginia can compete with us."³⁰⁵

Social benefits are evident in the day-to-day interactions that are fostered by the densely developed and walkable neighborhood. A history of local pride in the district's character has been proven since the 1920s. Acknowledging preservation successes in Williamsburg, Virginia, and at Mount Vernon, Alexandria residents and business leaders set out to restore and protect their historic neighborhood, accentuating the associations with George Washington and Robert E. Lee.³⁰⁶ By 1946, the Old and Historic Alexandria District was locally established to limit demolitions and inappropriate alterations through a Board of Architectural Review. The local ordinance, strengthened through the years, has been supported by resident, civic, and business leaders, resulting in a comprehensive historic representation of early life in Alexandria.

Additionally, out of town visitors enliven the social setting and contribute to the

city's economic well-being by frequenting the broad selection of restaurants, shops, historic museums, and cultural establishments.

Economically, the Alexandria Historic District profits residents, businesses, and the city government. The strong sense of place provides for a relatively stable residential real estate sector.³⁰⁷ During the recent economic downturn, Old Town property values were more resilient than outlying suburban areas in the Washington, D.C., metropolitan region. Stable real estate values directly benefit the city of Alexandria's revenues by creating a dependable tax base.

The active city docket for the Board of Architectural Review (BAR) reveals the level of reinvestment generated by the historic district. The BAR considers fifteen to thirty cases per month, ranging from commercial signage to building additions.³⁰⁸ Through property reinvestment, each of these projects contributes to the local construction sector.

Additionally, the Alexandria Historic District provides the stage for a thriving heritage tourism economy. Historic sites within the district have been adapted as museums, restaurants, and spaces for the arts. In 2008, tourists spent an estimated \$192.8 million in Old Town.³⁰⁹ City wide, tourist spending reached \$771 million in 2011, contributing \$23.1 million to the city's tax revenue. This is a 22 percent increase from 2006. Six thousand people are currently employed by the city's tourist industry; seasonal employment figures are higher.

The district features seven heritage tourist sites. Gadsby's Tavern, Stabler-Leadbeater Apothecary, Alexandria Archaeology, and Lyceum are city owned and managed museums housed in historic buildings. Each site offers tours and special events

throughout the year. The Athenaeum, owned by the Northern Virginia Fine Arts Association, incorporates an art gallery and ballet school in its Greek Revival building. Constructed in 1753 on the bluffs of the Potomac, the Carlyle House Museum, a Georgian mansion, is the oldest building open to the public in Alexandria.

The economic benefits of heritage tourism have been documented for the Torpedo Factory Art Center. (Fig. 63) The former United States Naval Torpedo Station was rehabilitated and adapted for use as the arts center. It opened to the public in 1983. The



Fig. 63: The former United States Naval Torpedo Station (now the Torpedo Factory Art Center) has been rehabilitated as an art center. [Ann Horowitz; photograph, February 2013]

city owned building draws 500,000 people a year to its artists' studios, galleries, and art school. A recent study determined the Torpedo Factory generated \$16,229,685 in direct economic benefits to the city in 2008. At that time, the center employed 171 people with a payroll of \$2.1 million. In 2009, visitors spent an estimated \$15.4 million within the city as part of their stop in Alexandria.³¹⁰

The quality of life in Old Town is also enhanced by the environmental sustainability benefits inherent in the district's characteristic design. With fewer external walls exposed to the outside environment, the attached rowhouses use less energy for heat and air conditioning. Densely developed with mixed-use neighborhoods, Old Town residents can generally walk or use public transportation to access work, schools, entertainment, and shopping. Automobile travel is unnecessary when living in the historic district.

Natural Hazard Risks

The city of Alexandria is considered one of four “hot spots” vulnerable to the effects of sea level rise in the Northern Virginia region. Within Alexandria, Old Town and Jones Point are most at risk from flooding, storm surge, and erosion.³¹¹ Both locations were originally wetlands. Landfill of the wetlands created usable land, but at low elevations. These low-lying areas are currently prone to flooding during storm events, twice daily high tides, spring tides, and downstream runoff from the Potomac highlands watershed.³¹² In addition, the combined storm water and sewer systems cause flooding from tidal backups when sustained winds blow up the Potomac River northward.³¹³ The mean tide range in Alexandria is 2.62 feet (0.8 meters); the spring tide range is 2.88 feet (0.9 meters)³¹⁴

At King Street, the elevation ranges from one meter at the river to three meters at the corner of Lee Street, the location of the original shoreline. The elevation along Union Street and The Strand is one to two meters. At Jones Point, the elevation also ranges from one to two meters.³¹⁵ Jones Point is projected to be the first area in Alexandria

significantly affected by a moderate sea level rise.³¹⁶

Other factors determine Alexandria's susceptibility to sea level rise. The area's moderate level of land subsidence due to natural geologic factors will exacerbate the effects of heightened seas.³¹⁷ In addition, the increased number of storms producing more precipitation will combine with sea level rise and subsidence to produce more frequent flooding and storm surges. In Virginia, storm events are common with tropical storms impacting Virginia on average once a year and hurricanes occurring every 2.3 years.³¹⁸ If past trends continue, the incidence of potentially damaging storms will increase. The frequency of storm events between 1948 and 2011 has increased 33 percent in Virginia. These storms have produced a change of 11 percent more precipitation as measured over the same time period.³¹⁹ Winter nor'easters, commonly producing storm surges, have increased by 130 percent between 1984-2003, compared to the previous two decades.³²⁰

Hurricane Isabel provided an indication of the flooding and storm surge impacts that Alexandria may regularly face in the future due to sea level rise. Isabel first made landfall at Ocracoke, North Carolina, with peak wind gusts of 105 miles (169 kilometers) per hour.³²¹ Along the Outer Banks, storm surges were 6-8 feet (1.8-2.4 meters) along the North Carolina coast with 4-7 inches (10-18 centimeters) of rain.³²² By the time the hurricane hit the metropolitan Washington, D.C., area, the sustained winds had subsided to 45 miles (72 kilometers) per hour with 58 mile (93 kilometers) per hour gusts. Rainfall was measured at 2-3 inches (5-7.6 centimeters).³²³ The storm tide crested at 7.5 feet (2.3 meters) across the river at Washington, D.C.³²⁴ Storm tides occur when storm surge and astronomical high tides (during the new and full moons) combine to cause water levels to rise. The National Weather Service reported the unusually high storm surge resulted from

tropical storm force winds pushing water from the ocean up the Potomac, causing major flooding as far as Alexandria and Washington, D.C.³²⁵

Considerable flooding was noted at the intersection of King and Union Streets, covering nearly two blocks away from the river. A city police sergeant called the level of water “very unusual” while a 20-year resident claimed it was “insane.”³²⁶ The flood level was officially documented at 8.8 feet (2.7 meters) in Old Town Alexandria. According to the city’s *Potomac River Waterfront Mitigation Study*, this flood level categorizes Hurricane Isabel as an intermediate to extreme weather occurrence. To provide a context, nuisance flooding in Alexandria is identified as 4 feet (1.2 meters).³²⁷

Projected risks: 2050 and 2100

Sea level rise in Alexandria is projected to exceed the global average of one meter (39 inches) by 2100 due to subsidence. Average global sea level rise is 2 millimeters (.08 inches) per year while the tide gage at Washington, D.C., measures an average of 3.16 millimeters (.12 inches) per year.³²⁸ The 2050 and 2100 inundation maps for the Alexandria Historic District and Jones Point Park portray sea level rise based on the global averages, consistent with other case studies in this treatise. These inundation scenarios illustrate the gradual encroachment of the shoreline into the built environment. As the new shoreline develops and storm events intensify, more historic properties will become increasingly prone to damaging floods and storm surge.

Compared to ocean-facing shorelines in Virginia, erosion affects the city’s waterfront to a lesser degree. Wave force is minimized in the Alexandria area due to the limited fetch of the Potomac River and the fact that much of the shoreline is hardened

with rocks and seawalls.³²⁹

Using these projections, by 2050 thirteen historic buildings in the Alexandria Historic District may be flooded with 0.42 meters (one foot) of sea level rise. (Fig. 64) These properties, interpreting Alexandria's maritime history from the eighteenth to mid-twentieth centuries, are at the corner of King and Union Streets and at The Strand. All were constructed on landfill using brick, masonry, or a combination of both. The oldest buildings are located at King and Union Streets.

John Fitzgerald, war comrade and presidential secretary to George Washington, constructed Fitzgerald's Warehouse circa 1795–1797.³³⁰ (Fig. 65) William Ramsay developed the warehouse building on the northwest corner, 101 King Street, circa 1803.³³¹ (Fig. 66) The Corn Exchange, on the southwest corner, was constructed in 1871. It housed a successful grocery store considered as “the center of the wholesale district” in 1922.³³² Near The Strand, two additional nineteenth century warehouses may flood by 2050. The buildings are currently being rehabilitated for residential and commercial use. Two twentieth century commercial buildings at The Strand, the Torpedo Factory, the Old Dominion Boat Club, and the former Beachcomber restaurant are also vulnerable to inundation.

By 2100, ten additional historic properties are likely to be flooded as sea level rise increases to nearly one meter (3 feet). (Fig. 67) Inundation would extend west on King Street and south on South Union Street. Like the properties affected in 2050, these buildings were developed in response to the waterfront economy. The buildings are brick

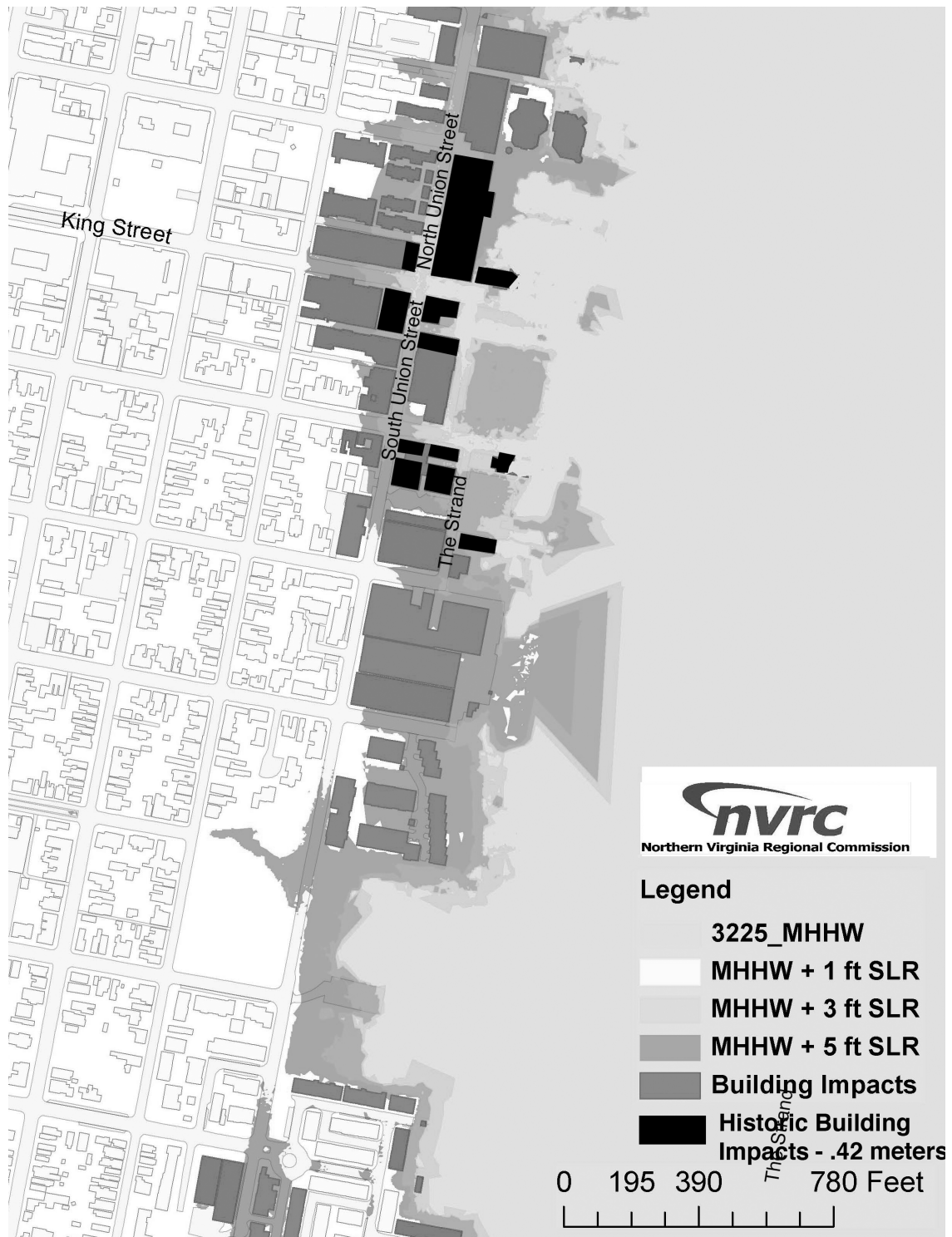


Fig. 64: Sea level rise is projected at approximately 0.42 meters (one foot) in Alexandria by 2050. Thirteen historic buildings (marked in black) will be flooded. [Northern Virginia Regional Commission using LiDAR elevation data collected by the United States Department of Defense; sea level rise map, December 2012]



Figs. 65, 66: Fitzgerald's Warehouse (left), built circa 1797-1798, is the oldest building in the Alexandria Historic District associated with the city's maritime history. It is one of the most vulnerable to flooding and storm surge in the district. The corner building at 101 King Street (right) portrays another early example of Alexandria's seafaring past that is prone to frequent flooding. The attached buildings to the left were also used as warehouses, composing the city's wholesale district. During extreme storm events, flooding temporarily inundates the entire block. Today, the area is a popular center of entertainment for tourists and residents. [Ann Horowitz; photographs, February 2013]

and stone masonry located on landfill. They represent commercial shops and warehouses from the nineteenth to early twentieth centuries.

At Jones Point, the projected sea level rise for 2050 would begin to inundate the park's existing wetland areas to the north. (Fig. 68) The shoreline would move closer to the lighthouse and the cornerstone. Two residential rowhouses, constructed in the 1940s, may be partially inundated at the park's northwest border.

A large portion of the park is likely to be inundated by 2100 based on current projections. (Fig. 69) The lighthouse, cornerstone, and recreational amenities would be flooded. Fourteen historic residences, including two former buildings associated with the shipbuilding industry, would be affected northwest of the park.

Adaptations implemented and proposed

With a history of periodic flooding, the city of Alexandria has implemented methods to adapt to this natural hazard. City leaders acknowledge the waterfront's

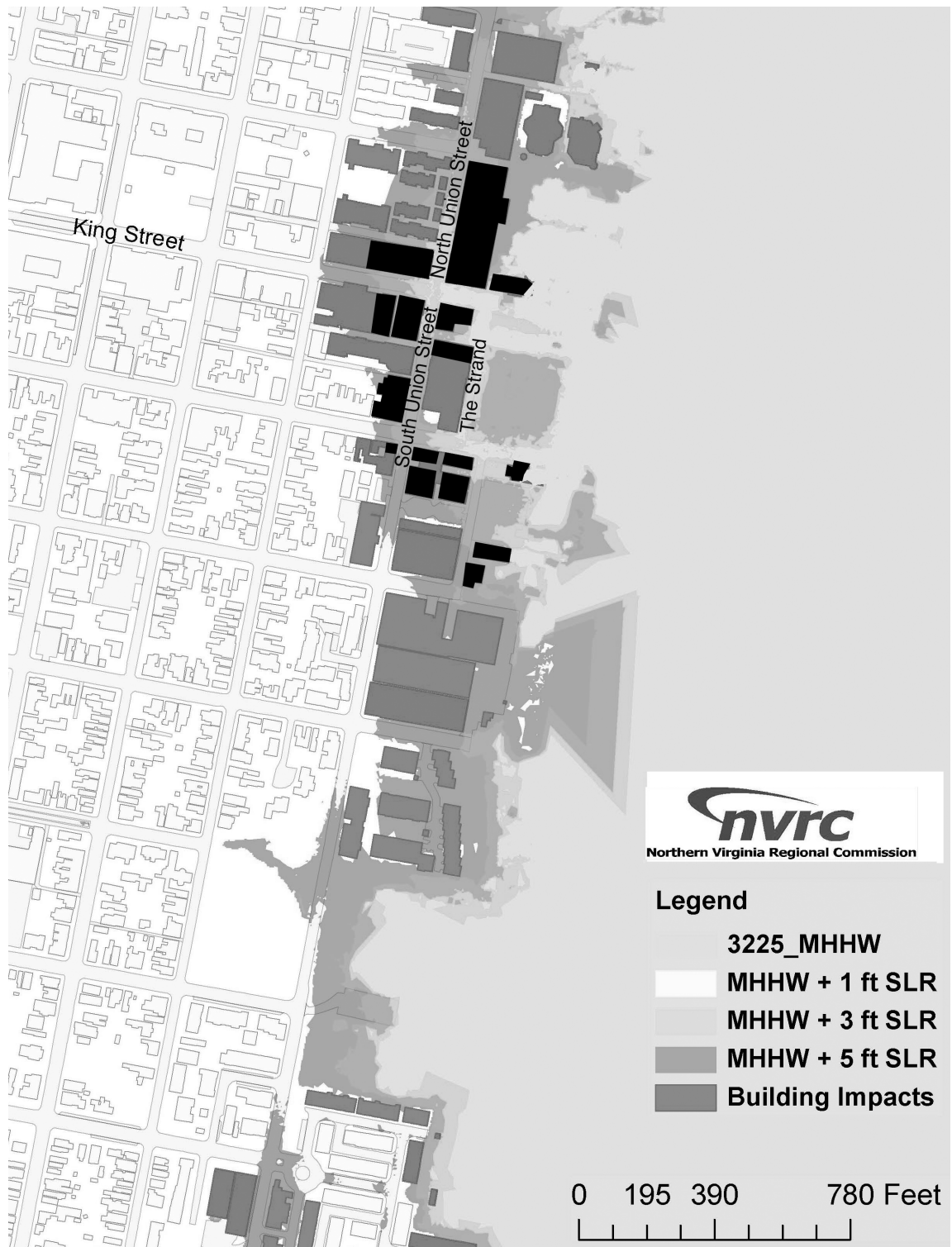


Fig. 67: Twenty three historic buildings (marked in black) are projected to be flooded by a sea level rise of approximately one meter (3 feet) by 2100. [Northern Virginia Regional Commission using LiDAR elevation data collected by the United States Department of Defense; sea level rise map, December 2012]

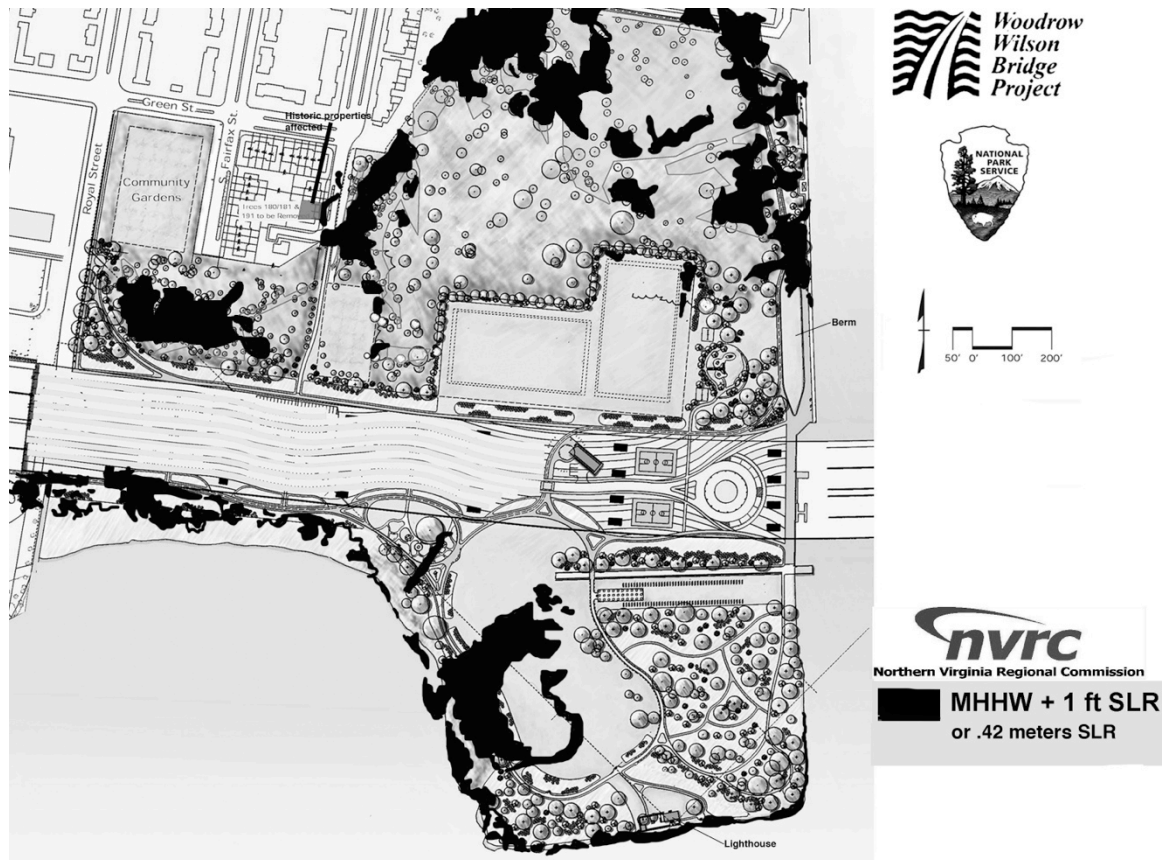


Fig. 68: At Jones Point, the overlay (marked in black) indicates sea level rise inundation of approximately 0.42 meters (one foot) by 2050. The inundation overlay does not reflect the protection offered by the 2011–2012 adaptations. In this figure, the area near the berm is inundated, the shoreline merges closer to the lighthouse, and two historic properties (marked in gray) northwest of the park are partially inundated. [National Park Service; Jones Point Wetlands Delineation Map, n.d. and Northern Virginia Regional Commission using LiDAR elevation data collected by the United States Department of Defense; sea level rise map, December 2012]

vulnerability to sea level rise, responding with three reports that propose adaptations for the future. The potential loss of the valuable economic and social contributions associated with the historic district has prompted these proposals.

At Jones Point, the National Park Service included adaptations in its recent park improvements. These have increased the level of protection for the historic resources

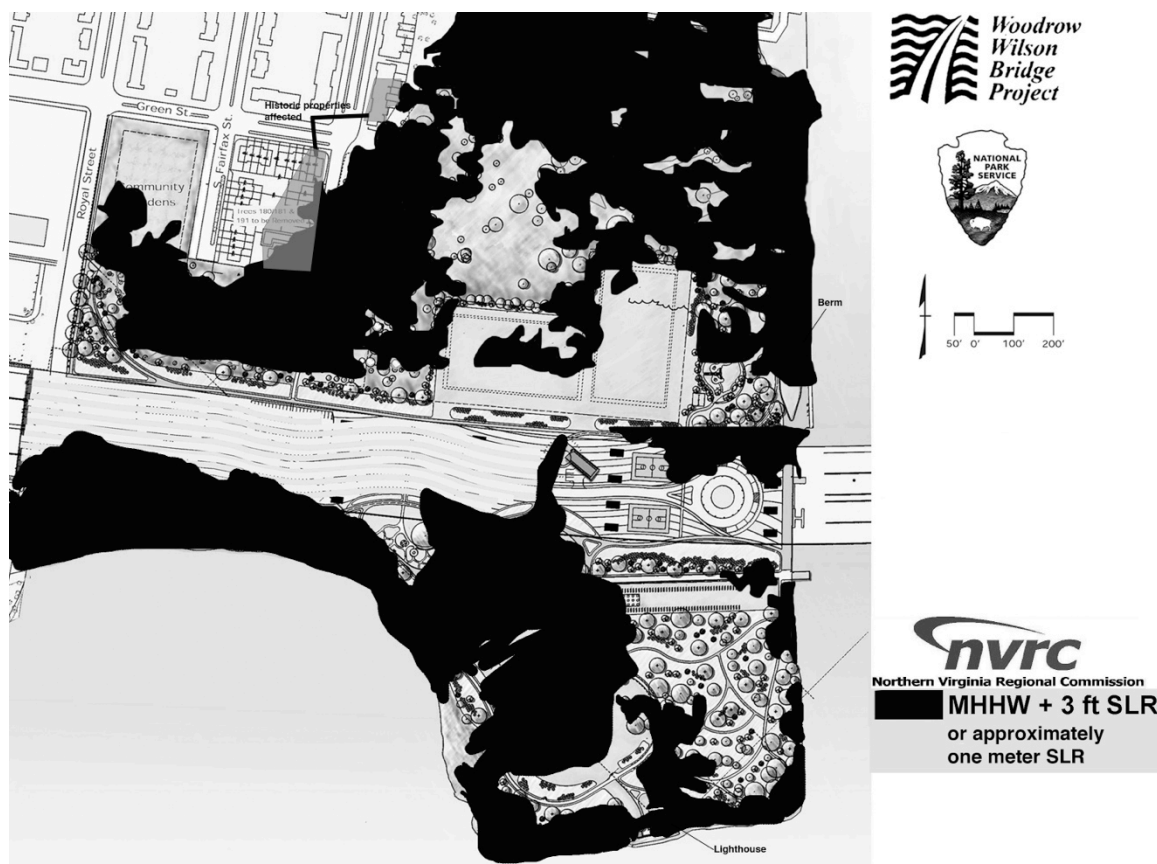


Fig. 69: Inundation from nearly one meter (3 feet) of sea level rise covers a large portion of Jones Point Park by 2100. Fourteen historic properties are compromised northwest of the park and the lighthouse and cornerstone are flooded. The benefits, however, of the berm, lighthouse seawall, and stormwater drainage improvements are not considered by the elevation data. [National Park Service; Jones Point Wetlands Delineation Map, n.d. and Northern Virginia Regional Commission using LiDAR elevation data collected by the United States Department of Defense; sea level rise map, December 2012]

within its boundaries and have been applied to reduce flooding in the adjacent historic district.

Implemented Adaptations

Within the historic district, a city-sponsored sandbag distribution program, a non-structural adaptation, has been used to protect properties. The effectiveness, however, has not been formally measured.³³³ (Fig. 70) City zoning ordinances, additional non-



Fig. 70: In preparation for Hurricane Sandy in 2012, the owners of Fitzgerald's Warehouse constructed sandbag walls at doors, windows, and at wooden panels below windows. The absence of sandbags along masonry walls suggests the flood proof qualities of the material. [Ann Horowitz; photograph, October 2012]

structural adaptations, also are in place to mitigate the effects of flooding from incremental sea level rise.

Article VI, Section 6-300, the Floodplain District ordinance, requires that first floor heights on new or substantially altered buildings within the FEMA floodplain area must meet or exceed the 100-year flood level. Floor space below this height can be used for parking, storage, or entrances. Residential use, however, is not permitted.³³⁴

Requirements to increase permeable surfaces for the absorption of precipitation are found in Article VI, Section 6-200, the Waterfront Park and Recreation Zone Ordinance, the Alexandria Open Space Plan, and within the city's comprehensive master plan.³³⁵ The maintenance of permeable surfaces is also stressed in Article XIII, the Environmental Management Ordinance. This was enacted in response to Virginia's

Chesapeake Bay Preservation Act of 1988. Non-structural adaptations are included in the act to limit flooding through the creation of Resource Protection Areas (RPAs), marked by 100-foot (30.5 meter) buffers along the top banks of tidal shorelines. Within this buffer, development and redevelopment is limited. Impervious surfacing cannot be added in the buffer zones.³³⁶

Supplemental, non-structural adaptations initiated by individual property owners are evident in the historic district's flood-prone area. At 104 South Union Street, the front door features metal slots to install a floodgate. (Fig. 71) The interiors at Fitzgerald's



Fig. 71: Slots at the front door of a South Union Street commercial building indicate the use of a temporary flood gate when flooding is predicted. [Ann Horowitz; photograph February 2013]

Warehouse and the Torpedo Factory have been finished with materials that can withstand flood inundation. (Figs. 72, 73) Polished cement floors can be easily cleaned after waters subside. The masonry walls are left exposed at Fitzgerald's Warehouse while the



Figs. 72, 73: Building materials, used inside the Torpedo Factory (left) and Fitzgerald's Warehouse, are adaptable to the damages caused by flooding. [Ann Horowitz; photograph, February 2013]

corrugated metal half walls at the Torpedo Factory were added during building rehabilitation. Furniture in both locations is temporarily stationed in place and can be easily moved in anticipation of a flood.

The Jones Point Park improvements display a mix of hard, soft, and non-structural adaptations to minimize flooding. Brent Steury, the Natural Resources Program Manager for Jones Point Park, stated that the NPS considered projections for sea level rise when planning the adaptations. The Park Service, however, was limited to adaptations that could be contained within the Virginia state boundaries, the low water mark of the Potomac River.³³⁷ This legal boundary excluded adaptations that would project out into the river. Along the park's northern shore, a rip-rap wall and offshore plantings have been installed to limit erosion from the Potomac River.³³⁸ An earthen berm was constructed at

this location. Creatively, the NPS incorporated the berm, a soft adaptation, into their site interpretation. (Fig. 74) The berm design emulates the size and shape of a ship. An interpretive sign explains that the berm's location was the previous site of the shipbuilding facility.

At the southern shore, a seawall has been reconstructed to protect the lighthouse and District of Columbia cornerstone. (Fig. 75) The seawall was designed to create more



Figs. 74, 75: An earthen berm (left) shields the northern shoreline of Jones Point Park. The adaptation's form was interpretively designed to represent the footprint of a ship. The NPS constructed a seawall with a rip-rap border to minimize the effects of sea level rise. From this perspective, the creation of additional shoreline by extending the seawall toward the river is evident. [Ann Horowitz; photograph, February 2013]

land area between the river and the lighthouse, increasing the protection from flooding, storm surge, and erosion.³³⁹ A rip-rap wall was added between the river and the seawall to minimize wave force. The District of Columbia cornerstone, now encased within the seawall, bears witness to years of sea level rise. It originally was constructed on dry

ground, but now sits at the base of the seawall at the river's edge.³⁴⁰ Placing the historic marker within the seawall protects the object from erosion. (Fig. 76)



Fig. 76: The seawall protects the boundary stone from further erosion, yet it can be viewed through the glass cover. [Ann Horowitz; photograph, February 2013]

Additionally, the Jones Point improvement plans included the installation of a higher capacity stormwater drainage system, a non-structural adaptation. This adaptation was implemented to mitigate the flooding that extended inland due to undersized storm drain culverts in the park and under the historic neighborhood.³⁴¹

The sea level rise map for 2100, showing the inundation of the lighthouse, berm, and historic properties, does not take into account the benefits of these adaptations. The LiDAR data used to create these maps were collected in 2008, prior to the 2011–2012 adaptations applied at Jones Point Park. The actual inundation may be minimized at the park due to the combination of hard, soft, and non-structural adaptations implemented by the National Park Service.

