

Sea Level Rise Adaptation Report Beaufort County, South Carolina



Executive Summary

March 2015

S.C. Sea Grant Consortium Product # SCSGC-T-15-02



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Research Institute



Acknowledgements

This report is the collaborative effort of stakeholders in Beaufort County, South Carolina, and a project team consisting of the Beaufort County Planning Department, South Carolina Sea Grant Consortium, Social and Environmental Research Institute, North Carolina Sea Grant, and Carolinas Integrated Sciences and Assessments program at the University of South Carolina. The project team assembled a Beaufort County Stakeholder Group, which met five times from August 2013 to November 2014. This group of local decision makers learned about sea level rise and the impacts to Beaufort County and discussed possible actions to increase the County's resiliency. The group drew heavily upon the local knowledge and experience of its members, and also reached out to colleagues and engaged a larger audience in two public workshops. The project team drafted this report with frequent consultation with the Stakeholder Group.

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The project team would like to thank the Beaufort County Stakeholder Group for their time, enthusiasm, and dedication to seeing this project through to completion. The project team would also like to thank all of the stakeholders who participated in interviews or workshops and provided their local knowledge and opinions to develop opportunities for Beaufort County to become more resilient to future sea level rise impacts. The College of Charleston provided several resources in support of this project, including GIS capabilities and printing services, and the South Carolina Department of Natural Resources helped facilitate the public workshops.



Affiliations of Beaufort County Stakeholder Group Members

Beaufort County Council
 Beaufort County Planning Department
 Beaufort County School District
 Beaufort Soil & Water Conservation District
 Gullah/Geechee Sea Island Coalition
 Town of Bluffton

Beaufort County Department of Public Works
 Beaufort County Stormwater Utility
 Beaufort Group, LLC
 Coastal Conservation League
 National Stormwater Center

Project Team

[Beaufort County Planning Department](#)
[South Carolina Sea Grant Consortium](#)
[Social and Environmental Research Institute](#)
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[Carolinas Integrated Sciences and Assessments](#)



¹ College of Charleston. 2014. "Office of Research & Grants Administration." http://orga.cofc.edu/pub/compliance_irb_index.shtml



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Introduction

Beaufort County, South Carolina, is a low-lying coastal county with a high sensitivity to tidal flooding and storm surge. Just over half of Beaufort County is open water, sounds, marshes, and estuaries and two thirds of its dry land is located within a flood zone. Given these vulnerabilities, community leaders pressed for the inclusion of sea level rise as an issue to consider in the [2010 Beaufort County Comprehensive Plan](#). The Plan calls for the County government to anticipate and plan for sea level rise impacts.

In response, the Beaufort County Planning Department joined with the project team to investigate opportunities for the County to adapt, or increase its capacity to adapt, to future sea level rise impacts. Adaptation is the process of adjusting one's activities to a changing environment to take advantage of benefits and reduce negative effects. Adaptive capacity is the ability of a community to make those adjustments.

The project team assembled a Beaufort County Stakeholder Group, consisting of local decision makers and stakeholders, which met five times in 2013-2014 and was frequently consulted during the development of this final report. The group drew heavily upon the local knowledge and technical experience of its members, and also reached out to colleagues and engaged a larger audience in two public workshops.

This executive summary highlights the three major sections of the full report: Beaufort County's vulnerability to sea level rise and coastal flooding, stakeholder-generated adaptation actions to respond, and a final section that briefly reviews how community input was gathered. The summary puts the data front and center, whereas the full report includes far more detail, especially regarding community commentary on adaptation actions and additional information about helpful tools or actions being taken in other communities.

With this report, Beaufort County has begun the process of preparing for sea level rise. As a next step, the Beaufort County Stakeholder Group recommends these adaptation actions be considered by the Beaufort County Regional Implementation Committees and the Beaufort County Council Natural Resources Committee.



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Beaufort County's Vulnerability

Local sea level has risen 6 inches since 1965, according to long-term data available at Fort Pulaski, GA, [tide gauge](#) on the Savannah River. As a result, Beaufort County experiences tidal flooding more frequently than in past decades (Figure 1). While most of these floods are minor nuisances today, the threat of major flooding is likely to increase rapidly with faster rates of sea level rise (Figure 2).

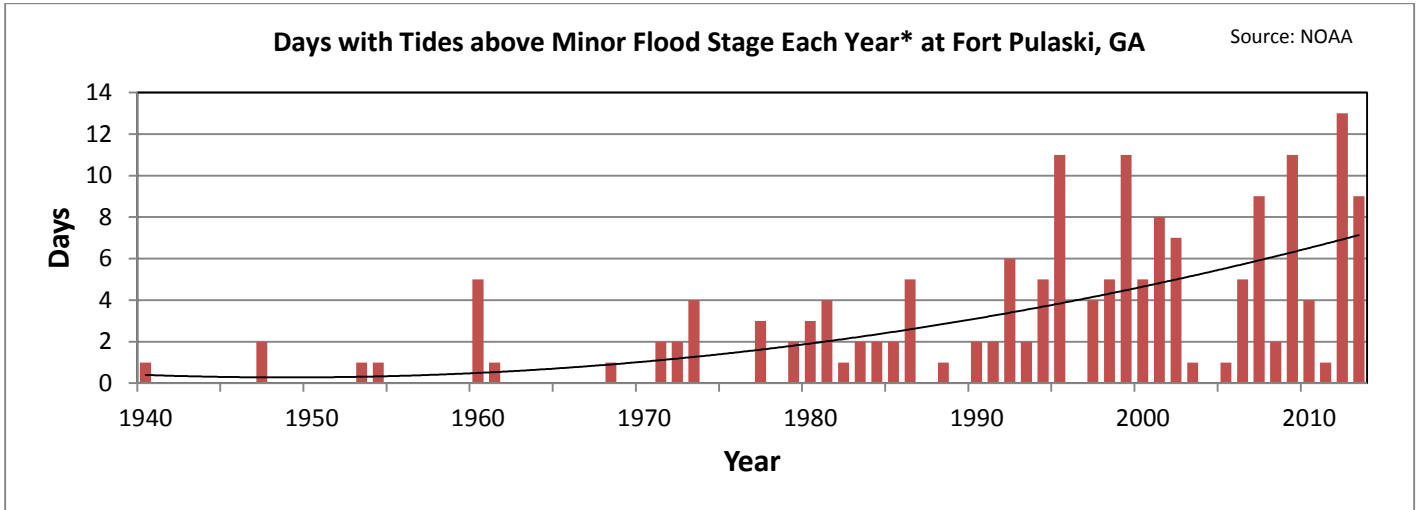


Figure 1: Extreme tides have become more common in recent decades according to tide gauge data at [NOAA Station 8670870](#) Fort Pulaski, GA. The graph displays the number of days each year when tide levels exceeded the National Weather Service [minor flood stage](#), defined as 1.7 ft. above the mean higher high tide ([MHHW](#)). The upward trend is likely due to relative sea level rise in the area (6 in. between 1965-2015). *We use the meteorological year from May 1 to April 30 so we do not split the winter storm season.

Scientists are confident that sea level will continue to rise, but they are uncertain about the pace. They expect local sea levels to rise another 3-7 inches by 2040.

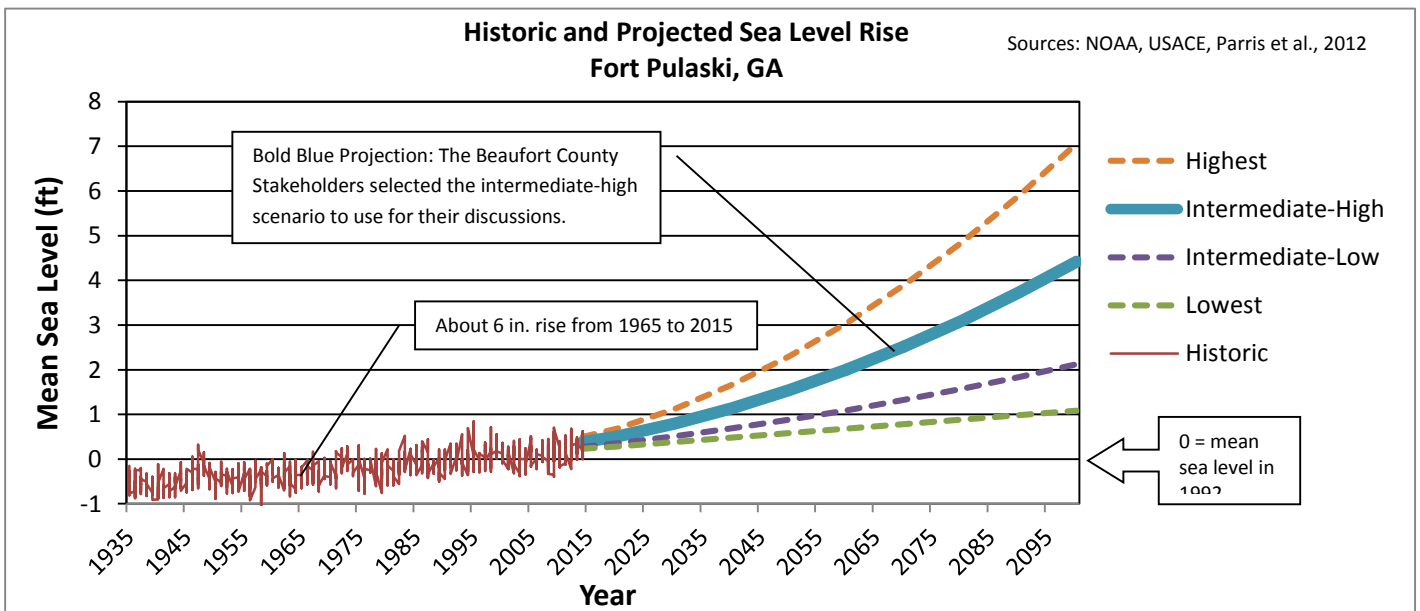


Figure 2: [Historic data](#) from the Fort Pulaski, GA, tide gauge are displayed with future [global sea level scenarios](#) provided by the U.S. National Climate Assessment and modified to incorporate the gradual sinking of the land surface in the region (land subsidence).



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Tidal Flood Map of Beaufort County, South Carolina

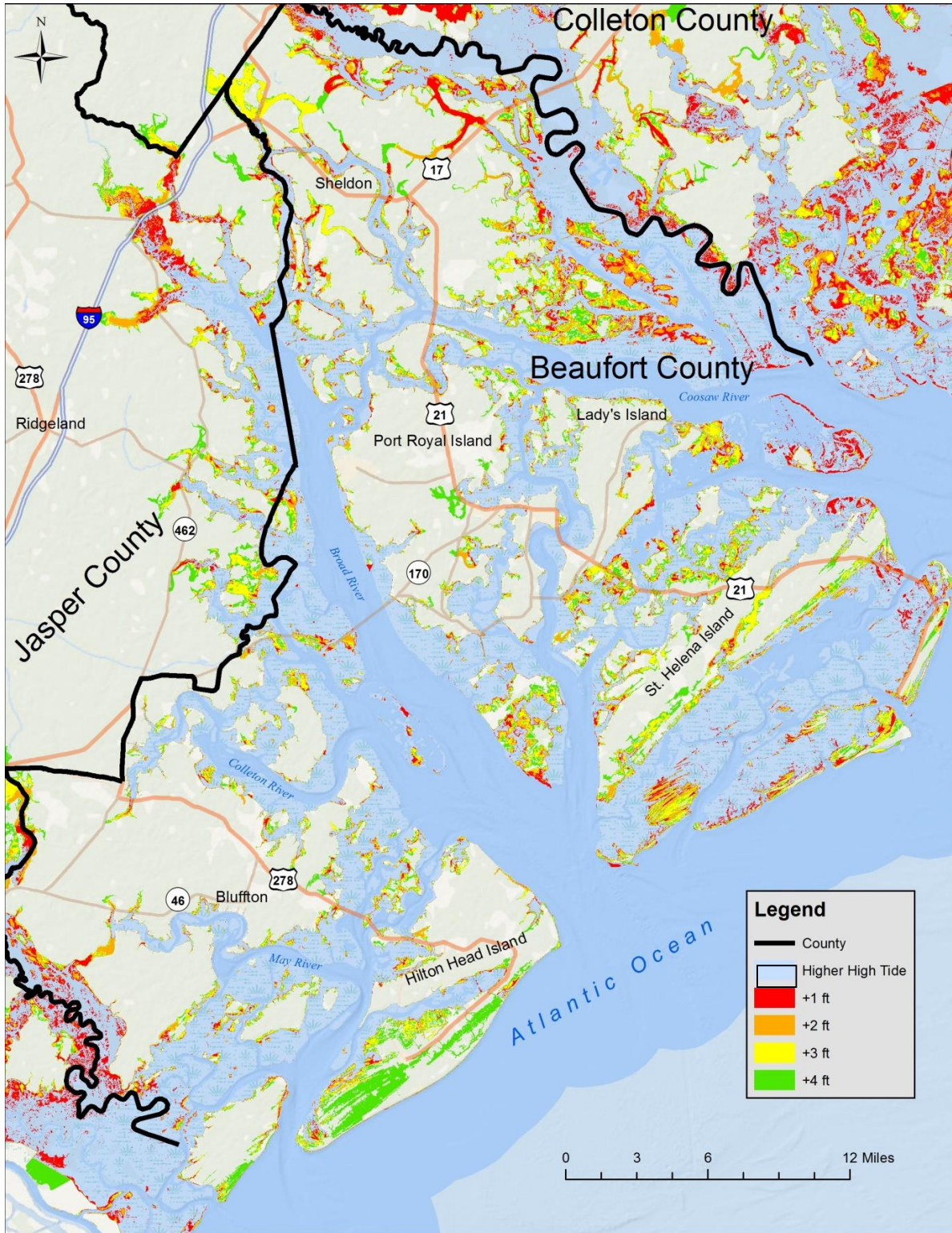


Figure 3: This flood map indicates where tidal flooding will likely occur at designated water levels above the current Mean Higher High Water mark, or the average higher high tide. Future average high tides could extend into the +1 ft. zone by 2040 and the +2 ft. zone by 2065 according to the National Climate Assessment’s Intermediate-High [sea level rise scenario](#). Semi-regular [extreme tides](#) already approach the +2 ft. zone. Future extreme tides could extend into the +3 ft. zone by 2040 and the +4 ft. zone by 2065. Sources: [NOAA](#); [Esri](#)®.



