Beaufort County Long-Term Resilience Strategy

2024

Contents

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Executive Summary

As Beaufort County prepared to update its Comprehensive Plan, a County-led Sea Level Rise Task Force was convened to assess current conditions and updated projections of **sea level rise** and extreme weather impacts in Beaufort County over the next thirty years. The primary concern is flooding, which the County is already experiencing localized changes due to a combination of tide elevation increases, changes in rainfall event intensity, and hurricane and **tropical cyclone** impacts. The flooding impacts of these factors are compounded by the increasing population and rate of development being experienced countywide.

The Sea Level Rise Task Force first convened in 2019. The task force assessed current conditions in Beaufort County using available localized data supplemented with state averages. Then, the Task Force analyzed future projections to develop a fuller picture of the anticipated impacts of flooding in the County. Based on the current available data, sea level rise is projected to increase in Beaufort County between 1 to 1.5 feet by the year 2050. While 1.5 feet of sea level rise does not at first seem significant, properties that currently experience flooding issues intermittently as a result of **king tides** that happen several times a year will begin regularly experiencing inundation at every **spring tide**, which happens twice a month. At the same time, rainfall events, hurricanes, and tropical storms are anticipated to last longer and more rapidly intensify, creating heightened probabilities for flooding frequency in the county.

Once equipped with an understanding of future flooding and weather projections, the Task Force developed a chart of related impacts. They include, but are not limited to, septic tank failures, lost tourism and jobs revenue, and overwhelmed infrastructure. Overall, flooding impacts will permeate into every facet of life here in Beaufort County if actions are not taken to mitigate the anticipated effects and improve **resilience**.

Understanding the need to plan ahead, the Task Force developed proactive and protective plans and policies to best bolster Beaufort County against flooding impacts. The recommended strategies have been organized into four resilience planning phases (awareness, study, action, and reassess) and are implementable across both the public and private sectors of Beaufort County. Each strategy has been identified with potential partners and collaborators as well as indicators of successful implementation. The most important strategies target better coordination within government agencies and partners, improve targeted local data collection to inform policies and plans, and recommend regular revisions to update science, progress, and strategies for adaptation.

Ultimately, Beaufort County will continue to see an increase in flooding and extreme weather events. The County needs to begin preparations now to adapt to anticipated impacts and improve overall resilience. This report will act as a guide by providing up-to-date data, recommended resilience strategies, and mechanisms for regular reassessment.

Section 1. Introduction

This report is a revision of the 2015 Beaufort County Sea Level Rise Action Plan developed by S.C. Sea Grant Consortium and the Carolinas Integrated Sciences and Assessments. It includes an update of the sea level rise projections and climate change impacts driving changes Beaufort County is already experiencing as well as a suite of recommendations developed by the Sea Level Rise Task Force for how Beaufort County can improve its resilience to various hazards.

Beaufort County is experiencing changes in localized flooding due to a combination of sea level rise, a changing climate affecting rainfall patterns, and development. This report primarily focuses on helping the County prepare for a rising sea level, but where appropriate, it also includes recommendations that help the County mitigate localized flooding from multiple sources and prepare for a changing climate as it pertains to land use, growth, and development.

1.1 Overview

Beaufort County, like many coastal areas in the southeast, faces the challenge of increasing population compounded by an increased potential for flooding and other risks due to sea level rise (more people and more assets in harm's way). 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 much of its upland is located within a flood zone.

The impacts of a changing climate, which include sea level rise, present significant future challenges to Beaufort County. Coastal flooding is the primary concern. Beaufort County's low elevation combined with its 6 to 10-foot tidal range make it vulnerable to any increase in average sea level. A rise of 1 to 1.5 feet may not at first appear to have consequential impacts on the County's landscape, but combined with semi-regular extreme high tide events, significantly more acres of urban and residential land could regularly experience flooding. In addition to the built environment, salt marshes will struggle to migrate upland to keep pace with sea level rise. In places where marsh migration is impeded by development, marsh acreage may be lost. The impact of coastal flooding is compounded by extreme rain events, which are projected to occur at greater frequency due to climate change. Higher water tables as a result of sea level rise will impact drainage and septic systems in low-lying areas. Finally, sea level rise may adversely impact aquifers with greater salinity, threatening agriculture and those relying on groundwater as their potable water source.

In 2015, the County participated in a process facilitated by the Carolinas Integrated Sciences and Assessments and S.C. Sea Grant Consortium to identify vulnerability to sea level rise and to

develop initial ideas for how the County can begin to plan and prepare. The recommendations generated in that process were incorporated into the County's 2015 Comprehensive Plan update. As the County began to prepare for the 2020 Comprehensive Plan revision, it recognized the need to identify more specific planning and policy actions to begin the implementation process.

In 2019, the County convened the Beaufort County Sea Level Rise Task Force made up of county and municipal staff, local environmental experts, as well as members of the development community. Beginning in the fall of that year, the Task Force went through a series of exercises to identify the various impacts from sea level rise that Beaufort County could experience and then identified various ways that the County could address those impacts. Following those exercises, the Task Force further developed and discussed the identified responses and proposals, in particular discussing efficacy, governance, legality, and need. In December 2020, the task force met one last time to help organize and categorize the potential responses and proposals, ultimately developing the framework for this report.

1.2 Goal of This Report

This document is not designed to provide specific projects for all hazards affecting Beaufort County, but rather is intended to provide support for policy and planning to improve resilience overall in the County.

This report also provides the most up-to-date science related to sea level rise in Beaufort County and can help inform decision-making and act as a reference. The science in this report is closely linked to the National Climate Assessment and should be updated regularly to reflect emerging science.

Finally, this report provides a range of planning and policy development strategies that Beaufort County can undertake over the coming decade to better position itself for implementing resilient actions. This includes incorporating resilience planning and policy into the 2025 and 2030 comprehensive plan updates, including adopting the recommendations made by the Sea Level Rise Task Force through this report. Some strategies help to address more immediate needs and planning, while others are intended to give the County a plan for continually updating and understanding what to expect in the long-term to improve readiness for the coming changes related to sea level rise in a changing climate. These are practical and proactive recommendations intended to benefit the whole of the County.

1.3 How to Use This Report

This report is designed to provide support for policy and planning to improve resilience throughout Beaufort County. To be effective, the data and strategies within must be continually updated as new data is collected and analyzed. The provided action matrix will offer recommended strategies to begin improving resilience within Beaufort County today, while providing opportunities for reassessment.

Finally, words highlighted in **bold purple** are defined in the Glossary. See **"Section 8. Glossary" on page 36**.

Section 2. Overview of Current Rainfall and Sea Level Trends Influencing Flooding

Flooding in Beaufort County comes from multiple sources that often interact and exacerbate conditions. These sources include tidal flooding, sea level rise, and extreme precipitation. All sources contribute to increases in groundwater, which leads to drainage problems and standing water.

- Sea level has risen by about 1.14 feet since 1901 at the Charleston Harbor tide gauge[1].
- Since 2000, sea level has risen about 6 inches[2].
- Sea level will continue to rise, with projections for South Carolina calling for additional increases between 0.66 feet and 0.72 feet by 2030, 0.92 feet and 1.08 feet by 2040, and 1.18 feet and 1.51 feet by 2050. These are based on the NOAA 2022 intermediate-low, intermediate, and intermediate high scenarios (see **"Appendix C: Sea Level Rise projections for South Carolina" on page 42**.)[3]
- Due to a lack of long-term measuring stations, there is no documented trend in Beaufort County or South Carolina for changes in frequency of extreme heavy rain.
- Anecdotally from residents, rainfall intensity and the frequency of extreme rainfall events has increased, but that increase can't be quantified.

This section will describe how conditions have been documented and highlights changes that have occurred.

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[1] National Oceanic and Atmospheric Administration. *Sea level trends*. NOAA Tides & Currents. Retrieved January 11, 2024.

[2] National Oceanic and Atmospheric Administration. Sea level trends. NOAA Tides & Currents. Retrieved October 3, 2021.

[3] National Aeronautics and Space Administration. *Fort Pulaski Sea Level Rise for Different Sea Level Scenarios*. Interagency Sea Level Rise Scenario Tool. Retrieved August 2, 2022.

2.1 About Tidal and Rainfall Records

Beaufort County lacks its own long-term recording stations for tides, but has one long-term recording station for rain and other climate records. We are using the following measurement sites for characterizing past, present, and future conditions:

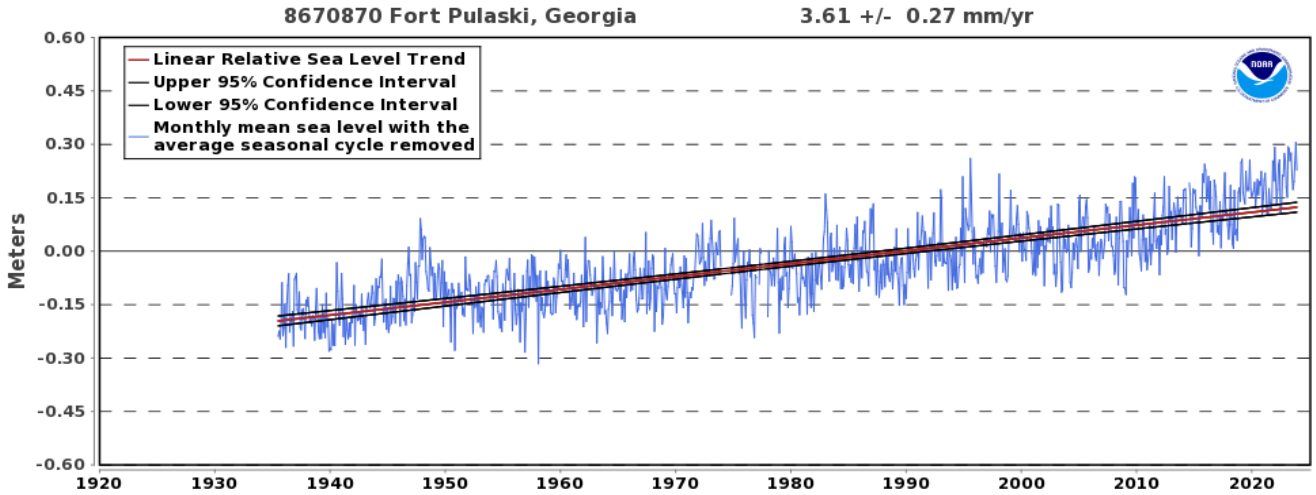
For tidal measurements: Beaufort County sits between two NOAA tide gauges: one in the Charleston Harbor and one at the entrance of the Savannah River in Fort Pulaski, GA. Because of the distance between the two and the localized nature of impacts, neither gauge fully reflects the number and type of storm surge or tidal flooding events experienced throughout Beaufort County. However, the overall trends and average measurements taken at both gauges are virtually identical. In this report, we use the Ft. Pulaski gauge for past conditions and for future sea level projections based on the 2022 Sea Level Rise Technical Report.

For rainfall measurements: The closest long-term measurement site is in Yemassee. These long-term measurement sites date back more than 100 years, making their data more appropriate for analyzing long-term climate trends.

2.2 Past Sea Level Trends in South Carolina

Since 1935, the sea level has risen about 1.18 feet at the Ft. Pulaski gauge[4]. In this time frame, the average rate of rise per year is about 3.61 millimeters[5], as illustrated in **Figure 1**. Since 2000, the sea level at the gauge has risen about 6 inches, though calculations for a precise amount will not be complete until 2025 when NOAA releases a new **tidal epoch datum**.

Figure 1: Sea Level Trend at Ft. Pulaski Gauge



Source: NOAA/National Ocean Service; COOPS

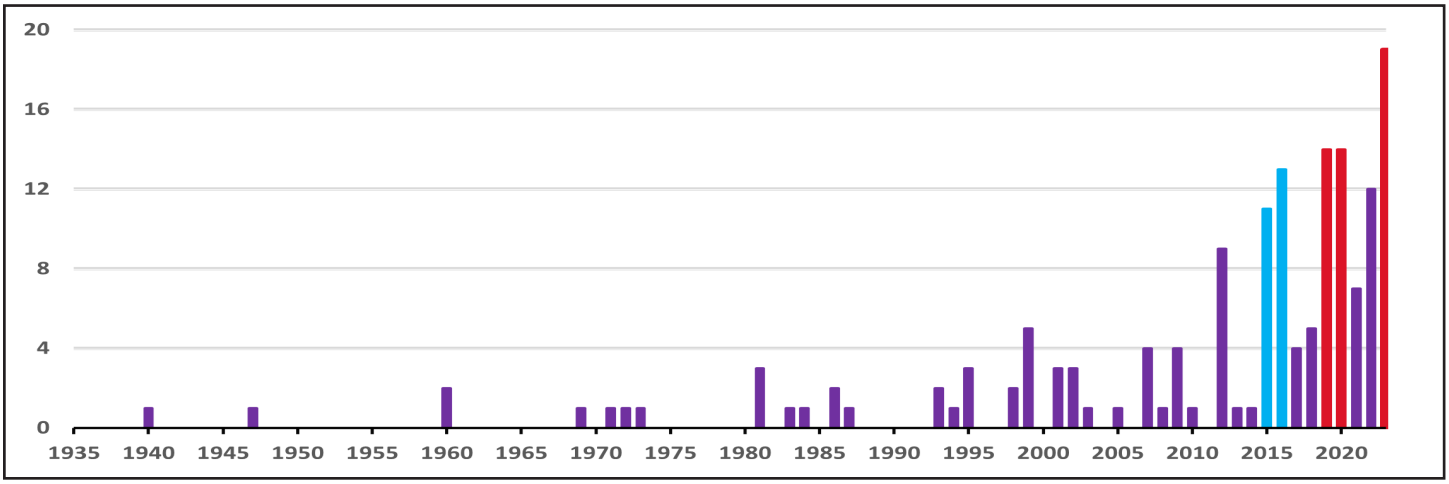
[4] National Oceanic and Atmospheric Administration. *Sea level trends*. NOAA Tides & Currents. Retrieved January 11, 2024.