Proposed Adaptations

Locally, the city has initiated three studies that propose adaptations to minimize the effects of sea level rise in the Alexandria Historic District. The first, *The Environmental Action Plan 2030*, presents a broad city strategy for addressing climate change and environmental quality. The 2008 report introduces the need for addressing climate change at the local level. The broad goals include the monitoring of sea level rise on the waterfront in order to effectively plan adaptations. It recommends the gradual separation of sanitary sewer and stormwater infrastructure, a non-structural adaptation.³⁴²

A second report, the *Potomac River Waterfront Flood Mitigation Study*, provides a comprehensive evaluation of possible adaptations to protect Alexandria's waterfront from sea level rise impacts. An initial assessment in the report acknowledges the difficulty of implementing structural adaptations because of Old Town's dense urban character.³⁴³

This 2010 analysis weighs sixteen criteria to establish an adaptation priority list. The evaluated criteria (ranked in order of importance) are: 1) flooding reduction capability, 2) property owners' costs, 3) commercial revenue losses, 4) aesthetics, 5) ability to construct, 6) city liability, 7) Potomac River viewshed impacts, 8) private property purchase, 9) state and federal funding, 10) repetitive property damage, 11) cost of flood insurance, 12) property ownership, 13) environmental impacts, 14) limits imposed on recreational use, 15) influence on historic and archaeological resources, and 16) regulatory requirements.³⁴⁴ Each adaptation is assigned a numerical weight based on the criteria it satisfies. This results in the selection of the nine highest ranked adaptations for further study. They are (in order of ranking): 1) seawall; 2) pedestrian floodwall; 3)

acquisition of repetitively flooded properties; 4) sandbags or other temporary barriers; 5) raised road elevations; 6) building elevations; 7) flood proofed buildings; 8) strengthened floodplain and zoning ordinances; and, 9) relocation of storage and utilities to upper floors.³⁴⁵

The study further examines the impacts each of the nine adaptations has on natural and cultural resources. Last, a cost-benefit analysis is conducted. In addition to assessing the cost effectiveness of the adaptations, the cost-benefit analysis also gauges the most cost effective flood level to adapt to. It determines that the city should plan for 6 foot (1.8 meter) high floods that have a probability of occurring every 10 years.³⁴⁶ To mitigate this flood level, the study determines that protection is needed at the base of Oronoco Street (outside the district) and at the base of King Street to the base of Wolfe Street.

The study selects a 550-foot (167-meter) long, six-foot (1.8-meter) high pedestrian floodwall as the best performing and most cost effective adaptation after all considerations are calculated. Protection would be afforded to 43 commercial and 23 residential properties, a mixture of historic and contemporary buildings.³⁴⁷ In addition, the King and Union Streets intersection and The Strand would be elevated to minimize road closures during floods. At the elevated King and Union Street intersection, a park is also proposed so pedestrians will not be cut off from the river. These adaptations create a new pedestrian amenity, discontinue the sandbag program, and reduce the need to close roads.³⁴⁸ The perceived benefits outweigh the “indirect adverse effect” of closing off the river view from approximately thirty historic properties.³⁴⁹ To maintain some views of the river, automatic floodgates at the terminuses of King, Prince, and Duke Streets are to

be placed within the pedestrian floodwall. These would remain open until threats of flood or storm surge are imminent.³⁵⁰ Despite the benefits, the pedestrian floodwall and the elevated roadways would not offer flood and storm surge protection against severe storms.³⁵¹

The elevation of the roads may also compromise the integrity of the historic district. Road width, removal of historic landscaping, and the use of incompatible road materials could affect the design, setting, materials, and feeling of the historic district. If sidewalk elevations are included, the architectural integrity of buildings' lower floors would be negatively impacted.³⁵²

In addition, the mitigation study proposes the implementation of non-structural adaptations. City-initiated improvements to the stormwater drainage system, enhancement of the floodplain and zoning ordinance, and expanding the sandbag program are recommended due to widespread benefits.³⁵³

Non-structural adaptations adopted by property owners for individual buildings receive favorable ratings. Flood proofing, floodgates, custom flood proof doors, custom flood proof windows, berms created by raised patios, elevations of internal floors are recommended as cost effective. The report also encourages the relocation of lower floor or basement valuables, storage, and utilities to upper stories in the waterfront commercial and King Street areas.³⁵⁴

Although ranked sixth, the study considers the elevation of entire buildings as not applicable to the building stock in the Alexandria historic district. Elevating brick buildings is technically difficult. Further, elevating attached buildings, composing a city block, would be highly impractical. For this reason, the mitigation study directs its

analysis to the internal elevation of the first floor instead of the elevation of the building.

Some of the individual property adaptations have limits to the protection they provide. In the King Street area, flood proofing would protect historic buildings only up to a three-foot (0.91 meters) flood level.³⁵⁵ Raising the internal elevation of the first floor by one foot (0.31 meters) is possible for only 16 historic properties in the flood-prone area. In historic properties where internal elevation is not an option, the study recommends the installation of flood proof doors and windows. Both adaptations afford the same benefits.³⁵⁶

In addition to the nine adaptations chosen, the study evaluates berm protection for the historic residences northwest of Jones Point. The study finds that seventeen historic properties within the local historic district would be flooded by 3.35 feet (one meter) of water during an extreme flood event. The probability of this occurring is every 100 years.³⁵⁷ The proposed berm is 1,370 linear feet (418 meters) with an average height of nine feet (2.7 meters). After further calculations, the study determines the Jones Point berm is not a cost effective option.³⁵⁸

All of the adaptation proposals evaluated in the *Potomac River Waterfront Flood Mitigation Study* are located within the Alexandria Historic District and the Old and Historic Alexandria District. As a result, a local and federal review would assess the impacts of adaptation methods on the integrity of historic buildings and the district before construction could commence. For the local district, the Board of Architectural Review (BAR) would evaluate the effects of proposed alterations and additions caused by the pedestrian floodwall and the elevated roadway. The BAR would also review alterations to individual buildings: floodgates, flood proof doors and windows, and berms.

A federal review procedure, Section 106, would be triggered if federal funds are used for adaptation construction. The Virginia State Historic Preservation Office would become involved to determine if an adverse effect results from the addition of an adaptation in the historic district. This applies to the pedestrian floodwall or elevated road projects if federal aid is included in the construction budget.

The *Waterfront Small Area Plan*, approved by the city council in February 2012, is the third report that includes adaptation proposals for the city of Alexandria. This comprehensive plan designed to guide waterfront development acknowledges that sea level rise “presents a challenge to both the present and any future redeveloped state of the waterfront.”³⁵⁹ As a result, the plan takes into account quality of life, cost to the city, and preservation of the historic district in its support of implemented and proposed adaptations.³⁶⁰ The waterfront plan incorporates the adaptations proposed by the *Environmental Action Plan 2030* and the *Potomac River Waterfront Flood Mitigation Study*. In addition, it includes green infrastructure—natural swales, rain gardens, and bioretention areas—as adaptations to reduce flooding by collecting runoff from impervious surfaces.³⁶¹ The estimated cost to implement the waterfront flood mitigation plan is \$6.8 million.³⁶²

City resident response to the waterfront plan has been contentious. The Citizens for an Alternative Alexandria Waterfront Plan (CAAWP) organized to oppose its passage. CAAWP was against the commercial and hotel development aspects, saying that new construction was too dense and the proposed height limits were out of scale with the historic district. The group argued that new hotels would exacerbate traffic congestion in Old Town. Its alternative plan was to develop “Parks, Arts, and Museums” instead of

adding commercial businesses on the waterfront. CAAWP co-chair Andrew Macdonald stated that his group's proposal showed "the City's waterfront plan will have adverse impacts on the community and the historic identity of Old Town."³⁶³ After a review, the city determined the alternative plan would "cost between \$80 million and \$109 million" and "would not pay for itself."³⁶⁴ The city's Waterfront Small Area Plan Work Group held fifteen public meetings to review CAAWP's concerns, responding with seventy revisions to the original plan.³⁶⁵ In February 2012, the city council approved the waterfront plan. Individual residents, however, soon filed a series of lawsuits questioning the legality of the council's vote and the planning department's procedural methods.³⁶⁶

The inability of the city to move forward on the waterfront plan due to the lawsuits also delayed the implementation of the flood mitigation adaptation proposals. On February 15, 2013, the mayor and city manager announced the revision of a zoning ordinance that would allow the city council to vote again on the waterfront plan, presumably approve it, and bypass the delays caused by litigation.³⁶⁷ Staff from the Transportation and Environmental Services Department presented details of the King and Union Street intersection elevation soon after the February 15th announcement.

The city of Alexandria receives information on sea level rise and adaptation strategies through its participation in the Northern Virginia Regional Commission (NVRC). This collaborative planning group is composed of city and county government representatives, property owners, and Northern Virginia universities. They meet regularly to monitor local sea level rise, identify risks, and learn about adaptation efforts and opportunities. Further, the group is briefed on relevant local regulations that relate to climate change. The NVRC compiled the sea level rise vulnerability information for

Alexandria and Jones Point used in this treatise. Presently, the NVRC is producing a *Guidebook for Regional Adaptation* with the EPA.³⁶⁸

While planning adaptations, Alexandria did not receive financial or informational support from the state. Virginia is “largely unprepared and lagging behind” in planning for sea level rise according to the Natural Resources Defense Council.³⁶⁹ The state has not conducted a statewide assessment of sea level rise vulnerability nor has it coordinated adaptation planning with communities.³⁷⁰ The General Assembly agreed to finance a study on sea level rise impacts, at the urgent request of the Hampton Roads area delegates, if the document assessed “recurrent flooding,” not sea level rise.³⁷¹ The Virginia Institute of Marine Science (VIMS) at William and Mary completed the *Recurrent Flooding Study for Tidewater Virginia* and submitted it to the General Assembly in January 2013. VIMS worked collaboratively with state agencies, universities, interest groups, and the Hampton Roads Regional Planning Commission to develop the report.

Decision-makers and Stakeholders

A cross-departmental group of city employees as well as citizen commissions and work groups have been involved in adaptation planning for vulnerable buildings within the Alexandria Historic District. Colleges, universities, engineering consultants, and the regional planning commission contributed expertise to the three reports initiated by the city. Within the city government, the Transportation and Environmental Services, Planning and Zoning, and Recreation, Parks, and Cultural Activities departments collaborated on developing adaptation strategies. Residents represented the citizen views

by volunteering for commissions and work groups within these departments. The mayor and City Council were the ultimate decision-makers in support of the adaptation-related plans.

The Environmental Policy Commission, under the Transportation and Environmental Services department, proposed in the *Environmental Action Plan 2030* to create a subcommittee that would be assigned to monitor climate change and recommend relevant policy guidance and strategies. The group would be composed of representatives from the city staff, civic groups, scientists, and the business community.³⁷²

City departments involved in historic preservation contributed to the development of the *Waterfront Small Area Plan*, but not directly to adaptation planning. The Preservation Planning and Alexandria Archaeology divisions of city departments contributed historic research and ideas for historic interpretation. The Board of Architectural Review ruled on the local significance of some historic waterfront properties for inclusion in the plan. The Old Town Civic Association, a resident membership organization supporting historic preservation, provided input to the waterfront plan before the city council vote.

For Jones Point Park, the National Park Service was the decision-maker. The city and civic groups were stakeholders. The NPS worked collaboratively with the community during the development, public comment, and construction phases of the improvements. It requested feedback at Stakeholder Participation Panel meetings and at meetings with individual civic groups between 1998 and 2007. The NPS also worked closely with city government departments to develop the park's improvement plan.³⁷³

Summary of Findings: Alexandria, Virginia

Except for the NPS, the city of Alexandria has implemented few adaptations in the city. Individual property owners in chronically flooded areas have applied many of the existing adaptation solutions, similar to strategies outlined in English Heritage's *Flooding and Historic Buildings*. The *Potomac River Waterfront Flood Mitigation Study* proposes numerous options to safeguard historic buildings from chronic flooding. Nonetheless, these are not designed with sea level rise projections in mind. Flood mitigation efforts proposed in the study had been temporarily stalled because the plans were loosely linked with the controversial *Waterfront Small Area Plan*.

Residents' concerns regarding the waterfront plan related to increased height limits for new construction, higher building density, and more traffic congestion. They believed the proposed development would affect their quality of life and negatively affect the historic district. The public, however, did not question the wisdom of building in a flood zone or the effects of the flood mitigation proposals on quality of life and historic resources. This may have been due to a lack of community education programs on sea level rise science and its projected pressures on the waterfront. As the city begins to implement adaptation solutions from the waterfront plan, it could again meet resistance from an uninformed citizenry. Adaptation theory and research discussed in this thesis study stress the connection between public education and the development of successful local adaptation strategies that receive community support.

A cross-section of city departments participated in the development of the waterfront plan, as recommended by adaptation theorists and researchers. Preservation planners contributed expertise on the interpretation of the historical landscape, but were

uninvolved in developing adaptations or in ensuring that integrity remained unaffected in the historic district.

The flood mitigation study includes the use of a cost-benefit analysis to identify buildings to protect and adaptation strategies to implement. Economic terms define benefits in the analysis, ignoring the advantages of social and environmental factors. If widely applied, this type of analysis would favor adaptations in commercial areas with high real estate valuations over the protection of modest or low-income residential neighborhoods. As the study illustrates, adaptations for buildings in the historic commercial waterfront area earned high cost-benefit ratios. Low ratios are calculated for adaptation strategies designed to protect historic residential homes at the district's border. Consequently, adaptations are recommended for the commercial waterfront, but not for the residential area.

The National Park Service's improvements at Jones Point Park represent the most comprehensive adaptation plan applied in the case study cities. The NPS engaged the community through resident and city council stakeholder meetings. Local feedback was considered in the planning of adaptations. Land and historic resources were granted protection from adaptations in areas where flooding is projected by 2050 and 2100. The National Park Service's methods for protecting the lighthouse and boundary marker offer insight into the extent historic resources might be shielded from sea level rise impacts in the future. Like the St. Augustine historic seawall, the boundary marker lost a high degree of integrity. A seawall replaced the land between the lighthouse and the river to guard from erosion. The NPS chose to reduce integrity rather than have the historic resources destroyed by the increasing effects of sea level rise.

The Virginia state boundary delineated by the low mean tide line influenced the types of adaptation strategies the NPS could apply to the park. The commercial portion of the historic district would also be affected by the legal boundary limiting the types of possible adaptation approaches in that area.

The state of Virginia provides negligible support to Alexandria and its other communities on issues relating to sea level rise. Adaptation theory and research studies assert this does not impact the ability of local communities to plan, but the lack of state backing limits the implementation of a comprehensive adaptation plan.

Virginia's policy to replace sea level rise discussions with conversations on "recurrent flooding" may also influence the efforts of some communities on adaptation planning. Like the state, Alexandria's adaptation plans reveal that the city focuses its attention on mitigating current flood conditions as opposed to preemptively planning for the projected effects of sea level rise.

Successful adaptation implementation has been unevenly applied in Alexandria. The NPS followed through on a comprehensive plan, based on sea level rise projections, to protect Jones Point Park from sea level rise impacts. On the other hand, the city proposed flood mitigation measures without incorporating factors for projected sea level rise. Alexandria residents' dissatisfaction with the waterfront development proposals temporarily blocked the city's efforts to proceed with adaptations to mitigate current flooding problems. In the future, the implementation of a long-range, comprehensive adaptation plan may materialize with state support, cross-departmental participation at the local level, and public education programs on sea level rise projections and impacts.

Conclusion for Case Studies

St. Augustine, Elizabeth City, and Alexandria reflect the characteristic early European development patterns along the Atlantic Coast. The first settlers sought land on tidal estuaries to develop their towns, away from the ocean's direct coastal impacts, but close enough to accommodate shipping, trade, and travel. St. Augustine is the exception, located three miles from the ocean. It succeeded as a military and missionary post, although trade was attempted. The densely developed original town areas each portray a unique architectural and cultural past, qualifying them as National Register historic districts. The historic districts outside the first settled areas continue the rich, historical development narrative beyond the time of the first European residents.

Each city's cultural background influences its distinct historic districts, with natural building materials providing further significance. The Laws of the Indies, developed in Spain, dictate the form of St. Augustine's town plan. In addition, Spanish architectural practices were applied to invent the "St. Augustine Plan" for buildings.⁹⁸ Coquina and tabby, locally found construction materials, enhance the singular architectural style, creating a sense of place only found in St. Augustine. In Elizabeth City, the surrounding forests supplied plentiful lumber for the construction of buildings in the historic districts, many accented with decorative bargeboard. The town plat resembles the original city grid of Alexandria, possibly reflecting the both areas' British origins. The town planning rules mandated by Alexandria's first trustees created the area's signature rowhouse style. Brick served as the prominent building material in Alexandria due to the large deposits of clay in the soil.

The sense of place inherent in each of the case study cities establishes a high

quality of life, supporting social, economic, and environmental sustainability. The future of each city's historic record and quality of life, however, is found to be at risk. Low-lying lands are identified as susceptible to flooding, primarily in landfilled areas. As sea level rise intensifies, all of the historic districts could be significantly compromised by 2100 unless adaptation solutions are developed. Current flooding, storm surge threats, and land erosion conditions have prompted the cities to implement or propose adaptations to current flooding. These solutions have not factored in sea level rise except in Elizabeth City and at Jones Point Park in Alexandria. The specific sea level rise projections used by the two locations to plan adaptations, however, are not communicated in reports. While current adaptation plans may mitigate flood, storm surge, and erosion conditions in the short-term, the historic preservation community will need to become involved in the development of alternative, long-term adaptation plans to protect the cities' historic districts from the effects of sea level rise.

Adaptation planning requires the counsel of varied parties. In the case study cities, a broad range of decision-makers and stakeholders—city departments and political leaders, residents, regional planning agencies, colleges and universities, and state governments—have been involved in the development of adaptation strategies. The preservation community, however, has been largely absent from the planning discussion. Nonetheless, preservation policy at the federal, state, and local levels required preservation leaders to become included in St. Augustine and at Jones Point Park in Alexandria. The Section 106 process drew the city archaeologist and the Florida State Historic Preservation Office into planning for the new seawall. They suggested options to save a remnant of the historic seawall and evaluated potential impacts on historic

integrity. A local zoning ordinance directed the St. Augustine Historic Architectural Board to assess the alterations to the historic seawall prior to construction. The National Park Service was required to consider the impacts of park improvements on the Jones Point lighthouse and the cornerstone in the Environmental Assessment Report. The historic preservation community should also assume an adaptation planning role in instances when governmental policies do not mandate its participation. This advocacy position ensures the protection of historic resources during adaptation planning discussions.

State support for adaptation planning, critical to successful implementation of a comprehensive plan, varies among the case study cities. Political leaders in North Carolina and Virginia essentially ignore sea level rise projections and the need to adapt. In sharp contrast, Florida is one of the leading states addressing climate change mitigation and adaptation planning. As the effects of sea level rise intensify, St. Augustine's adaptation planning will benefit through access to funding, scientific data, and public education. Barring shifts in state policies, Elizabeth City and Alexandria may find it difficult to compete for federal funds earmarked for adaptation. The lack of specific sea level rise projections and an uninformed community could hinder the development and implementation of sound adaptation solutions.

CHAPTER V CASE STUDY DATA ANALYSIS

Introduction

All three Atlantic Coast case study cities—St. Augustine, Florida; Elizabeth City, North Carolina; and Alexandria, Virginia—have developed adaptation plans, although few specifically address the projected effects of sea level rise. Except at Jones Point Park in Alexandria, Virginia, and in Elizabeth City, North Carolina, the communities’ adaptation efforts mitigate current chronic flood conditions and exclude long-term solutions to sea level rise impacts. Nonetheless, the sea level rise scenarios based on the accepted projections of rise for 2050 and 2100 illustrate that the threats of floods, storm surges, and coastal erosion are very likely to worsen, increasing the vulnerability for these cities. As sea level rise accelerates, the cities’ National Register historic districts will face irreparable damage unless additional adaptations are applied. National Register designation may be compromised if historic properties are lost within the districts. The cities’ unique architectural and cultural legacies will likely deteriorate, reducing the residents’ quality of life.

My analysis of the adaptations chosen by the cities confirms that the combination of adaptation strategies is unique for each community. Additionally, the examination indicates that a series of local adaptations are necessary to minimize sea level rise vulnerability. Generally, the adaptation solutions have been initiated at the local levels with funding secured from all tiers of government. The case study cities have proposed

and implemented adaptations suggested by English Heritage, the British National Trust, the 1000 Friends of Florida, and the Mississippi Development Authority. Adaptation strategies used in Norfolk, Virginia, and Galveston, Texas, were also included in the cities' plans.

Some of the cities' adaptation solutions protect historic districts and occasionally impact historic integrity. The case studies reveal two instances when the preservation community considered the adaptations' effects on the integrity of historic resources. Aside from these proposal reviews, the preservation community was absent from initial adaptation planning and visioning discussions typically conducted within planning or public works departments. Opportunities exist for historic preservation professionals and historic property owners to join city planners, engineers, policy makers, scientists, environmentalists, disaster management teams, and emergency preparedness professionals in adaptation planning. In this way, they can ensure adaptation protection for historic properties that are vulnerable to sea level rise while providing a critical review aimed to minimize the effects on integrity.

Sea Level Rise Threats

By 2050 and 2100, the case study cities are similarly vulnerable to sea level rise. Each city, however, will experience different effects of sea level rise due to variations in geographic location and regional oceanography. Sea level rise is projected to be greater than global levels in Alexandria due to land subsidence. This will result in flooding that will likely be higher than in Elizabeth City, North Carolina, and St. Augustine, Florida.

Due to its ocean proximity, St. Augustine is more susceptible to the effects of ocean storms.

For the case study cities, projections reveal that immediate shorelines, areas around inland waterways, and previously filled wetlands could likely be flooded by 2050. With a sea level rise of approximately 42 centimeters (one foot) by 2050, flooding would likely occur in portions of the historic districts. By 2100, the land area affected by one meter (3.3 feet) of sea level rise increases. As shorelines move inland, historic districts will gradually lose integrity or face destruction caused by the associated effects of sea level rise unless adaptations are applied to safeguard them.

It is important that the case study cities begin adaptation planning in the near future since it is a time-intensive process. The cities could plan short-term strategies, applicable for 10–50 years, or institute a long-term approach, applying adaptations that are relevant for over 50 years.³⁷⁴ The use of shorter-term plans accommodates an incremental approach that allows for flexibility. As new sea level rise science data become available, local adaptation plans can be modified to better address the new information. Additionally, short-term plans, such as adaptations for flood proofing and flood resilience, tend to be less costly than engineered strategies applied for long-term benefits. On the other hand, long-term adaptations based on sea level rise projections supplant the need to frequently replace protective measures designed for the short-term.

Generally, the case study cities' planned or implemented adaptations act as short-term solutions. These may minimize sea level rise impacts on historic properties expected by 2050. But, by 2100 many of these adaptations could be obsolete if current sea level rise projections hold true. For example, the St. Augustine seawall and stormwater

improvements and Alexandria's proposed floodwall and street elevations may prove to be inadequate solutions if sea level rises up to one-meter (3.3 feet) by 2100.

National Register Historic Districts

Most of the National Register historic districts in the case study cities are likely to be affected by sea level rise. Adaptations, however, have been implemented or proposed for only the districts already subjected to repetitive flooding or wave action damage. This philosophy is indicative of the common practice in the United States that addresses sea level rise impacts only after repetitive damage or a catastrophic event. Adapting to protect the built environment before devastation occurs is often more cost effective and less disruptive than reactionary emergency management and recovery programs. Starting to plan now to protect all the historic districts through adaptations would extend the cities' unique cultural legacies.

Due to this mitigation philosophy, adaptations have been proposed or implemented unevenly among the historic districts. St. Augustine considered the flood-prone St. Augustine Town Plan and Lincolnville historic districts in adaptation plans, disregarding the Abbott Tract, Model Land Company, North City, Fullerwood Park, and Nelmar Terrace districts that are potentially vulnerable in the future. Adaptation plans have been proposed and implemented in Elizabeth City to minimize flooding in the Elizabeth City and Shepard Street–South Road historic districts. Nevertheless, adaptations have not been designed for the Northside and Riverside historic districts, two areas likely to be significantly impacted by 2050. The city of Alexandria has proposed numerous adaptation strategies to protect the Alexandria Historic District, the only

municipal National Register district at risk. Within the district, however, adaptations are not evenly apportioned. Proposed adaptations are concentrated only in the commercial area of the historic district. A preliminary proposal for a berm to protect historic residential properties was denied because the cost-benefit analysis did not support it.

Building Materials

The case studies reveal how building materials determine the types of adaptations that are possible. Unique to each case study city, the building materials—coquina and tabby in St. Augustine, brick in Alexandria, and wood in Elizabeth City—react in different ways to the effects of sea level rise. The characteristics of each building material rule out certain adaptation strategies and encourage the application of other solutions that will be more protective.

In St. Augustine, coquina and tabby buildings create the unique identity found in the colonial section of the city. Despite being prone to erosion and dissolution, centuries-old coquina buildings and the historic seawall continue to represent the cultural legacy of St. Augustine. More frequent floods, however, could hasten the deterioration of the coquina and tabby buildings and structures. Rising acid levels in the ocean and rainwater may compound the flood effects. In the St. Augustine Town Plan Historic District, raising the seawall is an appropriate adaptation to hold back floodwaters and storm surge, since the elevation of stone and masonry buildings is structurally impractical.

As the coquina quarry rock became depleted in the nineteenth century, residential construction in St. Augustine primarily shifted to wood. Frame buildings can deteriorate from water damage caused by repetitive flooding. Homes near inland bodies of water in

the Lincolnville and Abbott Tract historic districts were likely elevated approximately 60 centimeters (two feet) on coquina or concrete blocks when originally constructed. Although elevated, these properties could be threatened if water levels reach higher depths, a possibility by 2100.

Non-elevated frame buildings in the historic districts will likely be at risk of immutable damage due to sea level rise flooding and heightened storm surges. Powerful storm surges may even destroy elevated buildings that are supported by weak pier systems. A post-Hurricane Katrina assessment in Mississippi found that frame buildings elevated by sturdy concrete or steel frame piers remained intact after Hurricane Katrina in Mississippi.³⁷⁵ St. Augustine property owners could also apply these reliable concrete and steel frame techniques to historic frame properties unprotected by the seawall.

Like St. Augustine's coquina and masonry buildings, the attached brick rowhouses in Alexandria are unsuitable for building elevation. The properties along the river have endured years of repetitive floods, suggesting regular maintenance of mortar joints around the bricks and foundation stones. English Heritage recommends this cost effective adaptation to guard against flood damage. Character defining, wooden architectural features—doors and window frames—divide masonry exterior walls of the historic buildings. Temporary sandbag walls, suggested by English Heritage and the 1000 Friends of Florida, cover and protect the exterior wood paneling from water damage when floods threaten. While sandbags have been a successful adaptation, the strategy will not suffice as sea level rise intensifies. Following St. Augustine's example, Alexandria proposes to protect its stone and masonry buildings with a seawall, designed as a pedestrian floodwall.

In Elizabeth City, frame buildings are prominent in the historic districts, although some masonry buildings are located in the Elizabeth City and Riverside historic districts. A few elevated frame buildings are found only in the flood-prone Shepard Street–South Road historic district. The elevations may be original to the time of construction. Three-foot (91-centimeter) high cement block foundations, punctuated by air vents, elevate some properties in this district. Flooding has caused wood deterioration on non-elevated homes. The frame residences in the Riverside and Northside historic districts are not elevated in areas likely to be flooded by 2050. The elevation of at risk frame buildings in the densely built areas of the Elizabeth City, Northside, and Shepard Street–South Road historic districts, however, may be unachievable. Construction equipment required for elevation change may not fit in the minimal space between buildings in these districts. Building elevation could be accommodated in the less dense Riverside Historic District.

Comparison of Local Adaptation Approaches

In addition to building materials, the case studies demonstrate how the natural and built environments dictate the specific nature of local adaptation planning. The proximity to natural resources and open space, the development density, and economic valuation, are factors in the adaptation proposal or selection process. Economic, social, and political perspectives also influence the ways adaptations are applied.

An analysis of the case studies reveals that St. Augustine and Alexandria have implemented or proposed a wide range of adaptations in the hard, soft, and non-structural categories. (Table 6) All three cities have considered adaptations in the non-structural and soft categories. Common non-structural strategies include upgrades to stormwater

Case Study Adaptations by Type

	St. Augustine	Elizabeth City	Alexandria
Types of Adaptation:			
Hard Adaptations:			
seawall, floodwall	X		X-JPP, prop-OT
rip-rap wall	X at Castillo		X-JPP
floodgates			proposed
Soft Adaptations			
green infrastructure			proposed
berms			X-JPP
beach replenishment	X		
wetland reclamation	X	X, proposed	existed-JPP
open space acquisition		proposed	
water retention structure	X	proposed	
Non-Structural Adaptations:			
Floodproofing, Building retrofit:			
sandbags	suggested		X
floodgates at doors, windows			X, proposed
earthen berms around building	suggested		proposed
interior floodproof materials			X
exterior floodproof materials	X		
Flood resilience:			
sump pump in basement			suggested
add backflow valves to plumbing	suggested		suggested
relocate storage and utilities to upper floors	suggested		suggested
vents or windows in floors below base flood level	suggested		
Infrastructure:			
zoning, building codes	X	X	X
elevating new construction	X	X	X
stormwater for new construction	X	X	X
vegetative buffer zones			
on shorelines	X	X	X
stormwater drainage improvements	X	X	X-JPP, prop-OT
raise roads, sidewalks			proposed
elevated historic buildings	X	X	
improved sewer and water lines		X, proposed	proposed
reduce impervious surfacing		proposed	

Table 6. Data based on the study by Ann Horowitz, May 29, 2013. Key: X = action taken; JPP = Jones Point Park; OT = Old Town.

drainage systems and zoning and building codes. Soft adaptation solutions have been proposed or applied, although each city has adopted different approaches in this category.

Recent stormwater drainage improvements indicate that the impacts of sea level rise are becoming evident in all the case study cities. As sea level rises along the low-lying city shorelines, the gravitational force, which is needed to drain stormwater, diminishes.

Stormwater collection drainage systems can be adapted to address this problem by installing larger pipes or wider drainage canals. Riberia Street in St. Augustine, Elizabeth Street in Elizabeth City, and Jones Point Park in Alexandria are the sites of stormwater system upgrades. All the stormwater improvement projects have improved flood conditions in the local National Register historic districts. As sea level rise conditions intensify, the stormwater systems would require the addition of pumps to remove excess water more quickly. The St. Augustine Public Works Director, Martha Graham, mentioned this as a possible solution, although a “substantial financial investment” to protect St. Augustine from nuisance flooding.³⁷⁶ Stormwater, sewer, and water line upgrades are not likely to impact integrity unless historic resources are permanently altered in the course of construction.

Secondly, each locality includes zoning and building ordinances for the elevation of buildings in flood zones, the regulation of stormwater systems, and the preservation of shoreline vegetative buffer zones. Each of these requirements is directed toward new development and does not apply in historic districts. The elevation ordinance, nearly identical in all of the communities, results from a Federal Emergency Management Agency (FEMA) requirement. The regulation orders the first floor of new construction to

be elevated above the 100-year base flood elevations established by FEMA.

Municipalities participating in the Community Rating System (CRS), a FEMA Federal Flood Insurance Administration program, are required to adopt this ordinance. Residents in CRS localities are then eligible to receive discounts on their flood insurance. For non-CRS participants, FEMA encourages the inclusion of the elevation mandate in order for citizens to receive flood insurance, but discounts do not apply. Alexandria and St. Augustine take part in the CRS; Elizabeth City does not.

The elevation zoning ordinances do little to encourage the elevation of historic properties from flooding since the regulation is only applicable when substantial alterations are made. Martha Graham, Public Works Director in St. Augustine, explained that this has created a dilemma in a city where many of the properties are historic and most of the land has already been developed.³⁷⁷ A similar situation exists in the Alexandria Historic District. In Elizabeth City, scattered parcels of developable land are available for new construction where the elevation zoning ordinance would be relevant.

Historic district integrity could be compromised as a result of the FEMA directed ordinance. New, elevated properties may be incompatible in location, scale, and design with adjacent, non-elevated historic buildings. The Mississippi Development Authority's *Elevation Design Guidelines* discusses the importance of maintaining these elements of integrity within a historic district. A building elevated more than a few feet above its neighbors, upsets the visual cohesiveness of a historic neighborhood.³⁷⁸

Zoning ordinances for stormwater management are designed to ensure that the systems in new developments are built to accommodate current flood conditions. Elizabeth City includes the reduction of impervious surfaces in its stormwater

management plans. These ordinances do not stimulate stormwater upgrades in historic districts where flooding could be mitigated to protect historic properties. Alexandria's repetitive flooding in the historic district's commercial area may improve if the proposed project to decouple the sewer and stormwater systems is undertaken in the future.

Because stormwater systems are upgraded underneath or along city streets, they would not adversely affect the integrity of historic districts, although temporary impacts on historic setting are possible during the construction phase.

The cities' ordinances regulating vegetative buffer zones require that new development must be set back from the shoreline to maintain a permeable surface that absorbs floodwater and precipitation. In historic district areas like Alexandria and St. Augustine, this requirement does not apply because dense development is already established up to the shoreline. The historic districts of Elizabeth City are setback from the immediate shoreline, affording them more protection from the effects of sea level rise. The preservation of a vegetative buffer zone would have no affect on the integrity of Elizabeth City's historic districts.