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An Example of Impact: Mossy Oaks Flooding on August 10, 2014

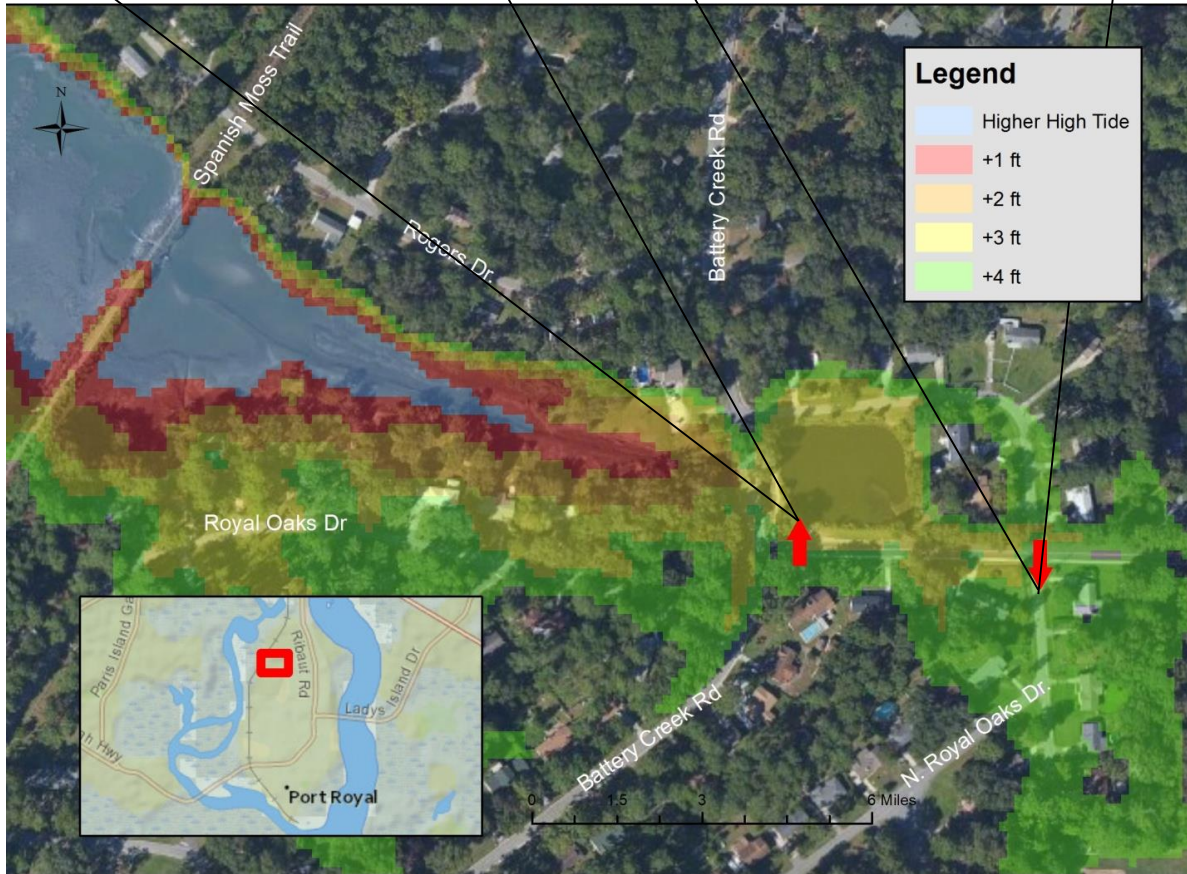
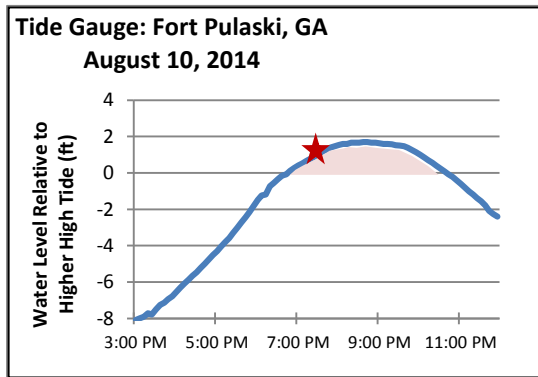


Figure 4: A real life example of tidal flooding occurred in the Beaufort neighborhood of Mossy Oaks on August 10, 2014. Heavy rains and exceptionally high tides combined to generate flooding in the +3-4 ft. zones. The photos above were taken at 7:30 p.m. (see red star in tide gauge data to the right), when the tide was about 1.5 ft. above the higher high tide line. The shaded area to the right identifies when the nearby water level exceeded the average higher high tide, which indicates potential flooding.












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Sea Level Rise Adaptation Action List

The following actions were identified by local stakeholders to help Beaufort County prepare for sea level rise.












	<p>1) Coordination, Cooperation, & Collaboration</p> <p><i>1.1: Improve coordination among governments and agencies.</i></p> <p><i>1.2: Facilitate a dialogue on how to balance public and private interests/responsibilities.</i></p>
	<p>2) Education & Information</p> <p><i>2.1: Develop and implement a public education campaign.</i></p> <p><i>2.2: Provide disclosure and disclaimer notice to purchasers of high risk properties.</i></p>
	<p>3) Emergency Management</p> <p><i>3.1: Incorporate future sea level rise impacts into emergency management plans.</i></p>
	<p>4) Land Management</p> <p><i>4.1: Maintain and strengthen setback policies.</i></p> <p><i>4.2: Install and encourage the use of living shorelines.</i></p> <p><i>4.3: Limit development in high risk areas.</i></p> <p><i>4.4: Use conservation to respond to sea level rise.</i></p> <p><i>4.5: Revise building codes to higher standards and incentivize better design.</i></p> <p><i>4.6: Preserve and restore ecosystems and species.</i></p> <p><i>4.7: Establish funding structures and/or tax districts to help property owners.</i></p> <p><i>4.8: Develop affordable housing in safer areas.</i></p> <p><i>4.9: Create a transfer of development rights program for low elevation properties.</i></p> <p><i>4.10: Assist with beach renourishment.</i></p>
	<p>5) Research & Monitoring</p> <p><i>5.1: Identify or establish environmental monitoring programs in the area.</i></p> <p><i>5.2: Identify trigger points for changing policy.</i></p>
	<p>6) Social Adaptation</p> <p><i>6.1: Address the impacts on disadvantaged social groups, values, and symbolic places.</i></p>
	<p>7) Transportation Adaptation</p> <p><i>7.1: Prioritize, elevate, and protect low-lying roads and causeways.</i></p>
	<p>8) Water Management</p> <p><i>8.1: Use low impact development practices.</i></p> <p><i>8.2: Build water control structures.</i></p>
	<p>9) Miscellaneous</p> <p><i>9.1: Support climate change mitigation programs.</i></p> <p><i>9.2: Increase the County's Community Rating System score.</i></p>

The Community’s Top Priorities

During the public workshop, participants were given three dots to individually rank their first, second, and third priorities on the table. In this tabulation of participant voting, each action item was given a weighted score depending upon its rank, as displayed below:

Participant Rank	Weighted Score
1	3
2	2
3	1

Items that did not receive priority votes were not necessarily unimportant to the participants. These adaptation actions encompass a broad range of near- and long-term strategies, and in general some of these longer-term strategies did not receive as many votes.













Overall Rank	Adaptation Action	Category	Weighted Score
1	Identify or establish environmental monitoring programs in the area.	 Research & Monitoring	60
2	Develop and implement a public education campaign.	 Education & Outreach	44
3	Prioritize, elevate, and protect low-lying roads and causeways.	 Transportation Adaptation	39
4	Improve coordination among governments and agencies.	 Coordination, Cooperation, & Collaboration	24
5	Maintain and strengthen setback policies.	 Land Management	22
6	Install and encourage the use of living shorelines.	 Land Management	18
7	Limit development in high risk areas.	 Land Management	16
8	Use conservation to respond to sea level rise.	 Land Management	14
9	Use low impact development practices.	 Water Management	11
10	Incorporate future sea level rise impacts into emergency management plans.	 Emergency Management	10
10	Revise building codes to higher standards and incentivize better design.	 Land Management	10

(Continued on next page.)



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Overall Rank	Adaptation Action	Category	Weighted Score
10	Identify trigger points for changing policy.	 Research & Monitoring	10
11	Facilitate a dialogue on how to balance public and private interests.	 Coordination, Cooperation, & Collaboration	8
12	Provide a disclosure and disclaimer notice to purchasers of high risk properties.	 Education & Outreach	7
12	Consider the impacts on disadvantaged social groups, values, and symbolic places.	 Social Adaptation	7
13	Preserve and restore ecosystems and species.	 Land Management	5
14	Establish funding structures and/or tax districts to help property owners.	 Land Management	4
15	Support climate change mitigation programs.	 Miscellaneous	3
16	Develop affordable housing in safer areas.	 Land Management	0*
16	Create a transfer of development rights program for low elevation properties.	 Land Management	0*
16	Assist with beach renourishment.	 Land Management	0*
16	Increase the County's Community Rating System score.	 Miscellaneous	0*
16	Build water control structures.	 Water Management	0*

*Items that did not receive priority votes were not necessarily unimportant to the public. Individuals could only vote on their top 3 priorities.



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Community Input Process

The project team relied on the input of the Beaufort County Stakeholder Group, their colleagues, and other members of the public. They sought this input in order to preserve the Beaufort County community's ownership of the results. There were three formal phases of community input: scoping interviews, stakeholder group meetings, and public workshops. The interviews and stakeholder group meetings were conducted as official academic research for the College of Charleston, a member institution of the S.C. Sea Grant Consortium. Therefore, the identities of participants must remain confidential.

Scoping Interviews (June 2013)

The first step in the project was to conduct interviews to gather background information on local environmental issues and the planning process in Beaufort County. Many of these key community members would later participate in the Beaufort County Stakeholder Group.

Stakeholder Group (August 2013 & February, May, November 2014)

In the next step, the project team invited a group of local decision makers to a meeting to discuss the consequences of and responses to sea level rise in a facilitated group discussion. The first two meetings in August 2013 were structured using the Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) process (see full report for more information). Later meetings were informal continuations of the discussion.

Public Workshops (August 2014)

On August 25 and 26, 2014, the S.C. Sea Grant Consortium hosted two public workshops seeking local input on the Stakeholder Group's list of adaptation actions. The open workshops were advertised publicly via e-mail, press release, paper flyer, and word of mouth during the month prior.

How the Community Input was Used

Community input was the cornerstone of this project. The scoping interviews provided the necessary context information for subsequent steps. For example, the project team learned about the extensive partnership of public and private groups involved in maintaining water quality across Beaufort County. This partnership represents a success story for environmental management and an effective local network to be accessed for climate adaptation efforts.

The Stakeholder Group, using the VCAPS process for structure, created the initial list of adaptation actions. Group members have continued to provide much needed advice throughout every stage of the project, including final edits.

The public workshops critiqued, expanded, and combined adaptation actions. Whereas membership to the Stakeholder Group was by invitation only to preserve the confidentiality of its members, the workshops offered a wider opportunity for anyone in the Beaufort County community to comment.



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Table of Contents

Introduction.....	1
Section I. Beaufort County Vulnerability Assessment	3
Section II. Community Input Process	12
Section III. Adaptation Actions	17
Category 1: Coordination, Cooperation, and Collaboration	18
Action 1.1: Inter-Governmental Cooperation.....	18
Action 1.2: Public/Private Dialogue	19
Category 2: Education & Information.....	20
Action 2.1: Public Education.....	20
Action 2.2: Hazard Disclosure and Disclaimer	21
Category 3: Emergency Management.....	22
Action 3.1: Updating Plans.....	22
Category 4: Land Management.....	23
Action 4.1: Setbacks	23
Action 4.2: Living Shorelines.....	25
Action 4.3: Limit Development.....	25
Action 4.4: Conservation.....	26
Action 4.5: Building Codes	27
Action 4.6: Preserve Ecosystems.....	29
Action 4.7: Funding Structures.....	30
Action 4.8: Affordable Housing	31
Action 4.9: Transfer of Development Rights	32
Action 4.10: Beach Renourishment.....	32
Category 5: Research & Monitoring	33
Action 5.1: Environmental Monitoring	33
Action 5.2: Trigger Points	34
Category 6: Social Adaptation	36
Action 6.1: Social Vulnerability	36
Category 7: Transportation Adaptation.....	37
Action 7.1: Elevate Roads	37

Category 8: Water Management 38

 Action 8.1: Low Impact Development. 38

 Action 8.2: Water Control Structures 39

Category 9: Miscellaneous 40

 Action 9.1: Mitigation Programs 40

 Action 9.2: Community Rating System..... 41

Appendix A: Climate Change and Stormwater Management VCAPS Diagram.....42

Appendix B: Climate Change and Sea Level Rise Planning VCAPS Diagram..... 43

Appendix C: Announcement for Beaufort County Sea Level Rise Public Workshops.....44

Appendix D: Agenda for Beaufort County Sea Level Rise Public Workshops..... 45

Key Terms

In the context of this project on Beaufort County, South Carolina, and sea level rise, we use the following definitions of these key terms:

Sea level rise: An increase in the average relative sea level over a period long enough to average out transients such as waves, tides, and storms.

Decision makers: Any group, institution, organization, or individual who makes decisions related to sea level rise or its impacts. This includes the state, county, and municipal governments, the military, private developers, marinas, homeowners, tribal groups, and environmental groups.

Adaptation: Adjustments made by decision makers that are intended to prepare for future sea level rise in a way that takes advantage of beneficial opportunities or reduces negative effects. This includes adapting to gradual sea level rise and related extreme events such as storm surges.

Adaptive capacity: The capacity of decision makers to adapt to sea level rise. Capacity includes resources, knowledge, and skills along with the political will and leadership to marshal those resources in a productive manner.

Resilience: A measure of Beaufort County's *present ability* to adapt to sea level rise without experiencing permanent harm. This differs from adaptive capacity because the latter is the *potential* for Beaufort County to adapt.

Sensitivity: A characteristic of a person, place, or thing that describes how easily harmed it is by sea level rise. A person who owns a home near sea level is much more sensitive to sea level rise than a person who owns a home on a high hill set back from the sea.

Vulnerability: This term includes all the above and summarizes the degree to which the County, or any specific location or stakeholder in the County, is susceptible to and unable to cope with anticipated sea level rise and its associated impacts. Vulnerability is a function of sea level rise, the sensitivity of the location or party, and its adaptive capacity.

Relevant Acronyms

FEMA:	<u>Federal Emergency Management Agency</u>
MHHW:	<u>Mean Higher High Water</u>
NOAA:	<u>National Oceanic and Atmospheric Administration</u>
NWS:	<u>National Weather Service</u>
SCDHEC:	<u>South Carolina Department of Health and Environmental Control</u>
SCDNR:	<u>South Carolina Department of Natural Resources</u>
SCDOT:	<u>South Carolina Department of Transportation</u>
USACE:	<u>United States Army Corps of Engineers</u>

Introduction

Beaufort County, South Carolina, is a low-lying coastal county with a high sensitivity to tidal flooding and storm surge. Just over half of Beaufort County is open water, sounds, marshes, and estuaries and two thirds of its dry land is located within a flood zone. Given these vulnerabilities, community leaders called for the inclusion of sea level rise as an issue to consider in the [2010 Beaufort County Comprehensive Plan](#). The Plan calls for the County government to anticipate and plan for sea level rise impacts.

In response, the Beaufort County Planning Department joined with the South Carolina Sea Grant Consortium, the Social and Environmental Research Institute, North Carolina Sea Grant, and the Carolinas Integrated Sciences and Assessments Program at the University of South Carolina (the “project team”) to investigate opportunities for the County to adapt, or increase its capacity to adapt, to future sea level rise impacts. Adaptation is the process of adjusting one’s activities to a changing environment to take advantage of benefits and reduce negative effects. Adaptive capacity is the ability of a community to make those adjustments.










The project team assembled a Beaufort County Stakeholder Group, consisting of local decision makers and stakeholders, which met five times in 2013-2014 and was frequently consulted during the development of this final report. The group drew heavily upon the local knowledge and technical experience of its members, and also reached out to colleagues and engaged a larger audience in two public workshops.

This report cites data on local sea level rise trends and reviews the 23 adaptation actions identified by the Beaufort County Stakeholder Group and members of the broader public. These 23 actions are grouped into nine categories and presented below. The report is divided into three major sections. The first is a vulnerability assessment that examines the nature of local sea level rise in Beaufort County and maps potential flood zones across the County. Section II recounts the methodology utilized to gather information and seek community input. This section includes the results of priority voting of the adaptation actions conducted by members of the public. Section III presents the findings on each adaptation action. This final section provides a brief description of the action, displays community comments in bullet points, and shares additional information including the experience of other communities and helpful tools and methods.

With this report, Beaufort County has begun the process of preparing for sea level rise. As a next step, the Beaufort County Stakeholder Group recommends these adaptation actions be considered by the Beaufort County Regional Implementation Committees and the Beaufort County Council Natural Resources Committee.

Sea Level Rise Adaptation Action List

The following actions identified by local stakeholders help Beaufort County prepare for sea level rise via direct adaptation of policy and by expanding the County's adaptive capacity.

	<p>1) Coordination, Cooperation, & Collaboration <i>1.1: Improve coordination among governments and agencies.</i> <i>1.2: Facilitate a dialogue on how to balance public and private interests/responsibilities.</i></p>
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	<p>9) Miscellaneous <i>9.1: Support climate change mitigation programs.</i> <i>9.2: Increase the County's Community Rating System score.</i></p>

Section I. Beaufort County Vulnerability Assessment

With its low-lying geography, Beaufort County is particularly vulnerable to elevated water levels. This section examines historic and future sea level rise and depicts the effect of heightened water levels on normal tide cycles. This includes the presentation of a county flood map that depicts future high tides and extreme high tides with 1-2 feet of base sea level rise. Lastly, this section explores what these water levels are like on the ground by recalling an August 2014, flood event at the Mossy Oaks neighborhood of Beaufort, S.C.

Sea Level Basics

Scientists use land-based tidal gauges and satellites to measure changes in sea level. Local sea level can rise for three reasons. (1) The volume of water in the ocean increases. This is currently happening for two reasons. First, ocean water is expanding as it warms. Second, glaciers and ice sheets on land are melting, leading more water to enter the seas. (2) Sea levels can also appear to change because land rises or falls. The shoreline of the eastern U.S. is generally sinking. This is called land subsidence. To some extent this is a natural process that has to do with the type of soils along the shore, but it can also be aggravated by groundwater removal. (3) Changes to ocean currents such as the Gulf Stream can lead to more water pushing up against the East Coast.