[5] National Oceanic and Atmospheric Administration. *Sea level trends*. NOAA Tides & Currents. Retrieved February 22, 2024.

This observed rise since 2000 connects with an abrupt increase in the frequency of **tidal flooding** and the number of days when the water at the gauge reaches the minor flooding threshold of 9.5 feet above **Mean Lower Low Water** (**MLLW**) set by the National Weather Service[6].

As illustrated in **Figure 2**, in 2015, the gauge recorded 11 flood days. In 2016, the tide gauge reached that threshold 13 days. Then in 2019 and 2020, the gauge recorded 14 flood days, and in 2023, it recorded 19 days. For more information about tidal flooding records broken down by number of events and thresholds, see **"Appendix A: A Detailed Look at Tidal Flooding Records at the Ft. Pulaski Gauge" on page 38**.

Figure 2: Total Number of Annual Flood Days at Ft. Pulaski Gauge



Source: NOAA/NOS, NWS, Beaufort County

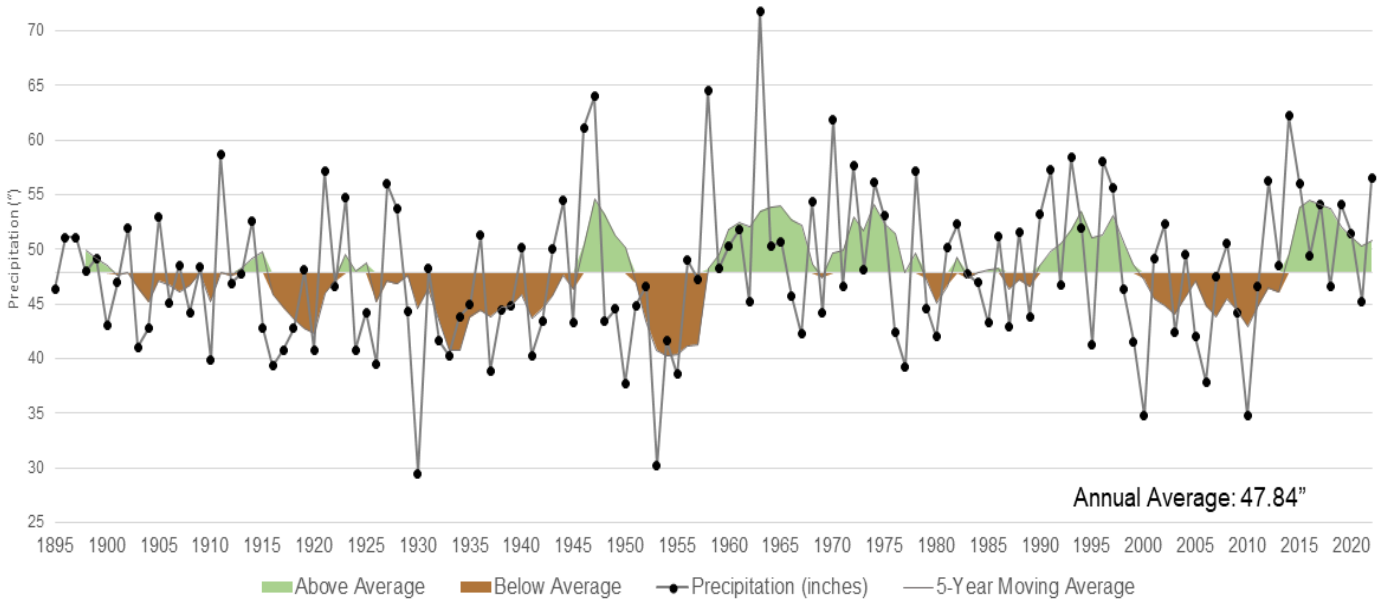
[6] U.S. Department of Commerce, NOAA. (2021, September 12). *Coastal Flood Event Database*. National Weather Service. Retrieved January 11, 2024.

2.3 Past and Current Rainfall Observations

Documenting and characterizing rainfall patterns throughout Beaufort County is difficult due to the highly localized nature of summer thunderstorms, climatic variations in coastal South Carolina influenced by the **ACE Basin**, and a lack of long-term rain gauge recording stations.

For the purposes of this report, we will use the long-term station in Yemassee for documenting annual rainfall maximums and we will use the S.C. Southern Climate Division for annual averages. At this station, as with all other long-term reporting stations in S.C., there is no strong signal for changes in average annual rainfall (**Figure 3**.)

Figure 3: Southern Climate Division Annual Average Precipitation (1895-2023)



There is a small signal for an increase in the average precipitation for fall, which is calculated using all rainfall in the full months of September, October, and November. See **"Appendix B: Annual Precipitation Records from the S.C. Office of the State Climatologist" on page 39** for graphics illustrating these trends.

This data does not break out changes in the frequency of heavy rain events, nor is it able to highlight any changes in extreme events or changing intensity at this scale. However, there is a statistically significant trend towards more intense precipitation, particularly for the more extreme, less likely events with lower probability of occurrence (i.e., the **50-, 100-, 200-, 500- and 1000-year events**). The **annual return interval** 50-year event has a 2% chance of happening in any year regardless of what happened in previous years. Similarly, the 100-year event has a 1% chance and the 200-year event has a 0.5% chance.

2.4 Hurricanes and Other Tropical Cyclones

Beaufort County has been affected by numerous tropical cyclone events in the past 150 years. A storm making direct landfall is rare (but happened in 1874, 1885, 1928, 2021, and 2022). However, a storm several hundred miles away can cause extreme damaging impacts. Since 2016, Beaufort County has been substantially affected by two tropical cyclones, with multiple others causing minor disruptions during the event.

- **2016 – Hurricane Matthew:** This storm moved parallel to the southeast coast before making landfall in northern Charleston County. Matthew brought hurricane-force winds, up to 17 inches of rain, and a 5-foot storm surge that caused major flooding, beach erosion, beach washover, and other damage on the barrier islands in the County. The storm tide of 12.56 feet above MLLW from Matthew was the highest tide on record at the Ft. Pulaski gauge.
- **2017 – Tropical Storm Irma:** This massive storm traveled up the west coast of Florida, with tropical storm-force winds extending out more than 500 miles from the center. Irma caused tropical storm-force winds, nearly 6 inches of rain, and the second highest storm tide, totaling 12.24 feet above MLLW, recorded at the Ft. Pulaski gauge. Flooding in downtown Beaufort reached record levels and is considered the storm of record.
- **2019 – Hurricane Dorian:** This storm moved parallel to the southeast coast before making landfall in North Carolina, causing moderate beach erosion and minor flooding.
- **2020 – Hurricane Isaias:** This storm moved parallel to the southeast coast before making landfall near Myrtle Beach, S.C.
- **2021 – Tropical Storm Danny:** This storm made landfall at Pritchard's Island in Beaufort County. It dropped over six inches of rain in areas of the County and brought tropical storm-force winds.
- **2021 – Tropical Storm Elsa:** This storm traveled up the west coast of Florida before crossing to the coastline of Georgia and traveling up the South Carolina coast. It caused severe storms and tornadoes in Beaufort County.
- **2021 – Tropical Storm Mindy:** This storm formed in the Gulf of Mexico before crossing to the Atlantic Ocean through Georgia. It dropped over four inches of rain in areas of Beaufort County.
- **2022 - Hurricane Nicole:** This storm formed in the Caribbean Sea before making landfall in Florida and tracking north to South Carolina as a tropical depression. It created tropical storm-force winds in Beaufort County.

- **2022 - Hurricane Ian:** This deadly storm formed in the Caribbean Sea and was a Category 3 Hurricane by the time it reached the Gulf of Mexico. It made landfall in Florida before re-entering the Atlantic Ocean where it restrengthened and made its second landfall near Georgetown, S.C. as a Category 1 Hurricane. It brought tropical storm-force winds and nearly four inches of rain to areas of Beaufort County.
- **2022 - Tropical Storm Colin:** This storm formed from a stationary front along the coast of South Carolina, making landfall near Hunting Island.
- **2023 - Tropical Storm Idalia:** This storm formed in the Caribbean Sea and entered South Carolina as a tropical storm. It brought gusts over 60 mph and nearly four inches of rain to Beaufort County. It also produced a storm surge that resulted in erosion of Beaufort County beaches.

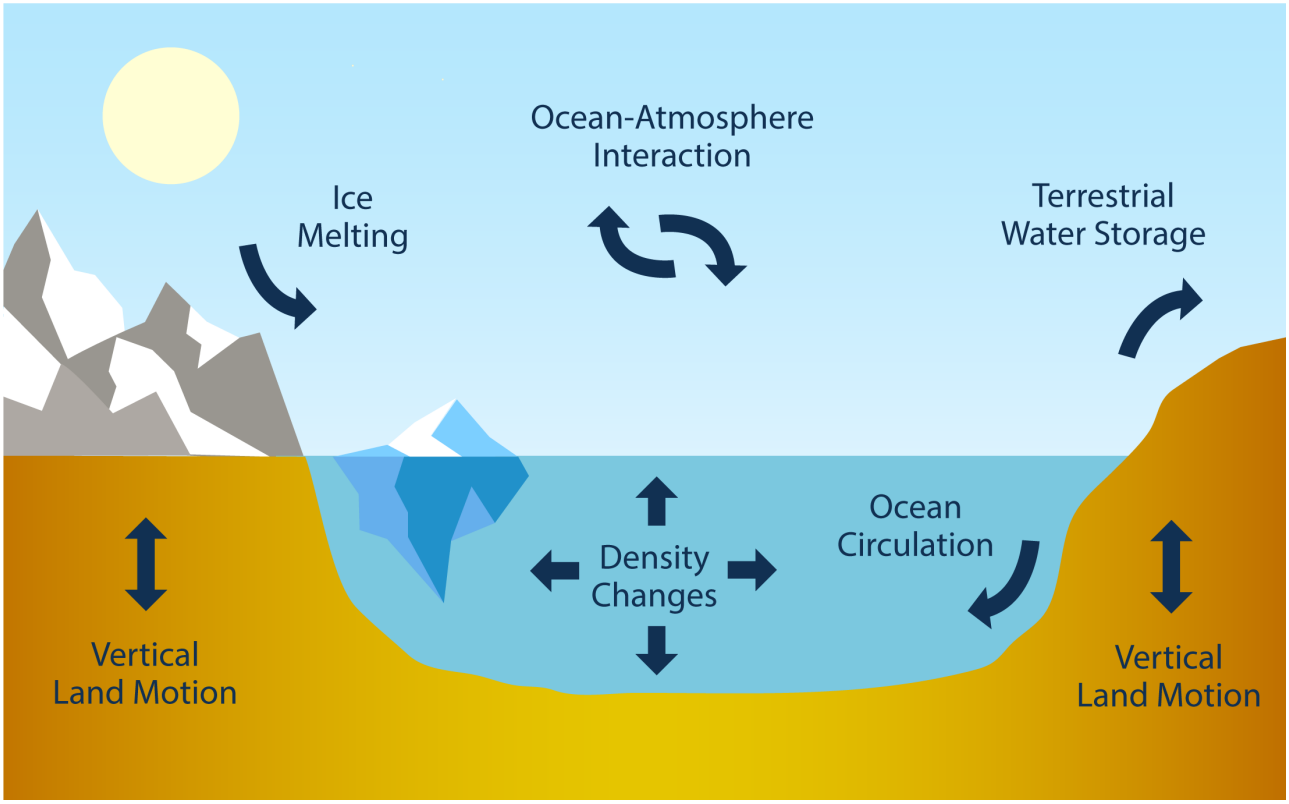
Section 3. Future Flooding and Storm Risks

Flooding in Beaufort County is occurring with increasing frequency and severity. This section will describe how flooding may change due to sea level rise, changes to rainfall, and tropical cyclones.

3.1 About Sea Level Rise

Sea level rise is caused by a number of factors illustrated in **Figure 4**. The predominant sources of sea level rise in Beaufort County since 1900 have been a combination of land elevation changes, increasingly warm ocean temperatures causing expansion and increase in volume of the water, and slowing of the Gulf Stream current offshore that pulls water away from the coasts. Sea level rise is projected to increase in the future due to those factors, plus a large influence of melting glaciers in Antarctica and Greenland. How fast glaciers will melt and precisely when South Carolina's coast will see the direct influences is still unclear, however projections provide a range of possibilities based on current evidence and understanding about the interactions of these changing processes.