The three case study cities propose or implement soft adaptations. The proximity of natural landscapes and the density of development influence the specific methods that are selected. Existing natural areas or open space, such as wetlands and beaches, are generally required to implement soft adaptation solutions on a large scale. Berms for individual properties and green infrastructure represent adaptations that can be developed in densely developed areas.

Elizabeth City's support of environmental conservation and preservation, evident in its land use plan, may account for the city's soft adaptation preference. During the

2009 public listening sessions, citizen participants voiced their support for soft adaptations as environmentally sound and relatively inexpensive solutions. Pasquotank County's rural setting may reflect the public's preference for the natural environment. Wetlands and open space are found within Elizabeth City, despite the densely developed historic area. The vegetative buffer zone, along most of the center city shoreline, absorbs floodwater and storm surges. The Charles Creek Park Wetlands were restored also in this area, minimizing some of the flooding effects on the Shepard Street–South Road and Elizabeth City historic districts.³⁷⁹ Additionally, the site of the proposed canal, a water retention feature, is located along the shoreline near the vegetative buffer area. If developed, this adaptation may improve flood conditions and reduce storm surge risk in the Elizabeth City and Shepard Street–South Road historic districts. Open space acquisition is a land use plan priority and is possible within Elizabeth City's historic districts. As an adaptation, open space would absorb the impacts of excess precipitation, river flooding, and storm surge.

The soft adaptations applied in St. Augustine were constructed in natural areas adjacent to the densely developed colonial section of the city. Within the Lincolnville historic district, the water retention structure was repaired at the existing Maria Sanchez Lake. Beach replenishment and wetland reclamation projects were undertaken on barrier islands east of St. Augustine. In the Alexandria Historic District, high building density led to the proposal for small-scale green infrastructure adaptations that could be incorporated into the built environment. At the district's urban fringe, larger-scale soft adaptations—the earthen berm and the preserved wetlands—could be accommodated at Jones Point Park. Soft adaptations in the case study cities do not compromise historic

integrity and significance since most strategies were based on existing natural areas.

Elizabeth City's soft adaptation preference is representative of strategies favored by English Heritage and the British National Trust. In Great Britain, hard barriers had been historically applied to hold back the sea. After centuries of use, a dependence on hard adaptations resulted in damage to the environment. The government seeks to limit environmental degradation by encouraging the use of soft and non-structural adaptations.

The adaptation approaches differ among the case study cities when hard and the non-structural adaptations of flood proofing and flood resilience are examined. St. Augustine and Alexandria have considered or adopted these adaptations while Elizabeth City has not. Regarding hard adaptations, seawalls effectively and equitably protect densely developed areas from storm surge and extreme wave heights, as described in the St. Augustine Town Plan and Alexandria historic districts. St. Augustine's location, three miles from the open ocean, is particularly vulnerable to the effects of ocean storms.

The two cities recognize that seawalls (as well as floodgates in Alexandria) are cost effective based on cost-benefit analyses. The benefits associated with the large number of buildings protected, the economic value of the properties, and the tax dollars generated support the construction of the costly seawalls. The St. Augustine Town Plan and Alexandria historic districts house businesses and support employment while generating tax revenue through tourism. The loss of these income-producing assets—the historic buildings—would be a detriment to the local economies.

The hard adaptation examples in St. Augustine and Alexandria impact the integrity of the historic districts' commercial areas. St. Augustine's Avenida Menendez seawall affects the design, setting, materials, workmanship, and feeling of the historic

seawall, although ocean storm impacts had previously altered its integrity. Because of the new seawall, a section of the historic structure is maintained, something that would not have been possible otherwise. Alexandria's proposed pedestrian floodwall with floodgates at street terminuses, alters the historic location and setting by eliminating the river viewshed.

Density and economic advantage were not considerations in the decisions to apply hard adaptations at the National Park Service (NPS) units in St. Augustine and Alexandria. At the Castillo de San Marcos and Jones Point Park, hardening the shoreline guards these historic resources from sea level rise impacts. The use of a rip-rap wall at the Castillo de San Marcos minimizes the dissolution of the historic seawall, although it was not designed with future sea level rise projections in mind. During current high tides, the rip-rap adaptation is nearly submerged. Rip-rap walls at Jones Point Park protect the shoreline and the base of the seawall from erosion. The seawall shields the historic lighthouse and the Washington, D.C., cornerstone from the effects of sea level rise. The NPS staff for Jones Point applied sea level rise projections to plan the park's hard adaptations. They chose sea level rise strategies based on the historical, architectural, and cultural value of the historic resources, rather than on economic contributions to the local economy.

The NPS hard adaptations affect district integrity to varying degrees. The rip-rap walls add another visual dimension to the settings, however they do not compromise integrity. At Jones Point Park the seawall imposes little effect on the lighthouse's integrity, but hides and isolates the cornerstone, impacting the historic object's design and setting. Like the historic St. Augustine seawall, the cornerstone would soon be lost if

the Jones Point seawall did not protect it.

Federal FEMA policy for CRS participants guides the non-structural, building retrofit adaptations of flood proofing and flood resilience established by St. Augustine and Alexandria. As CRS participants, St. Augustine and Alexandria are encouraged through the FEMA incentive program to publicize methods that property owners could apply in the areas of flood proofing and flood resilience. FEMA awards points to CRS localities for flood mitigation strategies in the areas of public information, mapping and regulation, flood damage reduction, and flood preparedness. The more points a community earns, the lower the flood insurance premiums are for its citizens. As a non-CRS participant, Elizabeth City is not required to post flood proofing and flood resilience recommendations with its adaptation plans.

Regardless of an area's CRS status, property owners in communities vulnerable to sea level rise would benefit from information on the building retrofit adaptations promoted by FEMA and also recommended by English Heritage and the 1000 Friends of Florida. Flood proofing and flood resilience are relatively inexpensive to implement and can be individually designed to suit a building. Flood proof adaptations offer protection up to one meter (3.3 feet) of flooding, potentially safeguarding properties for the long-term until 2100. In Alexandria, historic properties could be safeguarded by 2050 through the elevation of internal floors by one foot (0.31 meters). Permanent building retrofit alterations such as air vent covers, drainage ditches, individual earthen berms, and floodgates may affect the integrity of a historic building. Flood resilience techniques protect historic buildings during minor flooding, provide a short-term benefit, and generally do not compromise integrity.

Alexandria is considering the raising of roads and sidewalks, a non-structural, infrastructure adaptation. In Norfolk, Virginia, this adaptation did not provide long-term benefits. The Alexandria adaptation proposal ignores the potential harm to adjacent historic buildings and district integrity. During floods, roads and sidewalks running along historic blocks would be free of water while flooding would affect the historic buildings even more than before. In addition, the elevation of infrastructure could affect the design integrity of the buildings by concealing architectural features and making access difficult.

Cost Benefit Analysis Drawbacks

Cost-benefit analyses—prioritizing adaptations by economic factors—have the potential to shift sea level rise protection from historic districts with low valuations to income generating historic areas with high real estate assessments. For example, the cost-benefit analysis from Alexandria’s *Potomac River Waterfront Flood Mitigation Study*, incorporates a ranking system that assigns a higher priority to adaptations safeguarding economic valuations and commercial revenue than to historic and archaeological resources. Working class, residential historic districts, such as Elizabeth City’s Northside and Shepard Street–South Road historic districts, may be at greater risk of sea level rise impacts if a similar cost-benefit analysis is applied to them in the future. Conversely, historic districts such as the St. Augustine Town Plan and Alexandria historic districts will likely be protected by adaptations due to high property assessments and to the heritage tourism industry they support.

Decision-makers and Stakeholders

Local decision-makers and stakeholders involved in the adaptation process are

similar in the case study cities. City and county public works, engineering, and planning departments have initiated proposals and implemented programs under the supervision of a city manager. Citizens serving on commissions and boards were included in the decision-making exercise with a city council or commission approving the adaptation proposal or project. The public was informed of the adaptations at public hearings and community meetings after proposals were formulated, but not during the planning stage.

Local historic preservation decision-makers and stakeholders participated in St. Augustine when the city archaeologist assessed the historic seawall's condition and the SHPO suggested adaptation options during the planning stage. Additionally, the preservation commission reviewed the alteration plans developed for the historic seawall. Otherwise, the local historic preservation communities in the case study cities were detached during the planning process. Elizabeth City's Senior Planner, Angela Cole, stated that the preservation department does not monitor flood effects or plan for adaptations protecting historic properties. She noted that the city engineer and the Department of Public Utilities oversee the impacts of flooding and plan mitigation projects in the city. The Department of Building Inspections evaluates the elevation of buildings. In Alexandria, the preservation planning director and the Office of Historic Alexandria's Archaeology department participated in the historical interpretation of the waterfront in the *Waterfront Small Area Plan*. Adaptations included in the plan were derived from the *Potomac River Waterfront Flood Mitigation Study* commissioned by Transportation and Environmental Services, a public works and engineering city department.

The states provide a varied level of support for the case study cities' adaptation

planning efforts. Florida actively addresses sea level rise and its effects on the shoreline. Of the three analyzed, it is also the state most vulnerable. One meter (3.3 feet) of sea level rise would inundate large areas of state land.³⁸⁰ The governor and state legislators initiated programs to study Florida's vulnerability and promote the incorporation of adaptation strategies into local comprehensive plans. The governor's task forces and the Department of Economic Opportunity lead the state governmental bodies involved with adaptation planning. The Department of Environmental Protection administers the beach protection programs. The Florida State Historic Preservation Office (SHPO) became involved in the new seawall discussion during the planning stage and the Section 106 Review.³⁸¹

In contrast, the North Carolina and Virginia governors and legislatures refuse to formally acknowledge climate change or sea level rise. Last year, the North Carolina legislature voted to restrict its state employees from applying current scientific projections prior to 2016. Until then, state departments, including the Department of Environment and Natural Resources (DENR), must base adaptation decisions on linear historic sea level rise trends, which are lower than current scientific projections.³⁸² Nonetheless, DENR and its divisions, such as the Coastal Resources Commission and the Albemarle-Pamlico National Estuary Partnership, continue to conduct informational meetings and guide communities through the implementation of adaptation programs.

Other than commissioning the *Recurrent Flooding Study for Tidewater Virginia*, Virginia's political leadership has been ineffectual in furthering the adaptation discussion. The governor and the Virginia General Assembly reviewed the study in January 2013, but have not responded legislatively. Within state government, the Virginia

Department of Environmental Quality's Coastal Zone Management Program (CZM) provided grants to Hampton Roads, the Middle Peninsula, and the Northern Virginia Regional Commissions for nine local adaptation studies. The CZM has not initiated sea level rise programs of its own, though.

Academic institutions and regional planning commissions fill technical and informational voids left unresolved by state and federal governments. These organizations are stakeholders in the case study cities' adaptation efforts. For St. Augustine, the Northeast Florida Regional Council coordinates sea level rise resiliency assessments with the University of Florida and the Guana Tolomato Matanzas National Estuarine Research Reserve. Additionally, the UF and GTM NERR initiatives resulted in the compilation of technical sea level rise vulnerability data presented at the December 2012 public educational sessions. For Elizabeth City, East Carolina University developed the sea level rise data featured in this study's vulnerability projections for 2050 and 2100. Likewise, the Northern Virginia Regional Commission collected the sea level rise data for Alexandria.

Federal programs and agencies fulfill roles in the adaptation implementation programs of St. Augustine and Alexandria. The Coastal Barrier Resources Act (CoBRA) of 1982 was applied in St. Johns County to protect barrier beaches, providing a storm and wave buffer for St. Augustine. Although an after-the-fact adaptation, FEMA funded the Avenida Menendez seawall as an emergency response to the ongoing devastation of the historic seawall. At the Castillo de San Marcos, the NPS constructed the rip-rap wall to minimize wave force on the historic seawall. Further, the NPS applied adaptations that incorporated sea level rise data at Jones Point Park in Alexandria.

Federal agencies collected the scientific data used to project future sea level rise scenarios in St. Augustine and Alexandria. The National Oceanic and Atmospheric Administration (NOAA) has mapped sea level rise scenarios for the coastal United States, although not all areas have been completed. As of January 2013, St. Augustine was the only case study area studied by NOAA. The Department of Defense provided the data determining sea level vulnerability for Alexandria.

At these early planning stages, the cities have successfully planned adaptation strategies with minimal state or federal government political support. Local municipalities took the initiative to plan adaptations, informing citizens after strategies were formalized. Residents did not take part in the preliminary planning stages. The case study cities featured many adaptations that can be locally financed, such as flood proofing, flood resilience, and infrastructure (non-structural) adaptations. Large-scale, hard adaptations such as the Avenida Menendez Seawall and soft adaptations like the Charles Creek Park Wetlands were subsidized by the federal and state governments, respectively. As the effects of sea level rise intensify, the case study cities may discover that they will need to rely more on the state and federal governments for adaptation funding and technical support. Before this happens, the states of North Carolina and Virginia must follow Florida's lead and accept the inevitability of climate change and the need for adaptation. With the states' acknowledgement of climate change, the case study cities will also benefit from the development of high quality sea level rise data, accurate vulnerability assessments, and the creation of public education programs.

The case study cities illustrate that a multidisciplinary team of decision-makers and stakeholders are involved in adaptation planning. The collaborative network,

however, must be broadened to include residents, property owners, the preservation community, and scientists. In “Wicked Challenges at Land’s End: Managing Coastal Vulnerability Under Climate Change,” Moser, Williams, and Boesch stress the importance of a community’s ongoing relationship with scientists as adaptation solutions are developed. In my thesis study, only the NPS at Jones Point Park and Elizabeth City considered scientific data when planning adaptations.

Conclusion

At the time of this thesis research, the case study cities of St. Augustine, Elizabeth City, and Alexandria were in the early stages of adaptation planning in response to current flood challenges. The local governments have proven they are capable of adaptation planning despite limited state and federal political support. Financial assistance, however, from the state and federal governments was required to fund the implementation of large-scale adaptation projects such as the Avenida Menendez Seawall and the comprehensive adaptation plan at Alexandria’s Jones Point Park. The support of the state governments could also improve the case study cities access to sea level rise science information and public education. To achieve ideal adaptation results, the cities must expand the collaborative planning process to include additional decision-makers and stakeholders. Further, it is critical that short and long-term adaptation planning begins immediately to avoid costly property devastation.

The cities’ historic preservation communities must join the adaptation collaborative planning process and assume a prominent role in protecting historic districts vulnerable to sea level rise. To accomplish this, it will be necessary for preservation

groups to become educated on sea level rise science, the potential effects on historic building materials, and the protective nature of specific adaptations. In addition, historic preservation professionals and property owners will need to realize that adaptations may affect integrity, but without the adaptation, the historic resource may be lost.

CHAPTER VI FINDINGS AND RECOMMENDATIONS

Introduction

My conclusions based on case study findings and supporting literature provide a guide for protecting National Register historic districts on estuarial shorelines from the impacts of sea level rise. For the historic preservation community, adaptation to sea level rise is a complex process requiring an understanding of sea level rise projections and their effects on historic resources. Historic preservation planners and citizen advocates must participate with local residents, multidisciplinary planning groups, and all levels of government to propose and implement sound adaptation strategies. Adaptation methods that anticipate sea level rise rather than merely accounting for current flooding can temporarily minimize the impacts of flooding, storm surge, and land erosion on historic properties. If sea level rise intensifies as projected, local governments will increasingly rely on state and federal agencies for technical and financial support. State government endorsement of climate change adaptation facilitates the granting of federal funds to local areas. The historic preservation community's perspective is essential in the adaptation planning process to extend the longevity of historic districts at risk, maintaining an area's quality of life.

Plan Adaptations in Anticipation of Sea Level Rise

The thesis research indicates that local governments design adaptation strategies

in response to current flooding, storm surge, and erosion risks. Sea level rise projections are not considered, except at Jones Point in Alexandria and Elizabeth City North Carolina. It is critical for local governments, including the historic preservation community, to acknowledge current sea level rise projections when designing adaptations. Otherwise, communities responding to current conditions will be confronted with a costly succession of temporarily relevant protective measures. In Chapter 6 of *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*, Titus and Craghan recommend that it is “economically rational to build in a safety factor today to account for future conditions.”³⁸³ Communities should adhere to this advice and plan today for adaptations that will address future sea level rise scenarios.

As participants in the effort, the historic preservation community should now consider adaptations to safeguard National Register districts. A preemptive adaptation plan potentially limits costly damage to the built environment and curbs economic and social disruption after storm events. Inaction may lead to the loss of irreplaceable historic buildings and historic district integrity. A district could be de-listed from the National Register of Historic Places if many aspects of integrity are negatively impacted.

A preemptive adaptation plan would have minimized Hurricane Sandy (October 2013) storm damage in Long Beach, New York. Citizens there rejected advice to protect the city from ocean storms with engineered dunes while nearby communities constructed 15-foot (4.6-meter) high sand barriers. Hurricane Sandy inflicted \$200 million in damage on unprotected Long Beach. Adjacent communities were comparatively spared.³⁸⁴ Reacting to the damage, the city of Long Beach recently commissioned an eight to ten-

foot (2.4 to 3-meter) high dune barrier, constructed and fully financed by the Army Corps of Engineers.³⁸⁵

Furthermore, planning now to adapt is essential since large-scale adaptation strategies require long periods of time to implement. Formulating project ideas, gaining stakeholder support, securing financing, and project construction consume years of planning. Adaptation protection planned now may not be conceivably in place for years. In the meantime, sea level will likely continue to rise and threaten property. For example, the planning for the Avenida Menendez Seawall began in 1999 after Hurricane Floyd damaged the historic seawall. Fourteen years later, the construction of the new seawall is nearly complete. Construction took one and one half years, while the remaining time was dedicated to project development, stakeholder education, decision-maker reviews, and funding solicitation. During the process, two hurricanes and one tropical storm caused further damage to the historic seawall.

Design Adaptation Strategies at the Local Level

Sea level rise and its effects reflect local conditions. Local residents and city governments are personally involved with the impacts of sea level rise on their natural and built environments. As a result, each of the case study city governments initiated proposals and plans for effective adaptations to flooding, storm surge, and erosion. The local governments were capable of financing short-term (10–50 years), non-structural and small-scale soft adaptations. Larger-scale, hard and soft adaptations, protective over the long-term (more than 50 years), required financial assistance from state and federal government sources.

Likewise, the historic preservation community's local knowledge of an area's historic properties contributes to effective adaptation planning. The group brings an understanding of the local historic, social, economic, and environmental values embodied in historic districts to the adaptation discussion. At the community level, historic preservation professionals and citizen activists are critical participants in the identification and prioritization of historic properties requiring protection from sea level rise.

Adaptation research from the literature also confirms the importance of planning protective sea level rise strategies at the local level. In the chapter from *Collaborative Resilience* on "Getting to Resilience in a Climate-Protected Community," researcher Edward Weber writes that incorporating "community based 'folk knowledge' in problem solving processes" leads to "a more robust set of alternatives for solving problems, and a more reliable and realistic estimate of the parameters affecting program success."³⁸⁶ John Randolph, author of "Creating the Climate Change Resilient Community," criticizes Florida's "top-down" approach as lacking in critical local collaboration.³⁸⁷ Moser, Williams, and Boesch, in "Wicked Challenges at Land's End: Managing Coastal Vulnerability Under Climate Change," observe that many aspects of adaptation planning—education, building stakeholder support, collaborating with scientists, coordinating projects with upper levels of government, and establishment of funding—are manageable at the local level.³⁸⁸

This thesis research identifies specific adaptations that protect historic districts. Non-structural adaptations—stormwater upgrades, flood proofing, and flood resilience—minimize the sea level rise effects of flooding with little impact on historic significance.

Zoning and building codes, also non-structural adaptations, are often effective in mandating adaptation programs that can safeguard historic districts.

Soft adaptations succeed in protecting the built environment, but different strategies are applied according to density. Small-scale green infrastructure, such as natural or constructed swales, rain gardens, water retention areas, permeable surfaces, and individual berms, are appropriate in highly dense historic districts. Local governments or historic property owners typically fund these adaptations. To encourage property owner adaptations, the NPS could arrange federal funding through Historic Tax Credits by authorizing landscape adaptations as qualified rehabilitation expenditures (QREs) in building rehabilitations. Changes to the landscape surrounding historic properties validly preserve the built environment and its cultural heritage.

Large-scale, soft adaptations—wetlands protection and reclamation, barrier beach preservation, open space acquisition, beach and dune nourishment, and vegetative buffer zone creation—can be accommodated in low-density historic districts or near historic districts surrounded by open space. Soft adaptations rarely compromise the integrity of historic districts. In the case study cities, state and the federal governments generally initiated, regulated, and contributed funds to extensive soft adaptation projects. Soft adaptations may offer long-term protection, although continual and costly maintenance is required.

Hard adaptations shield densely constructed historic districts in the case study cities. Specifically, seawalls and floodgates are appropriate for compact districts where historic properties cannot be elevated. The federal government commonly subsidizes a community's hard adaptation projects. In St. Augustine, FEMA funded 75 percent of the

construction costs for the Avenida Menendez Seawall. Hard adaptations, however, often compromise historic district integrity as well as damage the natural environment. The Avenida Menendez Seawall in St. Augustine and the encasement of the Washington, D.C., boundary stone at Jones Point Park exemplify alterations to integrity.

Seawalls serve as long-term adaptations when constructed at heights anticipating sea level rise projections. St. Augustine and Alexandria, however, designed seawall heights for the short-term. With projected sea level rise, tropical storms could potentially overtop the cities' barriers by 2050. In other at-risk communities, citizens have rejected proposals for heightened man-made barriers that eliminated ocean views.³⁸⁹ Preliminary reviews of the proposed floodwall in Alexandria suggest that integrity of location and setting will be affected as the barrier blocks the river view. Local governments' inability to fund exponentially higher costs is another deterrent to the construction of taller seawalls.³⁹⁰

Elevating wood frame buildings can be advantageous in shoreline areas affected by floods and storm surges. Residential property owners in Freeport, Lindenhurst, and Babylon on Long Island elevated their homes prior to Hurricane Sandy and escaped the storm's most damaging effects.³⁹¹ Communities vulnerable to sea level rise could encourage the elevation of all frame buildings, including historic properties, above FEMA's base flood levels through local zoning and building codes.

The mass elevation of neighborhood properties, however, poses major challenges. First, the elevation of residential property can be costly, ranging from \$30,000 to over \$100,000 per property.³⁹² This could result in the inconsistent elevation of historic district properties, reducing district integrity. FEMA's Hazard Mitigation Grant Program and its

Increased Cost of Compliance (ICC) coverage program provide financial assistance for building elevation, but only after properties have been damaged by storms in communities declared as major disaster areas by the state.³⁹³ Additional FEMA elevation funding is available for properties currently affected by flooding, but only in communities participating in the National Flood Insurance Program (NFIP). These programs are: Pre-disaster Mitigation (PDM), Flood Mitigation Assistance, Repetitive Flood Claims (RFC), and Severe Repetitive Loss (SRL). Properties likely to be affected by sea level rise in the future, with no prior damage or risk level, are ineligible for financial support. Likewise, the Small Business Administration (SBA) grants low-interest loans exclusively for the elevation of storm-damaged homes.³⁹⁴ The FEMA and SBA financial assistance programs do not provide aid to communities and property owners wishing to preemptively elevate buildings according to sea level rise projections.

Three existing federal tax credit programs that are applied to historic property rehabilitations may offset the high costs of preemptive building elevation. Historic Tax Credits, Low-Income Housing Tax Credits, and New Market Tax Credits could be applied to the elevation of historic properties in specific categories. Historic Tax Credits are authorized for income producing properties; Low-Income Housing Tax Credits apply to affordable rental housing; and New Market Tax Credits are distributed to low-income census tracts with high poverty rates or low median family income.

Second, the widespread elevation of buildings leads to accessibility issues. Elderly and disabled residents may find it difficult to maneuver tall flights of stairs. Very long and costly ramps with ninety-degree landings could make elevated buildings more accessible.

Last, communities interested in pursuing property elevation must also consider the effects on integrity within historic districts. Setting, design, materials, workmanship, feeling, and association may be compromised in order to protect the buildings from flooding and storm surge. It is recommended that historic preservation planners apply the Mississippi Development Authority's *Elevation Design Guidelines* to the creation of zoning overlay or local historic district guidelines addressing property elevation.

The Alexandria proposal to raise roads and sidewalks is found to be the most damaging adaptation to historic property and to National Register integrity. Elevating infrastructure adjacent to historic district properties minimizes road flooding, but not the damaging water effects on buildings. Further, higher roads and sidewalks can obstruct architectural features of historic properties, compromising integrity. This study recommends that communities avoid raising roads and sidewalks in historic districts unless historic properties are elevated accordingly.

Planning to elevate the land beneath a historic district, however, requires federal funding and a community's willingness to accept a long, disruptive construction schedule. Galveston, Texas, established an early precedent for town elevation after the hurricane devastation in 1900. In February 2013, Highlands, New Jersey, approved raising the entire downtown area ten feet after Hurricane Sandy caused severe damage. At a cost of \$25 to \$30 million, the local government requested engineering expertise and financing from the Army Corps of Engineers to protect its community from future storms.³⁹⁵

Adaptations May Compromise Integrity

Adaptation strategies affect integrity within National Register historic districts to varying degrees. While adaptation alterations may be inevitable, historic preservation professionals must remain critically observant of potential changes to integrity of location, design, setting, workmanship, feeling and association. In National Register historic districts that are also designated as local historic districts, preservation planners and local commissions will need to include new design guidelines that address adaptations such as building retrofits, elevations, and landscape alterations that are historically appropriate. During design reviews, local commissions must weigh the benefits of an adaptation that protects a historic property against the harmful effects of sea level rise on building integrity. It is important that decision-makers carefully incorporate the community's values associated with vulnerable historic resources during the adaptation planning stage. Some residents may prefer that a property remain unaltered by an adaptation, either doubting sea level rise projections or acknowledging that it could limit the building's future. Others may insist that a historic property should be protected by an adaptation regardless of alterations to the resource. Ultimately, a local commission's rulings must evaluate whether the property conveys more meaning to the community as a gradual ruin or as a fully functioning but compromised property.

The State Historic Preservation Office (SHPO) staff reviews will also make this difficult decision when advising on Section 106, National Environmental Policy Act (NEPA), and Section 4(f) reviews regarding the impacts of federally funded adaptation solutions on National Register properties and districts. The historic preservation community chose alterations to integrity in order to protect the historic St. Augustine

Seawall and the boundary marker at Alexandria's Jones Point Park, realizing that the historic resources would be permanently lost without an adaptation response. Design and setting are altered at both sites, although the historic resources still exist as reminders of the past.

Add Social and Environmental Benefits to Cost-Benefit Analysis

Cost-benefit analyses that exclusively apply economic factors when gauging benefits disregard adaptation protection for residential and lower income historic districts. Conversely, historic districts with high real estate valuations and income generating potential are recommended for sea level rise protection. An imbalance of the comprehensive historical and cultural record will result if governments do not evenly evaluate historic districts.

Alexandria's *Potomac River Waterfront Flood Mitigation Study* developed by the CRS Corporation in 2010 examines benefits as: flood depth, structure value, structure content value, structure and content damage, business income loss, and residential displacement costs. Aside from flood depth, all the benefits address economic factors. Social and environmental benefits associated with historic districts (and quality of life) are not considered in Alexandria's cost-benefit analysis. When adaptations are being evaluated for National Register historic districts, cost-benefit analyses must include social, environmental, as well as economic benefits, in order to protect a comprehensive representation of a community's historic past.

My research determines that local governments often do not apply a cost-benefit analysis when planning adaptations to sea level rise impacts. In *Sea Level Rise and*

Global Climate Change, authors Newman, Yohe, Nicholls, and Manion report of costs commonly exceeding benefits at the community level. The authors assume factors other than costs and benefits are taken into account, suggesting an informal analysis of quality of life factors.³⁹⁶

The 2005 FEMA study, *Integrating Historic Property and Cultural Resource Considerations into Hazard Mitigation Planning*, contributes additional evidence supporting the importance of quality of life factors in a cost benefit analysis. FEMA discovers the value of familiar places and local landmarks as areas of emotional comfort for populations who experience devastating property losses.³⁹⁷ This confirms the necessity of including quality of life aspects in cost-benefit analyses.

As sea level rise affects more communities, local governments will compete for adaptation funding. As a result, decision-makers will increasingly rely on cost-benefit analyses to determine the most protective and cost effective projects for implementation. The historic preservation community must advocate for an inclusive assessment of benefits—social, environmental, and economic—to ensure that all historic districts remain at the forefront of sea level rise protection.

Quantifying subjective social and environmental benefits requires the development of a numerical measurement system. Two studies provide the methods to translate social and environmental factors into quantifiable terms. Local governments can apply these practices to quantify benefits for cost-benefit adaptation calculations. The first, The Economist Intelligence Unit's Quality-of-Life Index successfully assigns weights based on a population's numerical ranking of quality of life benefits.³⁹⁸ Another research study by the University of Florida, *Contributions of Historic Preservation to*

Quality of Life of Floridians, stresses the importance of including community indicators in assessing an area's quality of life. Community indicators are assigned numerical values and applied to analyze historic preservation in economic, social, and environmental terms, providing a quantifiable measure for quality of life. "Housing affordability, community draw factors, community use factors, heritage cultural interactions, civic museum partnerships, and neighborhood participation" are factors included in the community indicators analysis. These factors would be also appropriate as benefits when considering the cost effectiveness of adaptations in historic districts.³⁹⁹ In addition, National Register criteria associated with a historic district's nomination should be assigned numerical values and considered a benefit in the cost-benefit calculation.

Educate Local Stakeholders on Sea Level Rise

My analysis of the case study cities reveals that the public is largely unaware of sea level rise science and its projected local impacts. All of the adaptation theorists and researchers discussed in Chapter III—Pelling, Weber, Randolph, and Moser, Williams and Boesch—agree that educating the local citizenry is essential in order to build political support for adaptation decisions. Further, a knowledgeable public can participate in the visioning and planning stages to develop adaptations that address the specific needs and values of the local community. The historic preservation community must also take part in public education sessions concerning sea level rise science and the associated local risks. By understanding the potential scenarios for inundation, the group will be adept at identifying the likely risk levels for historic properties, the first step in adaptation planning.

Citizens of St. Augustine and Elizabeth City have been recently informed of projections for sea level rise and local vulnerabilities. While the Alexandria city government and its citizen commissions possess some knowledge, it has not been communicated to the public. The Alexandria citizens' continued disapproval of the *Waterfront Small Area Plan* could signify how an uninformed public can hinder project support and implementation.

On the other hand, educating the public is not a guarantee that they will back adaptation plans to accommodate sea level rise impacts and protect the built environment. Obstacles to adaptation include a coastal community's skepticism of sea level rise science or disbelief that it will personally affect them. Others may prefer to "wait and see" how sea level rise affects their shorelines before committing to the expense and disruption generated by adaptation plans. The adaptation policy to retreat may seem more logical to residents of some localities. Additionally, the local historic preservation community may prefer not to chance altering the historic character of historic properties through adaptation for a sea level rise scenario that could never materialize.

Although these views are contrary to my thesis research findings, I accept that the decision on how, when, or whether to adapt is ultimately up to the local community. The historic preservation community interprets cultural history through the decisions previous generations made regarding the built environment. Local decision-makers in the twenty-first century will reveal the community's cultural values to future generations through the ways they have chosen to address sea level rise impacts and adaptation strategies.

Nonetheless, I recommend that local historic preservation professionals begin to fully document valued historic resources along vulnerable shorelines if community

sentiment doubts sea level rise projections, reflects a reactionary disaster management philosophy, or prefers adapting through retreat. With each of these positions, historic properties are at risk of deterioration or permanent damage. The early American historical record should be preserved after the historic property no longer serves as a visual reminder. The Historic American Buildings Survey and Historic American Engineering Record (HABS and HAER) and the Historic American Landscape Survey (HALS) could prepare detailed property records for unprotected, at risk properties. These documents would preserve the architectural and cultural record for historic properties lost to the effects of sea level rise.