Tidal gauges measure the relative change in sea level. It is “relative” because it does not include the movement of the land itself. Satellites measure absolute mean sea level by measuring the height of the sea from the center of the Earth. Because oceans naturally rise and fall with winds, storms, tides, and seasons, all measures of sea level need to be averaged over a long time period to arrive at a clear trend.

Beaufort County experiences a semidiurnal tide. There are two high tides and two low tides of approximately equal size every day, though one of the two high tides is slightly higher than the other and one of the two low tides is slightly lower than the other (Figure 1).

The average height of all high tides is known as Mean High Water (MHW). The average height of the higher of the two daily tides is known as **Mean Higher High Water (MHHW)**, or the higher high tide line. These averages are calculated using tide gauge observations during a 19-year period known as the [National Tidal Datum Epoch](#). The current epoch is 1983-2001.

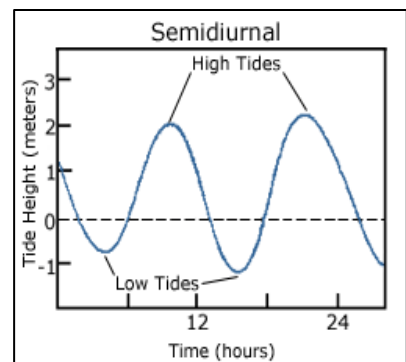


Figure 1: Semidiurnal tides consist of two daily high tides and two daily low tides of approximately equal height. Source: NOAA

Differences in coastal land type from mudflats to marshes to forest are determined by the interaction of tidal cycles and ground elevation. For example, salt water marsh grasses thrive in elevation zones where they are flooded by water for part of the day. Many plants cannot survive when exposed to excessive salt water. MHHW can be used as the approximate boundary line between wetlands vegetation like salt marsh and upland vegetation like oak trees.

The [National Weather Service](#) (NWS) distinguishes three primary [flood stages](#): minor flooding, moderate flooding, and major flooding.² **Minor flooding** consists of minimal or no property damage, but possibly some public threat (e.g., inundation of roads). **Moderate flooding** refers to some inundation of structures and roads near water bodies. **Major flooding** refers to extensive inundation of structures and roads. The NWS designates flood stages in Beaufort County at the following local [data points](#):

- Minor Flooding: 1.7 ft. above MHHW
- Moderate Flooding: 2.1 ft. above MHHW
- Major Flooding: 2.5 ft. above MHHW

Observed Local Data

This project uses long-term tide gauge data from nearby [NOAA station 8670870](#)³ at Fort Pulaski, GA. Although sited about 10 miles outside of the Beaufort County line, this station provides the long term data necessary for identifying sea level trends. It can be used as a proxy for major trends across the County, but may differ somewhat from specific tide gauges within the County, especially if they are located on an insulated river. Since the station's establishment in 1935, relative mean sea level has risen an average of 0.12 inches per year (Figure 2). This translates to 1.2 in./decade or 1.0 ft./century.

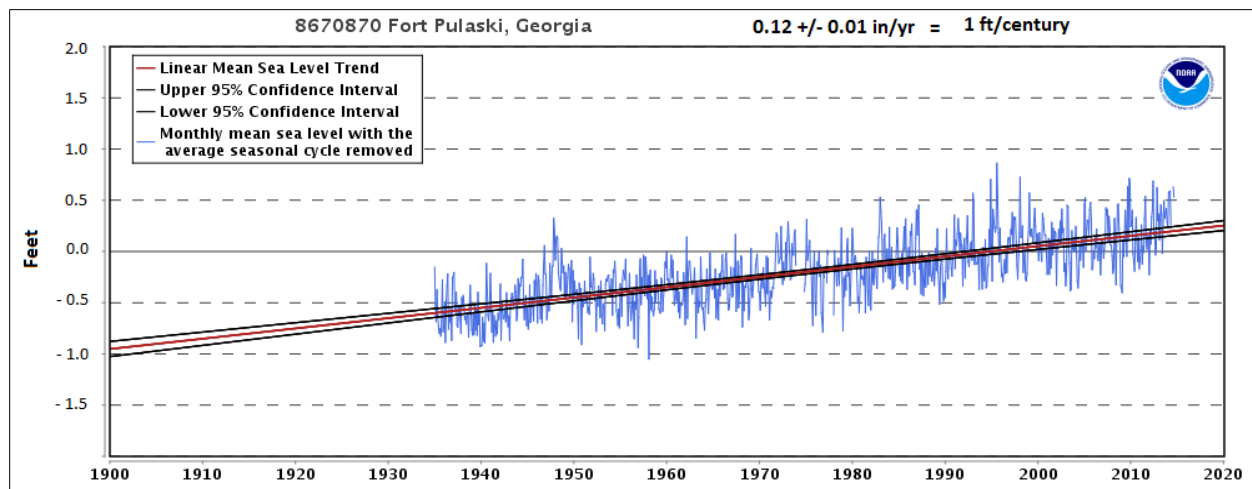


Figure 2: Mean sea level is rising at NOAA station 8670870 near Beaufort County, S.C.

² Caldwell, David B. 2012. "National Weather Service Manual 10-950, Operations and Services Hydrologic Services Program, NWSPD 10-9 Definitions and General Terminology." National Weather Service. <http://www.nws.noaa.gov/directives/sym/pd01009050curr.pdf>

³ NOAA. 2014. "Fort Pulaski, GA – Station ID: 8670870." *Tides & Currents*. <http://tidesandcurrents.noaa.gov/stationhome.html?id=8670870>

Naturally, water levels can be quite variable, fluctuating daily with tides. Figure 3 shows the highest monthly tide levels recorded at Fort Pulaski. These data are used to create annual exceedance probabilities, which quantify the water levels likely to be exceeded with 99%, 50%, 10%, and 1% probability every year. The exceedance probabilities indicate that water levels at 1-2 ft. above MHHW are common, with NWS minor flood stage and moderate flood stage occurring at least yearly and bi-yearly, respectively.

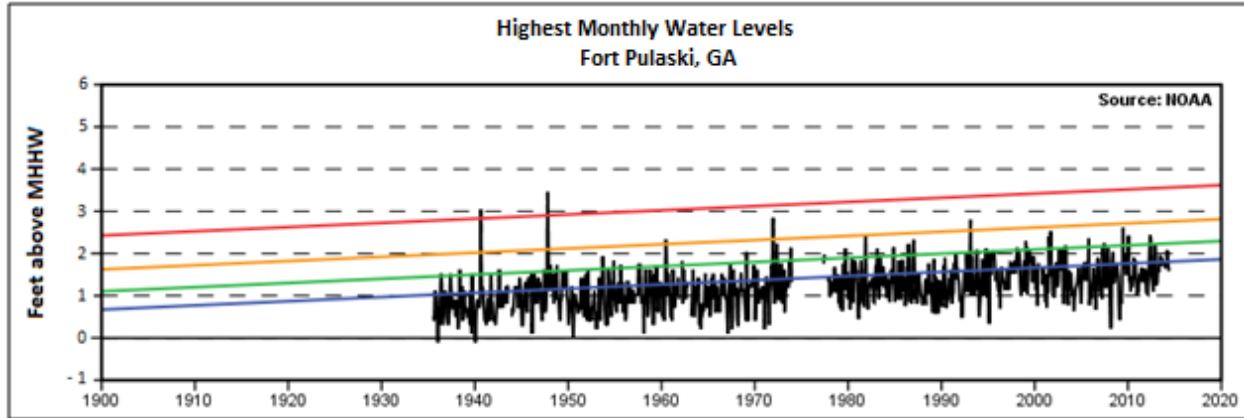


Figure 3: Data on highest monthly water levels (black line). The color lines represent the water level associated with 99% (blue), 50% (green), 10% (orange), or 1% (red) annual probability of reoccurrence, or the probability that water levels will be reached at least once during the year.

However, the annual exceedance probability levels do not measure the probability of extreme tides happening multiple times in the year. Figure 4 shows the number of days each year when tides exceeded the NWS minor flood stage. These flood events have increased over time. Although these data include tides associated with storm surge, the overall trend is due to the increased height of regular high tides.

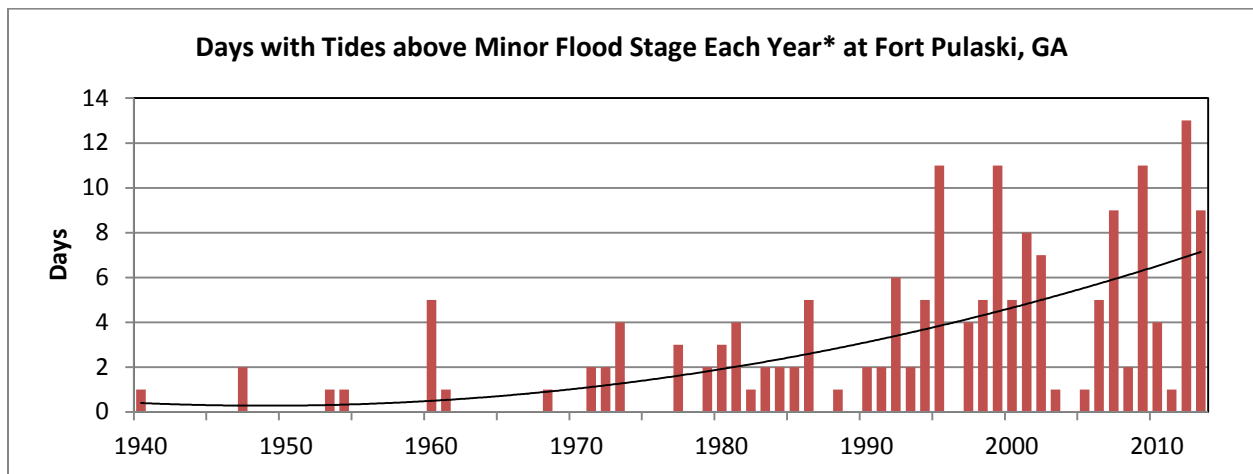


Figure 4: Extreme tides have become more common in recent decades according to tide gauge data at NOAA Station Fort Pulaski, GA. The graph displays the number of days each year when tide levels exceeded the NWS minor flood stage, defined as 1.7 ft. above the mean higher high tide (MHHW). The upward trend is likely due to the combination of sea level rise and land subsidence occurring in the area.
*We use the meteorological year from May 1 to April 30 so we do not split the winter storm season.

Future Sea Levels

Global mean sea level is increasing due to thermal expansion and ice melt. Like mercury in a thermometer, water expands when heated. This increases the surface height of the ocean. Atmospheric heat melts ice, including land-based ice sheets and glaciers, adding additional water volume to ocean basins. These two forces are expected to intensify due to atmospheric heat trapped by the presence of greenhouse gases like carbon dioxide (CO₂).

The U.S. National Climate Assessment provides global sea level rise projections for four planning [scenarios](#)⁴ (Table 1; Figure 5). These scenarios are based on the full range of possibilities expressed among scientific studies. The four scenarios are guides for climate adaptation planning that communities can use to decide for themselves how precautionary they want to be. Preparing for the lowest scenario will save resources, but may leave the County vulnerable to future sea level rise risk. On the other hand, preparing for the highest scenario could protect critical infrastructure and reduce future impacts, but may prove costly and unwarranted if seas do not rise as high as anticipated in that scenario.

Table 1: Sea level rise [scenarios](#) for the U.S. National Climate Assessment.⁵

Scenarios	Description
Lowest	A scenario based on the continuation of historical trends derived from tide gauge data beginning in 1900.
Intermediate-Low	A scenario based primarily on thermal expansion, without significant ice melt.
Intermediate-High	A scenario based on thermal expansion and some ice sheet loss.
High	A scenario based on the calculation for the highest possible glacier and ice sheet loss by the end of the century.

The National Climate Assessment projections are intended for global average sea level rise. Therefore, it is important to consider local contributions to sea level rise⁶. Relative mean sea level in Beaufort County is rising more quickly than the global average due to land subsidence. Subsidence is the gradual sinking of the land surface due to natural compaction of coastal soil and/or excessive withdrawal of underground liquids like water and oil. According to the U.S. Army Corps of Engineers Sea Level Rise Curve Calculator,⁷ the rate of land subsidence at Fort Pulaski is 0.05 in./yr. It is assumed that the land surface will continue to subside at a similar rate into the future.

⁴ Parris, Adam, Peter Bromirski, Virginia Burkett, Dan Cayan, Mary Culver, and John Hall. 2012. *Global Sea Level Rise Scenarios for the United States National Climate Assessment*. National Oceanic and Atmospheric Administration (NOAA). http://cpo.noaa.gov/sites/cpo/Reports/2012/NOAA_SLR_r3.pdf.

⁵ Ibid.

⁶ The contribution of the Gulf Stream and other ocean currents are difficult to predict and are not considered in Figure 5. Ocean currents typically interact with sea level in cycles that can be averaged out over more than ~20 years.

⁷ USACE. 2014. "Sea-Level Change Calculator." *Responses to Climate Change*. <http://www.corpsclimate.us/ccaceslcurves.cfm>

Figure 5 incorporates the rate of local land subsidence into the four global sea level rise scenarios to provide localized projections up to year 2100. Scientists are 90% confident that global mean sea level will rise within the 1 ft. to 7 ft. range of these scenarios by the end of the century, but cannot attribute a probability to any specific scenario.

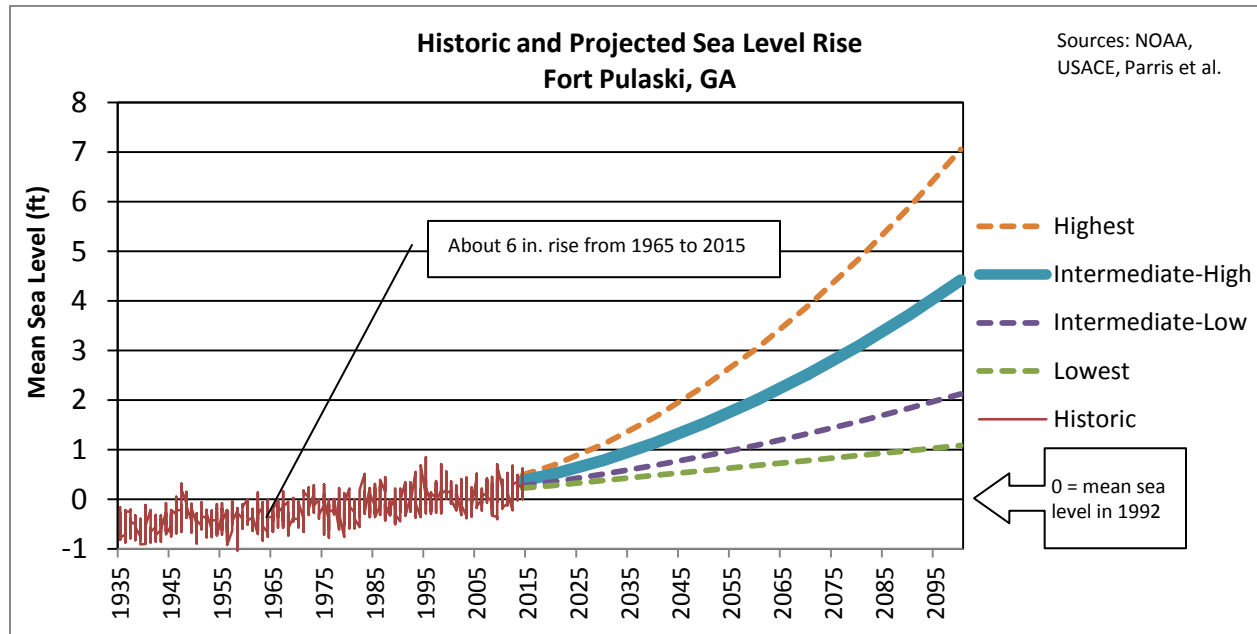


Figure 5: Historic data from the Fort Pulaski tide gauge are displayed with future global sea level scenarios provided by NOAA and modified to incorporate the gradual sinking of the land surface in the region (land subsidence). The intermediate-high scenario (bolded blue line) was selected as the planning scenario by the Beaufort County Stakeholder Group.

As mean sea level increases, tidal flooding within the year becomes more common. Figure 6 displays a projection of tidal flood events in the next six decades based on the National Climate Assessment scenarios. Even if local sea level rises at its historic rate (Lowest Scenario), the number of tidal floods will increase to an average of 40 events per year by 2060. If sea level rises at its highest projected rate, tidal flooding could occur at nearly every high tide of the year.