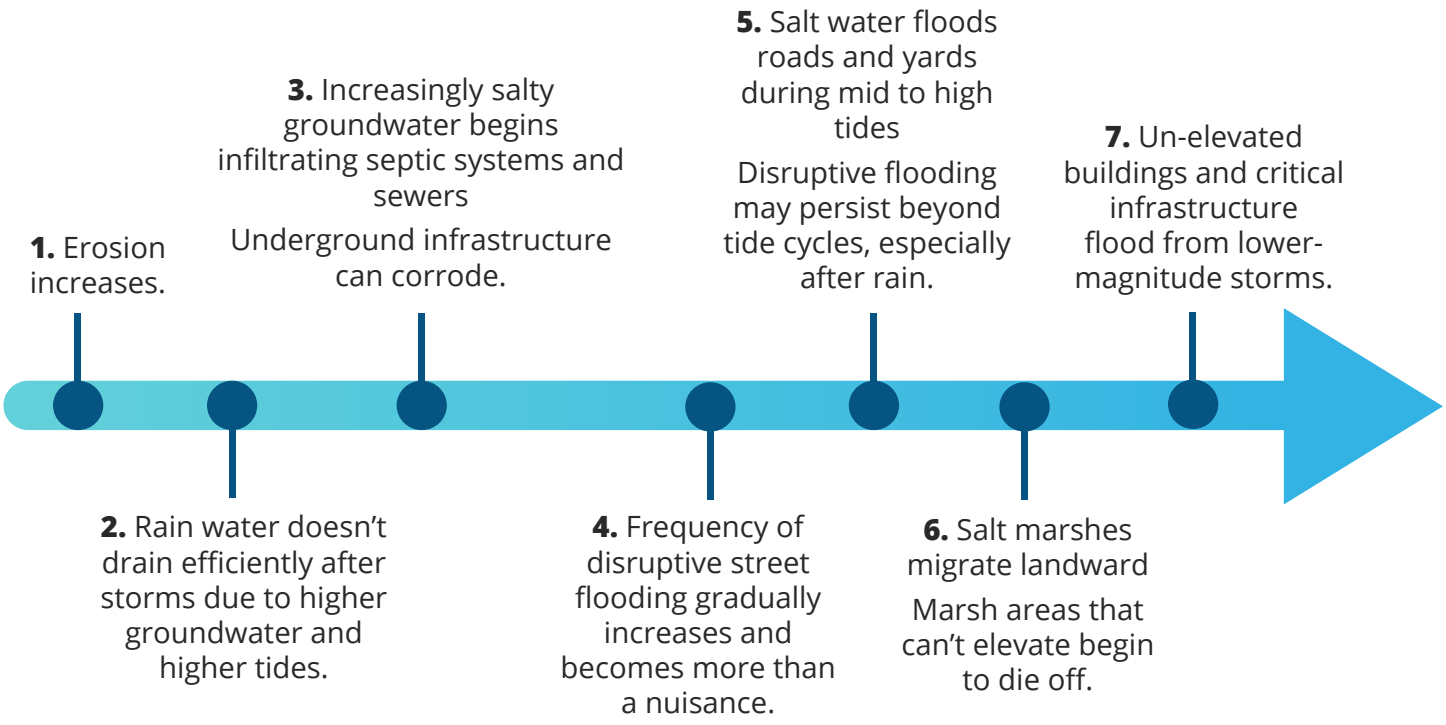
Figure 4: What Causes Sea Level Changes



Source: Sarah Watson, S.C. Sea Grant Consortium, recreated from Milne, 2009

We can see the effects of sea level rise through changes in how often various types of problems, such as street flooding and erosion, occur. **Figure 5** illustrates some of the primary indicators that Beaufort County and other South Carolina coastal communities are experiencing. The effects initially seem small, but other problems develop quickly and the frequency at which they occur accelerates.

Figure 5: Effects of Sea Level Rise in Coastal Communities



Source: Sarah Watson

One of the biggest challenges when it comes to envisioning the effects of sea level rise is connecting with tidal variation. Projections center on the rise in **mean sea level (MSL)**, but that does not communicate how high tide in the future will look. Using a "**total water level**" **approach** can help communicate this. In **Table 1**, top flood heights are listed in relation to the recorded height above **mean higher high water (MHHW)**. In **Table 2**, we use memorable flood heights connected with sea level rise to paint a fuller picture of what this means.

For example, five feet of sea level rise in **Table 2** will look like the flooding locally experienced during Hurricane Irma plus two additional feet of water. Visualizing future sea level rise in this way helps us to understand what sea level rise will actually look like here in Beaufort County.

Table 1: Examples of Top Flood Heights at Ft. Pulaski Gauge

Date	Event	Ranking	Height Above MHHW	Total Storm Tide
10/08/2016	Hurricane Matthew	1	5.06 feet	12.56 feet
09/11/2017	Tropical Storm Irma	2	4.74 feet	12.24 feet
10/15/1947	Cape Sable Hurricane	3	3.36 feet	10.86 feet
11/07/2021	November 2021 King Tide	4	2.95 feet	10.45 feet
10/27/2015	October 2015 King Tide	5	2.93 feet	10.43 feet
11/10/2022	November 2012 King Tide	6	2.91 feet	10.41 feet
11/23/2018	November 2018 King Tide	8	2.75 feet	10.25 feet
06/04/2023	June 2023 King Tide	10	2.7 feet	10.20 feet

Source: NOS/NOAA, NWS.

Note: MHHW is 9.5ft at the Ft. Pulaski Gauge.

Table 2: Total Water Approach in Beaufort County

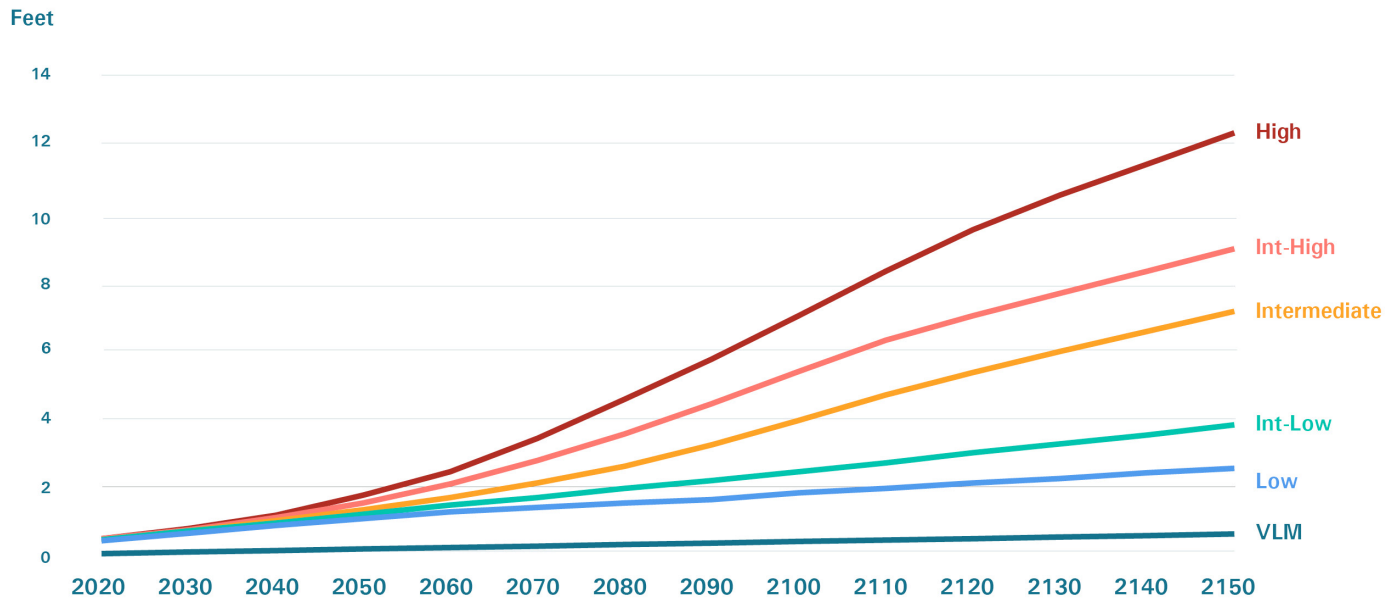
Above MHHW	Current Equivalent Event	Sea Level Rise (SLR)
1 foot	Full/New Moon Tide (Spring Tide)	MHHW + 1ft SLR
2 feet	King Tide	Full/New Moon + 1ft SLR
3 feet	Cape Sable Hurricane or Nov 2021 King Tide	King Tide + 1ft SLR
4 feet	None Documented	Nov. 2021 + 1ft SLR
5 feet	Tropical Storm Irma or Hurricane Matthew	Nov. 2021 + 2 ft SLR
6 feet	None Documented	Irma/Matthew + 1ft SLR

3.2 Future Sea Level Projections

In 2022, NOAA developed a suite of projections for future sea level rise, which is the basis for the Fifth National Climate Assessment, released in 2023. An interagency task force comprised of NASA, NOAA, the U.S. Army Corp of Engineers, and others, have taken those projections and localized them to the NOAA tide gauges[7], which are considered the reference data points for localized relative sea level rise. In **Figure 6**, the projections downscaled to the Ft. Pulaski gauge are illustrated. See **"Appendix C: Sea Level Rise projections for South Carolina" on page 42** for chart with scenario numbers for each decade.

[7] National Aeronautics and Space Administration. *Fort Pulaski Sea Level Rise for Different Sea Level Scenarios*. Interagency Sea Level Rise Scenario Tool. Retrieved August 4, 2022.

Figure 6: NOAA 2022 Sea Level Projections for the Ft. Pulaski Gauge



Source: NOAA et al, 2022, [2022 Sea Level Rise Technical Report Data Files](), S.C. Sea Grant Consortium

The projection line labeled "VLM" solely depicts the rate of rise based on geological **vertical land movement** (VLM)[8]. The rate of VLM in this projection is not highly localized and is not connected to local groundwater withdrawal or building compaction of soils. The projection line labeled "Low" depicts the rate of rise as the historic linear trend and does not include effects from climate change. The other projections connect sea level rise with global climate change **emissions scenarios**.

Sea level projections illustrate the change to the overall averages to sea level. What these projections do not effectively illustrate are the changes in extreme high tides, storm surges, increased frequency in sunny day tidal flooding, changes to the shallow **groundwater** table, marsh migration and loss, land loss, erosion, and other impacts.

States and communities along the east coast have varied approaches for selecting planning scenarios. Recommended practices include selecting multiple scenarios to apply to various types of decision-making based on life-span, risk tolerance, implementation timeline, and ability to retrofit.

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[8] Sweet, W., Kopp, R.E., Weaver, C.P., Obeysekera, J.T., Horton, R.M., Thieler, E.R., & Zervas, C.E. (2017). *Global and Regional Sea Level Rise Scenarios for the United States Technical Report*. [NOAA Technical Report CO-OPS 083](), Silver Spring, MD. Retrieved October 3, 2021.

3.3 Future Rainfall Projections

Projections for how rainfall may change in the future currently are not able to provide details for changes in the intensity, duration, and frequency of rainfall events. General projections from the Fifth National Climate Assessment predict an overall annual increase in total precipitation of between 5% and 10%. However, that average does not include the variations that make up that average. But scientists predict that the frequency and intensity of extremes – both wet and dry – will continue to increase[9]. This translates to longer dry periods and more extreme wet periods with high impact and high intensity events, like **rain bombs**. According to the National Climate Assessment, the frequency and severity of extreme precipitation events are projected to continue increasing in the Southeast. By the end of the century, projections indicate that the number of heavy rainfall days (two-day events with at least a five-year return period) will double, with a 37% increase in the total amount of rain falling on the heaviest precipitation days[10].

It is important to note that the frequency of community disruption from standing water, street flooding, and submerged septic systems due to heavy rain is likely to increase due to sea level rise reducing the drainage capacity of engineered systems, ditches, and the groundwater table. This means that a storm that would not have caused persistent and disruptive flooding in 2021 may do so in 2031 or 2041.

3.4 Future Hurricanes and Other Tropical Cyclones

Beaufort County has experienced a range of effects from hurricanes and tropical storms, with each individual event bringing specific hazards based on storm direction and dynamics. Hurricanes and tropical storms are primarily fueled by warm sea surface temperatures. Atmospheric steering currents and upper-level winds affect how storms travel and maintain intensity. Precisely how Beaufort County's future risk for hurricanes and tropical storms may change is unclear. However, climate science research is highlighting three core ways future conditions may affect storm frequency and effects[11].

- **Frequency:** There is no strong consensus on how climate change will affect the total number of storms that form. Some research suggests that the overall number of storms

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[9] Marvel, K., W. Su, R. Delgado, S. Aarons, A. Chatterjee, M.E. Garcia, Z. Hausfather, K. Hayhoe, D.A. Hence, E.B. Jewett, A. Robel, D. Singh, A. Tripati, and R.S. Vose, 2023: Ch. 2. Climate trends. In: *Fifth National Climate Assessment*. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023.CH2

[10] Kunkel, K.E., T.R. Karl, M.F. Squires, X. Yin, S.T. Stegall, and D.R. Easterling, 2020: Precipitation extremes: Trends and relationships with average precipitation and predictable water in the contiguous United States. *Journal of Applied Meteorology and Climatology*, 59 (1), 125-142. https://doi.org/10.1175/jamc-d-19-0185.1

[11] Emanuel, K. (2017). Will Global Warming Make Hurricane Forecasting More Difficult?, *Bulletin of the American Meteorological Society*, 98(3), 495-501. Retrieved Aug 30, 2021.

may decline due to increases in wind shear and other forces that inhibit tropical cyclone development. Other research suggests an increased frequency in less severe events due to wider expanses of ocean with tropical cyclone-sustaining water temperatures.