For communities choosing to collect further evidence proving that sea level rise impacts will occur, historic preservation planners should encourage municipalities to plan now for short-term (10 to 50 years) adaptations. Many short-term solutions are less costly and disruptive to the environment and historic integrity. Sea level rise can be then re-evaluated to determine if long-term (over 50 years) adaptation methods are necessary while short-term adaptations are in place.

Local Governments: Expand Participation within Adaptation Planning Groups

The case study cities demonstrate the participation of multidisciplinary teams of decision-makers and stakeholders in adaptation planning. The scientific and preservation communities, however, were not fully engaged in the adaptation process. Scientific vulnerability studies were available to the cities, although the information was not accessed for implemented adaptations (except at Jones Point Park and Elizabeth City). It is essential that communities develop close relationships with scientists from academic

and governmental groups in order to plan adaptations according to the most current sea level rise science. The scientific community continually monitors and adjusts sea level rise data according to the rate of global climate warming, glacial and polar ice melting, and land subsidence. Further, scientists' expertise in developing coastal vulnerability indices (CVIs) is necessary for accurate sea level rise vulnerability assessments specific to a local area. Localities can access sea level rise data from academic institutions; state coastal management and natural resource offices; the National Resource Council; and, federal agencies such as the U. S. Global Change Research Program, the National Oceanic and Atmospheric Administration (NOAA), the United State Geological Survey (USGS), and the Environmental Protection Agency (EPA).

Similarly, local adaptation planning for sea level rise did not incorporate the views of the local preservation community. Preservation planners from Elizabeth City, North Carolina, and Alexandria, Virginia, were uninvolved in the lead department's (typically public works or engineering) local adaptation planning initiatives. The St. Augustine preservation planner's lack of response might have suggested the same. Preservation planners must not only collaborate in the visioning process, but also advocate for historic property protection from sea level rise. Their involvement should also include monitoring an adaptation's effects on historic building and district integrity.

In addition to adaptation planning, local preservation planners must participate in public education efforts. Historic property owners should be notified of methods that protect properties from the effects of sea level rise. English Heritage's *Flooding and Historic Buildings* and *Disaster Mitigation Strategies for Historic Structures: Protection Strategies* by the 1000 Friends of Florida offer excellent, low-cost, non-structural

adaptation suggestions for flood proofing and flood resilience. Preservation professionals should adapt strategies from these resource guides to suit their communities' building characteristics, neighborhood attributes, and sea level rise vulnerabilities.

State and Federal Governments: Support Adaptation Efforts at Local Levels

While adaptations are best initiated and planned at the local level, state and federal governmental assistance is required when the implementation of adaptation strategies exceeds a community's technical and financial capabilities. Localities may be able to solely finance non-structural adaptations, such as stormwater upgrades, zoning and building code revisions, and building retrofits, applied during the early stages of sea level rise. But, as the effects of sea level rise increase, the number of adaptation solutions and the corresponding costs escalate. Communities will require supplemental funds and accurate scientific data from the federal and state governments to implement and subsidize engineered soft and hard adaptations. All of the adaptation theorists and researchers— Pelling, Weber, Randolph, and Moser, Williams and Boesch—cited in this thesis study acknowledge that state and federal government support for climate change resilience is essential for the implementation of a comprehensive, local adaptation strategy.

Like Florida, Maryland and Delaware supports climate change mitigation and adaptation. Both states also recommend the inclusion of a comprehensive adaptation plan, developed by a multidisciplinary group, within local government master plans. Delaware actively conducts sea level rise public education sessions throughout the state. Importantly, both states project statewide shoreline inundation based on current sea level

rise data. Assessments include the identification of nationally, state, and locally designated historic resources that are vulnerable to sea level rise.

Specifically, Maryland requires “the integration of coastal erosion, coastal storm, and [sea level rise] adaptation and response planning strategies into existing state and local policies and programs.”⁴⁰⁰ The state’s Department of Natural Resources (DNR) assisted Dorchester, Somerset, and Worcester counties with adaptation planning.⁴⁰¹ DNR based these plans on three feet (0.91 meters) of sea level rise by 2100. To preemptively plan, the department recommends that the counties allow a 25-year time frame for designing adaptations.⁴⁰²

The federal government subsidizes expensive adaptation options at the local level through state channels. Federal agency adaptation financing from FEMA and the Army Corps of Engineers, however, is only available for properties with existing flood vulnerabilities or for communities devastated by a natural disaster. Federal funding programs do not encourage preemptive adaptation planning at the state and local levels based on sea level rise projections.

It is critical that the federal government recognizes the relative cost effectiveness of anticipatory adaptation and establishes funding and technical assistance that flows from states to local governments. Federal assistance is also practical since adaptation strategies minimize damage that would be otherwise financed through disaster response measures. FEMA’s \$18 billion debt to the Treasury Department, prior to Hurricane Sandy, is evidence that disaster relief is unsustainable.⁴⁰³ The probable intensification of

sea level rise will place even greater demands on the current emergency management system.

Despite the absence of preemptive efforts, existing federal agencies are well positioned to adopt roles encouraging anticipatory planning and implementation at the local level. The NPS exhibited expertise in adaptation planning and implementation for the protection of historic resources at Jones Point Park in Alexandria, St. Augustine, and Cape Hattaras. Like its English counterpart, English Heritage, the NPS could advise historic shoreline communities on protecting historic properties from the effects of sea level rise through adaptation strategies. In addition, NPS has the capability to develop loan, grant, or tax credit programs that are applicable to historic resources. These could be applied to funding local adaptation strategies.

The United States Department of Housing and Urban Development's (HUD) Sustainable Housing and Communities Initiative may develop as a federal effort supporting preemptive adaptation planning. The initiative's goal is to provide technical planning guidance and distribute grants that champion local sustainability. The Sustainable Housing and Communities Initiative could operate similarly to England's Department for Environment, Food and Rural Affairs (Defra), supporting community sea level rise resiliency plans that benefit the natural and historic environments. The HUD program is designed to coordinate its efforts with other federal agencies, such as FEMA, the Department of Transportation (DOT), and the Environmental Protection Agency (EPA)—agencies involved in flood mitigation and planning for sea level rise impacts.

Additionally, federal agencies provide valuable scientific data and technical analysis critical to preemptive adaptation planning. The Environmental Protection

Agency (EPA), United States Geologic Survey (USGS), and National Oceanic and Atmospheric Administration (NOAA), are expected to continue their development and distribution of sea level rise science information for national, state, and local use.

Further Research

Protecting National Register historic districts and individual properties from the effects of sea level rise requires four additional areas of study and research. First, the identification of additional historic resources not listed in the National Register of Historic Places is essential to comprehensively protect the country's architectural and cultural heritage from the increasing threats of flooding, storm surge, and erosion. Many important historic properties remain undocumented and are not designated in national, state, or local registries. The next area of research requires locational mapping of all historic resources, particularly properties from the "recent past." Historic resources must be accurately located and the registries transferred to Geographic Information Systems (GIS), standard software used in the planning field. When accessible through GIS, historic properties can be superimposed over local sea level rise scenarios (developed using high-resolution elevation data such as LiDAR surveys), resulting in accurate projections of vulnerability levels. Third, the local historic preservation community must prioritize its historic resources based on community values. As sea level rise threatens, it may not be feasible to save all historic properties. Additionally, a priority list may protect historic properties from unnecessary demolitions by emergency responders after storm devastation. Last, it will be necessary for the historic preservation community to determine how to address shoreline retreat. Building relocation is one option,

successfully applied to the Cape Hattaras Lighthouse. For historic properties that will be lost to sea level rise impacts, HABS, HAER, and HALS should thoroughly document properties that face eventual demolition.

Conclusion

Through my research, I arrived at an answer to my thesis question: How can hard, soft, and non-structural adaptation methods be applied to protect the cultural heritage of National Register historic districts from global climate change impacts such as sea level rise? Adaptation strategies indeed safeguard historic properties from sea level rise impacts, but some solutions may diminish integrity.

Certain conditions must be met for adaptations to preserve historic properties on low-lying shoreline areas. First, adaptation strategies must be preemptive, not reactive. Anticipatory adaptation allows for time-intensive planning, provides for cost-effective alternatives, and reduces property damage. Second, adaptations must be locally planned. Locally specific sea level rise vulnerabilities have to be considered to accurately plan adaptation strategies. Adaptations developed at the local level also address the unique needs and characteristics of a community, including the protection of locally valued historic resources.

Third, guarding all types of National Register historic districts from sea level rise must include social and environmental factors, not only economic considerations, into an adaptation cost-benefit analysis. A multidisciplinary cost-benefit assessment will guarantee adaptation protection for lower income and residential National Register historic districts in addition to economically valuable historic districts.

Adaptation planning is a political process, requiring the involvement of citizens and all levels of government. Educating local stakeholders on climate change science and the local effects of sea level rise represents the fourth condition. An informed community contributes local knowledge and values to the adaptation visioning process. Its political support for adaptation is critical to moving strategies from proposals to implementation. Fifth, local governments must expand their adaptation planning networks. Cross-departmental participation is essential for well-developed adaptation policies. Planning groups must include members from the historic preservation and the climate science communities. Last, state and federal governments must acknowledge climate change and the need for preemptive adaptation planning. Their support is critical to adaptation success at the local level. Local governments depend on state and federal governments for sea level rise science data and financial assistance to accurately plan and efficiently implement adaptation solutions.

With these elements addressed, the longevity of historic districts could be extended until shoreline retreat is necessary. At this point, the historic preservation community will need to address the relocation and documentation of historic properties.

CHAPTER VII CONCLUSION

Adapting to sea level rise is a complex and lengthy process. Diverse social, political, and economic points of view must coalesce to establish clear adaptations goals. Questions on the validity of sea level rise projections, concerns about adaptation impacts on the natural and built environment, lack of political support, and insufficient funding are some of the obstacles to adaptation implementation. States that choose to ignore sea level rise science provide a great disservice to their local communities as federal funding and technical assistance are distributed to other competing areas. Financially challenged communities with additional and imminent pressing demands find it difficult to shift the emphasis of government priorities towards adaptation planning. The historic preservation community may hesitate to apply adaptations that are based on uncertain sea level rise projections. Some adaptation methods alter historic properties and impact integrity, such as the Avenida Menendez and Jones Point Park seawalls. Historic preservation planners, advocates, and owners of historic properties may not choose to risk the historic character of buildings in response to an indefinite, future hazard. Reconciling all these concerns and making progress in planning can take decades if a community chooses to adapt to sea level rise.

Since rates of projected sea level rise and adaptation methods are specific to each geographic area, the decision to adapt or to “do nothing” (maintaining the status quo) rests with the locality. The historic preservation community plays a role in either

decision. If adapting to sea level rise, historic preservation planners, citizen advocates, and historic property owners must emerge as vocal decision-makers and stakeholders in the adaptation process. It is essential that they advocate for adaptation protection of historic properties, ensuring that a high level of historic integrity is maintained. In areas choosing against adaptation, it is the responsibility of the historic preservation community to develop an adaptation plan of retreat. This includes documentation of properties that will be eventually demolished due to sea level rise or the relocation of historic properties if inland areas are available.

Nonetheless, my thesis research supports adapting to accommodate sea level rise and protecting historic properties from flooding, storm surge, and erosion. This study's research and data affirm the hypothesis. Yes, hard, soft, and non-structural adaptation methods can be applied to protect the cultural heritage of National Register historic districts from global climate change impacts such as sea level rise. Sea level rise data may pose an element of uncertainty as to the rate of rise, but the body of scientific studies strongly substantiates the likelihood of higher seas, more frequent storms, and increased flooding.

Comprehensive adaptation plans may address projected sea level rise incrementally through short-term methods or long-term strategies. Adaptation solutions may be imperfect, however, they prolong the livelihood of National Register historic districts. These areas create the unique sense of place that is associated with each shoreline community. Historic districts also contribute to an area's social, economic, and environmental well-being and vitality. The unique historical narrative of a place will be

preserved, safeguarding cultural identity for future generations when a community chooses to adapt.

The effects of sea level rise threaten the country's connections to its shoreline heritage, embodied by National Register properties. The gradual increase of flood events and wave damage from severe storms are our wake-up calls. The historic preservation community must preemptively plan for the protection of valued historical resources, continuing the rich cultural heritage of the United States. The time to start is now.

GLOSSARY

Introduction

Adaptation alternatives and sea level rise impacts are described in the glossary.

Sources for the terms are the: “Types of Coastal Structures,” United States Army Corps of Engineers, Coastal and Hydraulics Laboratory; *Coastal Sensitivity to Sea Level Rise*, James G. Titus and Michael Craghan; *Recurrent Flood Study*, Center for Coastal Resources Management; *Flooding and Historic Building*, English Heritage; *Elevation Design Guidelines*, Mississippi Development Authority; “Permeable vs. Impermeable Surfaces,” University of Delaware, Cooperative Extension; “Sea level rise in Norfolk: Netherlands flood prevention presentation,” City of Norfolk, Virginia; and the National Oceanic and Atmospheric Administration.

Adaptation Terms

Beach Replenishment or Nourishment

The addition of sand to beaches, usually from dredging offshore and deposits, to mitigate the effects of erosion and to protect inland areas from storm surges and flooding. A soft adaptation.

Berm

An engineered, raised bank of earthen construction, bordering a body of water, designed to hold back floodwater and storm surge. A soft adaptation.

Breakwater

Barrier structures constructed off shore and usually parallel to the shoreline. Reduce the erosive effects of waves on the land. A hard adaptation.

Building Elevation

Raising buildings to heights above the Federal Emergency Management Agency (FEMA) 100-year flood levels. Limited elevations raise buildings less than five feet or one story. Significant elevations raise buildings one story or more.

Building Retrofit

A category of non-structural adaptations designed specifically for one building.

Bulkhead

A vertical retaining barrier that minimizes erosion by keeping shoreline land from eroding into a body of water. Not typically high enough to protect land from flooding or storm surges. Suitable to protect areas from low energy waves and currents. A hard adaptation.

Defensive Barrier

An adaptation that holds back high seas and storm surge.

Dike

Earthen defensive barriers that protect interior lowlands by restraining and diverting excessive water. A soft adaptation.

Dune Replenishment

Reconstruction of dunes—natural or man-made—to absorb the effects of high waves and storm surge, protecting inland areas from storm damage. Must be reconstructed after severe storms. A soft adaptation.

Erosion

A gradual loss of land surface (rocks, soil, sand) worsened by high water levels and high energy waves generated by severe storms.

Floodgate

Large scale, engineered adaptation, providing barrier protection when gates are closed. Beneficial for areas with active shipping, transportation, and recreational water routes. A hard adaptation.

Flooding

Temporary high water levels resulting from weather events such as severe thunderstorms, tropical storms, and hurricanes. Flooding typically occurs when precipitation falls faster than it can be absorbed by the soil. In coastal areas, storm surges, high tides, and storm driven waves can flood the land.

Flood proofing

Reduces the amount of water entering the interior of a building during floods. A non-structural adaptation.

Flood resilience

Reduces property damage if water flows into a building. A non-structural adaptation.

Green Infrastructure

Planted areas that absorb rainwater and excessive flooding. Roof gardens, green roofs, vegetative buffer zones are examples. A soft adaptation.

Groin

A barrier that extends perpendicular from the shore into the sea as single structure or as a “groin field” to reduce beach erosion, stabilizing beach areas. A hard adaptation.

Hard Adaptation

Large-scale barrier protections that are engineered and technical solutions to sea level rise.

Inundation

Permanent water coverage of the land due to sea level rise.

Jetty

Stone structures implemented to maintain deep navigational channels, protecting harbors and inlets. Similar to a groin. A hard adaptation.

Levee

Earthen defensive barriers that protect lowlands by restraining and diverting excessive water. Same as Dike. A soft adaptation.

Non-Structural Adaptation

Policies and strategies that reduce damage in areas or to individual properties vulnerable to sea level rise. Examples are: flood proofing, flood resilience, infrastructure, building elevation, and zoning code adaptations.

Offensive barrier

Adaptations that limit the force of waves before they reach land.

Permeable Surfaces

Porous surfaces that absorb water, minimizing flooding and stream bank erosion. Areas of vegetation, gravel, and permeable pavers are examples.

Retreat

An adaptation option to acquire vulnerable property with the intention of demolition or relocation. Less costly in rural areas than engineered adaptations where land values are low. Can be cost prohibitive in areas of dense development. An environmentally sustainable adaptation solution.

Revetment

An erosion-proof facing applied to slopes or dikes to protect land from erosion caused by strong waves. Also act as barriers to safeguard land from flooding. A hard adaptation.

Rip-rap Wall

A type of revetment, composed of loose rocks, that minimizes land erosion caused by low energy waves. Also applied at the base of seawalls to reduce wave force. A hard adaptation.

Sandbag Barrier

Individual bags of sand, stacked to create a temporary barrier around buildings prone to flood risk. A non-structural adaptation.

Seawall

Engineered, large scale, vertical barrier protecting expansive inland areas from storm surges and high water levels. A hard adaptation.

Soft Adaptation

Engineered solutions constructed of natural materials, designed to protect the natural and built environments.

Storm Surge

Atypical water levels, driven toward the land by the wind and waves of severe storms. Water levels are above astronomical tides and cause widespread flooding. The extreme force of storm surges can destroy buildings located at low elevations.

Stormwater Management

Municipally planned adaptation that reduces flooding in a local area or neighborhood. The installation of larger stormwater pipes or wider drainage canals facilitates the flow of excess water. Pumping mechanisms may be added in areas of low elevation. A non-structural adaptation.

Water Storage Area

An engineering system that stores excess rainfall and floodwater in large retention ponds. Drains gradually without a pumping mechanism. Often constructed in areas that have been abandoned due to repetitive flooding. A hard adaptation.

Wetlands Reclamation

The rebuilding of wetlands in areas prone to flooding. Marshes absorb excess rainwater, reduce inland flooding, and cushion storm surge effects. A soft adaptation.

Zoning and Building Codes

Local planning codes regulating development and construction. In the case studies, the codes have been created to address stormwater management, building elevation, and vegetative buffer zones in areas vulnerable to the effects of sea level rise. A non-structural adaptation.

ENDNOTES

1. Intergovernmental Panel on Climate Change, “AR4 SYR Synthesis Report - 5.4 Emission Trajectories for Stabilization,” 2007, http://www.ipcc.ch/publications_and_data/ar4/syr/en/mains5-4.html#footnote28.
2. Susanne C. Moser, S. Jeffress Williams, and Donald F. Boesch, “Wicked Challenges at Land’s End: Managing Coastal Vulnerability Under Climate Change,” *Annual Review of Environment and Resources* 77 (2012): 57–58.
3. Virginia Burkett and Margaret Davidson, *Coastal Impacts, Adaptation, and Vulnerabilities* (Washington, DC: Island Press, 2012), 11.
4. United States Geological Survey, “Relative Coastal Vulnerability Assessment of National Park Units to Sea-Level Rise,” September 1, 2009, <http://woodshole.er.usgs.gov/project-pages/nps-cvi/>.
5. Daniel J. Weiss and Jackie Weldman, “Disastrous Spending: Federal Disaster-Relief Expenditures Rise Amid More Extreme Weather,” *Center for American Progress*, April 29, 2013, <http://www.americanprogress.org/issues/green/report/2013/04/29/61633/disastrous-spending-federal-disaster-relief-expenditures-rise-amid-more-extreme-weather/>.
6. The Intergovernmental Panel on Climate Change (IPCC) is an organization of 1,300 international scientists studying climate change. The organization’s reports are often cited in articles related to climate change.
7. Intergovernmental Panel on Climate Change, “IPCC Fourth Assessment Report: Climate Change 2007,” 2007, http://www.ipcc.ch/publications_and_data/ar4/syr/en/mains1.html#1-1.
8. National Oceanic and Atmospheric Administration, “NOAA Research,” 2011, http://www.research.noaa.gov/climate/t_carboncycle.html.
9. Intergovernmental Panel on Climate Change, “IPCC Fourth Assessment Report: Climate Change 2007.”
10. “NOAA Research”
11. Ibid.

12. U.S. Global Change Research Program, "Global Climate Change Impacts in the United States," 2009. <http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf>
13. National Aeronautics and Space Administration, "What's the Difference Between Weather and Climate?" February 1, 2005, http://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html.
14. "Climate Change Panel Warns of Severe Storms, Heatwaves and Floods." The Guardian, March 28, 2012, <http://www.guardian.co.uk/environment/2012/mar/28/climate-change-global-warming-storms-floods>.
15. Spring tides are the high tides that occur twice a month during the full and new moons.
16. "FEMA: Impact of Climate Change on the NFIP," June 22, 2010, <http://chl.erdc.usace.army.mil/dirs/events/319/08%2087th%20CERB%20Crowell.pdf>.
17. Burkett and Davidson, 11.
18. U.S. Global Change Research Program.
19. United States Census Bureau, "Census Data & Emergency Preparedness," November 5, 2012, <http://www.census.gov/newsroom/emergencies/>.
20. United States Geological Survey, "Relative Coastal Vulnerability Assessment of National Park Units to Sea-Level Rise," September 1, 2009, <http://woodshole.er.usgs.gov/project-pages/nps-cvi/>. Together these factors create a coastal vulnerability index (CVI) that is used to assess the likelihood of sea level rise effects on shorelines. The NPS and the USGS developed CVIs for six Atlantic Coast national park units to assist in plans for cultural resource protection.
21. United States Geological Survey, "Sea Level Rise Accelerating in U.S. Coast," September 24, 2012, http://www.usgs.gov/newsroom/article.asp?ID=3256&from=rss_home#.UEe5aKTyaUQ. Land subsidence is a sinking of the ground that occurs on a regional scale by vertical movement of the Earth's crust when fluids such as hydrocarbons and ground water are drained from sedimentary rock.
22. United States Census Bureau, "Census Data and Emergency Preparedness."

23. The National Register of Historic Places is an inventory of historic sites portraying the country's rich architecture, historic, engineering, and cultural heritage. In addition to historic properties listed at the national level, states and municipalities maintain their own historic resource inventories. These lists would also include historic properties at risk of climate change effects. Because state and local inventories are not available in a centralized source, National Register listings will be referenced only in this study.
24. Rustin A. Quaide, National Park Service, "National Register Bulletin: How to Apply the National Register Criteria for Evaluation," November 28, 2001, <http://www.cr.nps.gov/nr/publications/bulletins/nrb15/nrb15.pdf>.
25. "National Historic Landmarks: National Park Service, What Is?," June 28, 2011, <http://www.nps.gov/nhl/whatis.htm>.
26. May Cassar and Robyn Pender, "Climate Change and the Historic Environment," 2003, 26, <http://discovery.ucl.ac.uk/2082/1/2082.pdf>.
27. Ibid., 6.
28. English Heritage, *Flooding and Historic Buildings*, April 2010, 20, <http://www.english-heritage.org.uk/content/publications/publicationsNew/guidelines-standards/flooding-and-historic-buildings/flooding-and-historic-buildings-2nd-ed.pdf>
29. Rachel Cleetus, "Mold After the Hurricane," *New York Times*, May 16, 2013, <http://www.nytimes.com/2013/05/17/opinion/mold-after-the-hurricane.html>.
30. Ibid.
31. 1000 Friends of Florida, Florida Department of State, Division of Historical Resources and the Florida Division of Emergency Management, *Disaster Mitigation for Historic Structures: Protection Strategies*, August 2008, 46.
32. Ibid., 23.
33. Warren Boeschstein, *Historic American Towns Along the Atlantic Coast*, (Baltimore, Maryland: Johns Hopkins University Press, 1999), 1–3. Many Atlantic Coast settlements located along the Fall Line, the geological cliff boundary between the Piedmont and Coastal Plain provinces. Waterfalls created by the Fall Line attracted early settlers interested in harnessing waterpower for industrial development.

34. Ann Horowitz, *Identifying Historic Resources Vulnerable to Sea Level Rise: An Urgent Need to Preserve the Early American Record*. (unpublished document, Goucher College, December 18, 2012).
35. The study considered properties at elevations up to six meters as “vulnerable to sea level rise” since storm surges have the potential of causing damage up to this height.
36. W. Neil Adger, Jon Barnett, F. S. Chapin, III, and Heidi Ellemor, “This Must Be the Place: Underrepresentation of Identity and Meaning in Climate Change Decision-making,” *Global Environmental Politics* 11: 2 (2011): 4.
37. Quaide.
38. Ibid.
39. The Preservation Act of 1966 made grants available for each state to establish a State Historic Preservation Office (SHPO) The SHPOs coordinate statewide preservation activities with the federal efforts of the National Park Service, a bureau of the Department of Interior. One of the primary duties of the SHPO is to guide the development of National Register with the review of nominations.
40. David Felce, and Jonathon Perry, “Quality of Life: Its Definition and Measurement,” *Research in Development Disabilities* 16:1 (January-February 1995): 51.
41. Timothy McLendon, Kristin Larsen, JoAnn Klein, Rhonda Phillips, Glenn Willumson, Lori Pennington-Gray and John Confer, “Contributions of Historic Preservation to the Quality of Life in Florida: Executive Summary,” <http://ufdc.ufl.edu/files/UF00090906/00001/UF-Historic-report-final-2006.pdf>, 2006, 13.
A list of the community indicators used to measure the impact of historic preservation on quality of life is found in “Contributions of Historic Preservation to the Quality of Life in Florida: Executive Summary,” 13, <http://ufdc.ufl.edu/files/UF00090906/00001/UF-Historic-report-final-2006.pdf>. The community indicators fall into four categories. These are: gauging, protecting, enhancing, and interfacing. Gauging assesses the type and quantity of historic resources as well as the preservation activity. Protecting examines the preservation-related ordinances and regulations. Enhancing identifies preservation organizations, community partnerships, and incentive programs. Interfacing analyzes the uses of historic properties.
42. Robert A. Young, *Stewardship of the Built Environment: Sustainability, Preservation, and Reuse*, (Washington, DC: Island Press, 2012), xvi.
43. Ibid., 13.

44. Adjer, Barnett, Chapin, and Ellemor, 5.
45. Jeremy J. Hess, Josephine N. Malilay, and Alan J. Parkinson, "Climate Change: The Importance of Place," *American Journal of Preventive Medicine* 35:5 (November 2008); 20.
46. Federal Emergency Management Agency, *Integrating Historic Property and Cultural Resource Considerations Into Hazard Mitigation Planning*, (Washington, DC: Federal Emergency Management Agency, 2005), http://www.fema.gov/pdf/fima/386-6_Book.pdf.
47. Boeschstein, 23.
48. Young, 35, 161-162.
49. Elizabeth Pearson, "When and Why Have Americans Supported Higher Taxes?" *Scholars Strategy Network*, November 2012, http://www.scholarsstrategynetwork.org/sites/default/files/ssn_basic_facts_pearson_on_supporting_higher_taxes.pdf.
50. Young, 137. *Historic Preservation: An Introduction to Its History, Principles, and Practice (Second Edition)* by Tyler, Ligibil, and Tyler provides a detailed description of these funding and planning tool programs on pages 240-256.
51. Ibid., 34.
52. National Trust for Historic Preservation, "Main Street Reinvestment Statistics," 2013, [http://www.preservationnation.org/main-street/about-main-street/reinvestment-statistics-1.html?utm_source=facebook&utm_medium=like&utm_campaign=Main Street Reinvestment Statistics](http://www.preservationnation.org/main-street/about-main-street/reinvestment-statistics-1.html?utm_source=facebook&utm_medium=like&utm_campaign=Main+Street+Reinvestment+Statistics).
53. Ibid. The United States Congress defunded the Save America's Treasures Program since fiscal year 2011-2012.
54. Young. 168.
55. National Park Service, "Heritage Areas, National Park Service, National Heritage Areas Program," n.d., <http://www.nps.gov/history/heritageareas/INDEX.html>.
56. McLendon, Larsen, Klein, Phillips, Willumson, 21-23.
57. Young, 97.
58. Ibid., 98.

59. Donovan Rypkema, "Sustainability, Smart Growth and Historic Preservation," April 8, 2012, <http://restorejacksonville.com/2012/04/08/donovan-rypkema-sustainability-smart-growth-and-historic-preservation/>.
60. Young, 92.
61. Ibid., 98.
62. Ibid, 100, 102.
63. Food and Agriculture Organization of the United Nations, *Chapter 3: Coping With a Changing Climate: Considerations for Adaptation and Mitigation in Agriculture*, n.d., 38, <http://www.fao.org/docrep/012/i1315e/i1315e03.pdf>.
64. Ibid., 35.
65. Hugh Miller, discussion with author, February 10, 2013.
66. National Park Service, "Moving the Cape Hattaras Lighthouse," April 26, 2013, <http://www.nps.gov/caha/historyculture/movingthelighthouse.htm>.
67. Maria Caffrey and Rebecca Beavers, "Protecting Cultural Resources in Coastal US National Parks from Climate Change:" 92, *The George Wright Forum* 25, no. 2 (2008): 86-97, <http://www.georgewright.org/252caffrey.pdf>.
68. Kenneth R. Fletcher, "Tangier Island and the Way of the Watermen," *People & Places, Smithsonian Magazine*, April 1, 2009, <http://www.smithsonianmag.com/people-places/Tangier-Island-and-the-Way-of-the-Watermen.html?c=y&page=1>.
69. Susan Svrluga, "Tangier Island Will Get Long-awaited Jetty to Protect Harbor, Officials Say," *Washington Post*, November 21, 2012, sec. Local, http://www.washingtonpost.com/local/virginia-news/tangier-island-will-get-long-awaited-jetty-to-protect-harbor-officials-say/2012/11/20/0a93407a-3345-11e2-bfd5-e202b6d7b501_story_1.html.
70. Ibid.
71. Adaptations that are not engineered or technologically developed are defined as non-structural adaptations in this study. The term "non-structural" is applied as an engineering term, not one related to architecture.
72. Moser, Williams, and Boesch, 65.

73. Center for Coastal Resources Management, "Recurrent Flooding Study," 7, no. 2 (Fall 2012): 5, http://www.ccrm.vims.edu/publications/pubs/rivers&coast/fall2012_recurrent_flood.pdf.
74. Ibid.
75. Texas State Historical Association, "Galveston's Response to the Hurricane of 1900," *Texas Almanac*, 1999 1998, <http://www.texasalmanac.com/topics/history/galvestons-response-hurricane-1900>.
76. Ibid.
77. Peter Appleborne, "Highlands, N.J., Proposes Raising the Borough to Escape Hurricanes," *New York Times*, February 22, 2013, <http://www.nytimes.com/2013/02/23/nyregion/highlands-nj-proposes-raising-the-borough-to-escape-hurricanes.html>.
78. National Oceanic and Atmospheric Administration US Department of Commerce, "The Great Galveston Hurricane of 1900," July 19, 2012, http://celebrating200years.noaa.gov/magazine/galv_hurricane/welcome.html#today.
79. "Seawall," *Galveston and Texas History Center at the Rosenberg Library*, October 2004, <http://www.gthcenter.org/exhibits/seawall/index.html>.
80. John H. Lienhard, "No. 865: Raising Galveston," 1997-1988, <http://www.uh.edu/engines/epi865.htm>.
81. Hurricanes: Science and Society:, "1915 Galveston Hurricane," accessed January 16, 2013, <http://www.hurricanescience.org/history/storms/1910s/Galveston/>.
82. "Seawall," *Galveston and Texas History Center at the Rosenberg Library*.
83. James C. McKinley, "Galveston Seeks \$2.2 Billion in Storm Relief," *New York Times*, September 23, 2008, sec. US, <http://www.nytimes.com/2008/09/23/us/23ike.html>.
84. The Times Picayune, "Galveston Seawall Repairs After Hurricane Ike to Be Finished April 1," January 12, 2010, http://www.nola.com/hurricane/index.ssf/2010/01/repairs_on_galveston_seawall_d.html.
85. Eric Berger, "Ike Dike May Be Among Sandy's Casualties," *Houston Chronicle*, November 4, 2012, <http://www.chron.com/news/houston-texas/houston/article/Ike-Dike-may-be-among-Sandy-s-casualties-4005871.php>.