Flood Mapping

To determine the impact of future projections in sea level, the Beaufort County Stakeholder Group selected two data points from the intermediate-high scenario: +1 ft. sea level rise by 2040 and +2 ft. sea level rise by 2065 (Figure 5). These two points represent the length of a mortgage (about 30 years) and infrastructure design life (about 50 years) respectively, from the time this project was initiated. The project team used Esri's geographic information systems software, ArcGIS®, to map the potential impact of elevated water levels across Beaufort County (Figure 7).

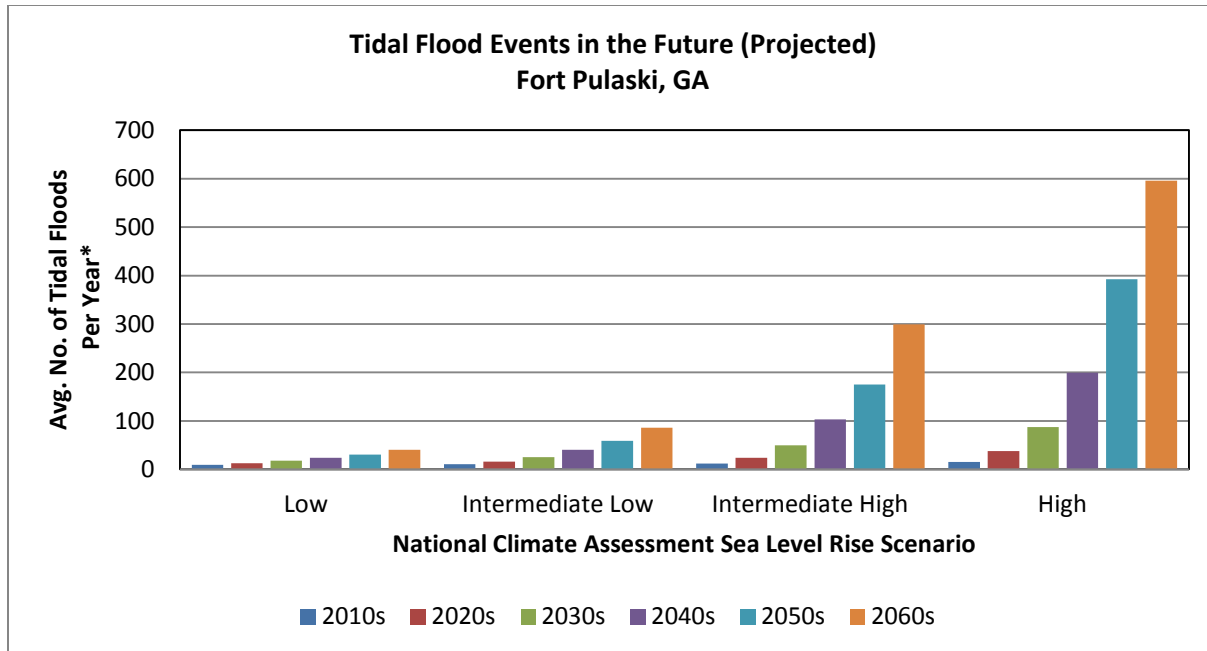


Figure 6: Flood events surpassing the NWS minor flood stage (1.7 ft. MHHW) will become more common in the coming decades. The project team created these projections using tide gauge data from the NOAA Inundation Analysis [tool](#)⁸ and [methodology](#) described by NOAA.⁹ For each analysis, we averaged the number of flood events above the flood stage [threshold](#) at NOAA [station 8670870](#) Fort Pulaski, GA, over a 10-year period from 2000 to 2010. Because these data come from a 10-year period, it does not remove the effect of multi-year or multi-decadal oscillations in sea level. In other words, the analysis assumes that tidal data will be identical to 2000-2010, but with a higher base water level. *Tidal floods possible twice daily during high tides.

The project team used one-foot sea level rise contours provided by the NOAA Office of Coastal Management’s Sea Level Rise and Coastal Flooding Impacts Viewer.¹⁰ These layers were designed using 2002 Light Detection and Ranging (LiDAR) elevation data from the Beaufort County GIS Department. The layers simulate the vertical and horizontal movement of the tidal water line onto the topography of the land surface. This methodology is sometimes known as a “bathtub model” because the water fills the basin up to the modeled land surface just like water fills a bathtub. This type of mapping does not factor in other forces that will shape Beaufort County’s shoreline as the sea rises, including wave action due to storm surge, erosion of the shoreline, changing hydrological patterns, or the protection of shoreline by humans.

The base sea level layer in the model is set at Mean Higher High Water (MHHW) in order to distinguish currently dry land from wetlands. Layers at +1 ft. and +2 ft. MHHW are used to show future higher high tides in 2040 and 2065 (Intermediate-High scenario) and +3 ft. and +4 ft. are displayed to show the impact of semi-regular extreme tides (i.e., Figure 3).

⁸ NOAA. 2015. “Inundation Analysis Tool.” *Tides & Currents*. <http://tidesandcurrents.noaa.gov/inundation/>

⁹ Pendleton. 2013. “What’s the Frequency, Kenneth? (With Coastal Flooding That Is).” *Digital Coast*. <http://coast.noaa.gov/geozone/whats-frequency-kenneth-coastal-flooding/#.VL-5EfF83d>

¹⁰ NOAA Office for Coastal Management. 2014. “Sea Level Rise and Coastal Flooding Impacts Viewer.” *Digital Coast*. <http://coast.noaa.gov/digitalcoast/tools/slr>

Tidal Flood Map of Beaufort County, South Carolina

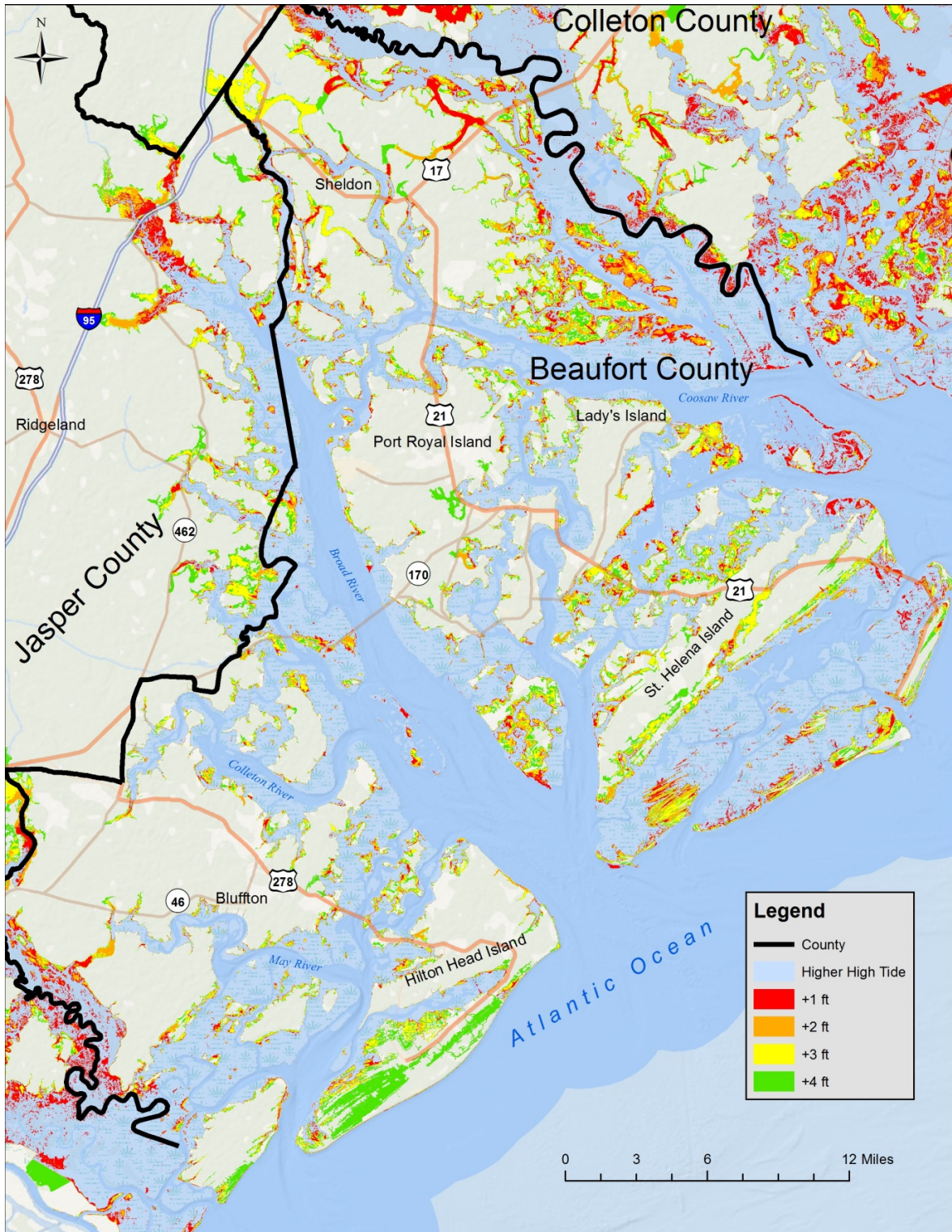


Figure 7: This flood map indicates where tidal flooding will likely occur at designated water levels above the current Mean Higher High Water mark, or the average higher high tide. Future average high tides could extend into the +1 ft. zone by 2040 and the +2 ft. zone by 2065 according to the National Climate Assessment’s Intermediate-High sea level rise [scenario](#). Semi-regular extreme tides already approach the +2 ft. zone. Future extreme tides could extend into the +3 ft. zone by 2040 and the +4 ft. zone by 2065. Sources: NOAA; Esri ©.

Figure 7 depicts the widespread impact of elevated water levels on Beaufort County, showing that sea level rise is a concern for the rural inland communities of the County just as much as the oceanfront Sea Islands. Daily high tides 1-2 ft. above current levels will first erode many of the isolated hammocks and extensive marshland of the Sea Islands. It will encroach onto the dry land adjacent to creeks and rivers.

If base sea level was 1-2 ft. higher than the current level, then semi-regular extreme high tides will be 3-4 ft. higher than current levels. As the yellow and green colors on Figure 7 indicate, these extreme tides could flood 20,000-30,000 acres of dry land. While much of the vulnerable land resides in the low-density rural regions of northern Beaufort County, up to 9,000 acres of urban and residential land uses could be flooded without protection. These tides could cause significant property damage in properties not built to current FEMA flood zone standards.

The most extreme floods today offer a glimpse into the regular tidal floods of the future. In mid-August 2014, local water level approached 2 ft. above MHHW amid several days of intense rainfall. Drainage systems in the Mossy Oaks neighborhood of Beaufort, S.C. were overwhelmed. A local resident documented extensive flooding in the 3-4 ft. above MHHW zones displayed in Figure 8. In the real world, weather and the state of development can intensify the impact of tidal flooding.

Ultimately, the flood maps like those in Figure 7 and 8 depict a bathtub model of an unchanging world. In reality, Beaufort County and its residents will gradually respond to reoccurring floods. The Beaufort County Stakeholder Group was concerned with the big picture view of encroaching sea level rise. As presented in this report, the flood map is intended to inform members of the public and introduce sea level rise as a County-wide planning issue.

An Example of Impact: Mossy Oaks Flooding on August 10, 2014

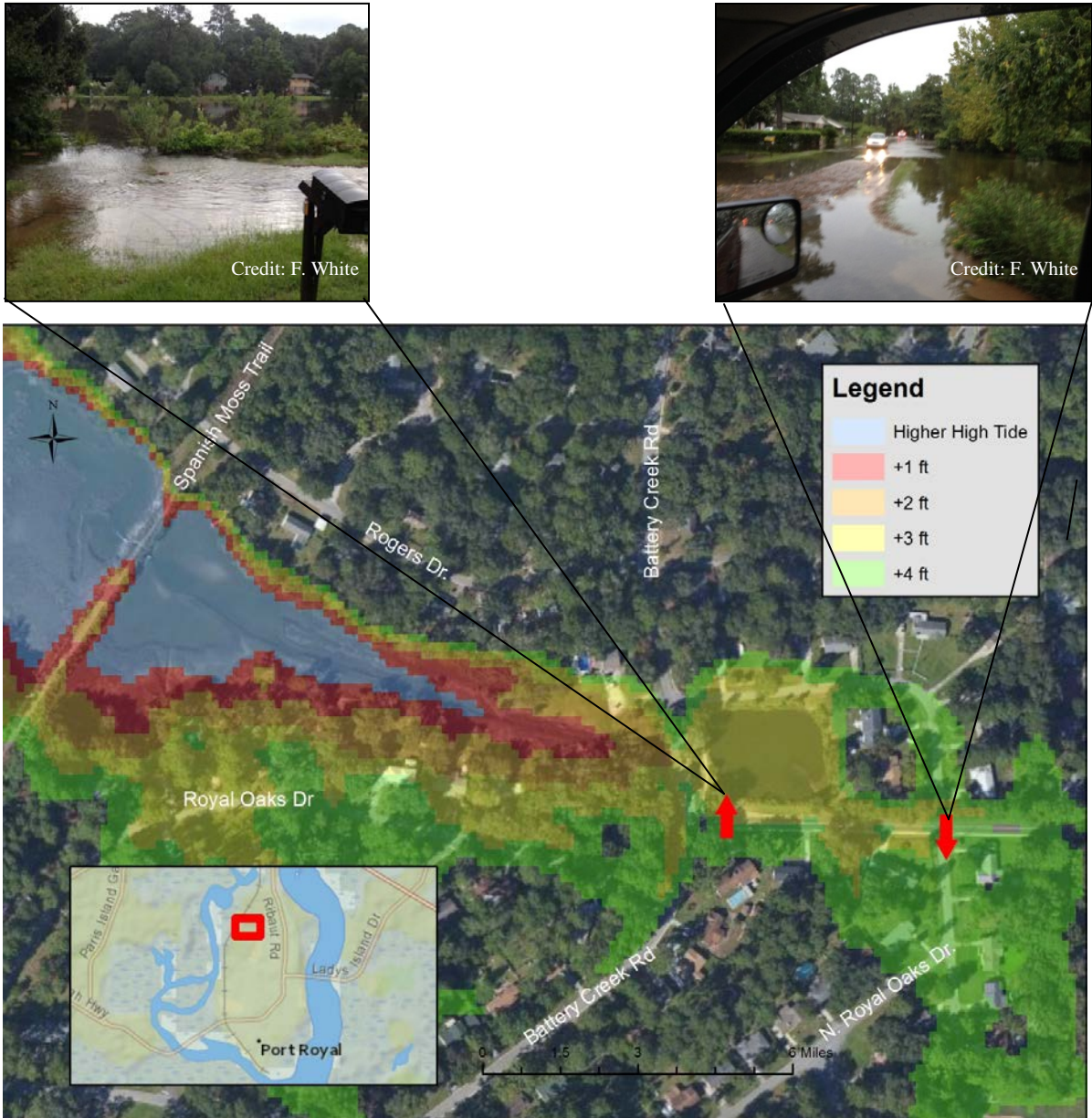
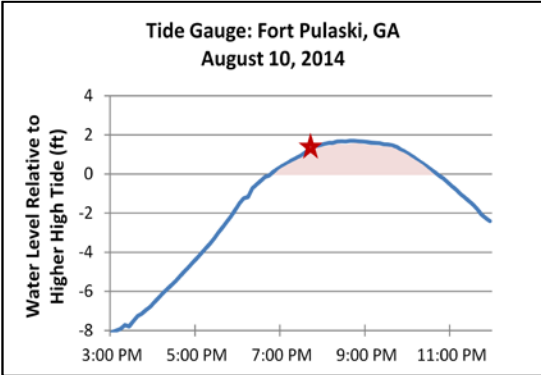


Figure 8: A real life example of tidal flooding occurred in the Beaufort neighborhood of Mossy Oaks on August 10, 2014. Heavy rains and exceptionally high tides combined to generate flooding in the +3-4 ft. zones. The photos above were taken at 7:30 p.m. (see red star in tide gauge data to the right), when the tide was about 1.5 ft. above the higher high tide line. The shaded area to the right identifies when the nearby water level exceeded the average higher high tide, which indicates potential flooding.



Section II. Community Input Process

The project team relied on the input of the Beaufort County Stakeholder Group, their colleagues, and other members of the public. They sought this input in order to preserve the Beaufort County community's ownership of the results. There were three formal phases of community input: scoping interviews, Stakeholder Group meetings, and public workshops. The interviews and Stakeholder Group meetings were conducted as official academic research for the College of Charleston, a member institution of the S.C. Sea Grant Consortium. Therefore, the identities of participants must remain confidential.