- **Intensity:** There is research highlighting the potential for an increased frequency of high intensity events with rapid intensification due to warmer sea surface temperatures. This type of event has been seen in the Atlantic and Gulf of Mexico more frequently in the past six years, with storms such as Harvey, Irma, Maria, Michael, Dorian, Laura, and Ida rapidly intensifying, in some cases overnight, from a tropical storm-level cyclone to a major hurricane of at least Category 3 strength[12].
- **Long-Duration Events:** Other research highlights the potential for the frequency of slow-moving storms that have weaker winds but produce extreme levels of rain similar to Hurricanes Harvey and Florence. These types of storms are the result of very weak to nonexistent upper-air steering currents and can linger over a region for days. As those types of storms weaken in intensity, especially if they were previously a very strong hurricane, the storm spreads out, affecting a wider area with heavy rainfall. Additionally, a warmer atmosphere can hold more water, further increasing the rainfall potential.

3.5 Other Extreme Weather Effects

Beaufort County will continue to assess other impacts of climate change, such as heat, and will continue to monitor specific actions that it has jurisdiction and authority to implement.

3.6 Conclusion

This section illustrated how conditions are changing in Beaufort County and how NOAA expects extreme weather and flooding occurrences will continue to increase. This information helps Beaufort County identify what resilience strategies may be needed to help residents and businesses prepare for the future.

[12] Emanuel, K. (2017). Will Global Warming Make Hurricane Forecasting More Difficult?, *Bulletin of the American Meteorological Society*, 98(3), 495-501. Retrieved Aug 30, 2021.

Section 4. Sea Level Rise and Extreme Weather Impacts on Beaufort County

The listed impacts in this section were compiled through multiple discussions with the Beaufort County SLR Taskforce. Impacts span all aspects of Beaufort County's way of life, from impeding the functionality of the County's infrastructure to interrupting citizen's daily lives through personal property losses and community disruptions. The list is intended to help inform the development of the various recommendations and does not include all possible effects or impacts.

4.1 Infrastructure

- Existing infrastructure may be sited too low in elevation and vulnerable to sea level rise – issue for water, sewer, roads, stormwater, and public buildings.
- Blocked or disrupted evacuation routes.
- Siting and resilience of new infrastructure will be affected by sea level rise impacts.
- Inadequate conveyance of "typical" storm events now (under-sized existing infrastructure).
- Groundwater levels can affect functionality of septic systems and other underground infrastructure.

4.2 Natural Resources Degradation

- Loss of salt marshes.
- Erosion of beaches, dunes, and bluffs.
- Potential changes to water quality and potential harmful algal blooms.
- Loss of wildlife habitat (particularly where seawalls or bulkheads are present).
- Invasive species may become more prevalent with changing temperature and weather patterns, leading to additional strain on native plants and animals.
- Change to native plants and animals.

4.3 Community Disruptions

- Flooded roads will make some areas increasingly impassible.
- Repeated flooding may lead to people leaving the area.

- Disruption of daily life during evacuation and recovery – closing of business and schools (during storms and non-tropical events).
- Long-term societal losses to public health and mental health due to strain of storm recovery.
- Inaccessible resources (food banks, pharmacies, etc).

4.4 Public Health Impacts from Flooding

- **Saltwater intrusion** may affect agricultural uses.
- Long-term emotional and physical stress responses among individuals.
- Vector changes (ticks and mosquitoes).
- Harmful algal blooms.
- Increasing instances of ***Vibrio*** infections in humans and shellfish.
- Septic Failure.
- Saltwater intrusion may affect drinking water wells.

4.5 Economic Loss

- Tourism industry disrupted during and after storms – leading to loss in revenue.
- Storm clean-up costs money and places financial strain on homeowners, businesses, and local governments.
- Homeowners and business owners may be subject to higher insurance costs.
- Evacuations cost residents and businesses in lost wages and revenues.
- Repetitive loss areas lower property values and become blighted.
- Military bases (especially Parris Island) could flood, interrupting operations and threatening long-term viability. Vulnerable to Base Realignment and Closure (BRAC).
- Agriculture depends on groundwater which may experience saltwater intrusion.

4.6 Cultural Loss

- Many African-American and Gullah/Geechee communities or cemeteries located in low-lying areas along water.

- Low-lying historic areas threatened – Historic Beaufort, Corners Community on St. Helena Island.
- Loss of marshes and water quality issues may lead to decline in local shellfish population – affect legacy ways of life.
- Saltwater intrusion may affect agricultural uses.

4.7 Personal Property Damage

- Wind and water damage from more frequent storms.
- Rising insurance costs for homeowners.
- Erosion of beaches leads to loss of land and structures (homes, businesses, etc.).

Section 5. Recommended Strategies to Improve Resilience in Beaufort County

Adapting to a sea level rise is not a linear process with a beginning and end, but instead a cyclical process including many opportunities for reassessment to improve awareness and understanding, guide data collection and study, and inform actionable practices and policies. To capitalize on that system, the strategies offered in this report have been categorized into four Resilience Strategy groups – Awareness, Study, Action, and Reassess. Within each Resilience Strategy group, definitions of the strategy, measurements of successful implementation, potential partners and collaborators, and recommended actions are provided.

The first recommendations are focused on learning more about impacts, monitoring changes, and identifying how to connect science-based projections into what that means for Beaufort County (Awareness and Study). As this occurs over the coming five years, we will begin developing guidelines for more focused policy and planning recommendations along with timelines for implementation (Action). Throughout much of these coming steps, the County will continually reassess the most up-to-date science and engage with residents and stakeholders to understand their perspectives and apply their knowledge and opinions into shaping future resilience recommendations (Reassess). The goals listed in this section are tied to those listed in the County's 2040 Comprehensive Plan and include much more detail about specific activities, priorities, timelines for initiation and completion, as well as identify generally needed resources.

5.1 Resilience Strategies: Awareness

Definition: Effectively communicating to and educating all relevant parties, facilitating conversations about applying science to decision-making, and providing opportunities for conversations about next steps.

Measures of Success: Coordination between all stakeholders and jurisdictions have put everyone on the same page. Our residents and stakeholders recognize what is at stake and support our efforts.

2040 Comprehensive Plan Connections: NE 1.1, NE 5.1, NE 5.2, NE 6.1

Strategy - Collaboration

HIGH PRIORITY—LOW EFFORT

Purpose: Work collaboratively to encourage communication and joint activities among

government agencies and the private sector to increase the region's capacity to adapt to sea level rise.

Actions

- Maintain an ongoing, collaborative working group called the Coastal Resilience Working Group (CRWG) made up of county and municipal staff, environmental experts, local military installation staff, and members of the development community tasked with assessing issues and ideas related to sea level rise and resilience.
- Identify the sea level rise and climate change scenarios, based on the National Climate Assessment and other science-based documents, to use for planning purposes that can be incorporated throughout county policy and comprehensive planning. Use it to update the Long Term Resilience Strategy plan on an ongoing basis.
- Work collaboratively with municipalities, MCRD Parris Island, and MCAS Beaufort to develop science-based decision-points that inform future policy changes and actions.
- Apply for a grant to work with the University of South Carolina, College of Charleston, DNR, and the S.C. Sea Grant Consortium on conducting research that can inform the decision-point development process.

Strategy - Information Sharing & Communication

HIGH PRIORITY—MEDIUM EFFORT

Purpose: Foster coordination among all partners and participants. Improve communication and connection among local government, state and federal agencies, and regional alliances and networks, to improve information sharing about flooding, sea level rise, and climate change effects.

Actions

- Work with S.C. Sea Grant Consortium, ACE Basin NERR, Clemson Extension, and other partners, to help foster better coordination and integration within county government departments on sea level rise and climate change.
- Develop and maintain relationships with MCRD Parris Island and MCAS Beaufort to build information sharing channels and coordinate resilience initiatives.
- Inform local decision makers and taxpayers about the impacts of increased risks of flooding, rain and storm impacts, and wind impacts on County infrastructure to build support for resilience initiatives.

Strategy - Expand Community-Level Science and Outreach Education

HIGH PRIORITY—MEDIUM EFFORT

Purpose: Foster opportunities to learn about climate change science and impacts.

Actions

- Develop a county-level website that is a compendium of Beaufort County specific flooding and sea level rise information, including outreach materials, the sea level rise GIS portal, and other data sources. This website may count as Community Rating System outreach credit if National Flood Insurance info is included.
- Develop a flood, sea level rise, and climate change impacts education roadshow program to connect with community groups, homeowners' associations, and professional organizations not already served by existing programs, and other similar organizations for community outreach and education.
- Work with S.C. Sea Grant Consortium, DNR, the ACE Basin NERR, MCRD Parris Island, MCAS Beaufort, Port Royal Sound Foundation, and other partners to develop public outreach materials.
- Work with other outreach-serving organizations in the County to train them on including flood, sea level rise, and climate change impacts in their work. This helps expand the County's educational footprint.

Strategy - Integration with Emergency Management

HIGH PRIORITY—MEDIUM EFFORT

Purpose: Fully incorporate and integrate future sea level rise and climate change impacts into emergency management and hazard mitigation plans.

Actions

- Invite the Emergency Management Division (EMD) to sit on the Coastal Resilience Working Group (CRWG).
- Collaborate and coordinate with EMD for selected CRWG members to join the Hazard Mitigation Planning teams.
- Partner with EMD, Beaufort County Planning and Zoning, S.C. Sea Grant Consortium, and

the College of Charleston's Lowcountry Hazards Center to assist with incorporating sea level rise and climate change impacts into emergency management and hazard mitigation plans.

- Work with EMD to identify other vulnerable critical public facilities such as schools, government buildings, pump stations, electrical substations, and stormwater infrastructure that may need to be improved or relocated.

Strategy - Living Shorelines

MEDIUM PRIORITY—LOW EFFORT

Purpose: Continue working with SCDHEC/OCRM on the living shoreline permitting process.

Actions

- Work with the state to incentivize living shorelines and to ensure contractors are properly trained on siting and installing living shorelines.
- Identify and map where living shorelines can be effectively used, including recommendations about which types of living shorelines to use in different environmental conditions.
- Develop county-level policies to require property owners seeking to establish erosion control or edge protection to use living shorelines or green infrastructure rather than hard infrastructure such as bulkheads or revetments, unless impractical based on water and shoreline conditions.

5.2 Resilience Strategies: Study

Definition: Gathering scientific data and stakeholder information to support decision-making and developing plans that identify future policies and strategies to improve Beaufort County's long-term resilience.

Measures of Success: Data and information collection that supports development of effective and appropriate policies and strategies is complete. We've developed a framework for proceeding with resilience actions. We've identified and developed preliminary policies and strategies.

2040 Comprehensive Plan Connections: NE 1.1, NE 3.1, NE 3.2, NE 3.3, StH 1.1, CF 1.1, CF 1.2

Strategy - Study Rainfall

HIGH PRIORITY—HIGH EFFORT

Purpose: Study how rainfall is changing, with a focus on extreme events, with the goal of helping to inform County and municipal stormwater standards.

Actions

- Work with the Office of the State Climatologist, the National Weather Service Charleston Office, and local military installations, non-profits, and others to engage residents in participating in the Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) program.
- Work with the Office of the State Climatologist, National Weather Service Charleston Office, S.C. Sea Grant Consortium, the Citadel, and College of Charleston Lowcountry Hazards Center on analyzing data.
- Work with other partners on exploring changes to the County's engineering standards for stormwater management.

Strategy - Better Characterize Local Tide Information

HIGH PRIORITY—LOW EFFORT

Purpose: Develop a program to monitor tide levels and conditions in Beaufort County's waterways to record sea level and tidal variations locally. Currently the County relies on tidal record data from Ft. Pulaski or Charleston, neither of which fully characterize conditions in the County.

Actions

- Work with partners to purchase and install tidal gauges at locations in Beaufort County. Possible locations could include the Whale Branch Bridge, the Broad River Bridge, and the bridge over Skull Creek at Hilton Head Island. Work with SCDOT to approve locations and installation.
- Learn from other S.C. coastal communities, such as Edisto Beach and Kiawah Island, about what they discovered in similar efforts.
- Seek partners to assist in funding and managing tidal gauges, including ACE Basin NERR, Palmetto Bluff Conservancy, Lowcountry Institute, S.C. Sea Grant Consortium, the College of Charleston, LCOG, MCRD Parris Island, and MCAS Beaufort.
- Explore partnerships to collect and manage data, and help maintain the gauges for the duration of the research projects.

- Work with research partners to analyze tidal data collected in Beaufort County to develop a suite of data products aimed at improving tidal flooding forecasting and high water marks.

Strategy - Plan for Water

HIGH PRIORITY—HIGH EFFORT

Purpose: Perform comprehensive water plans for vulnerable areas of the County to understand how water flows and learn how additional development and redevelopment can avoid creating or exacerbating flooding problems.