86. Office of Emergency Preparedness & Response, "Storm Surge Maps," accessed January 17, 2013, http://www.norfolk.gov/emergency/storm_surge_maps.asp.
87. Jon Hamilton, "Protection From The Sea Is Possible, But Expensive," *NPR.org*, accessed January 13, 2013, <http://www.npr.org/2012/11/06/164435330/protection-from-the-sea-is-possible-but-expensive>.
88. William Brangham, "Video: Rising Tide in Norfolk, Va.," *Public Broadcasting System, Need to Know*, April 27, 2012, <http://www.pbs.org/wnet/need-to-know/environment/rising-tide-in-norfolk-va/13739/>.
89. Jeanne Mooney, "Norfolk Resident Builds Berm to Protect Home from Floods," *PilotOnline.com*, April 19, 2009, <http://hamptonroads.com/2009/04/norfolk-resident-builds-berm-protect-home-floods>.
90. Emily Yehle, "Local Governments Seek Federal Aid for Planning, Adaptation," December 6, 2012.
91. Brangham, "Video: Rising Tide in Norfolk, Va."
92. Hampton Roads Planning District Commission, "Climate Change in Hampton Roads," (2011): 5, <http://hrpdc.org/Documents/Economics/2011/Hampton%20Roads%20Regional%20Competitiveness.pdf>.
93. Hamilton, "Protection From The Sea Is Possible, But Expensive."
94. *Sea Level Rise in Norfolk: Netherlands Flood Prevention Presentation*, 2012, http://www.youtube.com/watch?v=GiPx16D7Fw4&feature=youtube_gdata_player.
95. Brangham, "Video: Rising Tide in Norfolk, Va."
96. Ibid.
97. English Heritage, *Coastal Defence and the Historic Environment*, June 2012, 2, <http://www.english-heritage.org.uk/content/publications/publicationsNew/guidelines-standards/coastal-defence-and-the-historic-environment/coastaldefenceeh.pdf>.
98. Ibid.
99. Ibid., 7.
100. Ibid., 11–15.

101. National Trust, "Living with a Changing Coastline," n.d., <http://vimeo.com/14954579>.
102. 1000 Friends of Florida et al., *Disaster Mitigation for Historic Structures: Protection Strategies*, August 2008, 22, 33.
103. Ibid., 44.
104. Securing the floor foundation to piers may not withstand strong storm surges, although it may assist with keeping a building intact during flooding.
105. Mississippi Development Authority, *Elevation Design Guidelines*, n.d., 1, <http://www.msdisasterrecovery.com/documents/MDA%20EDG%20Final%20110308.pdf>.
106. Mississippi Development Authority, *Elevating Historic Properties*, accessed January 10, 2013, 3, http://www.msdisasterrecovery.com/documents/historic_properties-hpc.pdf.
107. Ibid., 7.
108. Ibid., 9, 17.
109. Axis Building, LLC, "Cost to Raise Your Home: NJ House Raising," accessed April 21, 2013, <http://www.njhouseraising.com/index.php/cost-to-raise-your-home>.
110. Luis Bojorquez-Tapia and Hallie Eakin, "Conflict and Collaboration in Defining the 'Desired State': The Case of Cozumel, Mexico," in *Collaborative Resilience*, edited by Bruce Evan Goldstein, Cambridge, Massachusetts: MIT Press, 2012, 155.
111. Mark Pelling, *Adaptation to Climate Change*, New York, NY: Routledge, 2010, 69, 81–82, 124.
112. Moser, Williams, and Boesch, 66-67.
113. John Randolph, "Getting to Resilience in a Climate-Protected Community," and Edward P. Weber, "Creating the Climate Change Resilient Community," *Collaborative Resilience*, edited by Bruce Evan Goldstein, Cambridge, MA: MIT Press, 2012, 141-143, 193.
114. Moser, Williams, and Boesch, 68.
115. Ibid., 66-67.

116. Pelling, 5, 164.
117. Ibid., 171.
118. Boeschstein, 265.
119. Historical Archaeology, "St. Augustine, FL: America's Ancient City," *Florida Museum of Natural History*, n.d., <http://www.flmnh.ufl.edu/histarch/sa.htm>.
120. National Park Service, "Florida Historic Places: St. Augustine Town Plan Historic District," n.d., <http://www.nps.gov/nr/travel/geo-flor/24.htm>.
121. "The History of Fort Mose," accessed March 10, 2013, <http://www.fortmose.org/history/history.html>.
122. Boeschstein, 262–263.
123. Ibid., 264.
124. Peter Guinta, "Part of Seawall Destined to Fall," *St. Augustine Record*, December 13, 2000, http://staugustine.com/stories/121300/new_1213000003.shtml.
125. Guinta, "Part of Seawall Destined to Fall."
126. Ibid.
127. Historical Archaeology, "St. Augustine, FL: America's Ancient City."
128. Ibid.
129. Boeschstein, 267.
130. City of St. Augustine, Florida, "Maria Sanchez Lake Weir Project," accessed March 7, 2013, http://www.staugustinegovernment.com/the-city/featured-stories-archive/1_06/mariasan-lakeweir.cfm.
131. Boeschstein, 268, 270–271.
132. Ibid., 272–273.
133. University of Florida, "University of Florida Historic St. Augustine Inc.," November 15, 2012, <http://www.staugustine.ufl.edu/>.
134. Boeschstein, 271.

135. Ibid., 278.
136. United States Census Bureau, “St. Augustine (city) QuickFacts,” January 10, 2013, <http://quickfacts.census.gov/qfd/states/12/1262500.html>.
137. Planning and Building Division, City of St. Augustine, “Architectural Guidelines for Historic Preservation,” October 2011, 26, http://staugustinegovernment.com/your_government/documents/AGHP10.29.12.pdf.
138. City of St. Augustine, Florida, *Historic Preservation*, accessed January 4, 2013, 14, http://www.staugustinegovernment.com/your_government/harb-arch-guidelines/3%20-%20Historic%20Preservation.pdf.
139. Ibid.
140. Dora Crouch and Alex Mundigo, “The City Planning Ordinances of the Law of the Indies Revisited,” *The Town Planning Review* 48, no. 4 (October 1977): 398–401, <http://www.jstor.org/stable/pdfplus/40103295.pdf?acceptTC=true>.
141. National Historic Landmarks Program, *Listing of National Historic Landmarks by State*, accessed March 4, 2013, <http://www.nps.gov/nhl/designations/Lists/FL01.pdf>.
142. National Park Service, “Castillo De San Marcos National Monument,” accessed March 11, 2013, <http://www.nps.gov/casa/index.htm>.
143. Florida Division of Historical Resources, Florida Trust for Historic Preservation, National Park Service, “The Conservation and Preservation of Coquina” (symposium on Historic Building Material in the Coastal Southeast, St. Augustine, Florida, January 24-26, 2000), 9, 19.
144. National Park Service, “Castillo De San Marcos National Monument.”
145. Florida Division of Historical Resources, “Florida’s History Through Its Places: Historical Reports,” accessed March 9, 2013, <http://www.flheritage.com/facts/reports/places/index.cfm?fuseaction=ListAreas&county=St.%20Johns#800>.
146. Planning and Building Division, City of St. Augustine, “Architectural Guidelines for Historic Preservation.”
147. City of St. Augustine, Florida, “Proposed National Register Nominations,” accessed March 8, 2013, http://www.staugustinegovernment.com/the-city/featured-stories-archive/3_07/nat_register_hist_dist.pdf.
148. Boeschstein, 267.

149. Student tour guide, “Flagler College Tour” (Flagler College, January 4, 2013).
150. Planning and Building Division, City of St. Augustine, “Architectural Guidelines for Historic Preservation.”
151. City of St. Augustine, Florida, “Proposed National Register Nominations.”
152. Florida Division of Historical Resources, “Florida’s History Through Its Places: Historical Reports.”
153. Peter Guinta, “Lincolnville Residents See Plans for Development,” *St. Augustine Record*, January 22, 2013, <http://staugustine.com/news/politics/2013-01-22/lincolnville-residents-see-plans-development>.
154. City of St. Augustine, Florida, “Proposed National Register Nominations.”
155. Planning and Building Division, City of St. Augustine, “Architectural Guidelines for Historic Preservation,” 20.
156. City of St. Augustine, Florida, “Proposed National Register Nominations.”
157. City of St. Augustine, Florida, “Nelmar Terrace Soon to Be Seventh on the National Register of Historic Districts,” March 9, 2013, http://www.staugustinegovernment.com/the-city/featured-stories-archive/2_11/NelmarTerraceNR.cfm.
158. Planning and Building Division, City of St. Augustine, “Architectural Guidelines for Historic Preservation.”
159. “Top 10 Cities for Historic Preservation,” *Livability*, accessed March 7, 2013, <http://livability.com/top-10/top-10-cities-historic-preservation/st.-augustine/fl>.
160. Jennifer Edwards, “Forbes: City Among ‘Top 10 Prettiest Towns’,” *St. Augustine Record*, April 4, 2012, <http://staugustine.com/news/local-news/2012-04-04/forbes-city-among-top-10-prettiest-towns>.
161. Tabby is a man-made material—a mixture of lime, sand, and shells. In St. Augustine, tabby was used as a mortar as well as a material to build floors, walls, and roofs.
162. National Trust for Historic Preservation, “Heritage Tourism Assessment & Recommendations,” *Citizens for the Preservation of St. Augustine, Inc.*, 2002, http://cpsa-staug.org/?page_id=86.
163. Ibid.

164. City of St. Augustine, Florida, "Fort Survey," August 2011, http://www.staugustinegovernment.com/the-city/featured-stories-archive/8_10/FortSurvey.cfm.
165. St. Johns County, Florida, "Tourism in St. Johns County," accessed March 12, 2013, <http://www.co.st-johns.fl.us/TDC/index.aspx>.
166. Crouch and Mundigo, 398–401.
167. Albert C. Manucy, *The Houses of St. Augustine, 1565-1821*, Florida: University Press of Florida, 1962), 11.
168. Ibid.
169. Ibid., 68.
170. United States Department of State Geographer, "Google Earth Elevation Data," 2013.
171. Martha Graham, Public Works Director, St. Augustine, discussion with author, February 1, 2013.
172. Jon Burpee, email correspondence with author, December 28, 2012. The date the parking lot was created through landfill is unknown.
173. Northeast Florida Regional Council, "Emergency Preparedness," in *Strategic Regional Policy Plan*, 1997, 58, <http://www.nefrc.org/pdfs/srpp/element3.pdf>.
174. Ibid., 58-59.
175. City of St. Augustine, Florida, "St. Augustine Seawall Flood Mitigation Project," August 22, 2011, http://www.ci.st-augustine.fl.us/the-city/featured-stories-archive/8_11/documents/seawallpresentation1Aa_001.pdf.
176. Northeast Florida Regional Council, *Volume 1-4: Northeast Florida Region Technical Data Report, Regional Hazards Analysis*, accessed March 5, 2013, 11-53, <http://www.nefrc.org/pdfs/SRESP%20web%20version/Vol%20One/VOL%20ONE%20CHAPTER%20II.pdf>.
177. Rhonda Parker, "TS Debby Impacts St. Augustine Sewer System, FEMA Aid Available for 11 Counties," *Examiner.com*, July 5, 2012, <http://www.examiner.com/article/ts-debby-impacts-st-augustine-sewer-system-fema-aid-available-for-11-counties>.
178. Northeast Florida Regional Council, "Emergency Preparedness," 58.

179. National Historic Landmarks Program, "St. Augustine Town Plan Historic District," accessed March 4, 2013, <http://tps.cr.nps.gov/nhl/detail.cfm?ResourceId=1028&ResourceType>.
180. City of St. Augustine, Florida, "St. Augustine Seawall Flood Mitigation Project."
181. Maurice Postal, Keith Joiner, and Tobin Lilly, *Northeast Florida*, The Likelihood of Shore Protection Along the Atlantic Coast of the United State, 2010, 331, <http://risingsea.net/ERL/shore-protection-retreat-sea-level-rise-Northeast-Florida.pdf>.
182. Ibid., 52.
183. National Oceanic and Atmospheric Administration , "Sea Level Rise and Coastal Flooding Impacts," accessed February 13, 2013, <http://www.csc.noaa.gov/slr/viewer/#>.
184. Ibid.
185. Cecile-Marie Sastre, "Historic St. Augustine Seawall, National Historic Preservation Act Section 106 Report," January 10, 2005, 11–12, <http://ufdc.ufl.edu/UF00095518/00002/1j>.
186. Manucy, 13.
187. National Park Service, "Castillo De San Marcos National Monument," May 6 and May 24, 2013, <https://www.facebook.com/CastilloNPS>.'
188. Allen Grove, "The Florida East Coast Railway Buildings at Flagler College," *A Photo Tour of Flagler College*, accessed March 11, 2013, http://collegeapps.about.com/od/phototours/ss/flagler-college-photo-tour_13.htm.
189. Sastre, 22.
190. Burpee, email correspondence with author, December 28, 2012.
191. Ibid.
192. Editorial staff, "Our View: Quick Federal Grant OK Needed for Seawall's Fix," *St. Augustine Record*, August 7, 2011, <http://staugustine.com/opinions/2011-08-17/our-view-quick-federal-grant-ok-needed-seawalls-fix>.
193. Guinta, "Part of Seawall Destined to Fall."
194. Ibid.

195. City of St. Augustine, Florida, “St. Augustine Seawall Flood Mitigation Project.”
196. Ibid.
197. St. Augustine Record, “Mica Gets Funding for Seawall,” *St. Augustine Record*, August 19, 2011, <http://staugustine.com/news/local-news/2011-08-20/mica-gets-funding-seawall>.
198. Jennifer Edwards, “Seawall Project Begins,” *St. Augustine Record*, February 13, 2012, http://staugustine.com/news/local-news/2012-02-13/seawall-project-begins#.UTT_HhnpZQ6.
199. Ibid.
200. This calculation is based on NOAA’s tide data stating the mean tide range in St. Augustine is 4.61 feet (1.4 meters); the spring tide range is 5.15 feet (1.6 meters).
201. Sheldon Gardner, “Downtown’s Flooding Problem Not Expected to Improve,” *StAugustine.com*, November 16, 2012, <http://staugustine.com/news/local-news/2012-11-15/flooding-problem-most-downtown-st-augustine-not-expected-improve>.
202. Ibid.
203. City of St. Augustine, Florida, “Code of Ordinances,” *Municode*, n.d., <http://library.municode.com/index.aspx?clientId=10951>.
204. St. Johns County, Florida, “St. Johns County Flood Facts,” 2012, <http://www.sjcfl.us/media/SJCFemaFlood.pdf>.
205. Postal, Joiner, and Lilly, 326.
206. Florida Atlantic University, National Commission on Energy Policy, *Florida’s Resilient Coasts*, 2007, 14, http://www.cakex.org/sites/default/files/Fl_ResilientCoast.pdf.
207. Governor’s Action Team on Energy and Climate Change, “Florida Climate Action Team: Technical Working Groups,” 2013, <http://www.flclimatechange.us/Adaptation.cfm>.
208. Florida Department of Economic Opportunity, *Implementing “Adaptation Action Area” Policies in Florida*, 2012, <http://www.floridajobs.org/fdcp/dcp/AdaptationPlanning/AAAPolicy.pdf>.
209. Florida Atlantic University, National Commission on Energy Policy, *Florida’s Resilient Coasts*, 16.

210. The Florida Division of Historic Resources has mapped National Register properties on GIS. This data can be overlaid on LiDAR maps to determine historic properties at risk.
211. Postal, Joiner, and Lilly, 342.
212. Ibid.
213. Martha Graham, (Public Works Director, St. Augustine), telephone interview with author, February 1, 2013.
214. Kathryn Frank (Assistant Professor, University of Florida), telephone interview with author, February 1, 2013.
215. Thomas Russell Butchko, *On the Shores of the Pasquotank: The Architectural Heritage of Elizabeth City and Pasquotank County, North Carolina* (Elizabeth City, North Carolina: Museum of the Albemarle, 1989), 3.
216. Ruth Little-Stokes, *National Register of Historic Places Inventory-Nomination Form: Elizabeth City Historic District*, October 18, 1977, <http://www.hpo.ncdcr.gov/nr/PK0003.pdf>.
217. Transportation through the Great Dismal Swamp Canal was limited to flat boats in 1805. In 1826, the canal opened to service larger ships. African Americans followed the forests and swamplands of the canal while escaping from slavery on the Underground Railroad. By 1899, the canal was once again enlarged. Today the canal is a state park as well as the Great Dismal Swamp National Wildlife Refuge. The site is listed on the National Register of Historic Places and is a National Civil Engineering Landmark.
218. Thomas Russell Butchko, *National Register of Historic Places Inventory Registration Form: Northside Historic District*, September 1, 1993, <http://www.hpo.ncdcr.gov/nr/PK0830.pdf>.
219. William A. Griffin, *Ante-bellum Elizabeth City: The History of a Canal Town*, (Elizabeth City, North Carolina: Roanoke Press, Inc., 1970), 69.
220. Catherine W. Bishir and Michael T. Southern, *A Guide to the Historic Architecture of Eastern North Carolina*, (Chapel Hill, North Carolina: University of North Carolina Press, 1996), 98.
221. Little-Stokes.

222. Thomas Russell Butchko, *National Register of Historic Places Inventory Registration Form: Northside Historic District*, March 4, 1994, <http://www.hpo.ncdcr.gov/nr/PK0830.pdf>.
223. Bishir and Southern, 98–99.
224. Boeschstein, 206.
225. Pasquotank County and Elizabeth City, North Carolina, *2004 Advanced Core Land Use Plan*, February 9, 2012, 83, 141, <http://www.co.pasquotank.nc.us/LandUse/Feb%20%2092012%20CERTIFIED%20LUP.pdf>.
226. United States Census Bureau, “Elizabeth City (city) QuickFacts,” January 10, 2013, <http://quickfacts.census.gov/qfd/states/37/3720580.html>.
227. Boeschstein, 206.
228. Little-Stokes.
229. Thomas Russell Butchko, *National Register of Historic Places Inventory Registration Form: Shepard Street–South Road Historic District*, March 11, 1994, <http://www.hpo.ncdcr.gov/nr/PK0833.pdf>.
230. Griffin, 69.
231. Butchko, *National Register of Historic Places Inventory Registration Form: Shepard Street–South Road Historic District*.
232. Thomas Russell Butchko, *National Register of Historic Places Registration Form: Elizabeth City State Teachers College Historic District*, February 28, 1994, <http://www.hpo.ncdcr.gov/nr/PK0421.pdf>.
233. Butchko, *National Register of Historic Places Inventory Registration Form: Northside Historic District*.
234. Pam Stefanowich, “Letter: Don’t ignore other historic areas, Daily Advance, May 10, 2007.
235. Pasquotank County and Elizabeth City, North Carolina, *2004 Advanced Core Land Use Plan*, 141, 184.
236. City of Elizabeth City. North Carolina, “Historic Preservation,” accessed February 6, 2013, http://www.cityofec.com/index.asp?Type=B_BASIC&SEC=%7B0A063787-1F83-4DC9-AF23-CCF0E06DCECC%7D.

237. Pasquotank County and Elizabeth City, North Carolina, *2004 Advanced Core Land Use Plan*, 141.
238. Elizabeth City Downtown, Inc., "Downtown Elizabeth City," November 28, 2012, <http://www.ecdowntown.com/>.
239. Jeff Hampton, "Elizabeth City Pulls in Record Tourism Numbers," August 10, 2012, <http://hamptonroads.com/2012/08/elizabeth-city-pulls-record-tourism-numbers>.
240. Pasquotank County and Elizabeth City, North Carolina, *2004 Advanced Core Land Use Plan*, 134.
241. Daily Advance, "Our View: Cultural Heritage Tourism a Community Booster" February 9, 2012, <http://www.dailyadvance.com/opinion/our-views/our-view-cultural-heritage-tourism-community-booster-907195>.
242. Elizabeth City Historic Neighborhood Association, "Elizabeth City Historic Neighborhood Association," 2007, <http://www.echna.org/>.
243. Elizabeth City Downtown, Inc.
244. Pasquotank County and Elizabeth City, North Carolina, *2004 Advanced Core Land Use Plan*, 141.
245. Young, 100–101.
246. Pasquotank County, North Carolina, "Pasquotank County," n.d., <http://www.co.pasquotank.nc.us/History.htm>.
247. Pasquotank County and Elizabeth City, North Carolina, *2004 Advanced Core Land Use Plan*, 15.
248. Daily Advance, "City's Flatness Worsens Flooding," *Daily Advance*, August 26, 2011.
249. Pasquotank County, North Carolina, *Pasquotank County Multi-Jurisdictional Hazard Mitigation Plan*, accessed February 2, 2013, IV–3, http://www.pasquotankcamdenem.com/EMWebsite/documents/LocalInfo/Pasquotank_HazardMitigationPlan.pdf.
250. Ibid., IV–22.
251. Butchko, *National Register of Historic Places Inventory Registration Form: Northside Historic District*.

252. State Climate Office of North Carolina, “Hurricanes: Statistics,” accessed February 8, 2013, <https://www.ncclimate.ncsu.edu/climate/hurricanes/statistics.php?state=NC>.
253. Pasquotank County, North Carolina, *Pasquotank County Multi-Jurisdictional Hazard Mitigation Plan*, IV–19.
254. National Weather Service, “Hurricanes in History,” accessed February 8, 2013, <http://www.nhc.noaa.gov/outreach/history/#floyd>.
255. Pasquotank County, *Pasquotank County Multi-Jurisdictional Hazard Mitigation Plan*, n.d., IV–11.
256. North Carolina Department of Cultural Resources, “Hurricane Floyd Damage Report: Historic Buildings,” November 15, 1999, <http://www.hpo.ncdcr.gov/floyd1.htm>.
257. National Weather Service, “NHC Tropical Cyclone Report,” accessed February 8, 2013, <http://www.nhc.noaa.gov/2003isabel.shtml?>.
258. National Weather Service, Raleigh, NC, “Hurricane Isabel,” accessed February 9, 2013, <http://www4.ncsu.edu/~nwsfo/storage/cases/20030918/>.
259. Claudia R. Brown, *Hurricane Isabel Damage To Historic Structures*, October 15, 2003, <http://www.hpo.ncdcr.gov/IsabelReport.pdf>.
260. Albemarle-Pamlico Conservation and Communities Collaborative and Albemarle-Pamlico National Estuary Program, *Public Listening Sessions: Sea Level Rise and Population Growth in North Carolina*, February 19, 2009, 29, http://portal.ncdenr.org/c/document_library/get_file?uuid=a756e1a5-1ece-4ae7-99c1-59b58cc7f076&groupId=61563.
261. Ibid.
262. National Oceanic and Atmospheric Administration Tides and Currents, “Duck, NC,” February 20, 2013, http://tidesandcurrents.noaa.gov/station_info.shtml?stn=8651370+Duck,+NC.
263. James M. Hawheee (Policy and Engagement Manager, Albemarle-Pamlico National Estuary Partnership), email correspondence with author, January 31, 2013.
264. Surging Seas, “Elizabeth City North Carolina, February 14, 2013, http://sealevel.climatecentral.org/surgingseas/place/cities/NC/Elizabeth_City#surge=5&show=cities¢er=15/36.3044/-76.2299

265. Pasquotank County and Elizabeth City, North Carolina, *2004 Advanced Core Land Use Plan*, 13, 31.
The exact sea level rise projections considered for the study are unknown.
266. Daily Advance, “City’s Flatness Worsens Flooding,” *Daily Advance*, August 26, 2011.
267. Daily Advance, “Rainstorm Leaves 900 in the Dark,” *Daily Advance*, May 6, 2012.
268. City of Elizabeth City, North Carolina, *Storm Water Management Ordinance*, 2001, A-6-9, 14, 16, <http://www.cityofec.com/vertical/Sites/%7b19DF6A6A-CE57-43EF-A53C-DE6F51122031%7d/uploads/%7b79F3F29F-78A3-4BC6-AE88-913C2D94D168%7d.PDF>.
269. Pasquotank County and Elizabeth City, North Carolina, *2004 Advanced Core Land Use Plan*, 25, 129.
270. The FEMA definition for base flood elevation is the level of surface water that has a 1% chance of occurring or exceeded in one year. Base Flood Elevations are noted as BFE on the FEMA Flood Insurance Rate Maps (FIRM).
271. Elizabeth City, *Unified Development Ordinance: Article 12, Environmental and Special Purpose Regulations*, 1999, 12-19-20, 12-23-24, 12-26, <http://www.cityofec.com/vertical/Sites/%7B19DF6A6A-CE57-43EF-A53C-DE6F51122031%7D/uploads/%7B73DFC232-EFBA-45FC-958C-B001665995DE%7D.PDF>.
272. Daily Advance, “City Celebrates Completion of Shepard–Water Project,” *Daily Advance*, March 30, 2012.
273. Daily Advance, “Water-Shepard Work Set to Begin Soon,” *Daily Advance*, August 7, 2011.
274. Wetlands not only provide flood protection, but also protect water quality and create habitats for wildlife.
275. Tracy Morris, and Patrick Smith, “Charles Creek Park Wetland Restoration: Year One Monitoring Report,” March 2008, [http://www.nceep.net/GIS_DATA/Charles%20Creek%20Park%20%2379%20\(EEP\)/MONITORING%20REPORTS/2007%20Report/1CharlesCreek_79_2007_MY1_MainBody.pdf](http://www.nceep.net/GIS_DATA/Charles%20Creek%20Park%20%2379%20(EEP)/MONITORING%20REPORTS/2007%20Report/1CharlesCreek_79_2007_MY1_MainBody.pdf).
276. Pasquotank County and Elizabeth City, North Carolina, *2004 Advanced Core Land Use Plan*, 138, 139, 141, 178, 184.

277. Ibid., 84.
278. AP3C is composed of Elizabeth City State University, Albemarle-Pamlico National Estuary Program, Cape Hatteras National Seashore, Environmental Defense, National Audubon Society, North Carolina Coastal Federation, North Carolina Coastal Land Trust, North Carolina Department of Environment and Natural Resources, North Carolina Division of Water Resources, Nature Conservancy (North Carolina Chapter), United State Forest Service-GAP, and the United States Fish and Wildlife Service-Roanoke Refuge. The Albemarle-Pamlico Sound is the second largest estuary in the United States, encompassing the water area bordered by the Outer Banks on the east and by the North Carolina mainland in the west. Five large rivers, including the Pasquotank, connect to the sounds.
279. Albemarle-Pamlico Conservation and Communities Collaborative and Albemarle-Pamlico National Estuary Program, 57, 60.
280. Ibid., 17.
281. Ibid.
282. Pasquotank County and Elizabeth City, North Carolina, *2004 Advanced Core Land Use Plan*, 11.
283. Angela B. Cole (Senior Planner, Elizabeth City, North Carolina), email correspondence with Ann Horowitz, February 15, 2013.
284. James M. Hawheee (Policy and Engagement Manager, Albemarle-Pamlico National Estuary Partnership) “NC DENR Climate Change Initiative,” discussion with author, May 10, 2013.
285. North Carolina State Historic Preservation Office, “Disaster Information,” accessed February 13, 2013, <http://www.hpo.ncdcr.gov/disaster.htm>.
286. Alexandria Archaeology, *Alexandria Waterfront History Plan*, 2010, 9, <http://alexandriava.gov/uploadedFiles/planning/info/Waterfront/AACWaterfrontHistoryPlan.pdf>.
287. Ethelyn Cox, *Historic Alexandria Virginia Street by Street: Survey of Existing Early Buildings* (Howell Press, 1989), x.
288. Ibid., xvi.
289. City of Alexandria, Virginia, “Discovering the Decades: 1790s,” accessed February 18, 2013, <http://alexandriava.gov/historic/info/default.aspx?id=28296>.

290. Christopher Goodwin & Associates, *Phase I and II: Archaeological Investigations at Cameron Farm and Cameron Mill. Hoffman Properties*, 2005, 18.
291. Alexandria Archaeology, *Alexandria Waterfront History Plan*, 12.
292. City of Alexandria, Virginia, "1700-1799 - A Timeline of Alexandria History," accessed February 17, 2013, http://www3.alexandriava.gov/city/timeline/alex_timeline_1700.html.
293. Lisa Kraus, John Bedell, and John LeeDecker, *John Bruin and the Slave Trade*, June 2007, 13, <http://alexandriava.gov/uploadedFiles/historic/info/archaeology/ARSiteReportBruinSlaveJailAX172.pdf>.
294. Alexandria Black History Museum, "Alexandria's African American History," April 2, 2012, <http://www.alexandriava.gov/historic/blackhistory/default.aspx?id=37214>.
295. William Seale, *A Guide to Historic Alexandria*, (Alexandria, Virginia: City of Alexandria 250th Anniversary Commission, 2000), 50–58.
296. City of Alexandria, Virginia, "Discovering the Decades: 1900s," January 5, 2011, <http://alexandriava.gov/historic/info/default.aspx?id=28728>.
297. Seale, 63–66.
298. United States Census Bureau, "Alexandria (city) QuickFacts," January 10, 2013, <http://quickfacts.census.gov/qfd/states/51/5101000.html>.
299. Raymond A. Mohl, *The New City: Urban America in the Industrial Age, 1860-1920* (H. Davidson, 1985), 28.
300. "Alexandria Sites on the National Register of Historic Places," January 3, 2013, <http://alexandriava.gov/historic/info/default.aspx?id=29750>.
301. Cox, x.
302. Barry Mackintosh, "Jones Point Lighthouse Ad District of Columbia South Cornerstone National Register of Historic Places Inventory-Nomination Form," January 24, 1980.
303. URS Corporation, *Potomac River Waterfront Flood Mitigation Study: Evaluation and Recommendation of Mitigation Measures*, July 2010, 4–3, http://alexandriava.gov/uploadedFiles/tes/info/Final_Potomac_Mitigation_Studyx.pdf.

304. John M. Berry, "Old Town Aura: A Delicate Mix," *Washington Post*, February 9, 1981.
305. Melissa Quinn, "Tourism Pays Big Dividends for City," *Alexandria Times*, October 2, 2012, <http://alextimes.com/2012/10/tourism-pays-big-dividends-for-city/>.
306. Seale, 63–66.
307. Young, 161–162.
308. City of Alexandria, VA, "Video Webcast Archive," n.d., http://alexandria.granicus.com/ViewPublisher.php?view_id=53.
309. Gibbs Planning Group, Inc., *King Street Retail Analysis*, 2009, 22, <http://alexandriava.gov/uploadedFiles/planning/info/kingstreet/20090619FINALGibbsKingStreetRetailAnalysis.pdf>.
310. Management Analysis, Inc., *A Study of the Torpedo Factory Art Center*, February 1, 2010, 6, 9, 11, <http://alexandriava.gov/uploadedFiles/recreation/arts/TORPEDO%20FACTORY%20STUDY%20Final%202.2.10.pdf>.
311. Northern Virginia Regional Commission, *Sustainable Shorelines Community Management in Northern Virginia Phase II*, December 2012, 10, <http://www.deq.virginia.gov/Portals/0/DEQ/CoastalZoneManagement/FundsInitiativesProjects/task12-07-09.pdf>.
312. City of Alexandria, Virginia, "Waterfront Small Area Plan," July 13, 2012, 29, <http://alexandriava.gov/special/waterfront/default.aspx?id=18940>.
313. City of Alexandria, Virginia, "Potomac River Flood Mitigation Study," February 13, 2013, <http://alexandriava.gov/uploadedFiles/special/WaterfrontPlan/PotomacRiverFloodMitigation21513.pdf>.
314. National Oceanic and Atmospheric Administration, "Tides and Currents," accessed March 12, 2013, <http://tidesandcurrents.noaa.gov/>.
315. United States Department of State Geographer, "Google Earth Elevation Data," 2013.
316. Northern Virginia Regional Commission, *Sustainable Shorelines Community Management in Northern Virginia Phase II*, 16.
317. Virginia Coastal Zone Management Program, *Section 309 Needs Assessment & Strategy*, April 2011, 30, <http://coastalmanagement.noaa.gov/mystate/docs/va3092011.pdf>.