Scoping Interviews (June 2013)

The first step in the project was to conduct interviews to gather background information on local environmental issues and the planning process in Beaufort County. Many of these key community members would later participate in the Beaufort County Stakeholder Group.

Participants

Interview candidates were selected based on their community standing and the relevance of their role to planning and environmental issues in Beaufort County. An initial contact list was proposed by Beaufort County planner Robert Merchant. Candidates were contacted via phone or e-mail. Fifteen people were interviewed. In-person interviews followed rules established by the College of Charleston's Institutional Review Board for research involving human participants.¹¹

Stakeholder Group (August 2013 & February, May, November 2014)

In the next step, the project team invited a group of local decision makers to a meeting to discuss the consequences of and responses to sea level rise in a facilitated group discussion. The first two meetings in August 2013 were structured using the Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) process (see Process section below). Later meetings were informal continuations of the discussion contained herein.

Participants

Most of the interviewees were invited to join the Stakeholder Group. Additional community members were added to the discussion in later meetings based on the need for their expertise. For example, two private business owners and additional county staff members were consulted during the process. There were a total of 19 group members over five meetings in Beaufort County.

Process

The group discussions were structured using the Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) [process](#).¹² VCAPS is an approach to decision support that

¹¹ College of Charleston ORGA. 2014. "Office of Research & Grants Administration." College of Charleston. http://orga.cofc.edu/pub/compliance_irb_index.shtml

¹² SERI & CISA. 2014. "VCAPS: Vulnerability, Consequences, and Adaptation Planning Scenarios." <http://vcapsforplanning.org/>

integrates local knowledge with scientific understanding. It has been previously used in at least 13 coastal communities, including Sullivan’s Island and McClellanville in South Carolina.¹³

VCAPS researchers lead community decision makers through group discussion about local issues affected by environmental change. Experts are invited to provide basic context about the science and decision makers use that information to collectively identify local vulnerabilities, consequences, and adaptation actions based on the climate hazard. During these discussions, the researchers create diagrams that represent how the decision makers understand the links between climate hazards and their consequences for Beaufort County, as well as the actions that government entities and private individuals or groups can take to reduce or prevent any consequences. Figure 9 displays the concept boxes used to organize a VCAPS diagram into a logical flow beginning with the relevant management concern and ending with the consequences initiated by climate hazards.

The Stakeholder Group created two VCAPS diagrams. The first diagram displayed a discussion on the impact of development and rainfall patterns on stormwater management (Appendix A).

The second diagram captures the effect of sea level rise and storm surge on planning (Appendix B).

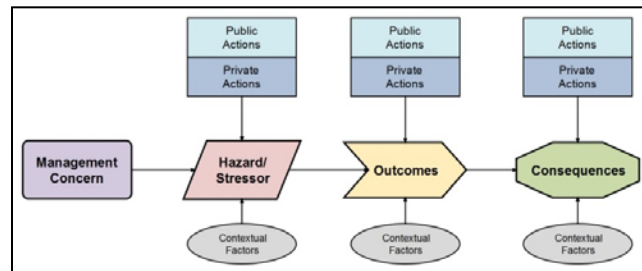


Figure 9: The legend for a Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) diagram shows how the focus group discussion was structured.

After initial meetings in August 2013, the Stakeholder Group reconvened in February and May 2014 to continue the discussion with the use of sea level rise flood maps created by the S.C. Sea Grant Consortium using geographic information systems (GIS) software. The maps provided a spatial focus to the group’s discussions about vulnerability.

Throughout these discussions, the Beaufort County Stakeholder Group identified many adaptation actions. Their actions were the foundation of the list contained in this report. The group met a final time in November 2014 to provide input on the draft report.

Public Workshops (August 2014)

On August 25 and 26, 2014, the S.C. Sea Grant Consortium hosted two public workshops seeking local input on the Stakeholder Group’s list of adaptation actions. The workshops were advertised publicly via e-mail, press release, paper flyer (Appendix C), and word of mouth during the month prior.

¹³ Webler, Thomas, Seth Tuler, Kirstin Dow, Jessica Whitehead, and Nathan Kettle. 2014. “Design and Evaluation of a Local Analytic-Deliberative Process for Climate Adaptation Planning.” [Local Environment](#). 17 July.

Participants

Seventy-seven people attended the two public workshops. Figure 10 identifies the affiliation of attendees according to a post-workshop evaluation survey. The three largest groups included concerned citizens, non-profit groups, and state agency employees.

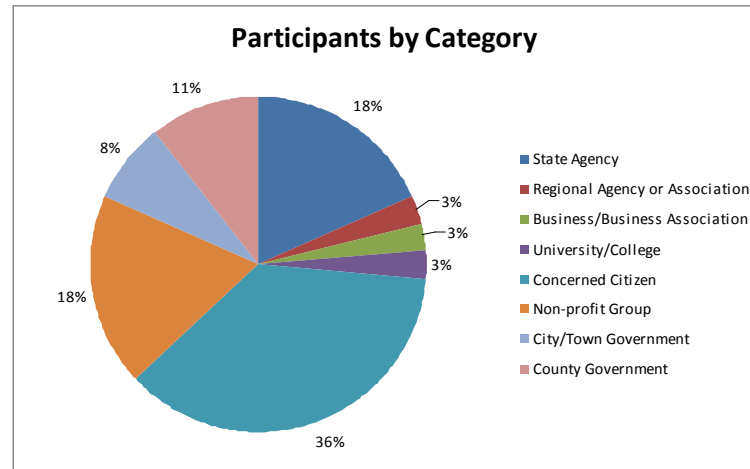


Figure 10: The affiliation of attendees to the Beaufort County Sea Level Rise Adaptation workshops according to a post-survey evaluation survey.

Workshop Format

Two public workshops were held in Beaufort County: one at the Bluffton regional library and another at the St. Helena regional library. Their formats were identical (Appendix D). The three-hour workshops were divided into two parts. The first half of the workshops was dedicated to presentations on Beaufort County's vulnerability to sea level rise and the progress of the Stakeholder Group in identifying adaptation actions. During the second half of the workshops, the project team facilitated separate breakout group discussions with 5-10 people. This structure allowed members of the public to provide their own informed commentary on potential adaptation actions for Beaufort County.

How the Community Input was Used

Community input was the cornerstone of this project. The scoping interviews provided the necessary context information for subsequent steps. For example, the project team learned about the extensive partnership of public and private groups involved in maintaining water quality across Beaufort County. This partnership represents a success story for environmental management and an effective local network to be accessed for climate adaptation efforts.

The Stakeholder Group, using the VCAPS process for structure, created the initial list of adaptation actions. Group members continued to provide much needed advice throughout every stage of the project, including final edits.










The public workshops critiqued, expanded, and combined adaptation actions. Whereas membership to the Stakeholder Group was by invitation only to preserve the confidentiality of its members, the workshops offered a wider opportunity for anyone in the Beaufort County community to comment.

Top Priorities of Workshop Participants

During the public workshops, each participant ranked their first, second, and third priorities from among 23 adaptation actions. In this tabulation of participant voting, each participant's first, second, and third priority were awarded a weighted score as displayed below:

Participant Rank	Weighted Score
1	3
2	2
3	1

Items that did not receive priority votes were not necessarily unimportant to the participants. These adaptation actions encompass a broad range of near- and long-term strategies, and in general some of these longer-term strategies did not receive as many votes.

Overall Rank	Adaptation Action	Category	Weighted Score
1	Identify or establish environmental monitoring programs in the area.	 Research & Monitoring	60
2	Develop and implement a public education campaign.	 Education & Outreach	44
3	Prioritize, elevate, and protect low-lying roads and causeways.	 Transportation Adaptation	39
4	Improve coordination among governments and agencies.	 Coordination, Cooperation, & Collaboration	24
5	Maintain and strengthen setback policies.	 Land Management	22
6	Install and encourage the use of living shorelines.	 Land Management	18
7	Limit development in high risk areas.	 Land Management	16
8	Use conservation to respond to sea level rise.	 Land Management	14
9	Use low impact development practices.	 Water Management	11
10	Incorporate future sea level rise impacts into emergency management plans.	 Emergency Management	10
10	Revise building codes to higher standards and incentivize better design.	 Land Management	10

Overall Rank	Adaptation Action	Category	Weighted Score
10	Identify trigger points for changing policy.	 Research & Monitoring	10
11	Facilitate a dialogue on how to balance public and private interests.	 Coordination, Cooperation, & Collaboration	8
12	Provide a disclosure and disclaimer notice to purchasers of high risk properties.	 Education & Outreach	7
12	Consider the impacts on disadvantaged social groups, values, and symbolic places.	 Social Adaptation	7
13	Preserve and restore ecosystems and species.	 Land Management	5
14	Establish funding structures and/or tax districts to help property owners.	 Land Management	4
15	Support climate change mitigation programs.	 Miscellaneous	3
16	Develop affordable housing in safer areas.	 Land Management	0*
16	Create a transfer of development rights program for low elevation properties.	 Land Management	0*
16	Assist with beach renourishment.	 Land Management	0*
16	Increase the County's Community Rating System score.	 Miscellaneous	0*
16	Build water control structures.	 Water Management	0*

*Items that did not receive priority votes were not necessarily considered unimportant. Each participant voted only for their top three priorities.

Section III. Adaptation Actions

This section provides expanded information on the 23 adaptation actions vetted by the Beaufort County Stakeholder Group and the public workshop participants. Each entry describes the action, lists participant comments, and cites relevant examples and useful resources.

More specifically, this section uses the following format:

Category #: Title

Action #: Title

Adaptation Action full sentence.

Each adaptation action listing will begin with a basic description of that action.

#.1: Community Input

The community input section is designed to summarize commentary from the interviews, Beaufort County Stakeholder Group, and the public workshops. Their commentary is structured into bullet points to increase readability. Please note: Not every adaptation action will be structured with the same bullet point categories. Participants did not always address the same issues regarding every action.

#.2: Additional Information

The additional information section includes information gathered by the project team beyond that discussed during the community input phases. This information is provided for additional context, to highlight the experiences of other communities, and to reference tools that may help Beaufort County implement the adaptation action.

Category 1: Coordination, Cooperation, and Collaboration

Action 1.1: Inter-Governmental Cooperation

Improve coordination among governments and agencies.

The number of government agencies with jurisdiction over common coastal issues makes collaboration challenging. By encouraging communication and joint activities, the County can increase its capacity to adapt to sea level rise.

1.1.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Future of military presence
 - Government disunity across agencies
 - Security of fresh drinking water supply in Savannah River
 - Need to identify responsibilities among agencies
 - Collection and availability of state environmental monitoring data
- Suggestions
 - Learn from other communities (i.e., Miami, N.C. Outer Banks, Norfolk)
 - Create a standing working group for climate change to capture grant funds for sustained programs
 - Regional coastal adaptation network could offer economy of scale advantage
 - Leverage other sea level rise and resiliency-focused efforts in S.C.
- With partners:
 - Military
 - Municipalities
 - Regional alliances/councils/networks, including the Metropolitan Planning Organization
 - Relevant federal and state agencies (FEMA, SCDHEC, SCDNR, SCDOT)
 - Utilities and public service districts

1.1.2: Additional Information

Increased partnership will take unique forms depending on the issue and the organizations involved. Beaufort County can begin by clarifying decision making authority among different agencies and levels of government in relation to specific actions outlined in this report.

Other communities have used collaboration as a strategy to adapt to sea level rise. An example is the Southeast Florida Regional Climate Change [Compact](http://www.southeastfloridaclimatecompact.org/)¹⁴ established in 2009. This ongoing effort involves four counties, all of their municipalities, partners, and all 5.6 million residents.

¹⁴Southeast Florida Regional Climate Change Compact. 2014. <http://www.southeastfloridaclimatecompact.org/>

Members used the alliance to establish a single unified baseline greenhouse gas inventory, sea level rise projection, and vulnerability assessment process. These integrated assessments have allowed the counties to identify 110 action items grouped within seven goal areas.

Action 1.2: Public/Private Dialogue

Facilitate a dialogue on how to balance public and private interests/responsibilities.

Environmental management is complicated by tensions between public and private interests. To overcome this barrier, public and private entities can clarify each other's responsibilities. The aim of dialogue is to cooperatively design effective management actions that minimize disruption to existing interests of all entities.

1.2.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - The effect of poorly-managed private infrastructure on overall environmental management
 - i.e., stormwater ponds, ditches, roadways, causeways
 - High risk properties that have lost market value
 - Limited funds to act
- Suggestions
 - Establish policy trigger points (see page 34) before engaging in dialogue
 - Understand private sector drivers and create policy that incentivizes private owners to adapt
 - Clarify areas that government will proactively support and areas private entities should support
 - Create special funding structures and/or tax districts to help property owners
 - Tax tourists for improvements they use
 - Maintain government role of disclosure and public education
- With partners:
 - Homeowners associations
 - Planned unit developments
 - Real estate agents

1.2.2: Additional Information

Internationally, [Public-Private Dialogue](#) (PPD) is a process used to craft more inclusive and sustainable development policies.¹⁵ It involves communicating proposed policy reforms to stakeholders and utilizing private sector participation to build more appropriate policies. Although this process is used primarily for economic development, it can provide a model for

¹⁵ The World Bank Group. 2014. "Public-Private Dialogue." *Investment Climate*.

<https://www.wbginvestmentclimate.org/advisory-services/cross-cutting-issues/public-private-dialogue/>

best practices in facilitating communication. The *PPD Handbook: A Toolkit for Business Environment Reformers*¹⁶ is one centralized source for guidance on PPD techniques.

Category 2: Education & Information

Action 2.1: Public Education

Develop and implement a public education campaign.

Public education or outreach campaigns involve reaching out to County residents to inform them of flood risk, the potential for environmental change, and relevant laws or policies. The objective is to increase local awareness about risk to inspire individuals and organizations to act.

2.1.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Importance of educating the public
 - Need to keep hearing from experts
 - Neighborhoods in low-lying areas
 - Resistance to climate adaptation policy
- Suggestions
 - Maintain a sustained effort
 - Use [Master Naturalist](#) style program¹⁷
 - Teach in local schools
 - Teach elected officials during planning orientation
 - Provide sea level rise information on County website
 - Inexpensive approach
 - Create community inventories of level of disaster preparedness
 - Engage in outreach to communities
- Education content
 - Changes to insurance rates
 - Risk levels
 - Current laws
 - Information with local focus
 - Impacts to wildlife

¹⁶ DFID, the World Bank Group, and OECD Development Centre. 2014. *Public Private Dialogue*. <http://www.publicprivatedialogue.org/>

¹⁷ Clemson University. 2014. "South Carolina Master Naturalist." *Clemson University*. <http://www.clemson.edu/public/naturalist/>

- Education partners:
 - Homeowner Associations (HOAs) / neighborhood communities
 - Churches
 - New property owners
 - Developers
 - Elected officials
 - [Gullah/Geechee Sea Island Coalition](#)

2.1.2: Additional Information

The Beaufort County Stormwater Education and Outreach [program](#) is a model education collaborative in the Lowcountry region. The County [Stormwater Utility](#) works through partners at [Clemson Extension](#) and the [Port Royal Sound Foundation](#) to educate and inform residents of environmental concerns. These and other established educators could integrate climate information into their current activities with the help of regional climate extension specialists at the [S.C. Sea Grant Consortium](#)¹⁸ and the [Carolinas Integrated Sciences and Assessments](#) (CISA) program¹⁹ at the University of South Carolina.

Action 2.2: Hazard Disclosure and Disclaimer

Provide disclosure and disclaimer notice to purchasers of high risk properties.

A disclosure and disclaimer notice is a document provided to property owners to officially inform them of a hazard they may experience on their property and to absolve the County of liability for damages incurred due to the hazard. There are many types of disclosures. The State of South Carolina requires a disclosure of beachfront erosion and Beaufort County [requires one](#) for the homes surrounding the Marine Corps Air Station. The [2010 Beaufort County Comprehensive Plan](#) called for the County to consider this type of notice in reference to the threat of sea level rise.²⁰

2.2.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Lack of disaster preparedness
 - County responsibility to maintain public infrastructure
 - Litigation for failure to disclose risks
 - Unachievable due to political will and liabilities
 - Stigmatized properties
 - Realtor opposition
 - Failure of current flood zone disclosures to discourage development

¹⁸ SCSGC. 2014. *South Carolina Sea Grant Consortium*. <http://www.scseagrant.org/>

¹⁹ Carbone, Greg. 2014. *Carolinas Integrated Sciences and Assessments*. <http://www.cisa.sc.edu/>

²⁰ Beaufort County. 2010. "Chapter 5: Natural Resources" in *2010 Beaufort County Comprehensive Plan*. Page 34.