Actions

- Create a baseline for future development by studying and analyzing how stormwater, sea level rise, and storm surge interact in an area determined by geology and geological conditions. Study how wetlands will expand based on future environmental and weather conditions.
- Use the Stormwater Master Plan as a starting point for watershed-based planning and to investigate areas with flooding issues and poor soils for drainage.
- Map areas with geology and soil conditions that are conducive to development. Define parameters for areas appropriate for development and provide restrictions for those that are not. Identify incentives for directing development to appropriate areas. Use this map to inform the Coastal Resilience Overlay District.
- Generate a "water diet" to identify how much additional stormwater the studied area can manage to assist planners, developers, and engineers in understanding how development can occur in that watershed and how low-impact development and green infrastructure can reduce impacts.
- Consider partnering with appropriate entities, such as the College of Charleston, the S.C. Sea Grant Consortium, and other agencies for additional resources.
- Consider updating wetland protection ordinances to close gaps created by the changes to the Clean Water Act.

Strategy - Study Groundwater

HIGH PRIORITY—MEDIUM EFFORT

Purpose: Study groundwater volume and salinity to help the County understand how various

services, such as water, sewer, and septic, are affected by rising sea levels and to help create timelines and decision points based on future projections.

Actions

- Work with the College of Charleston, University of South Carolina, SCDHEC, MCRD Parris Island, MCAS Beaufort, and other partners on characterizing groundwater volume and salinity, particularly in areas where agriculture relies heavily on groundwater for irrigation and other needs.
- Study and monitor the impacts of sea level rise and saltwater intrusion on groundwater supply. Work with the appropriate entities to do so.
- Work with USC, S.C. Sea Grant Consortium, and the College of Charleston to understand how sea level rise affects groundwater level and septic system functionality.
- Consider adopting watering and irrigation ordinances to promote the use of tertiary effluent reuse.
- Assess current codes and programs that already meet goals identified in sea level rise planning in order to ensure they are having the intended effects and consider the most up-to-date science.

Strategy - Identify Critical Infrastructure

HIGH PRIORITY—LOW EFFORT

Purpose: Define what counts as critical infrastructure for sea level rise planning in public, private, and quasi-public areas. Identify locations and any existing coordination between public and private entities for maintaining or upgrading critical infrastructure to meet future conditions.

Actions

- Map and analyze locations of existing vulnerable critical infrastructure and examine with projected future conditions. This includes developing an inventory of low-lying public facilities and infrastructure, including roads, sewer, water, public buildings, and stormwater infrastructure.
- Develop a strategy to retrofit the most vulnerable existing critical infrastructure facilities. Examples include raising structures or installing flood-proofing systems.

- Work with EMD and other local government officials to develop a risk rating system for existing critical facilities and roads.
- Evaluate whether facilities most at risk should be relocated in full or mitigated on existing sites.

Strategy - Identify Critical Roads

HIGH PRIORITY—LOW EFFORT

Purpose: Map and prioritize low-lying roads and causeways for protection and/or elevation as necessary.

Actions

- Develop inventory of low-lying roads that experience or have the potential to experience disruptive tidal and stormwater flooding.
- Develop prioritization criteria based on the importance of roadway improvements on such factors as average daily traffic counts (ADTs), lack of alternative routes, and importance of roadway for evacuations.
- Consider establishment of a minimum elevation requirement for new roads and road improvements.
- Develop policies for road construction elevation in the County to ensure sufficient future drainage and access during storms. Ensure other building policies support these efforts.

Strategy - Local Government Intervention

HIGH PRIORITY—MEDIUM EFFORT

Purpose: Develop criteria for identifying when the County intervenes, either though policy and/or funding regarding flooding and sea level rise impacts to public, quasi-public, and private infrastructure and individual properties to ensure equitable and proportional responses.

Actions

- Study and develop criteria based on income and other means.
- Study and identify funding streams and opportunities other than FEMA.
- Explore whether participation criteria includes public benefit in exchange for participating

in a buyout-program. Public benefits include beach and water access, wetland restoration for flood water storage, or similar type benefits to public good.

Strategy - New Public Facilities & Capital Improvements

HIGH PRIORITY—LOW EFFORT

Purpose: Develop policies that require the design and location of future capital improvements and critical infrastructure to account for projected sea level rise and lifespan of structure, as well as promoting energy efficiency and reduced carbon footprint.

Actions

- Coordinate with EMD on design and location of future critical infrastructure.
- Work with S.C. Sea Grant Consortium, MCRD Parris Island, MCAS Beaufort, BJWSA, and others to convene a Public Service Working Group exploring sea level rise and climate effects on drinking water supply/distribution and sewer service.
- Coordinate with Beaufort-Jasper Water and Sewer Authority and public service districts on Hilton Head.

5.3 Resilience Strategies: Action

Definition: Beaufort County and related jurisdictions are adopting and implementing the policies and strategies identified in the Study stage.

Measures of Success: Various policies and protocols that improve Beaufort County's long-term resilience are implemented. Buildings are higher and safer. Infrastructure is being made more resilient. Resilience is being put into action.

2040 Comprehensive Plan Connections: NE 4.1, NE 4.2, CF 3.1

Strategy - Build More Resiliently

HIGH PRIORITY—HIGH EFFORT

Purpose: Retrofit existing and place future utilities and critical infrastructure out of harm's way.

Actions

- Adopt a policy to discourage the use of engineered on-site septic systems in low-lying areas and in hydric soils by limiting density of residential development that is not on public sewer.

- Partner with DOT to retrofit the priority low-lying roads and causeways for protection and/or elevation as necessary. Whenever possible, replace low-lying causeways with bridges.
- Design and construct future capital improvements and critical infrastructure to account for projected sea level rise and lifespan of structure, as well as promoting energy efficiency and reduced carbon footprint.
- Retrofit most vulnerable existing critical infrastructure facilities.
- Periodically evaluate policies related to Base Flood Elevation (BFE) based on emerging scientific evidence and changing conditions in the future.

Strategy – Coastal Resilience Overlay

HIGH PRIORITY—MEDIUM EFFORT

Purpose: Adopt a coastal resilience overlay district that corresponds with areas in the 100-year and/or 500-year flood plain. Initial purpose of the district is to require informational disclosure to property buyers.

Actions

- Determine the appropriate criteria for the district. Initial focus should be on full real estate disclosure when property is transferred in low-lying areas. Disclosure should discuss the history of flood impacts and potential for future impacts.
- Remap the district after additional sea level monitoring work and water plan development occurs to recognize the combined impacts of sea level rise, king tides, and increased rainfall. The district should incorporate modifications to existing development standards.
- Develop a set of policies to require new infrastructure to be located outside of the Coastal Resilience Overlay district, unless deemed necessary.

Strategy – Protect Low-Lying Properties

HIGH PRIORITY—MEDIUM EFFORT

Purpose: Continue to promote smart growth principles of favoring infill and redevelopment over sprawl while recognizing that low-lying properties should not be targeted for intense development regardless of their location.

Actions

- Identify low-lying properties that serve important drainage and stormwater function based on elevation and soils.
- Utilize the Rural and Critical Lands Preservation or the Green Space programs to identify and preserve land best suited for future marsh migration. Leverage non-county funding through programs like the Lowcountry Sentinel Landscape and REPI.
- Develop a plan for targeting the most critical and vulnerable infill properties that serve important drainage and stormwater functions for acquisition or transfer of development rights.
- Develop policies that factor a property's suitability for development into future decisions on zoning amendments. Suitability for development should include factors such as elevation, soils, and vulnerability to sea level rise.
- Explore developing a County-run repetitive loss/severe repetitive loss buyout program. Consider revising definitions under the Rural and Critical Lands Preservation or the Green Space programs to target severe repetitive loss properties, low-lying and poorly drained lots, and lands suitable for future marsh migration.

5.4 Resilience Strategies: Reassess

Definition: Checking in to see if the policies and strategies are working as intended. Continuously examining scientific data that informs ongoing work under the Awareness, Study, and Action stages.

Measures of Success: Continuous examination of what we have implemented to ensure we are achieving the intended outcomes. Ongoing revision of plans, policies, and actions to incorporate the most recent scientific data necessary to inform effective resilience actions.

Strategy - Assess Current Codes and Programs

HIGH PRIORITY—HIGH EFFORT

Purpose: Examine and analyze existing codes and programs that have been implemented to meet the goals of identified sea level rise planning.

Actions

- Monitor and update policies and practices based on ongoing collection or study of tide levels, ground water volume and salinity, and rainfall.
- Reassess criteria for when the County intervenes, either through policy or funding regarding flooding and sea level rise impacts to public, quasi-public, and private

infrastructure and individual properties to ensure equitable and proportional responses.

- Monitor the application of the Southern Lowcountry Stormwater Ordinance and Design Manual and make necessary adjustments to the manual as revealed by new development and available science.
- Update the Coastal Resilience Overlay and policies that address how vulnerable critical infrastructure facilities are retrofitted and that require the design and location of future capital improvements and critical infrastructure to account for projected sea level rise and lifespan of the structure.
- Reassess criteria for retrofitting the most vulnerable existing critical infrastructure and for developing policies that impact the design and location of future capital improvements and critical infrastructure to account for updated projections of sea level rise and the lifespan of the structure, as well as promoting energy efficiency and reduced carbon footprint.

Section 6. Snapshot of Current Activities

Beaufort County is already working to address the flooding impacts caused by sea level rise, weather events, and compounded by development. The County has long held buffer requirements to keep buildings out of the path of coastal flooding and allow for marsh migration. In 2020, the County adopted an ordinance to regulate where and how much fill-dirt can be used to elevate low-lying areas on Lady's Island, which the County intends to expand. In 2019, the County adopted an ordinance to limit density in areas where sewer is not available. In 2021 and 2022, the County installed tide gauges in partnership with the Port Royal Sound Foundation and the Fripp Island Nature Center to begin collecting more localized and accurate tide data for the County. In 2021, the County updated its comprehensive plan, intentionally interweaving resilience throughout its ten elements to inform practices and policies across all aspects of life in the County.

The County also is a partner in a NOAA-funded project that will study groundwater impacts to underground infrastructure in four target areas. Researchers with the University of South Carolina, College of Charleston, S.C. Dept of Natural Resources, and the S.C. Sea Grant Consortium will use groundwater level data to work with the County and residents to identify specific challenges and help create detailed resilience planning in these areas. The target areas include St. Helena Island, Shellpoint, Mossy Oaks, and Alljoy.

Finally, in 2023, an interdepartmental group comprised of County staff motivated to improve community resilience coalesced. This group has been working to identify ways the County can internally improve resilience. Specifically, this group's goals are to preserve and protect County assets through two primary pathways: making resilience improvements to existing

infrastructure now, and incorporating resilience considerations at the outset of planning for future projects. Their priorities support, validate, and expand recommended strategies identified in this document. See **“Appendix D: Resilience Strategies Identified by Beaufort County Departments” on page 43** to learn more about this staff-led initiative and the specific strategies that have been identified by and for each department involved.

Section 7. Conclusion

Like many coastal areas in South Carolina, Beaufort County will experience impacts from sea level rise and extreme weather events. Fortunately, the County’s Sea Level Rise Task Force has worked to understand the projected future impacts in order to provide proactive strategies to bolster resilience. This report details actions we can take over the next decade to mitigate the most impactful consequences of sea level rise and better ensure the success of operations and livability here in Beaufort County over the next several decades.

Section 8. Glossary

ACE Basin: A vast estuary and tidal marsh in Colleton, Beaufort, and Charleston counties where the Ashepoo, Combahee, and Edisto rivers converge into the St. Helena Sound. It is one of the largest undeveloped estuaries on the east coast.

Annual Return Interval (ARI):

- 50-year storm: An event that has a 2 percent chance of occurring in any given year.
- 100-year storm: An event that has a 1 percent chance of occurring in any given year.
- 200-year storm: An event that has a 0.5 percent chance of occurring in any given year.
- 500-year storm: An event that has a 0.2 percent chance of occurring in any given year.
- 1,000-year storm: An event that has a 0.1 percent chance of occurring in any given year.

Datum: A fixed point on a scale that determines a baseline for various types of measurements, such as the North American Vertical Datum or NOAA's Mean Sea Level datums. These points vary based on location.

Emissions Scenarios: Future sea level rise estimates based on varying carbon emission output scenarios that could reasonably occur within a given time frame as a result of human activities. The amount of carbon emissions released into the atmosphere has an impact on the amount of sea level rise anticipated. The more carbon emitted, the higher the levels of sea level rise.

Groundwater: Water found below the surface of the earth, taking up space between soil particles and rocks. Groundwater is found in multiple layers, sometimes referred to as the water table or an aquifer.

King Tide: An especially high tide that typically corresponds with the alignments of the Earth, sun, and moon. These typically occur a few times a year, most notably in the spring and fall. The heights of these types of tides has increased due to sea level rise.

Mean Higher High Water (MHHW): A datum that marks the annual average of the daily highest high tide. Of the daily two high tides we experience, one is always higher than the other.

Mean Lower Low Water (MLLW): A datum that marks the annual average of the daily lowest low tide. Of the daily two low tides we experience, one is always lower than the other.

Mean Sea Level (MSL): A datum that marks the average sea level, with extreme variations and storm surges averaged out of the calculation.

Rain Bomb: Term used to describe a sudden, large amount of rainfall recorded in an area over a short period of time, often resulting in flash flooding. These can be difficult for weather

forecasters to predict because they often happen over small areas.