318. Virginia Institute of Marine Study, *Recurrent Flooding Study for Tidewater Virginia*, January 2013, 85, http://ccrm.vims.edu/recurrent_flooding/Recurrent_Flooding_Study_web.pdf.
319. Ibid., 88.
320. Ibid., 90.
321. National Oceanic and Atmospheric Administration, “Isabel Wind,” accessed February 9, 2013, <http://www.erh.noaa.gov/mhx/Images/IsabelWind.gif>.
322. United States Department of Commerce, *Hurricane Isabel September 18-19, 2003*, May 2004, 14, <http://www.nws.noaa.gov/om/assessments/pdfs/isabel.pdf>.
323. Kevin Ambrose, “Washington’s Worst Five Hurricanes and Tropical Storms,” *The Washington Post - Blogs*, August 25, 2011, http://www.washingtonpost.com/blogs/capital-weather-gang/post/washingtons-worst-five-hurricanes-and-tropical-storms/2011/08/23/gIQAR1ZtdJ_blog.html.
324. National Weather Service, “Tropical Cyclone Report: Hurricane Isabel,” January 16, 2004, 4, <http://www.nws.noaa.gov/om/assessments/pdfs/isabel.pdf>.
325. Ibid., 32.
326. Ibid., 37.
327. URS Corporation, 2–3.
328. Northern Virginia Regional Commission, *Sustainable Shorelines and Community Management Project: Phase I Report*, September 1, 2008, 25, <http://www.deq.virginia.gov/Portals/0/DEQ/CoastalZoneManagement/task12-06-08.pdf>.
329. Virginia Institute of Marine Study, 85.
330. Alexandria Archaeology, *Alexandria Waterfront History Plan*, 77.
331. Ibid., 78.
332. Ibid., 82.
333. Northern Virginia Regional Commission, *Sustainable Shorelines Community Management in Northern Virginia Phase II*, 15.
334. City of Alexandria, Virginia, “Waterfront Small Area Plan,” 29.

335. Ibid.
336. City of Alexandria, Virginia, *Waterfront Small Area Plan, Chapter 2: Goals and Waterfront Wide Elements*, February 25, 2012, 29, http://alexandriava.gov/uploadedFiles/planning/info/Waterfront/Chapter%202_High%20Quality%20for%20Print_FINAL_070612-2.pdf.
337. Brent Steury, (Natural Resources Program Manager, National Park Service), email correspondence with author, February 19, 2013.
338. City of Alexandria, Virginia, “Jones Point Park Improvements Project,” February 27, 2012, <http://alexandriava.gov/recreation/info/default.aspx?id=34692>.
339. National Park Service, “Jones Point Park Environmental Assessment, June 2007,” June 2007, 20, <http://parkplanning.nps.gov/document.cfm?parkID=186&projectID=13128&documentID=19647>.
340. Alexandria Archaeology Museum, City of Alexandria, Virginia, “Alexandria Heritage Trail,” January 5, 2013, <http://alexandriava.gov/HeritageTrail/#Jones%20Point>.
341. National Park Service, “Jones Point Park Environmental Assessment, June 2007,” 118–119.
342. City of Alexandria, Virginia, *Environmental Action Plan 2030*, June 2008, 30, 52, 53, http://ecocity.ncr.vt.edu/docs/FINAL_EAP_06_18_09.pdf.
343. URS Corporation, 4–10.
344. Ibid., 2–6.
345. Ibid., 2–7.
346. City of Alexandria, Virginia, “Waterfront Small Area Plan,” 29.
In Alexandria, a four foot (1.2 meter) flood occurs every 1.5 years; an eight foot (2.4 meters) flood every 30 years; and, a 10.2 (3.1 meters) foot flood every 100 years. As sea level rise increases, the probability of these flood heights being reached will become more frequent.
347. URS Corporation, 6–10, 6–19.
348. City of Alexandria, Virginia, “Waterfront Small Area Plan,” 29.
349. URS Corporation, 6–9.

350. City of Alexandria, Virginia, “Waterfront Small Area Plan,” 30.
351. URS Corporation, 7–1.
352. URS Corporation, 6–29.
353. Ibid., 7–1., 7-1
354. Ibid.
355. Ibid., 6–36.
356. Ibid., 6–39, 6–41.
357. Ibid., 6–19, 6–23.
358. Ibid., 6–25.
359. Ibid., 27.
360. City of Alexandria, Virginia, “Waterfront Small Area Plan,” 29.
361. Ibid., 28.
362. Ibid., 143.
363. Alexandria News, “CAAWP To Unveil Alternative Waterfront Plan,” *Alexandria News*, October 26, 2011, <http://www.alexandrianews.org/2011/2011/10/caawp-to-unveil-alternative-waterfront-plan/>.
364. Patricia Sullivan, “City Officials Reject Alternative Alexandria Waterfront Plan,” *Washington Post*, November 21, 2011, http://articles.washingtonpost.com/2011-11-21/local/35282542_1_city-plan-historic-city-public-input.
365. Carla Branch, “Alexandria City Council Approves Waterfront Small Area Plan,” *Alexandria News*, January 22, 2012, <http://www.alexandrianews.org/2012/01/alexandria-city-council-approves-waterfront-small-area-plan/>.
366. Taylor Holland, “Alexandria Forges Ahead with Waterfront Plan Despite Legal Battles,” *Washington Examiner*, August 22, 2012, <http://washingtonexaminer.com/alexandria-forges-ahead-with-waterfront-plan-despite-legal-battles/article/2505670>.

367. Rashad Young, "Letter to the Community Regarding the Waterfront Plan," February 15, 2013, <http://alexandriava.gov/uploadedFiles/special/WaterfrontPlan/CityManagerLettertoCommunityReWaterfrontAnnouncementFebruary152013.pdf>.
368. Northern Virginia Regional Commission, *Sustainable Shorelines Community Management in Northern Virginia Phase II*.
369. Jennifer Weeks, "Whatever You Call It, Sea Level Rises in Virginia," *Scientific American*, August 21, 2012, <http://www.scientificamerican.com/article.cfm?id=whatever-you-call-it-sea-level-rises-in-virginia&page=3>.
370. Ibid.
371. Ibid.
372. City of Alexandria, Virginia, *Environmental Action Plan 2030*, 52.
373. National Park Service, "Jones Point Park Environmental Assessment: Finding Of No Significant Impact," November 2007".
374. Moser, Williams, and Boesch, 65.
375. Ian N. Robertson, H. Ronal Riggs, Solomon C. S. Yim, and Yin Lu Young, "Lessons from Hurricane Katrina Storm Surge on Bridges and Buildings," *Journal of Waterway, Port, Coastal, and Ocean Engineering* 133, no. 6 (December 2007): 464.
376. Sheldon Gardner, "Downtown's Flooding Problem Not Expected to Improve.
377. Martha Graham, (Public Works Director, St. Augustine), discussion with Ann Horowitz, February 1, 2013.
378. Mississippi Development Authority, *Elevation Design Guidelines*, accessed January 20, 2013, 12.
379. The success of the wetlands reclamation project to minimize flooding in the Shephard Street – South Road Historic District is unclear since evidence of flooding exists on historic properties in the area. In addition, "High Water" warning signs are placed throughout the neighborhood.
380. Randolph, 141.
381. Vincent Birdsong, Vincent (Supervisor and Database Administrator, Florida Division of Historical Resources), discussion with author, October 19, 2012.

382. Jane J. Lee, "Update: Revised North Carolina Sea Level Rise Bill Goes to Governor," *Science*, July 3, 2012, <http://news.sciencemag.org/scienceinsider/2012/07/update-revised-north-carolina-se.html>.
383. Titus and Craghan, "Chapter 6: Shore Protection and Retreat," 101.
384. Mireya Navarro and Rachel Nuwer, "After Hurricane Sandy, Dunes Prove They Blunt Storms," *New York Times*, December 3, 2012, sec. Science / Environment, <http://www.nytimes.com/2012/12/04/science/earth/after-hurricane-sandy-dunes-prove-they-blunt-storms.html>.
385. "Army Corps of Engineers Project Update," *The City of Long Beach, New York*, March 19, 2013, http://www.longbeachny.gov/index.asp?Type=B_PR&SEC=%7B33BD7D65-42BC-45CB-ABAB-A6E2B4FB1BFB%7D&DE=%7B197B34A0-69CD-49D9-9587-7AA76E72A027%7D.
386. Weber, 193.
387. Randolph, 141-143.
388. Moser, Williams, and Boesch, 67.
389. Navarro and Nuwer.
390. Titus and Craghan, "Chapter 6: Shore Protection and Retreat," 101.
391. Sarah Crichton and Keith Herbert, "Advice for the Sandy-slammed from LIers with Raised Homes," *Newsday*, March 17, 2013, <http://www.newsday.com/classifieds/real-estate/advice-for-the-sandy-slammed-from-liers-with-raised-homes-1.4830830>.
392. Axis Building, LLC, "Cost to Raise Your Home: NJ House Raising," accessed April 21, 2013, <http://www.njhouseraising.com/index.php/cost-to-raise-your-home>.
393. Crichton and Herbert.
394. Eugene Palk, "What Sandy Victims Need to Know About New Height Rules for Their Homes," *NJ.com*, February 5, 2013, http://www.nj.com/news/index.ssf/2013/02/what_sandy_victims_need_to_kno.html.
395. Peter Appleborne, Highlands, "N.J., Proposes Raising the Borough to Escape Hurricanes," *New York Times*, February 22, 2013, <http://www.nytimes.com/2013/02/23/nyregion/highlands-nj-proposes-raising-the-borough-to-escape-hurricanes.html>.

396. James E. Neumann, E., Gary Yohe, Robert Nicholls, and Michelle Manion. *Sea Level Rise and Global Climate Change: A Review of Impacts to U.S. Coasts* (Washington, DC: Pew Center for Global Climate Change, February 2000), 26, http://www.c2es.org/docUploads/env_sealevel.pdf.
397. Federal Emergency Management Agency, *Integrating Historic Property and Cultural Resource Considerations Into Hazard Mitigation Planning*, v.
398. The Economist, *The Economist Intelligence Unit's Quality of Life Index*, The World in 2005, accessed April 23, 2013, http://www.economist.com/media/pdf/QUALITY_OF_LIFE.pdf.
399. McLendon, Larsen, Klein, Phillips, Glenn, Willumson, Pennington-Gray, Confer, 13.
400. Jessica Grannis, *Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use* (Georgetown Climate Center, October 2011), 17–18, http://www.georgetownclimate.org/sites/default/files/Adaptation_Tool_Kit_SLR.pdf.
401. "Sea Level Rise Response Strategy Worcester County, Maryland" features an in depth analysis of the projected effects of sea level rise on historic resources. The benefits of protecting as well as relocating the historic properties is briefly addressed in the study. <http://www.dnr.state.md.us/dnrnews/pdfs/Worcester.pdf>.
402. Grannis, 18.
403. Jennifer Liberto, "FEMA Funds May Not Be Enough to Cover Sandy Flooding Costs," *CNNMoney*, October 2012, <http://money.cnn.com/2012/10/31/news/economy/fema-flood-sandy/index.html>.

BIBLIOGRAPHY

- 1000 Friends of Florida on behalf of the Division of Historical Resources, Florida Department of State and the Division of Emergency Management, Florida Department of Community Affairs, Division of Historical Resources, Florida Department of State, Division of Emergency Management, and Florida Department of Community Affairs. *Disaster Planning for Florida's Historic Resources*. May 2006.
<http://www.1000friendsofflorida.org/?s=disaster+manual&x=0&y=0>.
- 1000 Friends of Florida, Florida Department of State, Division of Historical Resources and the Florida Division of Emergency Management, Florida Department of State, Division of Historical Resources, and Florida Division of Emergency Management. *Disaster Mitigation for Historic Structures: Protection Strategies*. August 2008.
- Adams, William R. *St. Augustine and St. Johns County: A Historical Guide*. Sarasota, Florida: Pineapple Press Inc., 2009.
- Adjer, W. Neil, Jon Barnett, F. S. Chapin, III, and Heidi Ellemor. "This Must Be the Place: Underrepresentation of Identity and Meaning in Climate Change Decision-making." *Global Environmental Politics* 11, no. 2 (2011): 1–25.
<http://www.tyndall.ac.uk/sites/default/files/adgeretal-gep2011.pdf>.
- Albemarle Economic Development Commission. "Elizabeth City." accessed February 2, 2013. http://discoverec.com/whos_here/industrysectors.php.
- Albemarle-Pamlico Conservation and Communities Collaborative, and Albemarle-Pamlico National Estuary Program. *Public Listening Sessions: Sea Level Rise and Population Growth in North Carolina*. February 19, 2009.
http://portal.ncdenr.org/c/document_library/get_file?uuid=a756e1a5-1ece-4ae7-99c1-59b58cc7f076&groupId=61563.
- Alexander, Edward P. "Alexandria Historic District National Register of Historic Places Inventory-Nomination Form." April 2, 1969.
http://www.dhr.virginia.gov/registers/Cities/Alexandria/100-0121_Alexandria_HD_1969_Final_Nomination_NRHP.pdf.

- Alexandria Archaeology Museum. *Alexandria Waterfront History Plan*, 2010.
<http://alexandriava.gov/uploadedFiles/planning/info/Waterfront/AACWaterfrontHistoryPlan.pdf>.
- Alexandria Archaeology Museum, City of Alexandria, Virginia. "Alexandria Heritage Trail." January 5, 2013. <http://alexandriava.gov/HeritageTrail#Jones%20Point>.
- Alexandria Black History Museum. "Alexandria's African American History." *City of Alexandria, Virginia*. April 2, 2012.
<http://www.alexandriava.gov/historic/blackhistory/default.aspx?id=37214>.
- Alexandria Convention and Visitors Association. "Alexandria Convention and Visitors Association: Historic Landmarks." accessed February 16, 2013.
<http://www.visitalexandriava.com/about-alexandria/history/historic-landmarks/#.USAGJOjiRdr>.
- Alexandria News. "CAAWP To Unveil Alternative Waterfront Plan." *Alexandria News*, October 26, 2011. <http://www.alexandrianews.org/2011/2011/10/caawp-to-unveil-alternative-waterfront-plan/>.
- Ambrose, Kevin. "Washington's Worst Five Hurricanes and Tropical Storms." *Washington Post*, August 25, 2011.
http://www.washingtonpost.com/blogs/capital-weather-gang/post/washingtons-worst-five-hurricanes-and-tropical-storms/2011/08/23/gIQR1ZtdJ_blog.html.
- Applebome, Peter. "Highlands, N.J., Proposes Raising the Borough to Escape Hurricanes." *New York Times*, February 22, 2013.
<http://www.nytimes.com/2013/02/23/nyregion/highlands-nj-proposes-raising-the-borough-to-escape-hurricanes.html>.
- Avrami, Erica, Randall Mason, and Marta de la Torre. *Values and Heritage Conservation*. The Getty Institute, Los Angeles, 2000.
http://www.getty.edu/conservation/publications_resources/pdf_publications/pdf/valuesrpt.pdf.
- Axis Building, LLC. "Cost to Raise Your Home: NJ House Raising." accessed April 21, 2013. <http://www.njhouseraising.com/index.php/cost-to-raise-your-home>.
- Badger, Emily. "5 Ideas That Could Have Prevented Flooding in New York." *The Atlantic Cities*, October 31, 2012.
<http://www.theatlanticcities.com/technology/2012/10/5-ideas-could-have-prevented-flooding-new-york/3754/>.
- Band, Larry, and David Salvesen, eds. *Climate Change Committee Report*, 2009.
http://www.ie.unc.edu/PDF/Climate_Change_Report.pdf.

- Beasley, Ellen. *The Alleys and Back Buildings of Galveston: An Architectural and Social History*. Houston, Texas: Rice University Press, 1996.
- Bellanante, Ginia. "Paying to Rebuild After the Storm, Now and in the Future." *New York Times*, November 16, 2012.
<http://www.nytimes.com/2012/11/18/nyregion/paying-to-rebuild-after-the-storm-now-and-in-the-future.html>.
- Berger, Eric. "Ike Dike May Be Among Sandy's Casualties." *Houston Chronicle*, November 4, 2012. <http://www.chron.com/news/houston-texas/houston/article/Ike-Dike-may-be-among-Sandy-s-casualties-4005871.php>.
- Berry, John M. "Old Town Aura: A Delicate Mix." *Washington Post*, February 9, 1981.
- Bishir, Catherine W., and Michael T. Southern. *A Guide to the Historic Architecture of Eastern North Carolina*. Chapel Hill, North Carolina: University of North Carolina Press, 1996.
- Boeschstein, Warren. *Historic American Towns Along the Atlantic Coast*. Baltimore, Maryland: Johns Hopkins University Press, 1999.
- Bojorquez-Tapia, Luis, and Hallie Eakin. "Conflict and Collaboration in Defining the 'Desired State': The Case of Cozumel, Mexico." In *Collaborative Resilience*, edited by Bruce Evan Goldstein, 153-176. Cambridge, Massachusetts: MIT Press, 2012.
- Branch, Carla. "Alexandria City Council Approves Waterfront Small Area Plan." *Alexandria News*, January 22, 2012.
<http://www.alexandrianews.org/2012/01/alexandria-city-council-approves-waterfront-small-area-plan/>.
- Brangham, William. "Video: Rising Tide in Norfolk, Va." *Public Broadcasting System, Need to Know*. April 27, 2012. <http://www.pbs.org/wnet/need-to-know/environment/rising-tide-in-norfolk-va/13739/>.
- Brown, Claudia R. *Hurricane Isabel Damage To Historic Structures*. North Carolina State Historic Preservation Office, October 15, 2003.
<http://www.hpo.ncdcr.gov/IsabelReport.pdf>.
- Brown, Paige. "A Storm Is a' Brewing." *From The Lab Bench*, June 12, 2012.
http://www.scilog.com/from_the_lab_bench/a-storm-is-a-brewing/.
- Building Conservation. "Flood Damage in Historic Buildings." 2010.
http://www.buildingconservation.com/articles/flood/flood_damage.htm.

- Burkett, Virginia, and Margaret Davidson. *Coastal Impacts, Adaptation, and Vulnerabilities*. Washington, DC: Island Press, 2012.
<http://www.coastalstates.org/wp-content/uploads/2011/03/Coastal-Impacts-Adaptation-Vulnerabilities-Oct-2012.pdf>.
- Butchko, Thomas Russell. *National Register of Historic Places Inventory Registration Form: Northside Historic District*. March 4, 1994.
<http://www.hpo.ncdcr.gov/nr/PK0830.pdf>.
- . *National Register of Historic Places Inventory Registration Form: Riverside Historic District*. March 11, 1994. <http://www.hpo.ncdcr.gov/nr/PK0832.pdf>.
- . *National Register of Historic Places Inventory Registration Form: Shepard Street Historic District*. March 11, 1994.
<http://www.hpo.ncdcr.gov/nr/PK0833.pdf>.
- . *National Register of Historic Places Registration Form: Elizabeth City Historic District (Boundary Expansion)*. March 7, 1994.
<http://www.hpo.ncdcr.gov/nr/PK0831.pdf>.
- . *National Register of Historic Places Registration Form: Elizabeth City State Teachers College Historic District*. February 28, 1994.
<http://www.hpo.ncdcr.gov/nr/PK0421.pdf>.
- . *On the Shores of the Pasquotank: The Architectural Heritage of Elizabeth City and Pasquotank County, North Carolina*. Elizabeth City, North Carolina: Museum of the Albemarle, 1989.
- Caffrey, Maria, and Rebecca Beavers. "Protecting Cultural Resources in Coastal US National Parks from Climate Change." *The George Wright Forum* 25, no. 2 (2008): 86-97. <http://www.georgewright.org/252caffrey.pdf>.
- Cassar, May, and Robyn Pender. "Climate Change and the Historic Environment." 2003.
<http://discovery.ucl.ac.uk/2082/1/2082.pdf>.
- Casselmann, Ben. "Planning the 'Ike Dike' Defense." *Wall Street Journal*, June 4, 2009.
<http://online.wsj.com/article/SB124407051124382899.html>.
- Center for Coastal Resources Management. "Recurrent Flooding Study." 7, no. 2 (Fall 2012): 1-8. http://www.ccrm.vims.edu/publications/pubs/rivers&coast/fall2012_recurrent_flood.pdf.
- Christopher Goodwin & Associates. *Phase I and II: Archaeological Investigations at Cameron Farm and Cameron Mill. Hoffman Properties*. 2005.

- Church, John A., and Neil J. White. "A 20th Century Acceleration in Global Sea-level Rise." *Geophysical Research Letters* 33, no. 1 (2006).
doi:10.1029/2005GL024826.
- City of Alexandria, Virginia. "1700-1799 - A Timeline of Alexandria History." accessed February 17, 2013.
http://www3.alexandriava.gov/city/timeline/alex_timeline_1700.html.
- . "Alexandria Historic District Expansion National Register of Historic Places Inventory-Nomination Form." October 31, 1984.
http://www.dhr.virginia.gov/registers/Cities/Alexandria/100-0121_Alexandria_HD_1984_NRHP_Addendum.pdf.
- . "Alexandria Sites on the National Register of Historic Places." January 3, 2013.
<http://alexandriava.gov/historic/info/default.aspx?id=29750>.
- . "Discovering the Decades: 1790s." accessed February 18, 2013.
<http://alexandriava.gov/historic/info/default.aspx?id=28296>.
- . "Discovering the Decades: 1900s." January 5, 2011.
<http://alexandriava.gov/historic/info/default.aspx?id=28728>.
- . *Energy and Climate Change Action Plan*. March 14, 2011.
<http://alexandriava.gov/uploadedFiles/tes/eco-city/DraftEnergyClimateActionPlan03.14.2011.pdf>.
- . *Environmental Action Plan 2030*. June 2008.
http://ecocity.ncr.vt.edu/docs/FINAL_EAP_06_18_09.pdf.
- . "Flooding Information." accessed February 16, 2013.
<http://alexandriava.gov/Flooding>.
- . "Historic District Boundaries." accessed February 3, 2013.
http://alexandriava.gov/uploadedFiles/planning/info/pnz_districtmap.pdf.
- . "Historic Preservation." accessed February 16, 2013.
<http://alexandriava.gov/historic/info/default.aspx?id=29674>.
- . "Jones Point Park Improvements Project." February 27, 2012.
<http://alexandriava.gov/recreation/info/default.aspx?id=34692>.
- . "Potomac River Flood Mitigation Study." presented at the Old Town Civic Association, February 13, 2013.
<http://alexandriava.gov/uploadedFiles/special/WaterfrontPlan/PotomacRiverFloodMitigation21513.pdf>.

- . “Video Webcast Archive.” accessed February 19, 2013.
http://alexandria.granicus.com/ViewPublisher.php?view_id=53.
- . “Waterfront Small Area Plan.” July 13, 2012.
<http://alexandriava.gov/special/waterfront/default.aspx?id=18940>.
- . *Waterfront Small Area Plan, Chapter 2: Goals and Waterfront Wide Elements*. February 25, 2012.
http://alexandriava.gov/uploadedFiles/planning/info/Waterfront/Chapter%202_High%20Quality%20for%20Print_FINAL_070612-2.pdf.
- . *Waterfront Small Area Plan, Chapter 5: Implementation*. February 25, 2012.
http://alexandriava.gov/uploadedFiles/planning/info/Waterfront/Chapter%205_High%20Quality%20for%20Print_FINAL_070612-6.pdf.
- City of Elizabeth City, North Carolina. *Article XII Environmental and Special Purpose Regulations*. September 13, 1999.
<http://www.cityofec.com/vertical/Sites/%7B19DF6A6A-CE57-43EF-A53C-DE6F51122031%7D/uploads/%7B73DFC232-EFBA-45FC-958C-B001665995DE%7D.PDF>.
- . “Elizabeth City National Register Historic Districts.” accessed January 27, 2013.
<http://www.cityofec.com/vertical/Sites/%7B19DF6A6A-CE57-43EF-A53C-DE6F51122031%7D/uploads/%7B00B1505B-10E8-4FB2-9A0D-2A6E29352119%7D.JPG>.
- . “Historic Preservation.” accessed February 16, 2013.
http://www.cityofec.com/index.asp?Type=B_BASIC&SEC=%7B0A063787-1F83-4DC9-AF23-CCF0E06DCECC%7D.
- . “Interesting City Statistics/Helpful Facts.” accessed February 2, 2013.
http://www.cityofec.com/index.asp?Type=B_BASIC&SEC={2A61F98E-FB96-4A6A-BDF1-DA36B3E75800}.
- . *Storm Water Management Ordinance*. 2001.
<http://www.cityofec.com/vertical/Sites/%7b19DF6A6A-CE57-43EF-A53C-DE6F51122031%7d/uploads/%7b79F3F29F-78A3-4BC6-AE88-913C2D94D168%7d.PDF>.
- . *Unified Development Ordinance: Article 12, Environmental and Special Purpose Regulations*. 1999.
<http://www.cityofec.com/vertical/Sites/%7B19DF6A6A-CE57-43EF-A53C-DE6F51122031%7D/uploads/%7B73DFC232-EFBA-45FC-958C-B001665995DE%7D.PDF>.

City of Long Beach, New York. "Army Corps of Engineers Project Update." *The City of Long Beach, New York*, March 19, 2013.
http://www.longbeachny.gov/index.asp?Type=B_PR&SEC=%7B33BD7D65-42BC-45CB-ABAB-A6E2B4FB1BFB%7D&DE=%7B197B34A0-69CD-49D9-9587-7AA76E72A027%7D.

City of Norfolk, Virginia. "Flood Prevention & Mitigation: Flood Awareness & Mitigation." accessed January 13, 2013. <http://www.norfolk.gov/flooding/>.

———. "Flood Prevention & Mitigation: Flooding Strategy." accessed January 13, 2013. http://www.norfolk.gov/flooding/flooding_strategy.asp.

———. "Flood Prevention & Mitigation: Tidally Influenced Flood Prone Areas." accessed January 13, 2013. http://www.norfolk.gov/flooding/flood_prone_areas.asp.

———. "Flood Prevention & Mitigation: What the City Is Doing." accessed January 13, 2013. <http://www.norfolk.gov/flooding/city.asp>.

———. "National Historic Districts." accessed January 18, 2013. http://www.norfolk.gov/planning/national_historic_district.asp.

City of St. Augustine, Florida. "Architectural Guidelines for Historic Preservation." October 2011. http://www.staugustinegovernment.com/your_government/documents/AGHP2.pdf.

———. "Architectural Guidelines for Historic Preservation." accessed March 4, 2013. <http://www.oldcity.com/>.

———. "Avenida Menendez Seawall Project." 2012. <http://staugustineseawall.com>.

———. "City Invites Citizens' Input on Seawall Project." accessed March 4, 2013. http://www.staugustinegovernment.com/the-city/featured-stories-archive/8_02/seawallproj.cfm.

———. "Code of Ordinances." *Municode*, accessed March 18, 2013. <http://library.municode.com/index.aspx?clientId=10951>.

———. "Flood Hazard Information." accessed January 27, 2013. <http://www.staugustinegovernment.com/businesses/flood-hazard-info.cfm>.

———. "Fort Survey." August 2011. http://www.staugustinegovernment.com/the-city/featured-stories-archive/8_10/FortSurvey.cfm.

- . *Historic Preservation*, accessed January 4, 2013.
http://www.staugustinegovernment.com/your_government/harb-arch-guidelines/3%20-%20Historic%20Preservation.pdf.
- . “Maria Sanchez Lake Weir Project.” accessed March 7, 2013.
http://www.staugustinegovernment.com/the-city/featured-stories-archive/1_06/mariasan-lakeweir.cfm.
- . “Nelmar Terrace Soon to Be Seventh on the National Register of Historic Districts.” accessed March 9, 2013. http://www.staugustinegovernment.com/the-city/featured-stories-archive/2_11/NelmarTerraceNR.cfm.
- . “Proposed National Register Nominations.” accessed March 9, 2013.
http://www.staugustinegovernment.com/the-city/featured-stories-archive/3_07/nat_register_hist_dist.pdf.
- . “Riberia St. Improvements.” accessed March 4, 2013.
<http://www.staugustinegovernment.com/the-city/featured-stories-archive/RiberiaSt.Improvements05.09.cfm>.
- . “Saving the Seawall.” accessed January 28, 2013. http://www.ci.st-augustine.fl.us/the-city/featured-stories-archive/8_11/save seawall2.cfm.
- . “St Augustine Seawall Project.” 2012. <http://staugustineseawall.com>.
- . “St. Augustine Seawall Flood Mitigation Project.” August 22, 2011.
http://www.ci.st-augustine.fl.us/the-city/featured-stories-archive/8_11/documents/seawallpresentation1Aa_001.pdf.
- Cleetus, Rachel. “Mold After the Hurricane.” *New York Times*, May 16, 2013, sec. Opinion. <http://www.nytimes.com/2013/05/17/opinion/mold-after-the-hurricane.html>.
- Climate Adaptation Knowledge Exchange. “Climate Adaptation Knowledge Exchange.” 2012. <http://www.cakex.org/>.
- Coastal & Hydraulics Laboratory. “Types of Coastal Structures.” *United States Army Corps of Engineers*. accessed April 30, 2013.
<http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=ARTICLES;513>.
- Colonial Place, Riverview Civic League. “Colonial Place, Riverview Civic League.” January 18, 2013. <http://cprv.net/>.
- Cox, Ethelyn. *Historic Alexandria Virginia Street by Street: Survey of Existing Early Buildings*. McLean, Virginia: EPM Publications, 1989.

- Crichton, Sarah, and Keith Herbert. "Advice for the Sandy-slammed from LIers with Raised Homes." *Newsday*, March 17, 2013.
<http://www.newsday.com/classifieds/real-estate/advice-for-the-sandy-slammed-from-liers-with-raised-homes-1.4830830>.
- Crouch, Dora, and Alex Mundigo. "The City Planning Ordinances of the Law of the Indies Revisited." *The Town Planning Review* 48, no. 4 (October 1977): 397–418.
<http://www.jstor.org/stable/pdfplus/40103295.pdf?acceptTC=true>.
- Crowell, Mark. "Impact of Climate Change on the NFIP." Coastal Engineering Research Board Meeting, June 22, 2010. <http://chl.erdc.usace.army.mil/dirs/events/319/08%2087th%20CERB%20Crowell.pdf>.
- Curry, Andrew. "Climate Change: Sites in Peril." April 2009.
http://archive.archaeology.org/0903/etc/climate_change.html.
- Daily Advance. "City Celebrates Completion of Shepard-Water Project." *Daily Advance*, March 30, 2012.
- . "City's Flatness Worsens Flooding." August 26, 2011.
- . "Our View: Cultural Heritage Tourism a Community Booster." February 9, 2012.
<http://www.dailyadvance.com/opinion/our-views/our-view-cultural-heritage-tourism-community-booster-907195>.
- . "Rainstorm Leaves 900 in the Dark." *Daily Advance*, May 6, 2012.
- . "Water-Shepard Work Set to Begin Soon." *Daily Advance*, August 17, 2011.
- Daniels, Jennifer. "Barrier to Aid Sea Wall." *St. Augustine Record*, January 31, 2011.
<http://staugustine.com/news/local-news/2011-01-30/barrier-aid-sea-wall#.UTT4oxnpZQ6>.
- Daytona Beach Museum of Arts and Sciences. "Dow Museum of Historic Houses." Accessed March 12, 2013. <http://www.moas.org/dowmuseum.html>.
- Dean, Cornelia. *Against the Tide: The Battle for America's Beaches*. New York, New York: Columbia University Press, 2001.
- Delaware Department of Natural Resources and Environmental Control. *Preparing for Tomorrow's High Tide*. July 2012. <http://www.dnrec.delaware.gov/coastal/Documents/SeaLevelRise/AssesmentForWeb.pdf>.