- Suggestions
 - Use disclosure as educational tool
 - Clarify public/private responsibilities in disclosure statement

2.2.2: Additional Information

A [disclosure notice](#)²¹ is currently required for properties residing within special flood hazard zones, however this brochure does not address sea level rise. Sea level rise will expand flood risk beyond the confines of current flood zones and intensify risk at the lowest elevations. These considerations can be incorporated into existing County flood awareness guides or packaged into a special disclosure addendum addressed only to those in the riskiest elevation zones.

Communities in Florida, Maryland, and Delaware have considered [disclosure statements](#) specific to sea level rise. The proposal in Delaware was rejected due to concerns about the potential impact on the real estate industry.²² This opposition suggests industry cooperation is vital for a successful disclosure notice.

Category 3: Emergency Management

Action 3.1: Updating Plans

Incorporate future sea level rise impacts into emergency management plans.

Emergency management planning often assumes the probability of extreme events will remain the same into the future. Sea level rise and other climate changes are likely to increase the probability of flooding and the intensity of hurricanes. A higher base sea level increases the height of storm surge and warmer Atlantic waters brew stronger hurricanes. Even storms that do not make landfall can influence regional wind patterns that cause elevated tides along the County's shoreline. These impacts can be considered in emergency plans to increase overall preparedness.

3.1.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Access of emergency services (EMS) during road flooding
 - Access to evacuation routes during road flooding
 - Advertising of [Palmetto Breeze](#) evacuation pick-up

²¹ Beaufort County. 2014. "[Citizen's Guide to Flood Awareness](#)."

<http://www.co.beaufort.sc.us/departments/Public-Safety/building-codes/documents/Flood-Brochure.pdf>

²² Montgomery, Jeff. 2013. "Climate change on the coast: Buyer-beware option considered." *Delaware Online*. Jan. 11. <http://www.delawareonline.com/article/20130111/NEWS08/301110053/Climate-change-coast-Buyer-beware-option-considered>

- Suggestions
 - Completely identify risk before updating plans
 - Create EMS contingency plan for coastal flooding
 - Provide additional support for vulnerable areas during evacuation
 - Public transportation
 - Early notification of evacuation
 - Perform storm evacuations during low tides
 - Prioritize elevating evacuation routes
 - Create neighborhood contingency plans
 - Use reserve funds for disaster relief and hazard mitigation

3.1.2: Additional Information

State governments in [New York](#)²³ and [Virginia](#)²⁴ are among those that have considered sea level rise from an emergency management perspective. These states have placed particular emphasis on ensuring that climate information remains consistent across plans and agencies. The New York committee recommends that agencies consider the increased demand for services post-disaster and the effect of sea level rise on evacuation routes. The committee calls for agencies to consider back-up measures for critical systems like drinking water and electricity, or the potential for sea level rise to spread contamination by flooding hazardous waste sites.

Category 4: Land Management

Action 4.1: Setbacks

Maintain and strengthen setback policies.

A setback line is a legal boundary used to create a corridor between development and the shoreline. New construction and reconstruction seaward of a setback line is prohibited. This physical separation can protect both built structures and the natural environment.

4.1.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Erosion of shoreline
 - Water quality
 - Setbacks from septic systems
 - Limitations of setbacks

²³ Grannis, Pete et al. 2010. "New York State Sea Level Rise Task Force Report to the Legislature." http://www.dec.ny.gov/docs/administration_pdf/slrtdrpt.pdf

²⁴ Watkins, John and Jim Redick. 2014. "Recommendations to the Secure Commonwealth Panel on the Issue of Sea Level Rise and Recurrent Flooding in Coastal Virginia." <http://www.norfolk.gov/DocumentCenter/View/17786>

- Suggestions
 - Strengthen setback policies
 - Maintain position of setbacks on growing shorelines (do not move seaward)
 - Adopt relevant recommendations of the Blue Ribbon Committee on Shoreline Management
 - Incorporate buffers in addition to setbacks
 - Enforce setbacks without exceptions
 - Consider elevation in setback regulations
 - Focus on river/creek/wetland setbacks

4.1.2: Additional Information

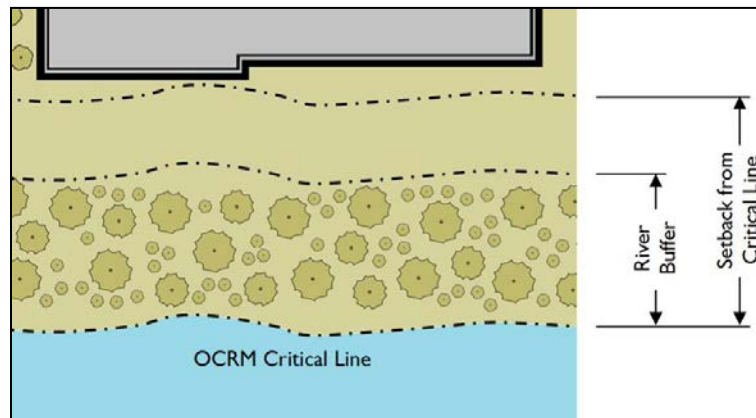


Figure 11: Vegetative buffers and construction setbacks are measured from the SCDHEC Office of Ocean and Coastal Resource Management's Critical Line, or the boundary of the shoreline.
Source: Beaufort County Planning Department

Non-beachfront setback and buffer restrictions in Beaufort County are stricter than the state standard. The County currently requires a 50 ft. natural buffer from all tidal waters, a 50 ft. setback for single-family residences, 100 ft. for townhouses, apartments, non-residential buildings, septic tanks, and tile fields, and 150 ft. for agricultural uses and golf courses. Beachfront setbacks are set by S.C. [law](#)²⁵ at 40 times the distance of the average annual erosion rate for the past 40 years from the baseline. The baseline is set at the crest of the primary sand dune. All setback lines must be established at least 20 ft. landward of the baseline, even when the shoreline has been stable or has experienced growth for the past 40 years. However, the Blue Ribbon Committee on Shoreline Management [recommended](#) that the baseline *never* be moved seaward from its position because 20 ft. is not sufficient space to allow protective dune systems to develop.²⁶ Thus far, the S.C. General Assembly has not adopted the recommendations of the Blue Ribbon Committee, but Beaufort County can implement its own version for County beaches.

²⁵ S.C. Code § 48-39-10 et seq.

²⁶ SCDHEC. 2013. *Blue Ribbon Committee on Shoreline Management Final Report*. S.C. Department of Health and Environmental Control (SCDHEC). <http://www.dhec.sc.gov/library/CR-010631.pdf>

Action 4.2: Living Shorelines

Install and encourage the use of living shorelines.

Living shorelines are an approach to stabilize shorelines using a variety of natural structures and organic materials. Living shorelines involve the stabilization of ground features using plants, sand, and reefs. The root systems of plants absorb water and keep the soil in place.

4.2.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Use of hardened structures (i.e. bulkheads, revetments, sea walls)
 - Viewed by some as an easy fix to an immediate erosion problem but cause longer-term problems
 - Lack of political will to prevent use of hardened structures
- Suggestions
 - Use living shorelines as an alternative strategy
 - Restore and/or maintain natural shoreline buffers
 - Encourage private property owners to maintain buffers with native vegetation
 - Supplement existing County requirement to leave natural buffers for new developments

4.2.2: Additional Information

A common living shoreline approach in the lowcountry is the restoration of oyster reefs. Oyster reefs can protect marsh habitats and the upland behind them from erosion if the conditions are right. Oysters do best when placed in environments with low wave energy. [SCDNR](#)²⁷ and [The Nature Conservancy](#)²⁸ each manage ongoing oyster restoration projects in South Carolina.

Action 4.3: Limit Development

Limit development in high risk areas.

Development is currently permitted in low-elevation land where tidal flooding is common and storm surge is severe. Although building codes are enforced and flood insurance is required, these waterfront properties are inherently risky. Traditional controls, like land-use zoning, could be used to limit development in such areas.

4.3.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

²⁷ SCDNR. 2015. "South Carolina Oyster Restoration and Enhancement." *South Carolina Department of Natural Resources*. <http://score.dnr.sc.gov/>

²⁸ TNC. 2015. "Oyster Reef Restoration." *The Nature Conservancy*. <http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/southcarolina/howwework/oyster-reef-restoration-southern-solutions-for-a-global-problem-1.xml>

- Concerns
 - Need for strong strategy to limit development
 - Development blocking marsh migration
 - Public liability for risky private developments
 - Government overreach in land-use regulations
 - Many areas already developed
- Suggestions
 - Use impact fees
 - Require developers to establish an escrow fund to maintain private infrastructure
 - Offer incentives to not develop
 - Prohibit sea walls along rivers and creeks
 - Encourage denser development at higher elevations

4.3.2: Additional Information

Land-use zones can be used as a tool to limit development directly. Special flood hazard zones are currently being added to comprehensive plans in Southeast Florida counties. These “adaptation action area” [overlays](#) can be defined as areas below, at, or near mean higher high water, areas with a hydrological connection to coastal waters, and areas designated as evacuation zones for storm surge²⁹ (especially below a Category 1 surge designation). The overlays establish additional, [stricter standards](#) or criteria for development and can be used as a basis for prioritization of funds just by being included in the future land-use map.³⁰

The Georgetown Climate Center wrote an extensive [legal analysis](#) of a model sea level rise overlay zone for Maryland local governments.³¹ This report cautions that local governments will need to make specific findings justifying enactment of policies in a special district to meet constitutional substantive due process requirements. Examples of justifications include risk levels, the shortcomings of existing flood plain maps to emphasize the heightened risk in future inundation areas, and the presence of rapid erosion.

Action 4.4: Conservation

Use conservation to respond to sea level rise.

Conservation and preservation programs involve the ordinary fee simple purchase or donation of development rights of a property. This prevents the property from being further developed. There are multiple motives for doing so, including the conservation of economic, natural, and cultural

²⁹ Florida Department of Community Affairs. “Adaptation Action Area White Paper”.

<http://www.southeastfloridaclimatecompact.org/wp-content/uploads/2014/09/adap-action-areas.pdf>

³⁰ South Florida Regional Planning Council. 2013. *Adaptation Action Areas: Policy Options for Adaptive Planning For Rising Sea Levels*. <http://www.southeastfloridaclimatecompact.org/wp-content/uploads/2014/09/final-report-aaa.pdf>

³¹ Grannis et al. 2011. “A Model Sea-Level Rise Overlay Zone for Maryland Local Governments”. Georgetown Climate Center. http://www.dnr.state.md.us/ccs/pdfs/GCC_MD-SLROrdRpt_FINALv3_11-2011.pdf

resources, protection of water quality in a critical area, the preservation of historic property, and the provision of open space views.

4.4.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Loss of economic, natural, and cultural resources due to development and sea level rise
 - Degradation of water quality
 - Potential abuse of land pricing
 - Expense of buying property
- Suggestions
 - Utilize Beaufort County's Rural and Critical Lands Preservation [Program](#) to target vulnerable areas that are likely to be inundated by high tides in the future
 - Analyze how this program can specifically be used to reduce sea level rise vulnerability in order to potentially justify future bond referendums that provide funding
 - Create tax incentives for limiting development rights on property while continuing historic uses

4.4.2: Additional Information

Prime conservation land is likely to shift with changing habitats and urban development patterns. Salt marsh will migrate onto former upland areas where not blocked by development. To ensure future marsh habitats through conservation, the likely pathways of marsh migration need to be identified.

It is difficult to accurately predict future habitat change, but there are some preliminary tools that can help planners. The NOAA Office for Coastal Management has a Marsh Impacts/Migration tab on its Sea Level Rise and Coastal Flooding Impacts [tool](#).³² This tool predicts marsh migration based on the concept that marsh grows within a specific range of elevation between land and sea.

Action 4.5: Building Codes

Revise building codes to higher standards and incentivize better design.

Building codes ensure private development is conducted in a manner that protects the public health, safety, and welfare of citizens. Building codes set minimum construction standards. They are designed to consider natural hazards like floods and hurricanes based on the probability of a particular event happening.

³² NOAA Office for Coastal Management. 2014. "Sea Level Rise Viewer." *Digital Coast*. <http://coast.noaa.gov/digitalcoast/tools/slr>

4.5.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Buildings in Beaufort County not adequately designed to handle gradual sea level rise and associated flooding and storm surge
 - Adequate enforcement of current building codes
 - Septic systems becoming a source of pollution
- Suggestions
 - Revise building codes to a higher standard than the [2012 International Building Codes](#)
 - Use incentives to produce better compliance with building codes
 - Update building codes in advance of a natural disaster to ensure good standards are enforced during recovery
 - Tie building code upgrades to planning thresholds: once local mean sea level records exceed the threshold, the building codes can be brought up to design standards that better reflect how the environment has changed
 - Implement stronger regulations for septic systems, including increasing setbacks from structures and shorelines
 - Consider replacing septic with sewer systems, while managing any additional development this might encourage
- Model building codes from other communities
 - [Bermuda](#): handling water runoff from houses
 - The Netherlands: building codes and other structures standards set for far worse than 1-in-100 year storm

4.5.2: Additional Information

The largest threat to buildings is flood damage. Beaufort County currently requires all buildings to have their lowest floor at base flood elevation, or the elevation at which there is a 1% annual probability of a flood. The current FEMA [Flood Insurance Rate Maps](#) do not incorporate calculations of future sea level rise, nor does the upcoming map update, which is scheduled for 2016. Therefore, flood risk may be higher than what base flood elevations suggest and wider than what the current special flood hazard zones suggest. A [report](#) created for the City of Annapolis, Maryland, proposed adding the projected sea level rise height in 2050 to minimum building elevations and floodproofing elevations in addition to a 2 ft. freeboard.³³ In addition to protecting structures, these regulations may also save on insurance costs by building points on FEMA's Community Rating System (see page 41).

³³ ERM. 2011. *Regulatory Response to Sea Level Rise and Storm Surge Inundation City of Annapolis, Maryland*. City of Annapolis. http://www.dnr.state.md.us/CoastSmart/pdfs/Annapolis_RRSLRnSSI.pdf

Action 4.6: Preserve Ecosystems

Preserve and restore ecosystems and species.

Ecosystems in Beaufort County provide many services including economic value, food, flood and erosion control, wildlife biodiversity, and several [social benefits](#).³⁴ Fish and shellfish in the County provide direct food sources to local residents and visiting tourists. Marsh grasses reduce flooding on the upland and oysters protect river banks from erosion. Ecosystems in Beaufort County nurture and protect a large variety of local wildlife species, including [endangered species](#) like the shortnose sturgeon, wood stork, Florida manatee, and the pondberry.³⁵ The local environment offers many social benefits including recreation, beauty, peace and relaxation, opportunities for socialization, nostalgia, legacy value (to pass on to descendants), spiritual value, inspiration, and learning. Lastly, many people believe local ecosystems have value in and of themselves.

4.6.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Health of oyster beds with growing human presence along the coast
 - Loss of critical marsh habitat
 - Erosion due to boat traffic and oyster harvesting
- Ecosystem values
 - Marshes and oyster reefs are living shorelines
 - Marsh systems act like sponges and absorb a large quantity of water during the tidal cycle
 - Oyster reefs offer habitat, filter water, and are a critical part of the food chain
- Suggestions
 - Prohibit sea walls near marshes
 - Increase restrictions on speed of boat traffic in critical waterways
 - Improve and better enforce Beaufort County's tree protection ordinance to ensure that large root systems continue to stabilize shorelines and reduce flood risks

³⁴ NCCOS. 2014. "Social Values of Ecosystem Services in Marine Protected Areas for Management Decision-making." The NOAA National Centers for Coastal Ocean Science.
<http://www.coastalscience.noaa.gov/projects/detail?key=190>

³⁵ SCDNR. 2014. "Rare, Threatened, and Endangered Species and Communities Known to Occur in Beaufort County, SC: June 11, 2014." South Carolina Department of Natural Resources.
<https://www.dnr.sc.gov/species/pdf/Beaufort2014.pdf>

4.6.2: Additional Information

Beaufort County's existing [efforts](#) to preserve water quality³⁶ serve a key role in protecting local ecosystems and species. Remaining priorities to protect and restore ecosystems depend on the specific impacts of sea level rise on a given habitat. This action will require a combination of research and monitoring, conservation, setbacks, and buffers.

Action 4.7: Funding Structures

Establish funding structures and/or tax districts to help property owners.

Governments can create special tax districts to help local communities pool funding for private localized infrastructure improvements.