Resilience: The ability of communities, economies, and ecosystems to successfully overcome and adapt to environmental changes and natural hazards.

Saltwater Intrusion: The movement of salt water into fresh water aquifers, which can lead to contamination of drinking or agricultural wells.

Sea Level Rise: An increase in the volume of the ocean due to a variety of factors, such as thermal expansion (warmer water takes up more space), melting glaciers in Antarctica and Greenland, and slowing down of large ocean currents. This results in more frequent tidal flooding.

Spring Tide: Slightly higher than average high tides that correspond with the new and full moon phases. These tides happen at least twice a month.

Storm Surge: A temporary rise in the surface level of the sea associated with storms, caused by wind and changes in atmospheric pressure; can cause extreme flooding and damage.

Tidal Epoch: A 19-year cycle that NOAA uses to calculate datums such as Mean Sea Level and Mean Higher High Water. The 2000 tidal epoch is based on records from 1983 to 2001. Tidal epochs are reconsidered for revision every 20-25 years.

Tidal Flooding: A temporary inundation of water caused by higher-than-usual tides. This type of flooding is becoming more frequent as sea level rise creates higher high tides. Also known as "sunny day flooding" because tidal flooding is not associated with or caused by rain. However, tidal flooding can be compounded by rain.

"Total Water Level" Approach: A way of visualizing future water levels by combining tidal variation and wave movements with sea level rise projections. Sea level rise projections are represented in mean heights above mean higher high tide and do not fully symbolize how tide levels will appear in real life.

Tropical Cyclone: Fast moving storm system that forms over oceans, fueled by warm, moist air and typically characterized by a low-pressure center, strong winds, and heavy rain.

Vertical Land Movement (VLM): A generic term for all processes that impact land elevation fluctuations at given locations (i.e. tectonic movements, subsidence, ground water extraction).

Vibrio: *Vibrio* refers to a strain of bacteria that thrives in warm salt and brackish water environments. It can cause human illness called vibriosis that can be contracted by eating raw or improperly cooked shellfish or through salt or brackish water exposure to open wounds.

Appendix A: A Detailed Look at Tidal Flooding Records at the Ft. Pulaski Gauge

Tidal records at the Ft. Pulaski gauge are kept by NOAA's National Ocean Service. The National Weather Service office in Charleston has developed a database of flooding records at the gauge and has posted it on its website. The database solely counts events, or each time a tide reaches the designated minor, moderate, or major flood thresholds. Records go back to 1935 for the Ft. Pulaski gauge. In **Table 3**, records since 2000 are listed by threshold level.

Table 3: Annual Flood Events Since 2000 at the Ft. Pulaski Gauge

Threshold	Minor (9.5-9.99 ft)	Moderate (10.0-10.49 ft)	Major (10.5+ ft)	Total Flood Events by Year
2000	0	0	0	0
2001	2	1	0	3
2002	3	0	0	3
2003	1	0	0	1
2004	0	0	0	0
2005	1	0	0	1
2006	0	0	0	0
2007	4	0	0	4
2008	1	0	0	1
2009	2	2	0	4
2010	1	0	0	1
2011	0	0	0	0
2012	9	0	0	9
2013	1	0	0	1
2014	1	0	0	1
2015	14	1	0	15
2016	11	1	1	13
2017	4	0	1	5
2018	3	2	0	5
2019	12	3	0	15
2020	13	2	0	15
2021	4	3	0	7
2022	10	2	0	12
2023	18	3	0	21

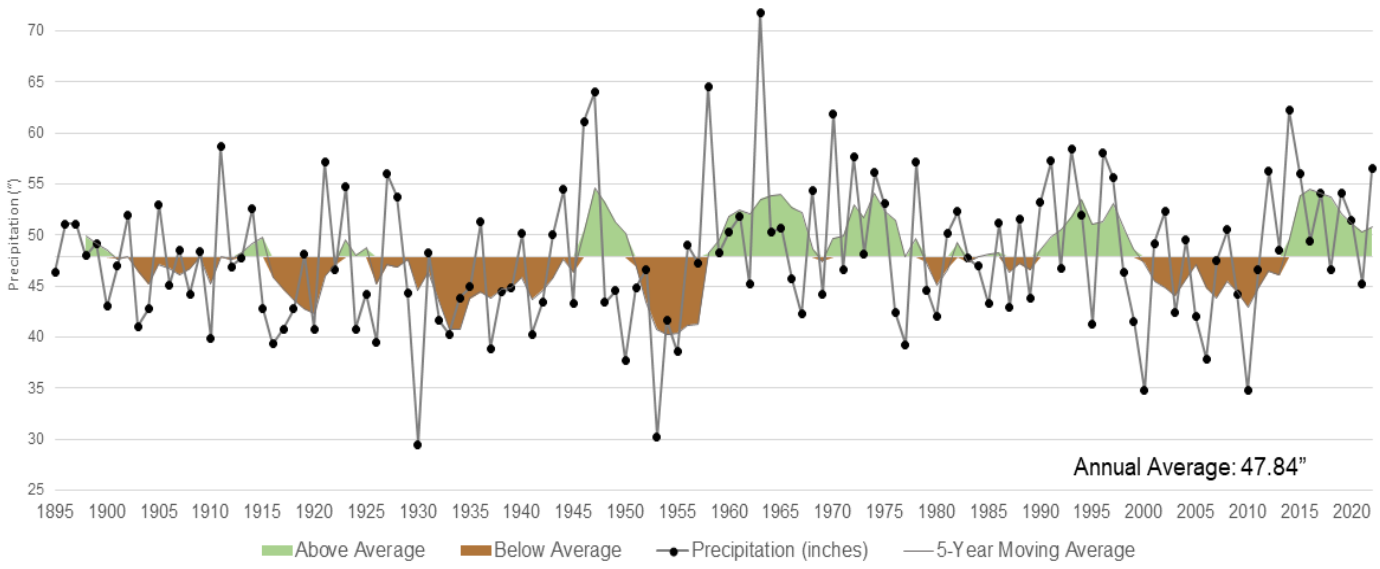
Source: National Ocean Service, National Weather Service

Appendix B: Annual Precipitation Records from the S.C. Office of the State Climatologist

Assessing precipitation changes over the long term can be challenging due to a lack of long-term recording stations and the highly localized nature of rainfall. For the purposes of this report, we're using two separate recording methods to highlight how rainfall patterns may or may not have changed. Examining a larger area has more statistical significance than a single location. The National Climatic Data Center and the S.C. Office of the State Climatologist use climate regions to better examine averages over the long term. The Southern Climate Division in South Carolina comprises of Allendale, Bamberg, Barnwell, Beaufort, Berkeley, Charleston, Colleton, Dorchester, Jasper, and Hampton counties.

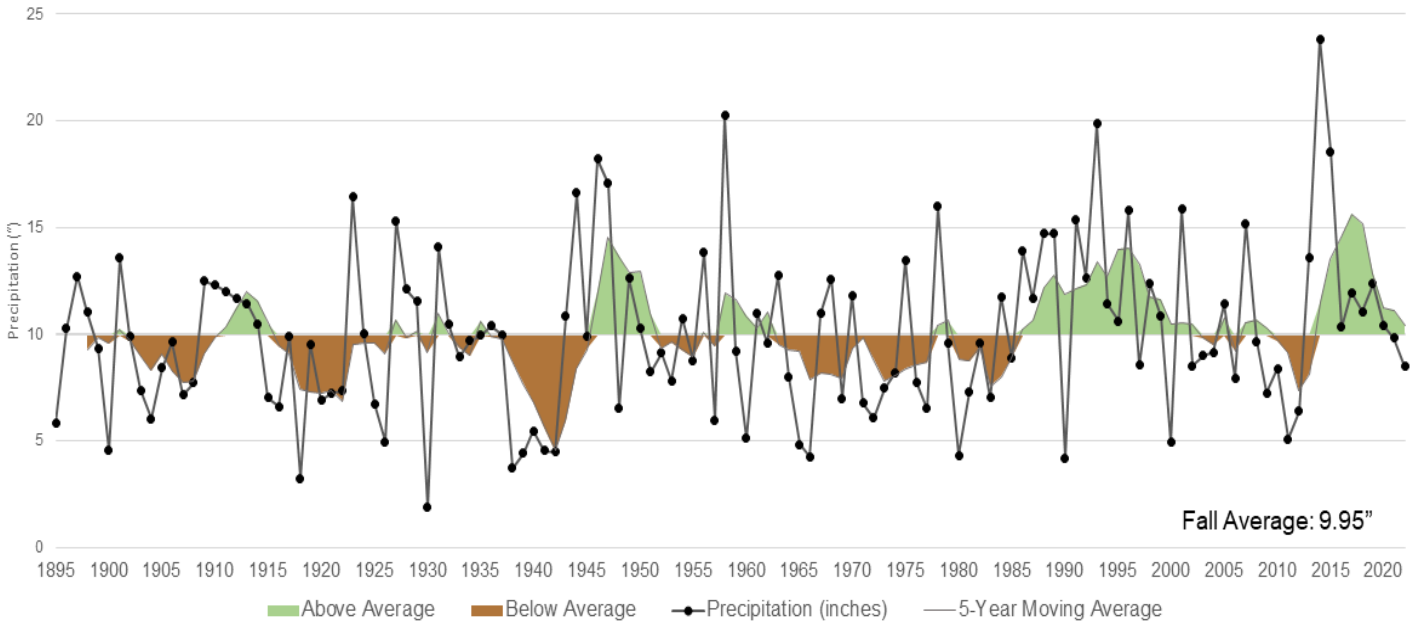
As illustrated in **Figure 7**, there is no defined trend in changes in annual precipitation. There is a slight trend showing an increase in average precipitation in meteorological fall, which is September, October, and November, illustrated in **Figure 8**.

Figure 7: Southern Climate Division Annual Average Precipitation (1895-2023)



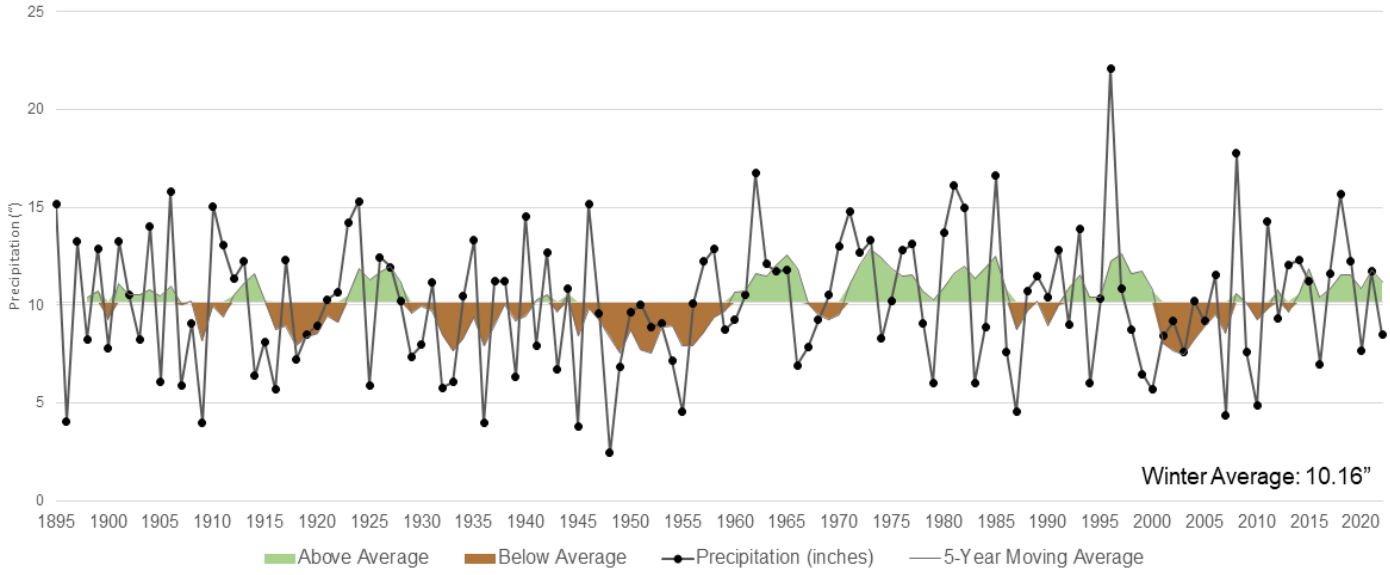
Source: Office of the State Climatologist/DNR

Figure 8: Southern Climate Division Fall Average Precipitation (1895-2023)