- . *Sea Level Rise Mapping: Society and Economy*, accessed April 25, 2013.
<http://www.dnrec.delaware.gov/coastal/Documents/SeaLevelRise/MappingSocEcon.pdf>.
- Department of Energy. *Climate Change and Infrastructure, Urban Systems, and Vulnerabilities*. February 29, 2012.
<http://www.esd.ornl.gov/eess/Infrastructure.pdf>.
- Department of State Geographer. "Google Earth Elevation Data." 2013.
- Detroit Photographic Co. "Alcazar Hotel Casino Pool." *Florida Memory*, ca 1905.
<http://floridamemory.com/items/show/27195>.
- Detroit Publishing Company. "Seawall and Beach, Galveston, Texas." Still image, 1910.
<http://www.loc.gov/pictures/item/det1994016277/PP/>.
- . "The Sea Wall, St. Augustine, Fla." 1902.
<http://www.loc.gov/pictures/resource/det.4a05603/>.
- Dismal Swamp Welcome Center. "History." 2013.
<http://www.dismalswampwelcomecenter.com/History.php>.
- Don Diego Quiroga y Lorada. "Sea Wall at St. Augustine, Florida." January 8, 1690. St. Augustine Historical Society.
- Donovan Rypkema. "Sustainability, Smart Growth and Historic Preservation." April 8, 2012. <http://restorejacksonville.com/2012/04/08/donovan-rypkema-sustainability-smart-growth-and-historic-preservation/>.
- East Carolina University. "North Carolina Coastal Atlas." *North Carolina Coastal Atlas*. 2009. <http://nccohaz.ecu.edu/flex/>.
- Editorial staff. "Our View: Quick Federal Grant OK Needed for Seawall's Fix." *St. Augustine Record*, August 7, 2011. <http://staugustine.com/opinions/2011-08-17/our-view-quick-federal-grant-ok-needed-seawalls-fix>.
- Edwards, Jennifer. "Barrier to Aid Sea Wall." *StAugustine.com*, January 31, 2011.
<http://staugustine.com/news/local-news/2011-01-30/barrier-aid-sea-wall>.
- . "Forbes: City Among 'Top 10 Prettiest Towns'." *St. Augustine Record*, April 4, 2012. <http://staugustine.com/news/local-news/2012-04-04/forbes-city-among-top-10-prettiest-towns>.

- . “Seawall Project Begins.” *St. Augustine Record*, February 13, 2012.
http://staugustine.com/news/local-news/2012-02-13/seawall-project-begins#.UTT_HhnpZQ6.
- . “Squabble over Seawall.” *St. Augustine Record*, November 5, 2009.
<http://staugustine.com/news/local-news/2009-11-05/squabble-over-seawall>.
- Elizabeth City Downtown, Inc. “Downtown Elizabeth City.” November 28, 2012.
<http://www.ecdowntown.com/>.
- Elizabeth City Historic Neighborhood Association. “Elizabeth City Historic Neighborhood Association.” 2007. <http://www.echna.org/>.
- Elizabeth City State University Center for Green Research and Evaluation. *Green Report: Metrics and Resources to Understand and Grow a Sustainable Economy in Northeast North Carolina*, October 2011.
<http://www.ecsu.edu/greencenter/docs/greenReport.pdf>.
- Elizabeth City Historic Neighborhood Association. “Elizabeth City Historic Walking Tour: Main Street Commercial District.” accessed February 6, 2013.
<http://www.echna.org/documents/MSCCommWeb.pdf>.
- English Heritage. *Climate Change and the Historic Environment*. June 2012.
<http://www.english-heritage.org.uk/content/publications/publicationsNew/guidelines-standards/climate-change-and-the-historic-environment/climate-change.pdf>.
- . *Coastal Defence and the Historic Environment*. June 2012. <http://www.english-heritage.org.uk/content/publications/publicationsNew/guidelines-standards/coastal-defence-and-the-historic-environment/coastaldefenceeh.pdf>.
- . *Flooding and Historic Buildings*. April 2010. <http://www.english-heritage.org.uk/content/publications/publicationsNew/guidelines-standards/flooding-and-historic-buildings/flooding-and-historic-buildings-2nd-ed.pdf>.
- . “Protected Landscapes.” *Historic Environment Local Management*. 2013.
<http://www.helm.org.uk/managing-and-protecting/protected-landscapes/>.
- . *Shoreline Management Plan Review and the Historic Environment*. June 2006.
<http://www.english-heritage.org.uk/content/publications/publicationsNew/guidelines-standards/shoreline-management-plan-review-and-historic-environment/shoreline-management-plan-review.pdf>.

- Environmental Protection Agency. "Climate Change Impacts and Adapting to Change." April 22, 2013. <http://www.epa.gov/climatechange/impacts-adaptation/>.
- . "Explore Climate Ready Estuaries." Data & Tools, January 11, 2013. <http://water.epa.gov/type/oceb/cre/explore.cfm>.
- Environmental Protection Agency, Region 3, Air Protection Division. "The Impact of Climate Change on the Mid-Atlantic Region." accessed January 5, 2013. <http://www.epa.gov/reg3artd/globclimate/ccimpact.html>.
- Fairbanks, George Rainsford. *The Spaniards in Florida: Comprising the Notable Settlement of the Huguenots in 1564, and the History and Antiquities of St. Augustine, Founded A.d. 1565*. Jacksonville, Florida: C. Drew, 1868.
- Fears, Darryl. "A New Way of Thinking as Sea Levels Rise." *Washington Post*, June 27, 2011. http://www.washingtonpost.com/national/health-science/a-new-way-of-thinking-as-sea-levels-rise/2011/06/23/AGq96TmH_story.html?wpisrc=emailtoafriend.
- . "Built on Sinking Ground, Norfolk Tries to Hold Back Tide Amid Sea-level Rise." *Washington Post*, June 18, 2012. http://www.washingtonpost.com/national/health-science/built-on-sinking-ground-norfolk-tries-to-hold-back-tide-amid-sea-level-rise/2012/06/17/gJQADUsxjV_story_2.html.
- Fears, Darryl, and Juliet Eilperin. "Coastal Cities Seek Protections Against Superstorms." *Washington Post*, November 4, 2012. http://articles.washingtonpost.com/2012-11-04/national/35503373_1_storm-water-houston-area-galveston.
- Federal Emergency Management Agency. "Elevation Certificate." *FEMA*. accessed March 28, 2013. <http://www.fema.gov/national-flood-insurance-program-2/elevation-certificate>.
- . "Environmental Planning and Historic Preservation Program." accessed March 28, 2013. <http://www.fema.gov/environmental-planning-and-historic-preservation-program>.
- . "Hazard Mitigation Planning Resources." accessed March 28, 2013. <http://www.fema.gov/hazard-mitigation-planning-resources>.
- . *Integrating Historic Property and Cultural Resource Considerations Into Hazard Mitigation Planning*, Washington, DC: Federal Emergency Management Agency, 2005. http://www.fema.gov/pdf/fima/386-6_Book.pdf.
- . "Natural Disasters." February 11, 2013. <http://www.ready.gov/natural-disasters>.

- . “Pre-Disaster Mitigation Program.” November 10, 2010.
<http://www.fema.gov/pre-disaster-mitigation-grant-program>.
- Felce, David, and Jonathon Perry. “Quality of Life: Its Definition and Measurement.” *Research in Development Disabilities* 16, no. 1 (February 1995): 51–74.
- Feuer, Alan. “Protecting New York City, Before Next Time.” *New York Times*, November 3, 2012, sec. N.Y. / Region.
<http://www.nytimes.com/2012/11/04/nyregion/protecting-new-york-city-before-next-time.html>.
- “Flagler College Tour.” Flagler College, January 4, 2013.
- Fletcher, Kenneth R. “Tangier Island and the Way of the Watermen.” *People & Places, Smithsonian Magazine*, April 1, 2009. <http://www.smithsonianmag.com/people-places/Tangier-Island-and-the-Way-of-the-Watermen.html?c=y&page=1>.
- Florida Atlantic University, National Commission on Energy Policy. *Florida’s Resilient Coasts*. 2007. http://www.cakex.org/sites/default/files/Fl_ResilientCoast.pdf.
- Florida Department of Community Affairs. *Protecting Florida’s Communities*. September 2005.
http://research.fit.edu/sealevelriselibrary/documents/doc_mgr/449/Florida_Community_Protection_-_DCA_2005.pdf.
- Florida Department of Economic Opportunity. “Florida Adaptation Planning.” 2013.
<http://www.floridajobs.org/community-planning-and-development/programs/technical-assistance/community-resiliency/adaptation-planning>.
- . *Implementing “Adaptation Action Area” Policies in Florida*. 2012.
<http://www.floridajobs.org/fdcp/dcp/AdaptationPlanning/AAAPolicy.pdf>.
- Florida Division of Historical Resources. “Florida’s History Through Its Places: Historical Reports.” accessed March 9, 2013.
<http://www.flheritage.com/facts/reports/places/index.cfm?fuseaction=ListAreas&county=St.%20Johns#800>.
- Florida Division of Historical Resources, Florida Trust for Historic Preservation, and National Park Service. “The Conservation and Preservation of Coquina.” 64. St. Augustine, Florida, 2000.

- Foderaro, Lisa W. "Fire Island Is Relieved, but More Vulnerable, After Hurricane Sandy." *New York Times*, November 19, 2012. <http://www.nytimes.com/2012/11/20/nyregion/fire-island-is-relieved-but-more-vulnerable-after-hurricane-sandy.html>.
- Food and Agriculture Organization of the United Nations. *Chapter 3: Coping With a Changing Climate: Considerations for Adaptation and Mitigation in Agriculture*. accessed January 9, 2013. <http://www.fao.org/docrep/012/i1315e/i1315e03.pdf>.
- Fort Mose Historical Society. "The History of Fort Mose." 2012. <http://www.fortmose.org/history/history.html>.
- Friends of the Torpedo Factory. "Torpedo Factory Art Center." accessed February, 19, 2013. http://www.torpedofactory.org/about_us.htm.
- Funk, McKenzie. "Deciding Where Future Disasters Will Strike." *New York Times*, November 3, 2012. http://www.nytimes.com/2012/11/04/opinion/sunday/deciding-where-future-disasters-will-strike.html?_r=0.
- Galveston and Texas History Center at the Rosenberg Library. "Seawall." *Galveston and Texas History Center at the Rosenberg Library*, October 21, 2004. <http://www.gthcenter.org/exhibits/seawall/index.html>.
- Gardner, Sheldon. "Downtown's Flooding Problem Not Expected to Improve." *StAugustine.com*, November 16, 2012. <http://staugustine.com/news/local-news/2012-11-15/flooding-problem-most-downtown-st-augustine-not-expected-improve>.
- . "Foundation of New Seawall About Halfway Done." *St. Augustine Record*, September 28, 2012. <http://staugustine.com/news/local-news/2012-09-27/foundation-new-seawall-about-halfway-done>.
- . "Parts of Downtown St. Augustine Flood as Severe Storms Move through the Area." *St. Augustine Record*, August 21, 2012. <http://staugustine.com/police-report/2012-08-21/parts-downtown-st-augustine-flood-severe-storms-move-through-area>.
- . "Riberia to Get Flood Relief." *StAugustine.com*, July 6, 2011. <http://staugustine.com/news/local-news/2011-07-06/riberia-get-flood-relief>.
- . "Video: Storms Flood Parts of Downtown St. Augustine." *StAugustine.com*, August 21, 2012. <http://staugustine.com/news/local-news/2012-08-21/storms-flood-parts-downtown-st-augustine>.

- Georgetown Climate Center. "Adaptation Clearinghouse." accessed April 21, 2013.
<http://www.georgetownclimate.org/adaptation/clearinghouse>.
- Georgia Department of Natural Resources. *After the Flood: Rebuilding Communities through Historic Preservation*, September 1997.
http://georgiashpo.org/sites/uploads/hpd/pdf/flood_rebuilding_communities.pdf.
- Ghent Neighborhood League. "Norfolk Citizen Flooding Task Force." *Ghent Neighborhood League*, November 11, 2011.
<http://ghentva.org/2012/11/11/norfolk-citizen-flooding-task-force/>.
- Gibbs Planning Group, Inc. *King Street Retail Analysis*, 2009.
<http://alexandriava.gov/uploadedFiles/planning/info/kingstreet/20090619FINALGibbsKingStreetRetailAnalysis.pdf>.
- Glass, Alexander, and Orrin H. Pilkey. "Denying Sea-level Rise: How 100 Centimeters Divided the State of North Carolina." *American Geosciences Institute*, April 21, 2013. <http://www.earthmagazine.org/article/denying-sea-level-rise-how-100-centimeters-divided-state-north-carolina>.
- Goldstone, Heather. "EPA Recommends Retreat from Rising Seas | Climatide." June 28, 2011. <http://climatide.wgbh.org/2011/06/epa-recommends-retreating-from-rising-seas/>.
- Goodyear, Sarah. "Lessons From Sandy: Even New Green Infrastructure Was Destroyed." accessed January 8, 2013.
<http://www.theatlanticcities.com/design/2013/01/lessons-sandy-even-new-green-infrastructure-was-destroyed/4340/>.
- Governor's Action Team on Energy and Climate Change. "Florida Climate Action Team: Technical Working Groups." 2013.
<http://www.flclimatechange.us/Adaptation.cfm>.
- Grannis, Jessica. *Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use*. Georgetown Climate Center, October 2011. http://www.georgetownclimate.org/sites/default/files/Adaptation_Tool_Kit_SLR.pdf.
- Gregg, Rachel M. "Albemarle-Pamlico National Estuary Program's Climate Ready Estuaries Project." March 29, 2010. <http://www.cakex.org/case-studies/822>.
- Griffin, William A. *Ante-bellum Elizabeth City: The History of a Canal Town*. Elizabeth City, North Carolina: Roanoke Press, Inc., 1970.

- Grove, Allen. "The Florida East Coast Railway Buildings at Flagler College." *A Photo Tour of Flagler College*. accessed March 11, 2013.
http://collegeapps.about.com/od/phototours/ss/flagler-college-photo-tour_13.htm.
- Guinta, Peter. "City Readies Seawall Project." *St. Augustine Record*, August 28, 2011.
<http://staugustine.com/news/local-news/2011-08-29/city-readies-seawall-project>.
- . "Lincolnvillle Residents See Plans for Development." *St. Augustine Record*, January 22, 2013. <http://staugustine.com/news/politics/2013-01-22/lincolnvillle-residents-see-plans-development>.
- . "Part of Seawall Destined to Fall." *St. Augustine Record*, December 13, 2000.
http://staugustine.com/stories/121300/new_1213000003.shtml.
- . "Riberia Opens to Traffic Soon." *St. Augustine Record*. Accessed March 4, 2013.
<http://staugustine.com/news/local-news/2011-12-13/riberia-opens-traffic-soon>.
- . "Salvaging the Seawall | StAugustine.com." *St. Augustine Record*, December 24, 2008. http://staugustine.com/stories/122408/news_1222408_002.shtml.
- Haffner, Ian. "Letter: City Has No Excuse for Downtown Flooding." *St. Augustine Record*. Accessed March 4, 2013.
http://staugustine.com/stories/092407/opinions_092407035.shtml.
- Halback Design Group, City of St. Augustine, Florida. *Final Master Plan & FY2011 Grant Applications Summary*. July 14, 2011.
http://www.halback.com/RCB/PDF/09.1.1RCB_Exec-Summary-Masterplan_FINAL_8.5x11_071411.pdf.
- Halbfinger, David M. "Cost of Coastal Living to Climb Under New Flood Rules." *New York Times*, November 28, 2012,
<http://www.nytimes.com/2012/11/29/nyregion/cost-of-coastal-living-to-climb-under-new-flood-rules.html>.
- Hamilton, Jon. "Norfolk, Va., Puts Flooding Survival Plan To The Test : NPR." *NPR.org*. Accessed January 13, 2013. <http://www.npr.org/2012/11/06/164362276/norfolk-va-puts-flooding-survival-plan-to-the-test>.
- . "Protection From The Sea Is Possible, But Expensive." *NPR.org*. accessed January 13, 2013. <http://www.npr.org/2012/11/06/164435330/protection-from-the-sea-is-possible-but-expensive>.
- Hampton, Jeff. "Elizabeth City Pulls in Record Tourism Numbers." August 10, 2012.
<http://hamptonroads.com/2012/08/elizabeth-city-pulls-record-tourism-numbers>.

- Hampton Roads Planning District Commission. "Climate Change in Hampton Roads." *PLANNING* (2011). <http://hrpdc.org/Documents/Economics/2011/Hampton%20Roads%20Regional%20Competitiveness.pdf>.
- Hardaway, C. S., and R. J. Byrne. *Shoreline Management in Chesapeake Bay*. Virginia Institute of Marine Science, College of William and Mary, 1999.
- Hess, Jeremy J., Josephine N. Malilay, and Alan J. Parkinson. "Climate Change: The Importance of Place." *American Journal of Preventive Medicine* 35, no. 5 (November 2008): 468–478. doi:10.1016/j.amepre.2008.08.024.
- Historical Archaeology. "St. Augustine, FL: America's Ancient City." *Florida Museum of Natural History*, n.d. <http://www.flmnh.ufl.edu/histarch/sa.htm>.
- Holland, Taylor. "Alexandria Forges Ahead with Waterfront Plan Despite Legal Battles." *Washington Examiner*, August 22, 2012. <http://washingtonexaminer.com/alexandria-forges-ahead-with-waterfront-plan-despite-legal-battles/article/2505670>.
- Horace J. Sheeley, Jr. "Alexandria Historic District Final National Register Nomination." November 8, 1966. http://www.dhr.virginia.gov/registers/Cities/Alexandria/100-0121_Alexandria_HD_1966_Final_Nomination_NHL.pdf.
- Horowitz, Ann. *Identifying Historic Resources Vulnerable to Sea Level Rise: An Urgent Need to Preserve the Early American Record*. unpublished document, Goucher College, December 18, 2012.
- Horton, John S. "View of St. Augustine, East Florida." *Library of Congress Geography and Map Division*, 1855. http://memory.loc.gov/cgi-bin/query/D?gmd:3:/temp/~ammem_tGi0:
- Horydczak, Theodor. "Map of Alexandria, Virginia Drawn by George Washington." Still image, 1920. <http://www.loc.gov/pictures/item/thc1995001253/PP/>.
- Hurricane City. "Saint Augustine, Florida Hurricanes." accessed March 4, 2013. <http://www.hurricanecity.com/city/saintaugustine.htm>.
- Hurricanes: Science and Society: "1915- Galveston Hurricane." Accessed February 8, 2013. <http://www.hurricanesociety.org/history/storms/1910s/Galveston/>.
- Hutchins, Sarah. "Study Stresses Threat Norfolk Faces from Flooding." *PilotOnline.com*, August 22, 2011. <http://hamptonroads.com/2011/08/study-stresses-threat-norfolk-faces-flooding>.

- Interagency Climate Change Adaptation Task Force. *Federal Actions for a Climate Resilient Nation*. October 28, 2011.
http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_adaptation_progress_report.pdf.
- Intergovernmental Panel on Climate Change. "AR4 SYR Synthesis Report - 5.4 Emission Trajectories for Stabilization." 2007.
http://www.ipcc.ch/publications_and_data/ar4/syr/en/mains5-4.html#footnote28.
- . "IPCC Fourth Assessment Report: Climate Change 2007." accessed December 29, 2012. http://www.ipcc.ch/publications_and_data/ar4/syr/en/mains1.html#1-1.
- International Panel on Climate Change. "Assessment Report 4, Working Group II, Chapter 18: Inter-Relationships Between Adaptation and Mitigation - 18.1.2 Differences, Similarities and Complementarities Between Adaptation and Mitigation." 2007.
http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch18s18-1-2.html.
- Joeckel, Jeff. "How to Complete the National Register Multiple Property Documentation Form, National Register of Historic Places Bulletins (NRB 16b)." July 11, 2001.
<http://www.nps.gov/nr/publications/bulletins/nrb16b/>.
- Johnston, Frances Benjamin. "Fatio House, St. Augustine, St. Johns County, Florida." Still image, 1936. <http://www.loc.gov/pictures/item/csas200800402/>.
- . "Llambias House, 31 St. Francis Street, St. Augustine, St. Johns County, Florida." Still image, 1936. <http://www.loc.gov/pictures/item/csas200800502/>.
- Jordan, Douglas. "Despite Slow Start, Weather, Seawall Project on Schedule." *StAugustine.com*, June 7, 2012. <http://staugustine.com/news/local-news/2012-06-07-0>.
- Kaufman, Leslie. "Norfolk, Va., on Front Line, Tackles Rise in the Sea." *New York Times*, November 25, 2010, sec. Science / Environment.
<http://www.nytimes.com/2010/11/26/science/earth/26norfolk.html>.
- Keifer, John M. "Flooding - Tidal and Rainfall." presented at the Presentation to City Council, Norfolk, Virginia, May 24, 2011.
<http://ghentnl.files.wordpress.com/2011/09/flooding-5-24-11-final.pdf>.
- Kraus, Lisa, John Bedell, and John LeeDecker. *John Bruin and the Slave Trade*, June 2007.
<http://alexandriava.gov/uploadedFiles/historic/info/archaeology/ARSiteReportBruinSlaveJailAX172.pdf>.

- Lee, Jane J. "Update: Revised North Carolina Sea Level Rise Bill Goes to Governor." *Science*. Accessed April 6, 2013. <http://news.sciencemag.org/scienceinsider/2012/07/update-revised-north-carolina-se.html>.
- Lewis, Roger K. "In Old Town, Planners Look to the Future with Sensitivity to the Past." *Washington Post*, November 18, 2011. http://www.washingtonpost.com/realestate/in-old-town-planners-look-to-the-future-with-sensitivity-to-the-past/2011/11/15/gIQA2Rb7XN_story.html.
- Liberto, Jennifer. "FEMA Funds May Not Be Enough to Cover Sandy Flooding Costs." *CNNMoney*, October 31, 2012. <http://money.cnn.com/2012/10/31/news/economy/fema-flood-sandy/index.html>.
- Lienhard, John H. "No. 865: Raising Galveston." 1997-1988. <http://www.uh.edu/engines/epi865.htm>.
- Little-Stokes, Ruth. *National Register of Historic Places Inventory-Nomination Form: Elizabeth City Historic District*. October 18, 1977. <http://www.hpo.ncdcr.gov/nr/PK0003.pdf>.
- Livability. "Top 10 Cities for Historic Preservation." *Livability*. accessed March 7, 2013. <http://livability.com/top-10/top-10-cities-historic-preservation/st.-augustine/fl>.
- Lowenthal, David. *The Past Is a Foreign Country*. Cambridge, England: University Press, 1985.
- Mackintosh, Barry. "Jones Point Lighthouse and District of Columbia South Cornerstone National Register of Historic Places Inventory-Nomination Form." January 24, 1980.
- Management Analysis, Inc. *A Study of the Torpedo Factory Art Center*, February 1, 2010. <http://alexandriava.gov/uploadedFiles/recreation/arts/TORPEDO%20FACTORY%20STUDY%20Final%202.2.10.pdf>.
- Manucy, Albert C. *The Houses of St. Augustine, 1565-1821*. Gainesville, Florida: University Press of Florida, 1962.
- Maryland Commission on Climate Change. *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase II: Building Societal, Economic, and Ecological Resilience*. January 2011. http://www.dnr.state.md.us/climatechange/pdfs/climatechange_phase2_adaptation_strategy.pdf.

- Maryland Commission on Climate Change, and Adaptation and Response Working Group. *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase I: Sea-level Rise and Coastal Storms*. August 2008. http://www.dnr.state.md.us/coastsmart/pdfs/comprehensive_strategy.pdf.
- Maryland Department of Natural Resources. "Climate Change." accessed March 24, 2013. <http://www.dnr.state.md.us/climatechange/>.
- . "Coast Smart Communities." accessed March 3, 2013. <http://www.dnr.state.md.us/CoastSmart/index.asp>.
- . "Sea Level Rise Interactive Map." accessed March 3, 2013. <http://www.mdmerlin.net/mapper.html>.
- Mason, Randall. *Economics and Historic Preservation: A Guide and Review of the Literature*. The Brookings Institution Metropolitan Policy Program, September 2005. http://www.brookings.edu/~media/research/files/reports/2005/9/metropolitanpolicy%20mason/20050926_preservation.pdf.
- McGranahan, Gordon, Deborah Balk, and Bridget Anderson. "The Rising Tide: Assessing the Risks of Climate Change and Human Settlements in Low Elevation Coastal Zones." *Environment and Urbanization* 19, no. 1 (April 1, 2007): 17–37. doi:10.1177/0956247807076960.
- McKinley, James C. "Galveston Seeks \$2.2 Billion in Storm Relief." *New York Times*, September 23, 2008, <http://www.nytimes.com/2008/09/23/us/23ike.html>.
- McLendon, Timothy, Kristin Larsen, JoAnn Klein, Rhonda Phillips, Glenn Willumson, Lori Pennington-Gray, and John Confer. *Contributions of Historic Preservation to the Quality of Life in Florida*. Florida: University of Florida, 2006. <http://ufdc.ufl.edu/files/UF00090906/00001/UF-Historic-report-final-2006.pdf>.
- Miller, Kristen L., Joseph R. Holstead, Hendrick DeBoer, and Mark Randall. "Seawall Construction Laws in East Coast States." February 7, 2012. <http://www.cga.ct.gov/2012/rpt/2012-R-0074.htm>.
- Miller, Kristen L., Janet L. Kaminski LeDuc, and Kevin McCarthy. "Sea-level Rise Adaptation Policy in Various States." October 26, 2012. <http://www.cga.ct.gov/2012/rpt/2012-R-0418.htm>.
- Mississippi Development Authority. *Elevating Historic Properties*. accessed January 10, 2013. http://www.msdisasterrecovery.com/documents/historic_properties-hpc.pdf.

- . *Elevation Design Guidelines*, accessed January 10, 2013.
<http://www.msdisasterrecovery.com/documents/MDA%20EDG%20Final%20110308.pdf>.
- Mitchell, Molly. "Recurrent Flooding Study." presented at the Flooding Mitigation Advisory Group, May 31, 2012.
<http://www.norfolk.gov/flooding/Meetings/ExpertGroup/May312012/VIMS-MOLLY.pdf>.
- Mohl, Raymond A. *The New City: Urban America in the Industrial Age, 1860-1920*. H. Davidson, 1985.
- Mooney, Jeanne. "Norfolk Resident Builds Berm to Protect Home from Floods." *PilotOnline.com*, April 19, 2009. <http://hamptonroads.com/2009/04/norfolk-resident-builds-berm-protect-home-floods>.
- Morris, Tracy, and Smith Patrick. *Charles Creek Park Wetland Restoration: Year One Monitoring Report*. March 2008.
[http://www.nceep.net/GIS_DATA/Charles%20Creek%20Park%20%2379%20\(EEP\)/MONITORING%20REPORTS/2007%20Report/1CharlesCreek_79_2007_MY1_MainBody.pdf](http://www.nceep.net/GIS_DATA/Charles%20Creek%20Park%20%2379%20(EEP)/MONITORING%20REPORTS/2007%20Report/1CharlesCreek_79_2007_MY1_MainBody.pdf).
- Moser, Susanne C., S. Jeffress Williams, and Donald F. Boesch. "Wicked Challenges at Land's End: Managing Coastal Vulnerability Under Climate Change." *Annual Review of Environment and Resources* 77 (2012): 51–78.
- National Aeronautics and Space Administration. "Global Climate Change." *Global Climate Change*. Accessed December 28, 2012. <http://climate.nasa.gov/>.
- . "What's the Difference Between Weather and Climate?" *NASA Features*, February 1, 2005. http://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html.
- National Historic Landmarks Program. *Listing of National Historic Landmarks by State*. n.d. <http://www.nps.gov/nhl/designations/Lists/FL01.pdf>.
- . "St. Augustine Town Plan Historic District." accessed March 4, 2013.
<http://tps.cr.nps.gov/nhl/detail.cfm?ResourceId=1028&ResourceType>.
- National Ocean Service. "Coastal Climate Adaptation." accessed January 10, 2013.
<http://collaborate.csc.noaa.gov/climateadaptation/default.aspx>.
- National Oceanic and Atmospheric Administration. "Chronological Listing of Tropical Cyclones Affecting North Florida and Coastal Georgia 1565-1899." May 2003.
<http://www.aoml.noaa.gov/hrd/Landsea/history/>.

- . “Climate Research Programs.” 2011.
http://www.research.noaa.gov/climate/t_carboncycle.html.
- . “Flooding.” *NOAA Watch*. accessed May 16, 2013.
<http://www.noaawatch.gov/themes/flooding.php>.
- . “Frequently Asked Questions.” 2009.
<http://www.aoml.noaa.gov/hrd/tcfaq/E24.html>.
- . *Global Sea Level Rise Scenarios for the United States National Climate Assessment*. December 6, 2012.
<http://www.realclimate.org/index.php/archives/2013/01/sea-level-rise-where-we-stand-at-the-start-of-2013/>.
- . “Sea Level Rise and Coastal Flooding Impacts.” accessed March 4, 2013.
<http://www.csc.noaa.gov/slr/viewer/#>.
- . “Storm Surge and Coastal Floods.” *NOAA Watch*, May 16, 2013.
http://www.noaawatch.gov/themes/coastal_inundation.php.
- . “Tides and Currents.” accessed February 20, 2013.
<http://tidesandcurrents.noaa.gov/>.
- . “Understanding Climate: Assessment Reports.” January 7, 2013.
<http://www.climate.gov/#understandingClimate/assessmentReports>.
- National Oceanic and Atmospheric Administration, North Carolina Division of Coastal Management, and North Carolina Department of Environment and Natural Resources. *Final Assessment and Strategy of the North Carolina Coastal Management Program, FY 2011-2015*. February 10, 2011.
http://dcm2.enr.state.nc.us/Program%20Assessment%20%20Strategy%20_FINAL%202-10-11_.pdf.
- National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resource Management. *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. 2010.
<http://coastalmanagement.noaa.gov/climate/docs/adaptationguide.pdf>.
- National Oceanic and Atmospheric Administration U.S. Department of Commerce, and United States Department of Commerce. “The Great Galveston Hurricane of 1900.” July 19, 2012. http://celebrating200years.noaa.gov/magazine/galv_hurricane/welcome.html#today.
- National Park Service. “Castillo de San Marcos National Monument.” accessed March 11, 2013. <http://www.nps.gov/casa/index.htm>.

- . “Castillo de San Marcos National Monument.” May 6, 2013. <https://www.facebook.com/CastilloNPS>.
- . “Castillo De San Marcos Tour.” St. Augustine, Florida, January 4, 2013.
- . *Coastal Adaptation to Climate Change*. September 2011. <http://www.nps.gov/climatechange/adaptationplanning.cfm>.
- . *Download of Google Earth Data of National Register Listings*. September 2012.
- . “Florida Historic Places: St. Augustine Town Plan Historic District.” accessed March 4, 2013. <http://www.nps.gov/nr/travel/geo-flor/24.htm>.
- . “Heritage Areas, National Park Service, National Heritage Areas Program.” *National Heritage Areas*. accessed May 21, 2013. <http://www.nps.gov/history/heritageareas/INDEX.html>.
- . “Jones Point Park Environmental Assessment, June 2007.” June 2007. <http://parkplanning.nps.gov/document.cfm?parkID=186&projectID=13128&documentID=19647>.
- . “Jones Point Park Environmental Assessment: Finding Of No Significant Impact.” November 2007. <http://parkplanning.nps.gov/document.cfm?parkID=186&projectID=13128&documentID=21364>.
- . “Jones Point Park Wetlands Study.” August 2005. <http://parkplanning.nps.gov/document.cfm?parkID=186&projectID=13128&documentID=12859>.
- . “Moving the Cape Hatteras Lighthouse.” April 26, 2013. <http://www.nps.gov/caha/historyculture/movingthelighthouse.htm>.
- . “National Historic Landmarks: National Park Service, What Is?.” June 28, 2011. <http://www.nps.gov/nhl/whatis.htm>.
- National Photo Company Collection. “Torpedo Station, Alex., Va.” Still image. *Library of Congress Prints and Photographs Online Catalog*, 1922 1921. <http://www.loc.gov/pictures/item/npc2008010511/>.
- . “Virginia Shipbuilding Corp., Alexandria, Va., Betsy Bell after Launching, May 24, 1919; Gunston Hall in Background.” Still image. *Library of Congress Prints and Photographs Online Catalog*, 1919. <http://www.loc.gov/pictures/item/npc2008011206/>.
- National Register of Historic Places. “ECHD Catalog.” February 7, 2013. http://www.historicelizabethcity.org/echd/ECHD_Catalog.php?serial=117.

National Society of The Colonial Dames of America. "Ximenez-Fatio House Museum." 2009. <http://www.ximenezfatiohouse.org/>.

National Trust. "Living with a Changing Coastline." accessed January 18, 2013. <http://vimeo.com/14954579>.