4.7.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Development in risk-prone areas is too inexpensive and easy
- Suggestions
 - Internalize cost of siting private development in environmentally risky areas
 - Restructure development impact fees to cover costs incurred by the County for maintaining vital infrastructure vulnerable to rising seas
 - Require developers to establish an escrow fund with an allocation for each lot so the neighborhood would have the funds to directly pay for the maintenance of local roads and stormwater ponds

4.7.2: Additional Information

Impact fees used for coastal flood protection measures could be tied to particular geographic areas by using an adaptation action area overlay zone (see page 26). The risk-based overlay could also provide a legal justification for a targeted tax which is then earmarked for specific infrastructure improvements in the area, including elevating roads, coastal armoring, and conservation purchases. Escrow accounts can similarly be used to foster resilience to sea level rise as recommended by the workshop participants. They are regularly used to set aside funds for hazard insurance. They have also been [utilized](#) on an international scale under the [Clean Development Mechanism](#) of the [Kyoto Protocol](#) to establish a forest protection condition on investments to donor countries.³⁷ Beaufort County may be able to require large developers to create escrow funds in the planned unit developments, but this requires further legal analysis.

³⁶ Beaufort County. 2015. "Water Quality Monitoring." <http://www.bcgov.net/departments/Engineering-and-Infrastructure/stormwater-management/water-quality-monitoring.php>

³⁷ Schwarze, Reimund, and John O. Niles. 2001. "The Long-Term Requirement for CDM Forestry and Economic Liability." In [Law and Economics of International Climate Change Policy](#). Springer Science+Business Media Dordrecht, the Netherlands.

Action 4.8: Affordable Housing

Develop affordable housing in safer areas.

The goal of affordable housing is to ensure the availability of low price homes for lower and moderate income buyers. However, cheaper land may also be riskier land. Low income homeowners may find it more difficult to recover from severe flooding than their more affluent neighbors. One action to adapt is to incentivize affordable housing only in areas outside of current and future flood zones.

4.8.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Residents living paycheck-to-paycheck in substandard housing
 - Public investment in recurring flood areas
- Suggestions
 - Collaborate on affordable housing at regional scale
 - Coordinate assistance of low income residents through the [Human Services Alliance](#) and the [Together for Beaufort County](#) initiative

4.8.2: Additional Information

NOAA's [Coastal County Flood Exposure Snapshot](#)³⁸ reveals that 50% of the Beaufort County population living in poverty resides within a FEMA-designated special flood hazard area (7,731 individuals). County incentives, such as density bonuses, could be limited to non-flood zones to encourage safer affordable housing. However, the geography, housing market, and availability of land may become barriers to affordable housing in safer areas. For example, work force housing should be sited near major employers, not in distant rural areas.

Existing affordable homes within the flood plain may experience increasing pressure from flooding and rising insurance costs. Subsidized policies in the [National Flood Insurance Program](#) will be gradually adjusted to actuarial rates in the coming years. The [Center for NYC Neighborhoods](#) published a [report](#) on the effect of rising flood insurance costs on affordable homes in the New York metro area.³⁹ The report calls for guidance on alternative mitigation actions and affordable financing options to elevate homes. It may be useful to conduct further research on how Beaufort County government can protect affordable homes in vulnerable areas.

³⁸ NOAA Office for Coastal Management. 2015. "Coastal County Snapshots." *Digital Coast*. <http://coast.noaa.gov/digitalcoast/tools/snapshots>

³⁹ Center for NYC Neighborhoods. 2014. *Rising Tides, Rising Costs: Flood Insurance & New York City's Affordability Crisis*. <https://cnycn.creatavist.com/risingtides>

Action 4.9: Transfer of Development Rights

Create a transfer of development rights program for low elevation properties.

[Transfer of Development Rights](#) (TDR) programs issue certificates representing development rights to property owners in “sender” areas where development is undesirable. These property owners can then sell the certificates to property owners in “receiver” areas, where the certificate is redeemable with a multiplier for additional dwelling units on the property. This maintains a low density for the sender area and a higher density for the receiver area by using market forces.

4.9.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Willingness of receiver area to increase density

4.9.2: Additional Information

The Town of Bluffton implemented a [successful TDR program](#) in the May River area, but designs for a [TDR program](#) surrounding the Marine Corps Air Station have not progressed. Success of these programs is highly dependent on the characteristics of the marketplace. This tool may not work everywhere.

Action 4.10: Beach Renourishment

Assist with beach renourishment.

Sea level rise will worsen beach erosion. If erosion rates increase dramatically, there may be pressure for Beaufort County to contribute to beach renourishment along developed beaches like Hilton Head, Fripp, and Harbor Islands.

4.10.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Continued erosion in renourished areas
 - Protection of places with historical and cultural significance
 - Reliance of Hilton Head Island on renourishment
 - Major cost
 - Supply of sand for nourishment
 - Vulnerability of low-lying land on the rear side of barrier islands

4.10.2: Additional Information

Beaufort County has not historically funded renourishment. Residents of Hilton Head and Daufuskie islands have been able to pay for their own renourishments. However, all of the

County's barrier islands will be at an increasing risk for erosion as sea level rises. The developed islands of Harbor and Fripp will be particularly vulnerable.

Category 5: Research & Monitoring

Action 5.1: Environmental Monitoring

Identify or establish environmental monitoring programs in the area.

Environmental monitoring programs will help governments keep an eye on the health of the local environment. This sort of monitoring system is already important because of environmental stressors related to development. Climate change will further increase the need for monitoring, especially because no one can foretell exactly how local ecosystems will respond to such drastic changes.

5.1.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Health of marsh
 - Opportunity of marsh to migrate
 - Relation of environmental health to social vulnerability (see page 36)
 - Need to identify risk of sea level rise to environment and people
 - Liability to disclose and mitigate risk
 - Clean Water Act regulation data needs
 - Information transparency
- Suggestions
 - Monitor the health of salt marshes, water quality, and salt water intrusion
 - Track flooding locations, sea level trends, erosion patterns, and infrastructure vulnerabilities
 - Manage at state agency level
 - Pay or manage volunteer community members to assist with data collection
 - Identify marsh migration pathways and conserve lands
- Data sources/tools
 - [Sea Level Affecting Marshes Model](#) (SLAMM)⁴⁰
 - NOAA [Sea Level Rise and Coastal Flooding Impacts Viewer](#)⁴¹
 - [Surface elevation table](#) monitoring devices to monitor marsh movement

⁴⁰ NOAA Office for Coastal Management. 2014. "Sea Level Affecting Marshes Model." *Digital Coast*. <http://coast.noaa.gov/digitalcoast/tools/slamm>

⁴¹ NOAA Office for Coastal Management. 2014. "Sea Level Rise Viewer." *Digital Coast*. <http://coast.noaa.gov/digitalcoast/tools/slr>

- [Light Detection and Ranging](#) (LiDAR) elevation data

5.1.2: Additional Information

A considerable amount of data monitoring is already conducted by state agencies and scientific organizations. However, budget constraints create data gaps. Agencies have discretion in what they monitor, and do not watch everything. For example, SCDHEC monitors daily water quality on beaches for recreational use, but they do not test inland waterways. With the right expertise and agency oversight, other organizations can fill gaps. For example, the nonprofit organization [Charleston Waterkeeper](#) monitors recreational waters along the Ashley and Cooper rivers in Charleston, S.C.

The U.S. Climate Change Science Program, in Chapter 14 of [Coastal Sensitivity to Sea-Level Rise](#),⁴² proposed a comprehensive science strategy for better understanding sea level rise and its impacts on U.S. coasts. They suggest creating a denser network of basic observations and observing systems, developing time-series data on environmental change, and establishing baseline data for the coastal zone. Long-term monitoring programs are already in place at the nearby [ACE Basin National Estuarine Research Reserve](#) (NERR), which includes some of Beaufort County. The ACE Basin is an optimal site for research and monitoring to understand natural impacts from sea level rise, but monitoring will also be needed in the more developed environment of Beaufort County.

Beaufort County can supplement critical gaps or identify organizations to serve the need. Officials can work with [SCDNR](#), [NOAA](#), [SCDHEC](#), [USC-Beaufort](#), and other organizations to use monitoring projects in decision support systems that link environmental problems to policy solutions. In some cases, Beaufort County has already stepped in to provide funding for a data gap. This is the case for [Light Detection and Ranging](#) (LiDAR), a remote sensing technology used to create high quality digital elevation models of the land surface. Beaufort County commissioned LiDAR in 2002 and again in 2013. Continued updates of the data will provide a better understanding of land-use change across decades.

Action 5.2: Trigger Points

Identify trigger points for changing policy.

Trigger points are monitoring thresholds used to avoid environmental or socioeconomic tipping points, wherein impacts become severe or irreversible. Trigger points can be used to justify and initiate proactive policy changes when a problem first develops or to avoid the consequences entirely. Awareness of thresholds and tipping points can be used to avoid the risky behavior of allowing consequences to accumulate until they are unmanageable. Many adaptation actions are

⁴² 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. 2009. [Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region](#). U.S. Climate Change Science Program.

designed to address problems associated with rapid sea level rise, not our current rate of slow change. However, sea level rise is expected to accelerate sometime during the 21st century. Therefore, establishing trigger points for adaptation actions can allow communities to strike agreement about policies that will preserve the status quo for as long as possible, while making a forward commitment to protect future populations.

5.2.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Lack of information to set trigger points
- Suggestions
 - Establish trigger points before engaging in public and private dialogue
 - Coordinate with state and municipal governments to ensure data consistency
 - Use currently collected data to propose trigger points

5.2.2: Additional Information

Trigger points are a key component of the [flexible adaptation pathways](#) approach.⁴³ This refers to adaptation approaches that focus on the uncertain and long-term nature of climate change by employing a risk-based decision framework involving thresholds and trigger points that enable the systematic adjustment of adaptation actions in response to new information and changing circumstances. The [Scottish ClimateXChange](#)⁴⁴ commissioned a helpful white paper on the topic, which includes specific case studies of this approach being planned or implemented in London, New York, and various locations in Australia and New Zealand. The authors note that the strategy keeps long term options open for as long as possible by setting the trigger points. Damage is minimized by preventing trends from exceeding unacceptable levels of risk.

Beaufort County could establish some simple parameters for trigger points based on risk levels. For example, a [project](#)⁴⁵ in Townsville, Australia, identifies levels of sea level rise associated with no action, nuisance management, intense management, and employing a retreat strategy. Different water levels and frequencies can be associated with each category of management and specific actions can be tied to each level. Nuisance management might involve stormwater upgrades, whereas intense management may require implementation of planning restrictions. The boundaries of each category are dependent upon the County Council's interpretation of acceptable risk and appropriate trigger points. Given socioeconomic impact data established in

⁴³ Moss, Anne and Suzanne Martin. 2012. "Flexible Adaptation Pathways." *ClimateXChange*. http://www.climatexchange.org.uk/files/9713/7365/7868/Flexible_adaptation_pathways.pdf

⁴⁴ Ibid.

⁴⁵ Queensland Department of Environment and Heritage Protection. 2013. "Guideline for Preparing a Coastal Hazard Adaptation Strategy." *Queensland Government*. <http://www.ehp.qld.gov.au/coastalplan/pdf/adaptation-strategy-guideline.pdf>

this project and otherwise available on Climate Central’s [Surging Seas](#) tool,⁴⁶ the County can identify specific thresholds beyond which risk becomes unacceptable.

Category 6: Social Adaptation

Action 6.1: Social Vulnerability

Address the impacts on disadvantaged social groups, values, and symbolic places.

The consequences of coastal flooding are social as well as economic and ecological. The same hazard can affect groups of people differently depending on their capacity to act or their ability to recover quickly. For example, economically disadvantaged groups may have less of a monetary cushion to absorb the costs of flood damage or may not be able to afford living in safer locations outside of the flood zone. Others may be economically secure, but have few friends or family in the area to provide support.

Place-based adaptation priorities should be informed by local preferences and culture. For example, land on St. Helena Island has been traditionally passed down among local Gullah people for generations. The loss of this land to the sea would have a cultural significance above and beyond the normal impact, especially because development has already changed land ownership significantly in some parts of the County.

6.1.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Sea Islands’ vulnerability to storm surge
 - Cultural significance of St. Helena communities
 - Cheap real estate in low lying areas
 - Displacement of culture and traditions, especially among Gullah people
- Suggestions
 - Use [Palmetto Breeze](#) bus system to evacuate vulnerable populations
 - Promote [heritage tourism](#) as alternative economy to preserve traditional culture
 - Collaborate with the [Gullah/Geechee Sea Island Coalition](#)
 - Examine family compound zones to assess cultural vulnerability to tidal flooding
 - Reference County Council’s [dedication](#) to cultural protection as a disaster recovery function
 - Create a socioeconomic inventory of hazard and/or disaster preparedness among communities (e.g., through churches)

⁴⁶ Climate Central. 2013. “South Carolina | Surging Seas: Sea Level Rise Analysis.” <http://sealevel.climatecentral.org/ssrf/south-carolina>

6.1.2: Additional Information

A common tool for identifying relative social vulnerability is the University of South Carolina Hazards and Vulnerability Research Institute's [Social Vulnerability Index](#), or SoVI.⁴⁷ This index synthesizes 30 socioeconomic variables, which research suggests contribute to a decrease in the community's capacity to respond to a disaster. The method ranks physical regions based on relative values, allowing a local community to understand who is most and least vulnerable within a county. This type of index can be used as the basis for prioritization of flood hazard assistance to areas with the most need.

Placed-based adaptation priorities can be established by using the assistance of local residents to map locations with special significance. However, this may require the County to consider how values differ among cultural sub-groups. One landmark may not mean much for the majority of residents, but it may be sacred to others.

Category 7: Transportation Adaptation

Action 7.1: Elevate Roads

Prioritize, elevate, and protect low-lying roads and causeways.

One key finding of the GIS analysis (see page 7) was the vulnerability of roadways to sea level rise in Beaufort County. Whereas most Beaufort County facilities and grounds are located out of harm's way, the state-owned transportation system runs across miles of low-lying islands, often connected by solitary causeways across the marshland. Many of these roads are already flooded during astronomical high tides. While the majority of these low-lying roads are non-critical routes, there are some hot spots along major arteries and evacuation routes in the lowcountry region.

7.1.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Expensive
 - Low areas along US-17 (an evacuation route)
 - Impact near critical facilities such as roads, schools, and evacuation routes
 - Limited easements for adequate stormwater management along raised roads
- Suggestions
 - Create risk-based prioritization of infrastructure vulnerabilities

⁴⁷ HVRI. 2013. "Social Vulnerability Index for the United States - 2006-10." *Hazards and Vulnerability Research Institute*. October 30. <http://webra.cas.sc.edu/hvri/products/sovi.aspx>

- Build new roads at higher elevations
- Use opportunities to raise roads, retrofit during maintenance and/or upgrades
- Restore ferry service to culturally important islands (i.e., Daufuskie Island)

7.1.2: Additional Information

Beaufort County can work through the [Lowcountry Council of Governments](#) or local [Metropolitan Planning Organization](#) to identify top priorities from a risk perspective. Improvements to evacuation routes can be justified based on their significance to the County and their risk to elevated water levels. Up to two miles of roadway surface along evacuation routes are lower than 3 ft. above MHHW. There is already a high probability for flooding at this level during high tide. Even a small change in base sea level will make such flooding of the evacuation route more likely.

However, raising the surface of a road may pose challenges. For some roads to be raised, their shoulders must be widened. If the road runs along a causeway, this could mean that the road base needs to be extended into the wetlands. Depending on specific drainage conditions, road construction may also cause flooding on adjacent properties. An engineering assessment can provide more information about the opportunities to raise specific roadway segments.

Category 8: Water Management

Action 8.1: Low Impact Development

Use low impact development practices.

[Low Impact Development](#) (LID) is an integrated, comprehensive approach to land development or redevelopment that works with nature to manage stormwater as close to its source as possible.⁴⁸ LID practices can protect local water quality and reduce urban flooding through best practices in stormwater management.

8.1.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Water quality
 - Flooding due to poorly maintained retention ponds
 - Maintenance of ditches and piping
 - More intense rain storms already happening
- Suggestions
 - Require stormwater pond maintenance

⁴⁸ EPA. 2014. "Low Impact Development (LID)." *United States Environmental Protection Agency*. October 3. <http://water.epa.gov/polwaste/green/>

- Consider all stormwater infrastructure
- Adjust design standards to anticipate sea level rise and precipitation conditions in 30-50 years
- Prioritize which communities will receive public support of private infrastructure
- Utilize community volunteers to maintain drainage system
- Use LID as a comprehensive approach

8.1.2: Additional Information

Current Beaufort County stormwater regulations are based on the 95th percentile storm, or 1.95 in. of precipitation over a 24-hour period. The design of infrastructure does not factor in the potential for more intense rain or higher tides.