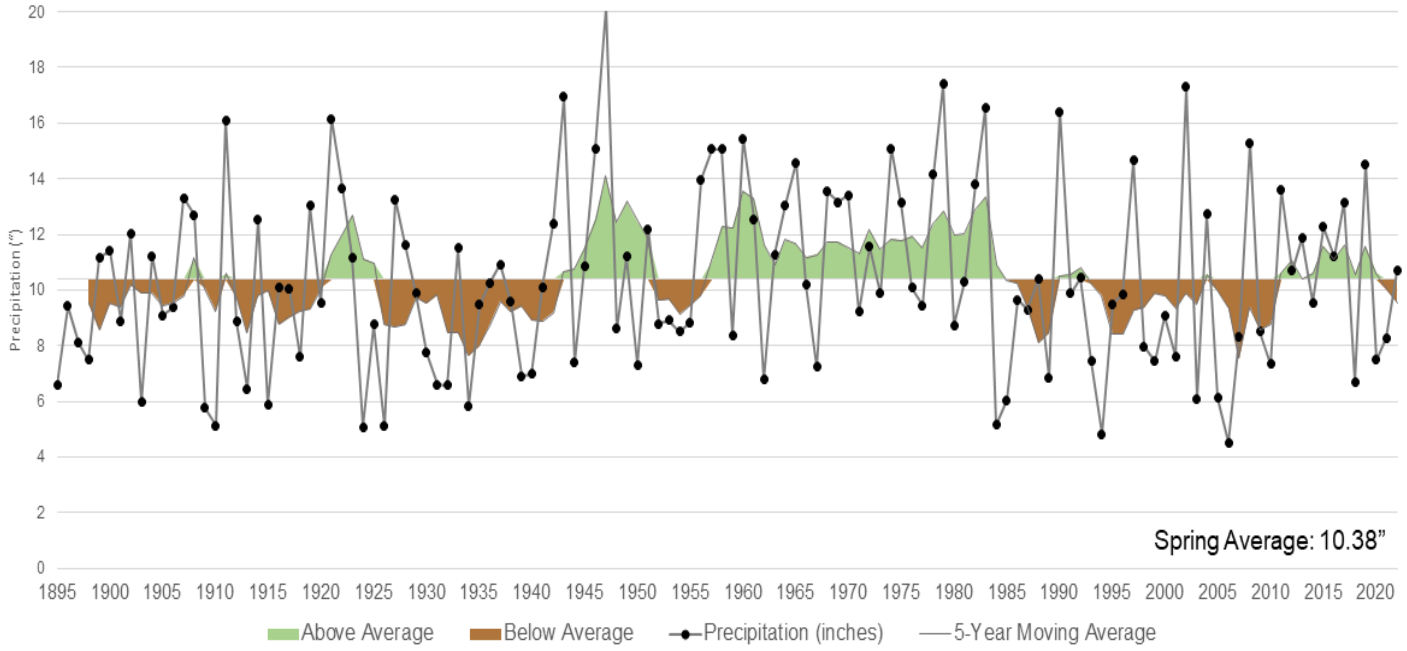
Source: Office of the State Climatologist/DNR

Figure 9: Southern Climate Division Winter Average Precipitation (1895-2023)



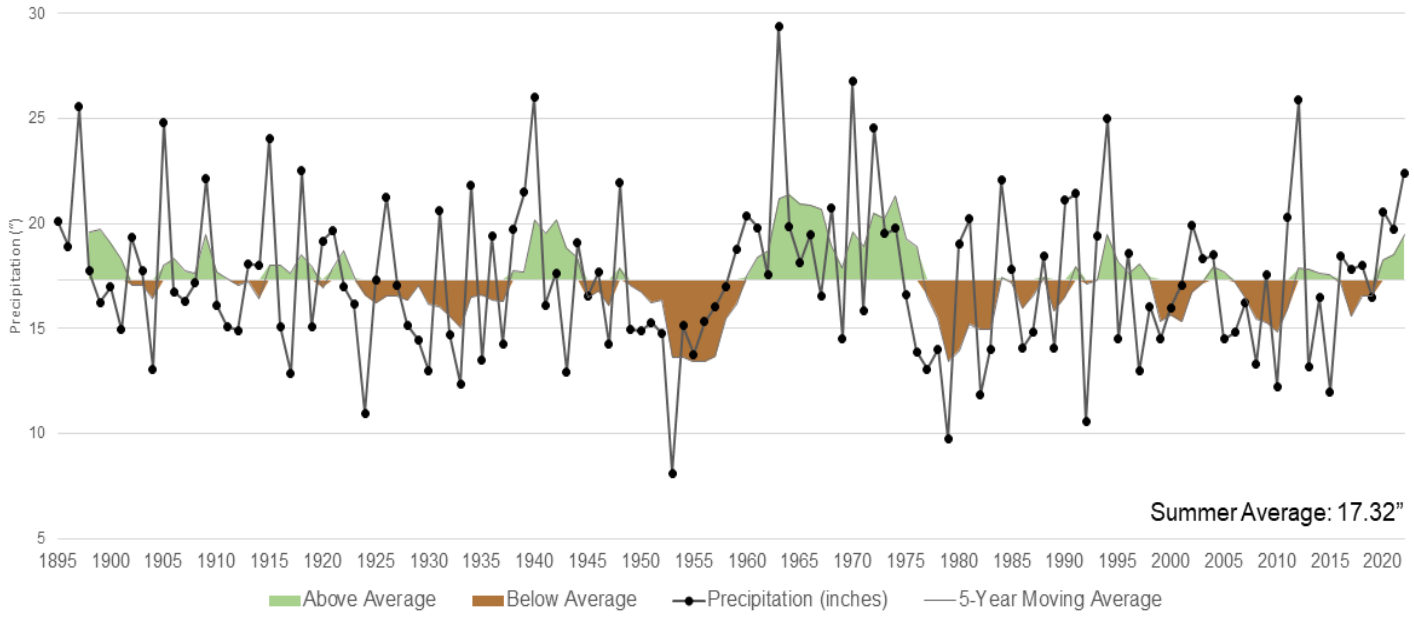
Source: Office of the State Climatologist/DNR

Figure 10: Southern Climate Division Spring Average Precipitation (1895-2023)



Source: Office of the State Climatologist/DNR

Figure 11: Southern Climate Division Summer Average Precipitation (1895-2023)

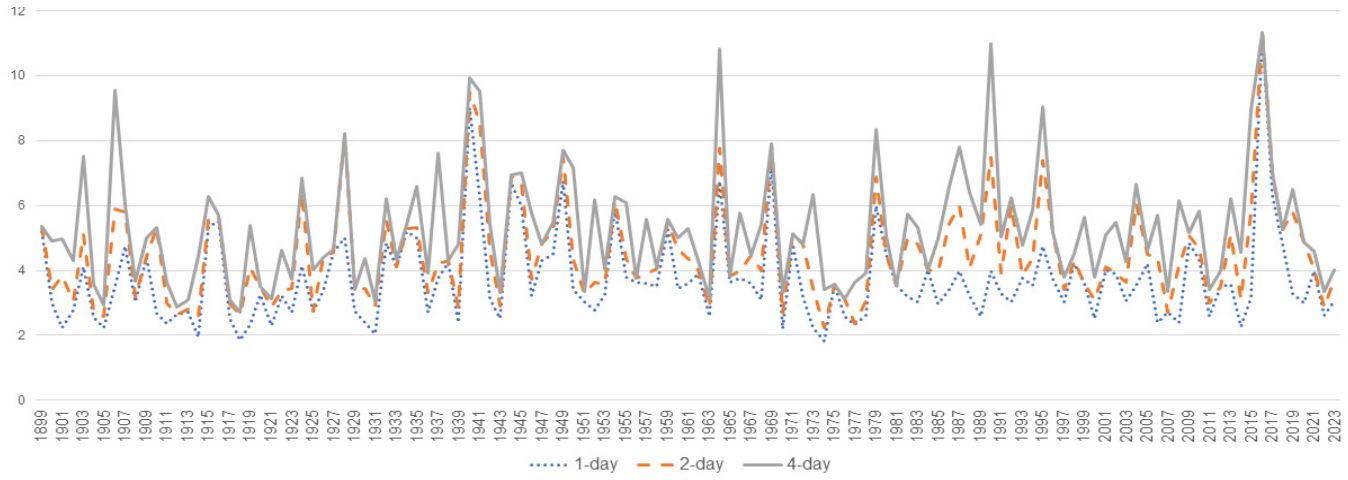


Source: Office of the State Climatologist/DNR

By zooming in to the long-term recording site at Yemassee, we can examine changes to daily maximum rainfall totals as a measure of how extreme precipitation may or may not be

changing. There is no real trend in the 1-day or 2-day maximum rainfall totals. Yet, there is a slight upward trend in 4-day maximum rainfall totals, as seen in **Figure 12**, which shows rain fall totals per year for 1-day, 2-day, and 4-day periods from 1899 to 2023.

Figure 12: Yemassee 1-day, 2-day, and 4-day Maximum Rainfall Totals



Source: Office of the State Climatologist/DNR

Appendix C: Sea Level Rise projections for South Carolina

Future rates of sea level rise vary depending on location for a number of reasons. The Sea Level Rise and Coastal Flood Hazard Scenarios and Tools Interagency Task Force, comprised of National Aeronautics and Space Administration (NASA), NOAA, Environmental Protection Agency, U.S. Geological Survey, and U.S. Army Corps of Engineers, downscaled the global sea level rise projections developed for the Fifth National Climate Assessment for the NOAA CO-OPS tidal gauges around the country. These calculations were incorporated into the Interagency Sea Level Rise Scenario Tool. The data for the Ft. Pulaski gauge is in Table 4 and is based on the sea level in 2000. Links to both the Scenario Tool and the NOAA 2022 report that forms the scientific basis for these projection curves are at the bottom of the table.

Table 4: NOAA 2022 Sea Level Rise Projections for Ft. Pulaski Gauge (in meters)

Year	Low	Int-Low	Intermediate	Int-High	High
2030	0.18	0.20	0.21	0.22	0.22
2040	0.25	0.28	0.30	0.33	0.35
2050	0.31	0.36	0.40	0.46	0.51
2060	0.37	0.43	0.51	0.63	0.75
2070	0.42	0.51	0.63	0.84	1.03
2080	0.45	0.58	0.79	1.07	1.38
2090	0.49	0.66	0.97	1.35	1.75
2100	0.54	0.73	1.19	1.64	2.14
2150	0.76	1.15	2.17	2.74	3.79

Source: Interagency Sea Level Rise Scenario Tool; NOAA, et al 2022

Appendix D: Resilience Strategies Identified by Beaufort County Departments

The interdepartmental group of staff members working to achieve a more resilient future for Beaufort County is comprised of representatives from the Planning & Zoning Department, Engineering Department, Capital Improvements and Facilities Management Departments, and the Public Works Department. This group has been working to identify ways Beaufort County can protect and preserve its assets as a starting point to addressing resilience within the County. Below are department-specific contributions to the Long-Term Resilience Strategy that were developed by the group. While each department identified slightly different strategies, a common theme across all departments is to improve the resilience of County-owned infrastructure and facilities.

Introduction

Beaufort County owns and maintains diverse public infrastructure, including public boat landings, fishing piers, roads, libraries, stormwater systems, bridges, causeways, government buildings, swimming pools, airports, recreation centers, parks, multi-use pathways and sidewalks, public safety facilities, solid waste facilities, and more. Managing these facilities is extremely complex and doesn't end once a facility has been designed and constructed. Post-construction, County staff continually maintain, assess, and upgrade facilities as needed. While local building codes, which reflect International Building Code requirements, require that some current environmental conditions be considered from the outset of design in order to increase the longevity of the facility, changing environmental conditions are exerting additional pressures that haven't been planned for. These changing conditions reduce the lifespan of facilities and

increase the cost of routine maintenance, renovations, and upgrades when systems fail. Such realities are motivating County staff to proactively address resilience to account for future conditions as a part of both planning new and renovating existing County-owned infrastructure.

To begin to address these needs, staff have compiled specific strategies their departments can accomplish, like vulnerability assessments and creating policies to consider resilience during the planning phase of projects. While these strategies may initially increase the financial burden of supporting infrastructure, it will reduce costs over the life of the facilities.

Facilities Management and Capital Projects

Several environmental factors are putting pressure on County-owned buildings. Rising tides, higher intensity rainfall events, higher intensity winds, and increased risk of tropical cyclones all take a toll on existing County-owned buildings. These factors also impact how we site and build future County-owned buildings for public or emergency use, ranging from libraries to fire stations. Such realities will limit where we build and may require the County to reject more cost-effective parcels of land that are threatened by environmental changes in favor of a better suited site, like those that are free of localized flooding and maintain accessibility during a storm event, now and in the future.

Higher intensity rainfall events have additional impacts on County-owned buildings, other than flood risks. These events result in larger amounts of water over shorter durations and stronger winds than the weather patterns we are used to seeing. Many of our County-owned buildings have near-flat roofs with drains and internal piped gutter systems that can be quickly overwhelmed by intense rain events. They require routine maintenance to remain free flowing and clear of debris, and higher intensity events will increase the frequency of these maintenance activities. Where more intense rainfall will more frequently impact the function of roofing and draining systems, wind-driven rain will threaten the entire building. The entire building envelope, including the roof, windows, soffits, and foundations, can be subjected to water infiltration when wind pushes rain into places typically protected from water.

The potential of damage from all of these environmental factors, wind, rain, and flooding, become heightened during a tropical event, like hurricanes. It's because of this reality that local building codes require higher design standards for both wind and flood protection than found in other parts of the country. Maintaining and adhering to higher design standards minimizes the risk of damage during an event, and further bolstering those standards to consider future conditions through our own policies lengthens the life of our county-owned buildings. However, meeting the current local codes, and raising our standards beyond them, carries a higher construction and operational cost.

Resilience Strategies: Awareness

Strategy - Expand Community-Level Science Outreach and Education

Purpose: Clearly communicating with the public and leadership at Beaufort County about the pressures facilities currently face, the anticipated effects of future conditions, and the costs of building to a higher standard with the goal of forming a foundation of support needed to fund and improve the resilience of our building infrastructure.