———. *Shifting Shores: Living with a Changing Coastline*. 2005. <http://www.nationaltrust.org.uk/servlet/file/store5/item349150/version1/shiftingshores-general.pdf>.

National Trust for Historic Preservation. "Disaster Response." *Preservationnation.org*, accessed December 29, 2012. [http://www.preservationnation.org/resources/technical-assistance/disaster-recovery/?utm_source=facebook&utm_medium=like&utm_campaign=Disaster Response](http://www.preservationnation.org/resources/technical-assistance/disaster-recovery/?utm_source=facebook&utm_medium=like&utm_campaign=Disaster+Response).

———. "Heritage Tourism Assessment & Recommendations." *Citizens for the Preservation of St. Augustine, Inc.* 2002. http://cpsa-staug.org/?page_id=86.

———. "Main Street Reinvestment Statistics." *Preservationnation.org*, 2013. [http://www.preservationnation.org/main-street/about-main-street/reinvestment-statistics-1.html?utm_source=facebook&utm_medium=like&utm_campaign=Main Street Reinvestment Statistics](http://www.preservationnation.org/main-street/about-main-street/reinvestment-statistics-1.html?utm_source=facebook&utm_medium=like&utm_campaign=Main+Street+Reinvestment+Statistics).

———. "Preparation for Local Organizations and Main Streets." *Preservationnation.org*. 2013. [http://www.preservationnation.org/resources/technical-assistance/disaster-recovery/local-orgs-prep.html?utm_source=facebook&utm_medium=like&utm_campaign=Preparation for Local Organizations and Main Streets](http://www.preservationnation.org/resources/technical-assistance/disaster-recovery/local-orgs-prep.html?utm_source=facebook&utm_medium=like&utm_campaign=Preparation+for+Local+Organizations+and+Main+Streets).

———. "Preparing for Floods." *Preservationnation.org*. accessed December 3, 2012. [http://www.preservationnation.org/resources/technical-assistance/disaster-recovery/preparing-for-floods.html?utm_source=facebook&utm_medium=like&utm_campaign=Preparing for Floods](http://www.preservationnation.org/resources/technical-assistance/disaster-recovery/preparing-for-floods.html?utm_source=facebook&utm_medium=like&utm_campaign=Preparing+for+Floods).

———. "Tourism Plans Respond to Visitor Interests in St. Augustine." *Preservationnation.org*. accessed March 4, 2013. [http://www.preservationnation.org/information-center/economics-of-revitalization/heritage-tourism/survival-toolkit/tourism-plans-respond-to-visitors-st-augustine.html?utm_source=facebook&utm_medium=like&utm_campaign=Tourism Plans Respond to Visitor Interests in St. Augustine](http://www.preservationnation.org/information-center/economics-of-revitalization/heritage-tourism/survival-toolkit/tourism-plans-respond-to-visitors-st-augustine.html?utm_source=facebook&utm_medium=like&utm_campaign=Tourism+Plans+Respond+to+Visitor+Interests+in+St.+Augustine).

———. *Treatment of Flood-Damaged Older and Historic Buildings*. Information Booklet No. 82. Washington, D.C.: National Trust for Historic Preservation, 1993. http://www.preservationnation.org/issues/gulf-coast-recovery/additional-resources/flood_booklet.pdf.

- National Weather Service. "Floyd." accessed February 8, 2013.
<http://www.erh.noaa.gov/er/akq/FloydTab.htm>.
- . "Hurricanes in History." accessed February 8, 2013.
<http://www.nhc.noaa.gov/outreach/history/#floyd>.
- . "NHC Tropical Cyclone Report." accessed February 8, 2013.
<http://www.nhc.noaa.gov/2003isabel.shtml?>
- . "Tropical Cyclone Report: Hurricane Isabel." January 16, 2004.
<http://www.nws.noaa.gov/om/assessments/pdfs/isabel.pdf>.
- National Weather Service, Raleigh, North Carolina. "Hurricane Isabel." accessed February 16, 2013. <http://www4.ncsu.edu/~nwsfo/storage/cases/20030918/>.
- Navarro, Mireya. "After Hurricane Sandy, Debating Costly Sea Barriers in New York Area." *New York Times*, November 7, 2012.
<http://www.nytimes.com/2012/11/08/nyregion/after-hurricane-sandy-debating-costly-sea-barriers-in-new-york-area.html>.
- Navarro, Mireya, and Rachel Nuwer. "After Hurricane Sandy, Dunes Prove They Blunt Storms." *New York Times*, December 3, 2012.
<http://www.nytimes.com/2012/12/04/science/earth/after-hurricane-sandy-dunes-prove-they-blunt-storms.html>.
- Nelson, Brian. "Rising Sea Levels Are Impacting St. Augustine." *1565 Today*, December 7, 2012. <http://1565today.com/rising-sea-levels-are-impacting-st-augustine/>.
- . "St. Augustine Beach Re-Nourishment Project." *1565 Today*, February 1, 2012.
<http://1565today.com/st-augustine-beach-re-nourishment-project/>.
- Neumann, James E., Gary Yohe, Robert Nicholls, and Michelle Manion. *Sea Level Rise and Global Climate Change: A Review of Impacts to U.S. Coasts*. Pew Center for Global Climate Change, February 2000.
http://www.c2es.org/docUploads/env_sealevel.pdf.
- Nicholas Institute Report. *Climate Ready Estuaries: A Blueprint for Change*. September 2010. http://portal.ncdenr.org/c/document_library/get_file?uuid=1f349a68-43a5-4989-8302-9928ae8d5774&groupId=61563.
- Nicholls, R. J. "Planning for the Impacts of Sea Level Rise." *Oceanography* 24, no. 2 (2011). http://www.tos.org/oceanography/archive/24-2_nicholls.pdf.
- NOAA Coastal Services Center. "Digital Coast." accessed January 10, 2013.
<http://www.csc.noaa.gov/digitalcoast/>.

North Carolina Department of Cultural Resources. "Hurricane Floyd Damage Report: Historic Buildings." November 15, 1999. <http://www.hpo.ncdcr.gov/floyd1.htm>.

North Carolina Department of Environment and Natural Resources. "Albemarle-Pamlico National Estuary Partnership - Home." Accessed February 8, 2013. <http://portal.ncdenr.org/web/apnep>.

———. "NCDENR - Albemarle-Pamlico National Estuary Partnership." accessed January 27, 2013. <http://portal.ncdenr.org/web/apnep>.

———. *NCDENR Climate Change Initiative Strategy Framework*, June 8, 2010. http://www.climatechange.nc.gov/pages/ClimateChange/NCDENR_Climate_Change_Initiative_strategy_framework_June_2010.pdf.

———. *North Carolina Department of Environment and Natural Resources Climate Change Initiative Strategy Framework*, June 30, 2010. http://www.climatechange.nc.gov/pages/ClimateChange/NCDENR_Climate_Change_Initiative_strategy_framework_June_2010.pdf.

———. "Sea Level Rise Information Page." accessed January 27, 2013. <http://portal.ncdenr.org/web/cm/sea-level-rise-information-page>.

North Carolina State Historic Preservation Office. "Disaster Information." accessed February 13, 2013. <http://www.hpo.ncdcr.gov/disaster.htm>.

Northeast Florida Regional Council. "Emergency Preparedness." In *Strategic Regional Policy Plan*, 1997. <http://www.nefrc.org/pdfs/srpp/element3.pdf>.

———. *Volume I-4: Northeast Florida Region Technical Data Report, Regional Hazards Analysis*. accessed March 5, 2013. <http://www.nefrc.org/pdfs/SRESP%20web%20version/Vol%20One/VOL%20ONE%20CHAPTER%20II.pdf>.

Northern Virginia Regional Commission. *Sustainable Shorelines and Community Management Project: Phase I Report*, October 1, 2008. <http://www.deq.virginia.gov/Portals/0/DEQ/CoastalZoneManagement/task12-06-08.pdf>.

———. *Sustainable Shorelines Community Management in Northern Virginia Phase II*, December 2012. <http://www.deq.virginia.gov/Portals/0/DEQ/CoastalZoneManagement/FundsInitiativesProjects/task12-07-09.pdf>.

Office of Emergency Preparedness & Response. "Storm Surge Maps." accessed January 17, 2013. http://www.norfolk.gov/emergency/storm_surge_maps.asp.

- . *Sustainable Shorelines Community Management in Northern Virginia Phase II*, December 2012. <http://www.deq.virginia.gov/Portals/0/DEQ/CoastalZoneManagement/FundsInitiativesProjects/task12-07-09.pdf>.
- Ohio Department of Natural Resources. “The Community Rating System and Flood Hazard Mitigation.” November 4, 2011. http://www.dnr.state.oh.us/water/pubs/fs_div/fetsht42/tabid/4129/Default.aspx.
- Old City. “St. Augustine, Florida.” *Old City*, May 27, 2013. <http://www.oldcity.com/>.
- Palk, Eugene. “What Sandy Victims Need to Know About New Height Rules for Their Homes.” *NJ.com*, February 5, 2013. http://www.nj.com/news/index.ssf/2013/02/what_sandy_victims_need_to_kno.html.
- Parker, Rhonda. “TS Debby Impacts St. Augustine Sewer System, FEMA Aid Available for 11 Counties.” *Examiner.com*, July 5, 2012. <http://www.examiner.com/article/ts-debby-impacts-st-augustine-sewer-system-fema-aid-available-for-11-counties>.
- Parker, Susan. “Nation’s Oldest City: Seawall Keeps the Ocean Out of St. Augustine.” *StAugustine.com*, February 6, 2011. <http://staugustine.com/news/local-news/2011-02-05/nations-oldest-city-seawall-keeps-ocean-out-st-augustine>.
- Pasquotank County. *Flood Damage Prevention Ordinance*. 2004. <http://www.co.pasquotank.nc.us/Departments/planning/Flood%20Zone%20Ordinance.pdf>.
- Pasquotank County and Elizabeth City, North Carolina. *2004 Advanced Core Land Use Plan*. February 9, 2012. <http://www.co.pasquotank.nc.us/LandUse/Feb%20%2092012%20CERTIFIED%20LUP.pdf>.
- Pasquotank County, North Carolina. “Flood Damage Prevention Ordinance.” accessed January 21, 2013. <http://www.co.pasquotank.nc.us/Departments/planning/Flood%20Zone%20Ordinance.pdf>.
- . “Pasquotank County.” accessed February 2, 2013. <http://www.co.pasquotank.nc.us/History.htm>.
- . “Pasquotank County Land Use and Development Policies.” accessed January 22, 2013. http://dcm2.enr.state.nc.us/planning/Pasquotank%20co/PolicyStatements_010912.pdf.
- . *Pasquotank County Multi-Jurisdictional Hazard Mitigation Plan*. accessed February 1, 2013. http://www.pasquotankcamdenem.com/EMWebsite/documents/LocalInfo/Pasquotank_HazardMitigationPlan.pdf.

- Patterson, T., S. Bastianoni, and M. Simpson. "Tourism and Climate Change: Two-way Street, or Vicious/Virtuous Circle?" *Journal of Sustainable Tourism* 14, no. 4 (2006): 339–348. <http://www.tandfonline.com/doi/abs/10.2167/jost605.0>.
- Pearson, Elizabeth. *When and Why Have Americans Supported Higher Taxes?* Scholars Strategy Network, November 2012. http://www.scholarsstrategynetwork.org/sites/default/files/ssn_basic_facts_pearson_on_supporting_higher_taxes.pdf.
- Pelling, Mark. *Adaptation to Climate Change: From Resilience to Transformation*. New York, New York: Routledge, 2010.
- Pilkey, Orrin H. "A Beachfront Retreat." *New York Times*, November 14, 2012, sec. Opinion. <http://www.nytimes.com/2012/11/15/opinion/a-beachfront-retreat.html>.
- Pineo, Rebecca, and Susan Barton. *Permeable Vs. Impermeable Surfaces*. University of Delaware, January 31, 2009. http://ag.udel.edu/udbg/sl/hydrology/Permeable_Impervious_Surfaces.pdf.
- Planning and Building Division, City of St. Augustine. "Architectural Guidelines for Historic Preservation." October 2011. http://staugustinegovernment.com/your_government/documents/AGHP10.29.12.pdf.
- Postal, Maurice, Keith Joiner, and Tobin Lilly. *Northeast Florida, The Likelihood of Shore Protection Along the Atlantic Coast of the United States*. 2010. <http://risingsea.net/ERL/shore-protection-retreat-sea-level-rise-Northeast-Florida.pdf>.
- Preserve America. *Preparing to Preserve: An Action Plan to Integrate Historic Preservation into Tribal, State, and Local Emergency Management Plans*. Preserve America, December 2008. <http://www.doi.gov/pmb/oepr/rppr/upload/12-18-08-Preparing-To-Preserve.pdf>.
- Quaide, Rustin A., National Park Service, "Section VIII: How to Apply the National Register Criteria for Evaluation, National Register of Historic Places Bulletin (NRB 15)." November 28, 2001. http://www.nps.gov/nr/publications/bulletins/nrb15/nrb15_8.htm.
- Quinn, Melissa. "Tourism Pays Big Dividends for City." *Alexandria Times*. October 2, 2012. <http://alextimes.com/2012/10/tourism-pays-big-dividends-for-city/>.
- Randolph, John. "Creating the Climate Change Resilient Community." In *Collaborative Resilience*, edited by Bruce Evan Goldstein. 127-148. Cambridge, Massachusetts: MIT Press, 2012.

- Reeder, Leslie A., Torben C. Rick, and Jon M. Erlandson. "Our Disappearing Past: a GIS Analysis of the Vulnerability of Coastal Archaeological Resources in California's Santa Barbara Channel Region." *Journal of Coastal Conservation* 16, no. 2 (October 12, 2010): 187–197. doi:10.1007/s11852-010-0131-2.
- Reid, Robin T. "Ancient Cities Lost to the Seas." *Smithsonian Magazine*, July 29, 2009. <http://www.smithsonianmag.com/history-archaeology/Ancient-Cities-Lost-to-the-Seas.html>.
- Reynolds, Charles Bingham. *The Standard Guide, St. Augustine*. St. Augustine, Florida: E.H. Reynolds, 1890.
- Riggs, S. R., S. J. Culver, D. J. Mallison, D. R. Corbett, and J. P. Walsh. *North Carolina's Coasts in Crisis: A Vision for the Future*, October 2008. <http://curs.unc.edu/curs-pdf-downloads/climatechgsymp/Riggs.pdf>.
- Robertson, Ian N., H. Ronald Riggs, Solomon C.S. Yim, and Yin Lu Young. "Lessons from Hurricane Katrina Storm Surge on Bridges and Buildings." *Journal of Waterway, Port, Coastal, and Ocean Engineering* 133, no. 6 (March 1, 2012): 463–483. <http://ascelibrary.org/doi/abs/10.1061/%28ASCE%290733-950X%282007%29133%3A6%28463%29?journalCode=jwped5>.
- Sallenger, Asbury H., Kara S. Doran, and Peter A. Howd. "Hotspot of Accelerated Sea-level Rise on the Atlantic Coast of North America." *Nature* 2, no. 12 (2012): 884–888. doi:10.1038/nclimate1597.
- Sastre, Cecile-Marie. "Historic St. Augustine Seawall, National Historic Preservation Act Section 106 Report." January 10, 2005. <http://ufdc.ufl.edu/UF00095518/00002/1j>.
- Science Daily. "New England, Mid-Atlantic Beaches Eroding, Losing 1. 6 Feet Per Year on Average." *ScienceDaily*. accessed January 5, 2013. <http://www.sciencedaily.com/releases/2011/02/110223154430.htm>.
- Sea Level Rise in Norfolk: Netherlands Flood Prevention Presentation*. 2012. http://www.youtube.com/watch?v=GiPx16D7Fw4&feature=youtube_gdata_player.
- Seale, William. *A Guide to Historic Alexandria*. Alexandria, Virginia: City of Alexandria 250th Anniversary Commission, 2000.
- Sheffer, Thomas. *The Key Role of Regional Coastal Adaptation Planning in the United States*. September 2010. <http://www.cakex.org/sites/default/files/Thomas%20Sheffer%20Paper.pdf>.

- Smit, Barry, and Olga Pilifosova. *Adaptation to Climate Change in the Context of Sustainable Development and Equity*. Intergovernmental Panel on Climate Change. 2007. <http://www.ipcc.ch/ipccreports/tar/wg2/pdf/wg2TARchap18.pdf>.
- Smith-Johnson, Robin. "Billingsgate: The Island That Disappeared." *Cape Cod Online*, October 19, 2012. <http://blogs.capecodonline.com/cape-cod-history/2012/10/19/billingsgate-the-island-that-disappeared/>.
- Sperling, Stephanie, Lauren Schiszik, C. Jane Cox, and Jessie Grow. *Sea Level Rise Strategic Plan, Anne Arundel County, Maryland: Vulnerability Assessment for Cultural Resources*. Anne Arundel County, Maryland: Anne Arundel County, Department of Planning and Zoning, Cultural Resources Division, September 30, 2010. <http://losttownsproject.org/projects/Sea%20Level%20Rise/SLR%20Cultural%20Resources%20Report.pdf>.
- St. Augustine Record. "Flooding Closes Some Streets Downtown." *St. Augustine Record*. Accessed March 4, 2013. <http://staugustine.com/news/local-news/2011-08-26/flooding-closes-some-streets-downtown#.UTUEahnpZQ5>.
- . "Mica Gets Funding for Seawall." *St. Augustine Record*, August 19, 2011. <http://staugustine.com/news/local-news/2011-08-20/mica-gets-funding-seawall>.
- St. Johns County Government. "Tourism in St. Johns County." accessed March 12, 2013. <http://www.co.st-johns.fl.us/TDC/index.aspx>.
- St. Johns County, Florida. "Flood Facts." accessed March 4, 2013. <http://www.sjcfl.us/FloodFacts/index.aspx>.
- . "Hurricane Storm Surge by Category." St. Augustine, accessed March 4, 2013. <http://www.staugustinegovernment.com/the-city/maps-libraries/hurricane-storm-surge.pdf>.
- . *St. Johns County Comprehensive Emergency Management Plan*, April 2012. <http://www.sjcemergencymanagement.org/cemp/4-mitigate.pdf>.
- . "St. Johns County Flood Facts." 2012. <http://www.sjcfl.us/media/SJCFemaFlood.pdf>.
- . "Stormwater." accessed March 4, 2013. <http://www.sjcfl.us/DevelopmentReview/Stormwater.aspx>.
- . "Wetlands and Upland Buffer Requirements." accessed March 4, 2013. <http://www.sjcfl.us/Environmental/Wetlands.aspx>.

- State Climate Office of North Carolina. "Hurricanes: Statistics." Accessed February 8, 2013. <https://www.ncclimate.ncsu.edu/climate/hurricanes/statistics.php?state=NC>.
- Stefanowich, Pam. "Letter: Don't Ignore Other Historic Areas." *Daily Advance*. May 10, 2007.
- Steury, Brent. "Sea Level Rise and Jones Point." February 19, 2013.
- Stiles, Skip. "Political and Programmatic Issues in Virginia." In *Political and Programmatic Issues in Virginia*. Norfolk, Virginia, 2013.
- Stipe, Robert E. *A Richer Heritage: Historic Preservation in the Twenty-First Century*. Chapel Hill, North Carolina: University of North Carolina Press, 2003.
- Sullivan, Patricia. "City Officials Reject Alternative Alexandria Waterfront Plan." *Washington Post*, November 21, 2011. http://articles.washingtonpost.com/2011-11-21/local/35282542_1_city-plan-historic-city-public-input.
- Surging Seas. "Elizabeth City, North Carolina." accessed February 14, 2013. http://sealevel.climatecentral.org/surgingseas/place/cities/NC/Elizabeth_City#surge=5&show=cities¢er=15/36.3044/-76.2299.
- Svrluga, Susan. "Tangier Island Will Get Long-awaited Jetty to Protect Harbor, Officials Say." *Washington Post*, November 21, 2012. http://www.washingtonpost.com/local/virginia-news/tangier-island-will-get-long-awaited-jetty-to-protect-harbor-officials-say/2012/11/20/0a93407a-3345-11e2-bfd5-e202b6d7b501_story_1.html.
- Tangier History Museum. "A Brief History of Tangier." *Tangier History Museum Newsletter*. accessed January 14, 2013. <http://www.tangierhistorymuseum.org/history/index.shtml>.
- Texas State Historical Association. "Galveston's Response to the Hurricane of 1900." *Texas Almanac*, 1999-1998. <http://www.texasalmanac.com/topics/history/galvestons-response-hurricane-1900>.
- The Economist. *The Economist Intelligence Unit's Quality of Life Index*. 2005. http://www.economist.com/media/pdf/QUALITY_OF_LIFE.pdf.
- The Florida Oceans and Coastal Council. *Climate Change and Sea Level Rise in Florida*. December 2010. http://www.flseagrant.org/coastalplanning/wp-content/uploads/2012/02/Climate_Change_and_Sea_Level_Rise_in_FL.pdf.
- The Guardian. "Climate Change Panel Warns of Severe Storms, Heatwaves and Floods." *Environment*, March 28, 2012. <http://www.guardian.co.uk/environment/2012/mar/28/climate-change-global-warming-storms-floods>.

- The Hazard Mitigation Technical Assistance Partnership, Inc. *Evaluation of CRS Credited Activities During Hurricane Floyd*. Federal Emergency Management Agency, September 25, 2000. <http://www.ncfloodmaps.com/pubdocs/pfloydrrpt.pdf>.
- Thieler, E. Robert, S. Jeffress Williams, and Rebecca Beavers. *Vulnerability of U.S. National Parks to Sea-Level Rise and Coastal Change*. United States Geological Survey, September 2002. <http://pubs.usgs.gov/fs/fs095-02/fs095-02.pdf>.
- Thieler, E. Robert, S. Jeffress Williams, and Erika Hammar-Klose. "National Assessment of Coastal Vulnerability To Sea-Level Rise." August 13, 2009. <http://woodshole.er.usgs.gov/project-pages/cvi/>.
- Thomas, Jeffrey. "Plan of the Town and Harbour of St. Augustine." *Library of Congress Geography and Map Division*, circa 1762. http://memory.loc.gov/cgi-bin/query/D?gmd:8:/temp/~ammem_tGi0::.
- Tierney, Kathleen J., Michael K. Lindell, and Ronald W. Perry. *Facing the Unexpected: Disaster Preparedness and Response in the United States*. Washington, D.C.: Joseph Henry Press, 2001.
- Times Picayune. "Galveston Seawall Repairs after Hurricane Ike to Be Finished April 1." January 12, 2010. http://www.nola.com/hurricane/index.ssf/2010/01/repairs_on_galveston_seawall_d.html.
- Titus, James G, K. Eric Anderson, Donald. R. Cahoon, Dean. B. Gesch, Stephen K. Gill, Benjamin. T. Gutierrez, E. Robert Thieler, and S. Jeffress Williams. *Coastal Sensitivity to Sea Level Rise: A Focus on the Mid Atlantic Region*. Synthesis and Assessment Product 4.1. U.S. Climate Change Science Program, January 2009. <http://downloads.climate-science.gov/sap/sap4-1/sap4-1-final-report-all.pdf>.
- Titus, James G, Y. Kuo Chin, Michael J. Gibbs, Tom B. LaRoche, M. Keith Webb, and Jesse O. Waddell. "Greenhouse Effect, Sea Level Rise, and Coastal Drainage Systems." *Journal of Water Resources and Planning Management* 113, no. 2 (March 1987): 216–225. <http://papers.risingsea.net/downloads/sea-level-rise-coastal-drainage.pdf>.
- Titus, James G, and Michael Craghan. "Chapter 6: Shore Protection and Retreat." In *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*, 85–104. U.S. Climate Change Science Program and the Subcommittee on Global Change Research, 2009. <http://www.climate-science.gov/Library/sap/sap4-1/final-report/sap4-1-final-report-Part2.pdf>.

- Titus, James G, and Stephen K. Gill. "Part II: Societal Impacts and Implications." In *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*, 85–138. U.S. Climate Change Science Program and the Subcommittee on Global Change Research, 2009. <http://www.climate-science.gov/Library/sap/sap4-1/final-report/sap4-1-final-report-Part2.pdf>.
- Titus, James G., and Charlie Richman. "Coastal Vulnerability Assessment of National Park Units to Sea-Level Rise." *Climate Research* 18, no. 205–228 (November 2, 2001). <http://www.int-res.com/articles/cr/18/c018p205.pdf>.
- Titus, James G, and Charlie Richman. "Maps of Lands Vulnerable to Sea Level Rise." March 10, 2009. <http://papers.risingsea.net/coarse-sea-level-rise-elevation-maps-article.html>.
- Tracton, Steve. "Remembering Hurricane Isabel, Five Years Later." *Washington Post*. accessed February 16, 2013. http://voices.washingtonpost.com/capitalweathergang/2008/09/remembering_hurricane_isabel.html.
- Tyler, Norman, Ted J. Ligibel, and Ilene R. Tyler. *Historic Preservation: An Introduction to Its History, Principles, and Practice (Second Edition)*. Second. New York, New York: W. W. Norton & Company, 2009.
- United Nations Educational, Scientific and Cultural Organization. "UNESCO World Heritage Centre." Accessed December 29, 2012. <http://whc.unesco.org/en/series/22/>.
- United States Census Bureau. "Alexandria (city) QuickFacts." January 10, 2013. <http://quickfacts.census.gov/qfd/states/51/5101000.html>.
- . "Census Data & Emergency Preparedness." accessed January 5, 2013. <http://www.census.gov/newsroom/emergencies/>.
- . "Elizabeth City (city) QuickFacts." January 10, 2013. <http://quickfacts.census.gov/qfd/states/37/3720580.html>.
- . "St. Augustine (city) QuickFacts." January 10, 2013. <http://quickfacts.census.gov/qfd/states/12/1262500.html>.
- United States Department of Housing and Urban Development. "Sustainable Housing and Communities." June 27, 2013. http://portal.hud.gov/hudportal/HUD?src=/program_offices/sustainable_housing_communities.

- United States Geological Survey . “Relative Coastal Vulnerability Assessment of National Park Units to Sea-Level Rise.” September 1, 2009.
<http://woodshole.er.usgs.gov/project-pages/nps-cvi/>.
- . “Sea Level Rise Accelerating in U.S. Atlantic Coast.” September 24, 2012.
http://www.usgs.gov/newsroom/article.asp?ID=3256&from=rss_home#UEe5aKTyaUQ.
- . “The Fall Line.” October 18, 2000.
<http://tapestry.usgs.gov/features/14fallline.html>.
- United States Global Change Research Program. *Global Climate Change Impacts in the United States*. 2009. <http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf>.
- University of Arizona. “Mapping Areas Potentially Impacted by Sea Level Rise.” accessed October 2012. <http://climategem.geo.arizona.edu/slr/us48prvi/index.html>.
- University of Florida. “University of Florida Historic St. Augustine Inc..” November 15, 2012. <http://www.staugustine.ufl.edu/>.
- University of Florida and Guana Tolomato Mantanzas National Estuarine Research Reserve. “Planning for Sea Level Rise in the Matanzas Basin.” accessed March 4, 2013. <http://planningmatanzas.files.wordpress.com/2012/12/frank-matanzas-workshop-dec-2012-low-res.pdf>.
- University of North Carolina at Chapel Hill. *Climate Change Committee Report*. 2009. http://www.ie.unc.edu/PDF/Climate_Change_Report.pdf.
- URS Corporation. *Potomac River Waterfront Flood Mitigation Study: Evaluation and Recommendation of Mitigation Measures*. July 2010. http://alexandriava.gov/uploadedFiles/tes/info/Final_Potomac_Mitigation_Studyx.pdf.
- Virginia Coastal Zone Management Program. “Climate Change Adaptation.” *Virginia Department of Environmental Quality*. accessed April 6, 2013.
<http://www.deq.state.va.us/Programs/CoastalZoneManagement/CZMIssuesInitiatives/ClimateChange.aspx>.
- . *Section 309 Needs Assessment & Strategy*. April 2011.
<http://coastalmanagement.noaa.gov/mystate/docs/va3092011.pdf>.
- Virginia Department of Emergency Management. “Storm Surge Inundation Maps.” 2012.
<http://www.vaemergency.gov/readyvirginia/stay-informed/hurricane/storm-surge>.

- Virginia Department of Environmental Quality. "Virginia CZM Program 2008 Coastal Grant Project Description and Final Summary." accessed April 6, 2013.
<http://www.deq.virginia.gov/Programs/CoastalZoneManagement/FundsInitiatives/Projects/2008Projects/2008VirginiaCZMGrantProjectTask120608.aspx>.
- Virginia Department of Historic Resources. "Historic Registers: City of Alexandria." accessed February 16, 2013.
http://www.dhr.virginia.gov/registers/Cities/register_Alexandria.htm.
- Virginia Institute of Marine Study. *Recurrent Flooding Study for Tidewater Virginia*. January 2013.
http://ccrm.vims.edu/recurrent_flooding/Recurrent_Flooding_Study_web.pdf.
- "Virginia Is for Lovers of History and Heritage Tourism." *Historic Polegreen Church Foundation*, February 14, 2013.
http://www.historicpolegreen.org/news/press_release.php?pr_id=67.
- Virginia Places. "Will Norfolk (and the Rest of Hampton Roads) Drown?" accessed January 13, 2013. <http://www.virginiaplaces.org/climate/norfolkdrown.html>.
- Weber, Edward P. "Getting to Resilience in a Climate-Protected Community." In *Collaborative Resilience*, edited by Bruce Evan Goldstein. 177-206. Cambridge, Massachusetts: MIT Press, 2012.
- Weeks, Jennifer. "Whatever You Call It, Sea Level Rises in Virginia." *Scientific American*, August 21, 2012. <http://www.scientificamerican.com/article.cfm?id=whatever-you-call-it-sea-level-rises-in-virginia&page=3>.
- Weiss, Daniel J., and Jackie Weldman. "Disastrous Spending: Federal Disaster-Relief Expenditures Rise Amid More Extreme Weather." *Center for American Progress*, April 29, 2013. <http://www.americanprogress.org/issues/green/report/2013/04/29/61633/disastrous-spending-federal-disaster-relief-expenditures-rise-amid-more-extreme-weather/>.
- Williams, Ron, and John M. Keifer. "Coastal Flooding Mitigation." presented at the Expert Advisory Panel, February 16, 2012.
<http://www.norfolk.gov/publicworks/SW/pdf/CityIntro.pdf>.
- Williams, S. J., and B. T. Gutierrez. "Sea-level Rise and Coastal Change: Causes and Implications for the Future of Coasts and Low-lying Regions." *Shore & Beach* 77, no. 4 (2009): 13–21. http://paos.colorado.edu/~whan/ATOC4800_5000/Materials/Williams_Gutierrez09_sealevelcoast.pdf.

- Williams, S. J., B. T. Gutierrez, J. G. Titus, K. E. Anderson, S. K. Gill, D. R. Cahoon, E. R. Thieler, and D. B. Gesch. "Chapter 13: Implications of Sea-level Rise to the Nation." In *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*. 179–184. U.S. Environmental Protection Agency, 2009.
- Williams, S. J., B. T. Gutierrez, J. G. Titus, S. K. Gill, D. R. Cahoon, E. R. Thieler, K. E. Anderson, D Fitzgerald, V Burket, and J Samenow. "Chapter 1: Sea-level Rise and Its Effects on the Coast." In *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*. 11–24. U.S. Environmental Protection Agency, 2009.
- Willott, Peter. "Work on Seawall Remains on Schedule." *StAugustine.com*, August 28, 2012. <http://staugustine.com/news/local-news/2012-08-28/work-seawall-remains-schedule>.
- Yehle, Emily. "Local Governments Seek Federal Aid for Planning, Adaptation." December 6, 2012.
- Young, Rashad. "Letter to the Community Regarding the Waterfront Plan." February 15, 2013. <http://alexandriava.gov/uploadedFiles/special/WaterfrontPlan/CityManagerLettertoCommunityReWaterfrontAnnouncementFebruary152013.pdf>.
- Young, Robert A. *Stewardship of the Built Environment: Sustainability, Preservation, and Reuse*. Washington, DC: Island Press, 2012.