The [ACE Basin](#) and [North Inlet-Winyah Bay](#) National Estuarine Research Reserves, [the Center for Watershed Protection](#), the [S.C. Sea Grant Consortium](#), and partners have recently published an [LID manual](#)⁴⁹ for coastal South Carolina. [Appendix G](#) of this manual includes actions for adapting stormwater management to climate change. These include implementing LID practices at the site scale to reduce runoff volumes, modifying practices to prevent bypass during intense storm events, periodically revisiting [design storms](#) and mapped flood plains, using adaptable plants in place of native species, and using stormwater as a water source for irrigation.

Action 8.2: Water Control Structures

Build water control structures.

Water control structures control the flow of tidal water to keep it away from designated areas. There are a variety of structures used to control tidal water. The most prominent example is a tide gate, or barrier across small creeks or drainage ditches, that opens during outgoing tides and closes during incoming tides to let low-lying areas above mean low water drain effectively.⁵⁰

8.2.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Fish kills due to closed tide gates during low tide
- Suggestions
 - Understand drainage patterns
 - Use system of low-lying ditches and tide gates
 - Identify where tide gates are needed

⁴⁹ NERRS Science Collaborative. 2014. "Low Impact Development in Coastal South Carolina: A Planning and Design Guide." *North Inlet-Winyah Bay National Estuarine Research Reserve*. <http://www.northinlet.sc.edu/lid/>

⁵⁰ 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. 2009. [Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region](#). U.S. Climate Change Science Program.

8.2.2: Additional Information

Tide gates can function well as an option to reduce flooding in the coming decades, but sea level rise may eventually reduce their effectiveness. Taking into account analyses developed by [Georgia Sea Grant](#), the University of Georgia's [Carl Vinson Institute of Government](#), and [Stetson University](#), Tybee Island, GA, is [investing](#) in stormwater valve gates as a cost-effective option to reduce tidal flooding risks in low-lying neighborhoods.⁵¹ If sea level rises too quickly, it could overwhelm older structures. For example, a [scientific model](#) of the New Jersey Meadowlands identified a critical point at which sea levels could no longer be maintained by the tide gate.⁵²

Category 9: Miscellaneous

Action 9.1: Mitigation Programs

Support climate change mitigation programs.

Whereas climate adaptation prepares a community for the impacts of a changing climate, mitigation programs reduce the drivers of global change. Rising seas are currently caused by warmer temperatures due to the heightened presence of greenhouse gases in the atmosphere. Each community can do its part to reduce greenhouse gas emissions.

9.1.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - Driver of sea level rise not addressed
- Suggestion
 - Reduce County greenhouse gas emissions

9.2.2: Additional Information

Emissions reduction is closely tied to energy efficiency. Several action items that reduce emissions are already identified in the [energy chapter](#) of the 2010 Beaufort County Comprehensive Plan.

Emission reductions can be prioritized by first conducting a greenhouse gas inventory. [Richland County](#) and the [City of Columbia](#) have conducted their own inventories that can be used as models. Richland County found that 74% of CO₂ emissions came from solid waste

⁵¹ Evans, Jason, Rob McDowell, Chuck Hopkinson, Jill Gambill, David Bryant, Kelly Spratt, and Wick Prichard. 2013. "Tybee Island Sea Level Rise Adaptation Plan Executive Summary." *City of Tybee Island*. <http://www.cityoftybee.org/Assets/Files/CityManager/TISeaLevelRiseAdaptationPlanExecSumm201306.pdf>

⁵² Walsh, S. and R. Miskewitz. "Impact of sea level rise on tide gate function." *Journal of Environmental Science and Health. Part A, Toxic/Hazardous Substances & Environmental Engineering* 48(4):453-463.

decomposition.⁵³ The City of Columbia found that its largest source was water delivery and wastewater facilities (totaling 57%).⁵⁴ More information about developing a greenhouse gas inventory, including tools, training, and funding sources can be found on the EPA's [website](#).⁵⁵

Action 9.2: Community Rating System

Increase the Community Rating System score.

The [Community Rating System](#) (CRS) is a voluntary incentive program built into FEMA's National Flood Insurance Program. The program seeks to encourage communities to initiate activities that exceed the minimum requirements of the National Flood Insurance Program. Completing activities will increase the CRS score of the community and provide discounts to the cost of flood insurance for policy holders in the community.

9.2.1: Community Input

Community stakeholders provided the following comments on this adaptation action:

- Concerns
 - High flood insurance costs
- Suggestions
 - Use CRS program to lower insurance rates

9.2.2: Additional Information

The CRS activities are oriented towards reducing flood damage, strengthening the insurance aspects of the program, and encouraging a comprehensive approach to floodplain management. Although these activities are designed to address short term flood risk, many, like open space preservation, address long term sea level rise as well. More information on the program can be obtained from the FEMA [website](#)⁵⁶ and [CRS Resources](#),⁵⁷ which includes a community Quick Check guide to simplify the process. Beaufort County has a Class 6 CRS classification, with goals of leading the community to be more disaster resistant by enhancing public safety and property protection, protecting the natural function of floodplains, and reducing flood insurance premiums. The County continuously strives to maintain and improve its CRS score by improving and complying with different CRS activities.

⁵³ Richland County Baseline Emissions Inventory. 2009.

<http://www.richlandonline.com/Portals/0/Departments/Sustainability/Docs/RichlandCountyBaselineEmissionsInventoryReport.pdf>

⁵⁴ City of Columbia Baseline Emissions Inventory. 2011. http://www.columbiasc.net/depts/city-council/docs/old_downloads/09_06_2011_Agenda_Items/09_6_2011_Work_Session/Baseline%20Presentation.pdf

⁵⁵ USEPA. 2014. "Developing a Greenhouse Gas Inventory." *United States Environmental Protection Agency*. <http://www.epa.gov/statelocalclimate/local/activities/ghg-inventory.html>

⁵⁶ FEMA. 2014. "National Flood Insurance Program Community Rating System." *Federal Emergency Management Agency*. <https://www.fema.gov/national-flood-insurance-program-community-rating-system>

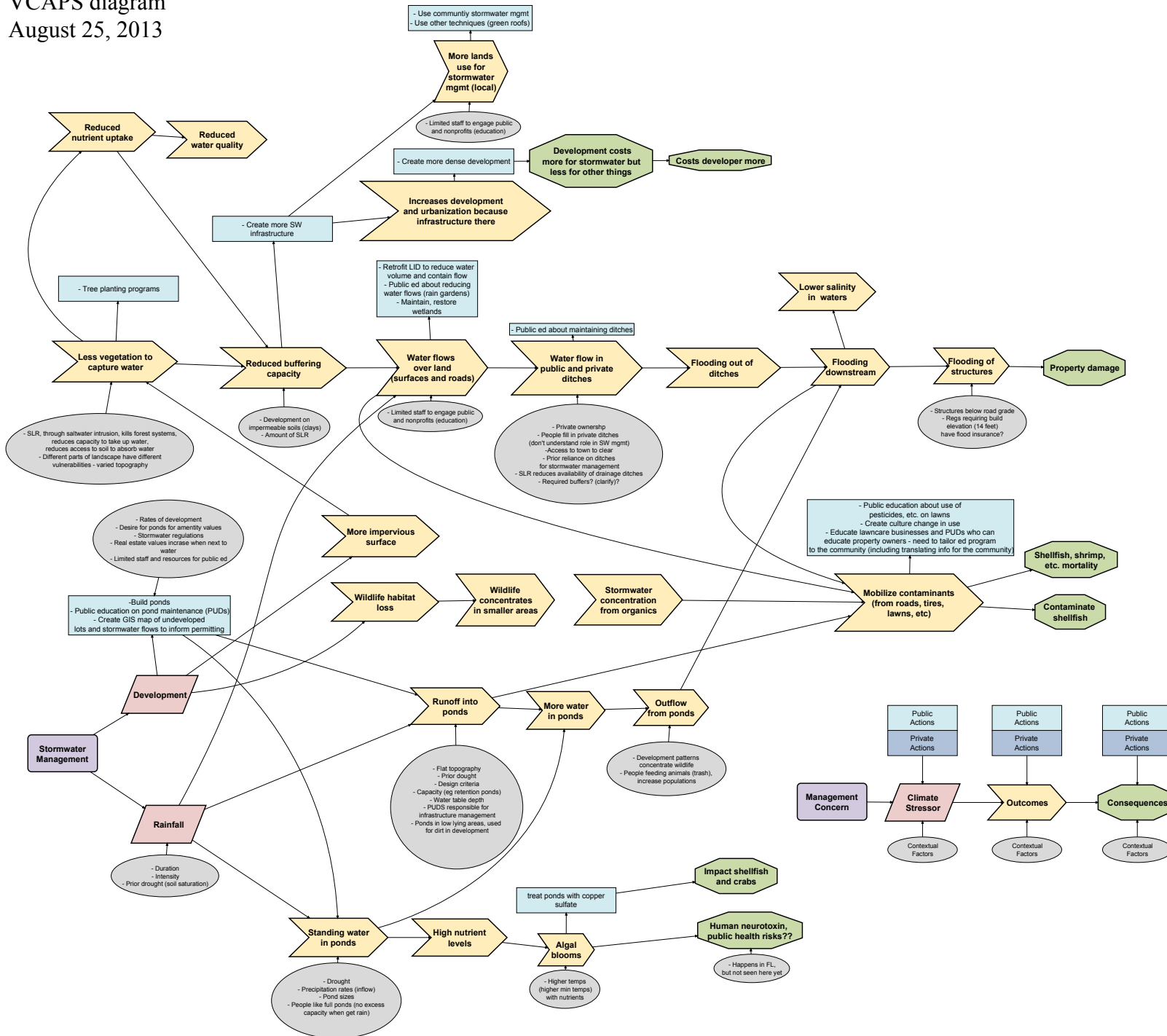
⁵⁷ CRS Resources. 2014. <http://crsresources.org/>

Appendix A

Climate change and stormwater management

VCAPS diagram

August 25, 2013

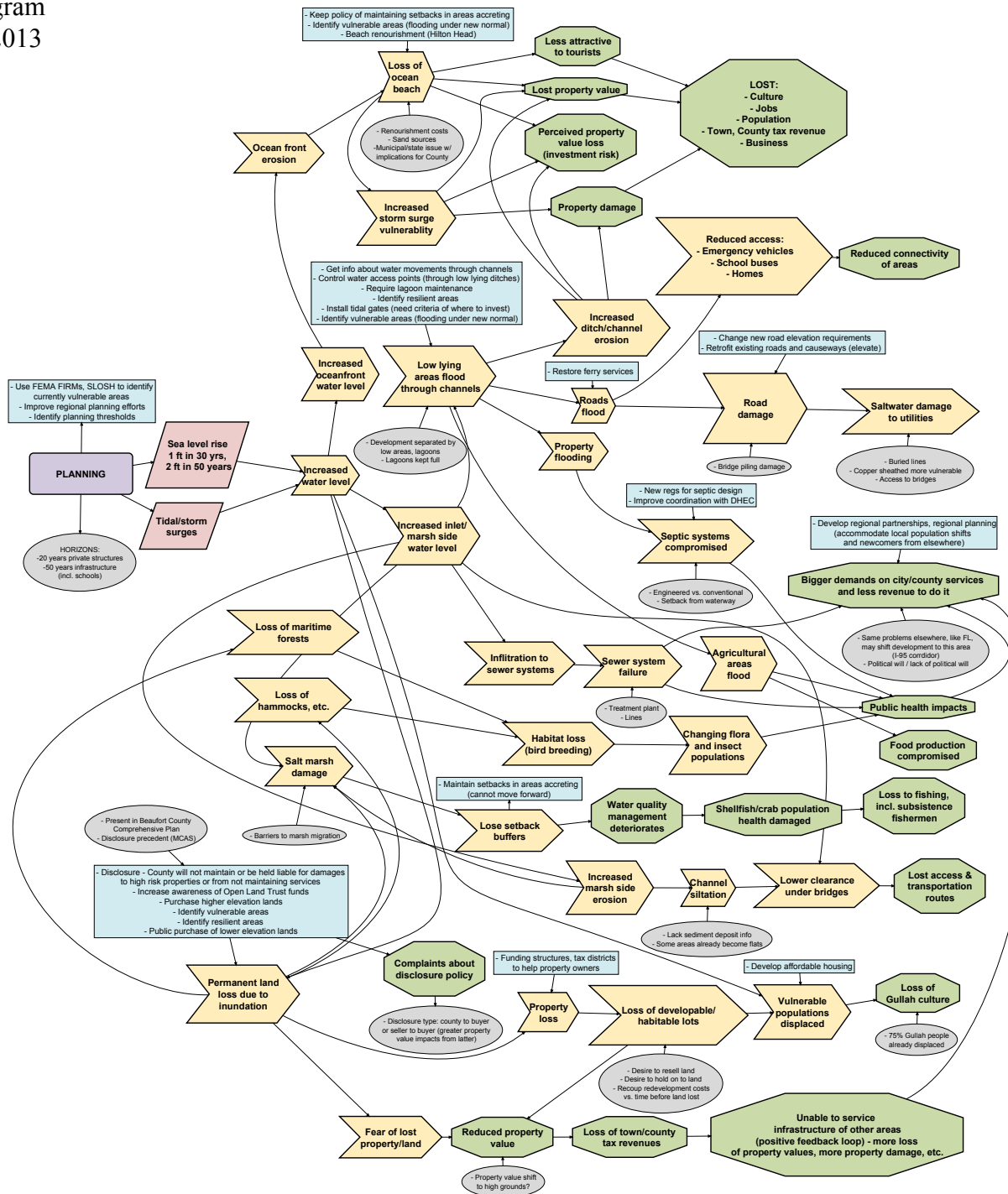


Appendix B

Climate change and sea level rise planning

VCAPS diagram

August 26, 2013



Appendix C

Announcement for Beaufort County Sea Level Rise Public Workshops

Sea Level Rise Adaptation Strategies for Beaufort County, S.C. Public Workshop

Southern county location:

Monday, August 25

1:00 PM – 4:00 PM

Large Meeting Room

Bluffton Branch Library

120 Palmetto Way

Bluffton, S.C. 29910

Northern county location:

Tuesday, August 26

1:00 PM – 4:00 PM

Large Meeting Room

St. Helena Branch Library

6355 Jonathan Francis Sr. Rd.

St. Helena, S.C. 29920

Cost: FREE

Registration required by August 20

For more information and to register, visit

<https://sites.google.com/site/beaufortslr/>

Questions? Send them to:

sean.bath@scseagrant.org or 843-953-2097

OBJECTIVES

- To share the latest science on sea level rise.
- To discuss Beaufort County vulnerabilities identified by a local group of interested staff and stakeholders.
- To solicit participants' additional input on adaptation strategies.
- To use participant input to write a plan for prioritized action for Beaufort County.

WHO SHOULD ATTEND

Municipal and county government officials and staff, interested citizens, natural resource managers, private sector associations and organizations

Organized and hosted by:



Social and Environmental
Research Institute



cisa 
carolinas integrated sciences & assessments

Appendix D

Agenda for Beaufort County Sea Level Rise Public Workshops

Beaufort County, SC, Public Workshop On Sea Level Rise Adaptation Strategies

Session 1: August 25, 2014
Bluffton Branch Library Large Meeting Room
120 Palmetto Way, Bluffton, SC 29910

Session 2: August 26, 2014
St. Helena Branch Library Large Meeting Room
6355 Jonathan Francis Sr. Rd., St. Helena, SC 29920

1:00	Welcome, Introductions, and Overview of Agenda	Robert Merchant , Beaufort County Planning Department Elizabeth Fly , SC Sea Grant Consortium and Carolinas Integrated Sciences and Assessments
1:20	Vulnerability to Sea Level Rise in Beaufort County	Elizabeth Fly , SC Sea Grant Consortium and Carolinas Integrated Sciences and Assessments Sean Bath , SC Sea Grant Consortium
1:45	Review of Working Group Findings and Adaptation Strategies	Jessica Whitehead , NC Sea Grant
2:00	Question and Answer	
2:15	Break	
2:25	Small Group Discussions	Facilitated group discussions about adaptation strategies, including a prioritization vote.
3:25	Report-outs and Full Group Discussion	Facilitators share key points of each small group with all participants.
3:50	Next Steps and Wrap-Up	Elizabeth Fly , SC Sea Grant Consortium and Carolinas Integrated Sciences and Assessments Robert Merchant , Beaufort County Planning Department



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