Actions

- Work with the Public Facilities Committee to bring them important information about the condition of our buildings and the need to assess their vulnerability to future conditions.

In 2021, the County completed a Facility Master Plan. This plan focused on the growth of staff and the need for expanded facilities and additional employee campuses to accommodate a growing team. A similar assessment needs to be completed for county facilities to assess their current condition and their vulnerability to future environmental forecasts in order to improve facility longevity and integrity, especially when faced with increasing pressures. To fully understand the scope of upgrades necessary to make our buildings more resilient, as well as the expected cost of doing so, we must conduct a Facility Condition and Vulnerability assessment.

Resilience Strategies: Study

Strategy - Identify Critical Infrastructure

Purpose: To utilize a Facility Condition and Vulnerability Assessment to determine how existing County-owned buildings can or cannot withstand projected weather conditions.

Actions

- Allocate funding with a request in the Capital Improvements Plan to hire professional consultants who will inventory each of our existing facilities, assessing their current condition and vulnerability to future weather and tidal conditions. This team would be expected to document the design and nature of each building system (e.g. roof, HVAC, foundation, generator, etc.) and determine each building's current age, condition, and rehabilitation needs for current and future environmental conditions. The result of this effort would be a prioritized list of rehabilitation needs and upgrades with cost estimates to be tackled over short- and long-term implementation plans.

Resilience Strategies: Action

Strategy - Build More Resiliently

Purpose: To develop and maintain resilient facilities and staff to support them.

Actions

- Implement the recommendations from the Facility Condition and Vulnerability Assessment.
- Develop a well-trained, resilience-aware workforce on resilient procedures and policies, providing resources and information, so staff can make decisions and take actions to effectively implement the Facility Condition and Vulnerability assessment recommendations.
- Closely coordinate with the Finance, Procurement, Building Codes, Public Works, Engineering, Planning & Zoning, and Human Resources departments to maintain a properly trained workforce, resilient facilities, and the facilities' associated operational needs.
- Implement improved building and design regulations to ensure we begin planning for resilience at the outset of the planning phase of new projects, thereby reducing the impact of costly upgrades and renovations in the future.

Planning for and incorporating resilience into our initiatives isn't a one-time process. It's cyclical and will need to be periodically revisited. We will need to regularly assess the actions we've taken to improve our County-owned facilities' resilience to ensure our upgrades are properly working, new technologies and data are incorporated, and additional changes are made as needed. We must constantly be intentional about incorporating resilience into our facilities.

Resilience Strategies: Reassess

Strategy - Assess Facilities and Programs

Purpose: To continually improve education campaigns, training programs, and our facilities by assessing what's in place and adapting it based on the most up-to-date science and knowledge.

Actions

- Periodically communicate with County elected leaders and staff about resilience initiatives and how they strengthen our planning, designing, construction, and operation of County-owned buildings.
- Regularly host staff training sessions incorporating the most recent data to inform and improve resilience initiatives.

- Conduct a Facilities Condition and Vulnerability Assessment every three to five years to stay current and ahead of the curve. Make sure to consider growth projections, as these will impact the need for new facilities in the County. Even if conditions or needs go unchanged, a reassessment will provide opportunities to update cost estimates and adjust priorities.

Engineering Department

In many ways, a jurisdiction's most expensive and important asset is its roadway system. Roadway systems enable the safe and efficient transport of goods and people. While allowing for commerce, they also provide safe evacuation routes during natural disasters. Beaufort County maintains more than 200 miles of paved roadways and over 70 miles of unimproved roadways. The County's municipalities, along with SCDOT, own and maintain the remainder of the public network, which is more than double the size of the County's. As the County feels the effects of climate change, including rising tides and more extreme rainfall events, its roadway system becomes more exposed to the risk of flooding. Given that our community is comprised of numerous sea islands and barrier islands served by causeways or bridges, and many of our other roads occur at low-lying elevations or are constructed on embankments that cross marshlands, the resilience of our roadway system impacts most of our community. If it's not already occurring, these roadways are at risk of over-topping or other failures in the future. For much of our community, these roadways provide the only viable evacuation route in the event of a hurricane or are the only connection to everyday needs, like grocery stores, medical facilities, and schools. They are literal lifelines in both good and bad times. It is necessary that we develop strategies to prevent the degradation of our roadways, our most valuable asset.

The entire state of South Carolina is feeling widespread impacts of climate change. In response to several years of destructive weather events related to changing environmental conditions, South Carolina created the South Carolina Office of Resilience (SCOR), who developed and published a Statewide Resilience and Risk Reduction Plan. While this plan identifies many strategies, it does not directly address infrastructure. We can look to other states and entities for examples of resilient road and transportation planning, though. The Virginia Department of Transportation has developed a Resilience Plan for their transportation network, going so far as creating an Office of Transportation Sustainability. The Delaware Department of Transportation has created a Division for Transportation Resilience and Sustainability. Other states along the Atlantic coast, including Florida and North Carolina, have also made investments in resilience, including creating dedicated departments and strategic plans. At the federal level, the U.S. Department of Transportation, Federal Highway Administration, U.S. Army Corps of Engineers, Department of Defense, and National Oceanic and Atmospheric Administration are all working toward improving infrastructure to be more resilient. Many guiding documents and programs

have been established through these agencies, accompanied by substantial increases in funding opportunities for resilience that our County can leverage for our own local projects.

Understanding the growing risks our infrastructure faces, the Beaufort County Engineering Department is developing a holistic approach to resilience that will address all of our engineering projects. Balancing the need to create and promote resilient infrastructure while being fiscally responsible and maintaining current levels of service will be challenging. The following emphasis areas will be incorporated into our resilience initiatives.

Resilience Strategies: Awareness

Strategy - Expand Community-Level Science Outreach and Education

Purpose: To ensure stakeholders, like elected officials, municipal groups, local non-profit organizations, and more, are aware of the need to incorporate resilience in transportation and roadway projects.

Actions:

- Work with stakeholders and advocacy groups to develop a coalition dedicated to sustainability and resilience in the local infrastructure network**.**

Beaufort County has an opportunity to become a leader in regional resilience. Due to our unique geography, location, and assortment of stakeholders, we can become an example of productive regional cooperation. Much of this work has already begun and is ongoing. Between the various conservation groups, municipal planning organizations, cultural organizations, the Department of Defense, and other stakeholders, there are many existing research and planning documents that can be built upon.

Resilience Strategies: Study

Strategy - Identify Critical Roads

Purpose: To determine our roadway network's ability to withstand future environmental conditions and identify new, resilient techniques for incorporation into projects.

Actions:

- Within one year, conduct a Vulnerability Assessment of at-risk infrastructure and develop an implementation plan based on the assessment.

  As required in the Comprehensive Plan and reiterated in the Long-Term Resilience Strategy, conducting a vulnerability assessment is one of the first steps toward improving the resilience of our County-owned infrastructure. This assessment should make sure to review, at a minimum, causeways, low-lying roadways, and culvert pipes. As part of the assessment, a

rating system shall be developed for project prioritization. The final deliverable will be a five-year implementation plan documenting recommended repair and estimated project costs.

Strategy - Identify Resilient Techniques

Purpose: Assess new techniques that can be incorporated into existing and future roadway projects to improve resilience.

Actions:

- Identify opportunities to utilize green infrastructure.

  Green infrastructure uses more natural processes to achieve the same effect as "gray" infrastructure, which can negatively impact adjacent properties. Additionally, much more funding is available for projects incorporating green infrastructure, signaling a general interest in shifting toward these development techniques. Even without funding, the use of green infrastructure in lieu of gray infrastructure can reduce initial project costs. Examples include using living shorelines to protect vulnerable causeways instead of or in combination with gray infrastructure, like rip-rap. Green infrastructure projects also create opportunities for teaming up with other stakeholders through funding opportunities like the Department of Defense's REPI Challenge program.

Resilience Strategies: Action

Strategy - Build More Resiliently

Purpose: Retrofit existing and place future utilities and critical infrastructure out of harm's way.

Actions:

- Review future projects with resilience and sustainability in mind to incorporate these aspects early in the planning and design process.

  By conducting resilience reviews during the planning and design process, we can identify areas to make projects more resilient, as well as sustainable. Identifying these opportunities for improvement early on and pairing them with a cost-benefit analysis will reveal the best long-term options for improving infrastructure. Many of our infrastructure projects possess a multitude of possibilities to incorporate resilience. Examples include: streetscaping projects with vegetated medians to provide opportunities to capture and treat stormwater, reducing localized flooding on roads and treating water before it impacts nearby salt marshes. Using vegetated slopes along causeways can slow the rate of erosion. Pervious pavement or geocell applications may lessen the impact of dirt road projects on the surrounding natural areas

and reduce the need for costly stormwater BMP installation.

- By the next funding window, establish a process to identify and pursue grant opportunities for funding resilience projects.

  The recently passed Bipartisan Infrastructure Law (BIL) has opened multiple avenues of funding, making available billions of dollars for resilience initiatives. It has also created new programs that facilitate resilience projects. Many of these opportunities can be found through grant programs like FEMA BRIC, PROTECT, and NOAA Climate Resilience Regional Challenge Grants, among others.

- Within one year, establish a minimum roadway elevation.

  Work with stakeholders to review tidal data and determine a minimum roadway elevation that takes into account current tide levels and anticipated sea level rise impacts. Develop an ordinance to adopt the new minimum as a part of County standards. Adapt existing at-risk County roads to the new standard.

- Become an Envision Certified entity within one year and have all projects evaluated for certification within two years.

  ASCE, APWA, and ACEC created the Institute for Sustainable Infrastructure (ISI) in collaboration with Harvard University. The ISI established the envision program, which is a framework and rating system that reviews civil infrastructure projects and provides multiple levels of verification relating to both the resilience and sustainability of a project. Agencies and private entities can become Envision Certified, opening the door to additional benefits and project ratings.

Resilience Strategies: Reassess

Strategy - Continually Assess Techniques and Programs

Purpose: To ensure the most up-to-date science and building techniques are understood and used.

Actions:

- Work with researchers and vendors to test new products or techniques. Incorporate successful products or techniques into ongoing programs for future projects.

  Beaufort County has already begun to build these relationships. The Engineering team has joined the CORE SC Infrastructure working group and has worked to build partnerships with organizations like The Ray. Through these partnerships, we can be a local driving force in

resilience and technological advancement in infrastructure. Additional opportunities may be present to work with organizations like NOAA, SC Sea Grant Consortium, and local higher education institutes to identify research opportunities to evaluate new technologies. Not far from Beaufort, Charleston County has led the way in this area and created a exemplary model for us to adapt to our own local needs.

Public Works Department

The Public Works Department is currently engaged in routine monitoring of County assets, including road infrastructure, bridges, boat landings, fishing piers, and drainage systems to determine the impacts of sea level rise. Each of these facilities is subject to tidal fluctuations that we experience today. Of particular concern are the impacts of King Tides, which currently bring water levels to above-average heights several times a year. As tides rise in Beaufort County, we will see normal daily tides that look like today's King Tides, and our infrastructure will become regularly exposed to the impacts of consistently higher water levels. The Public Works Department recognizes that proactively planning and budgeting for infrastructure improvement projects that take into consideration forecasted environmental trends will decrease the financial strain of acting after anticipated impacts begin degrading the integrity of our infrastructure. By taking action today, we can lessen the burden of a once-enormous financial outlay for capital projects in the future.

With this in mind, the Public Works Department has identified the following strategies as those most imperative to improving future resilience:

Resilience Strategies: Awareness

Strategy - Expand Community-Level Science Outreach and Education

Purpose: Conduct education campaigns targeting elected officials and citizens.

Actions:

- Continue to educate elected officials and citizens on the importance of planning for resilience.

Resilience Strategies: Study

Strategy - Identify Critical Infrastructure

Purpose: Identify critical infrastructure and determine how they withstand future environmental trends.

Actions:

- Most importantly, conduct a Vulnerability Assessment that identifies County-owned infrastructure that's in need of improvement to prolong its functional life considering anticipated worsening environmental trends. Use the results of the assessment to prioritize infrastructure upgrades and adaptation projects, then implement the recommendations.

Resilience Strategies: Action

Strategy - Build More Resiliently

Purpose: Improve standards, policies, planning, and design procedures to improve how we build.

Actions:

- Review and improve County standards and policies to address resilience related initiatives. These standards may improve our current building codes, floodplain policies, stormwater management practices, and engineering standards.
- Review and improve County facilities to accommodate resilient design. This is not only important for the general maintenance and management of our current facilities, but also sets an example for our community and neighbors.

Resilience Strategies: Reassess

Strategy - Continually Assess Techniques and Programs

Purpose: Continually review the vulnerability status of facilities.

- Supplement the work being conducted by the Planning & Zoning department by implementing cyclical reviews of facilities and adapting for resilience.

To jump-start this process, the Department has already begun identifying infrastructure it suspects or knows to be at risk of current tidal conditions and, especially, future anticipated conditions. These facilities are Paukie Island Road, Old Jericho Road Bridge, Half Moon Island Road, Witsell Road, Butcher's Island Boat Landing, Marshland Boat Landing, and Sugar Hill Boat Landing.