
Assessment of Vulnerability to Sea Level Rise and Recommended Mitigation Strategies for Pasquotank County, NC

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EXECUTIVE SUMMARY

As a low-lying coastal county in northeastern North Carolina, Pasquotank County faces possible impacts of sea level rise over the next century and beyond. Sea level rise could potentially threaten the livelihood and homes of many Pasquotank County residents. Our team of five UNC undergraduates was asked by county officials to assess the county's vulnerability to sea level rise and to develop potential mitigation strategies.

Over the past century, North Carolina has seen sea levels rise about one foot. The rate of sea level rise in the past two decades is nearly double that of the past century, and this rate is only expected to increase. Based on projections from several authoritative sources, the county should expect one foot sea level rise by 2050, two feet by 2060 to 2080, and three to four feet by 2100. The southern part of the county has the lowest elevation and will be the first area to be permanently submerged due to sea level rise. By 2050, only small sections of the county will be submerged. However, as sea level rises more than one foot beyond 2050, much greater portions of the county will be inundated. Particular at-risk areas include Bray's Estates, Matthews Acres and Glen Cove. The county can expect to lose about \$51 million in property value by 2050 and at least \$270 million by 2100 due solely to rising water levels. Several miles of roads will be submerged and people will be displaced from their homes.

Additionally, the likelihood of flooding will increase significantly. A flood that has a one percent chance of occurring in any given year today could have anywhere from a five percent to a fifty percent chance of occurring in any given year by 2050. About half of the county's land area could be within the one-hundred year floodplain by 2050. This heightened risk of flooding will endanger property owners in designated flood zones and other flood prone areas throughout the county. Not only will the likelihood of flooding increase, the height of floodwaters is expected to rise, as well.

We developed an array of mitigation strategies ranging from policy options to communication efforts to physical projects. The goal of these strategies is to reduce the county's risks of increased flooding and other effects of sea level rise. Certain examples include limiting development in the most vulnerable areas, preserving natural buffers, building community awareness, and protecting critical infrastructure. Our key policy proposal is that the county participate in the Community Rating System (CRS). The CRS awards points to the county for implementing various flood awareness and prevention strategies. By participating in the CRS and achieving a minimum number of points, the county can save homeowners with flood insurance up to 10 percent on their insurance premiums, for significant countywide savings. Specifically, we believe the county can easily reach Class 9 standing, which will result in a five percent premium reduction amounting to a savings of \$36,000 per year. By implementing additional efforts over the course of a few years, the county can move up to a Class 8 designation, under which flood insurance policyholders will receive a ten percent premium reduction. This would amount to a savings of \$72,000 per year. More importantly, however, the measures implemented as a part of CRS will help mitigate against the threat of sea level rise. In other words, the CRS actually provides an incentive for the county to adopt measures to mitigate against the possible effects of sea level rise.

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LIST OF ACRONYMS

- AE: 100-year flood zone
- AEFW: Floodway
- BFE: Base Flood Elevation
- CRS: Community Rating System
- DEQ: North Carolina Department of Environmental Quality (formerly DENR)
- FEMA: Federal Emergency Management Agency
- HMP: Hazard Mitigation Plan
- IPCC: Intergovernmental Panel on Climate Change
- MHHW: Mean Higher High Water
- NFIP: National Flood Insurance Program
- NOAA: National Oceanic and Atmospheric Administration
- RSLR: Relative Sea Level Rise

SFHA: Special Flood Hazard Area

SLR: Sea Level Rise

USACE: United States Army Corps of Engineers

VCAPS: Vulnerability Consequences and Adaptation Planning Scenarios

LIST OF KEY TERMS

100-year flood zone

An area that has a 1-percent annual chance of being flooded

500-year flood zone

An area that has a 0.02 percent annual chance of being flooded

Community Rating System (CRS)

A voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements.

Floodway

The channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.

Floodplain

An area of low-lying ground adjacent to a river that is subject to flooding.

Geographic Information Systems (GIS)

A computer program that manipulates, analyzes, manages, and presents all types of spatial or geographical data. This program was used to create many of the maps found in this report.

Light Detection and Ranging (LIDAR)

A remote sensing technology that uses pulsed laser light to measure elevation heights and Earth surface characteristics

National Flood Insurance Program (NFIP)

A federal program aimed at reducing the impact of flooding on private and public structures by providing affordable insurance for property owners and by encouraging communities to adopt and enforce floodplain management regulations.

Setback

A legal requirement mandating that no development occur within a certain distance from a body of water.

Subsidence

The gradual caving in or sinking of an area of land

1. INTRODUCTION

In September 1999, Hurricane Floyd caused extensive flooding across much of eastern North Carolina, including Elizabeth City and Pasquotank County. The record high flood levels made it the most devastating flood event for eastern North Carolina communities in recent history (PCMJHMP 2010). If a storm with characteristics similar to Floyd occurred today, flooding would reach levels three inches higher than it did in 1999 as a result of sea level rise. In the sixteen year timespan since Hurricane Floyd, the relative sea level along the coast of northeastern North Carolina has risen three inches (NOAA 2014b). In flat, low elevation coastal areas, just a few additional inches of water could be the difference between properties remaining dry and being completely submerged (Overton et al. 2015). With sea level rise expected to continue into the foreseeable future, it is important to understand how it might affect North Carolina communities.

As a low-lying coastal county in northeastern North Carolina (see *Figure 1*), Pasquotank County faces possible impacts of sea level rise over the next century and beyond. Sea level rise could potentially threaten the livelihoods and homes of many, if not all, Pasquotank County residents. Our team was asked by county officials to assess the county's vulnerability to sea level rise and to develop potential mitigation strategies.

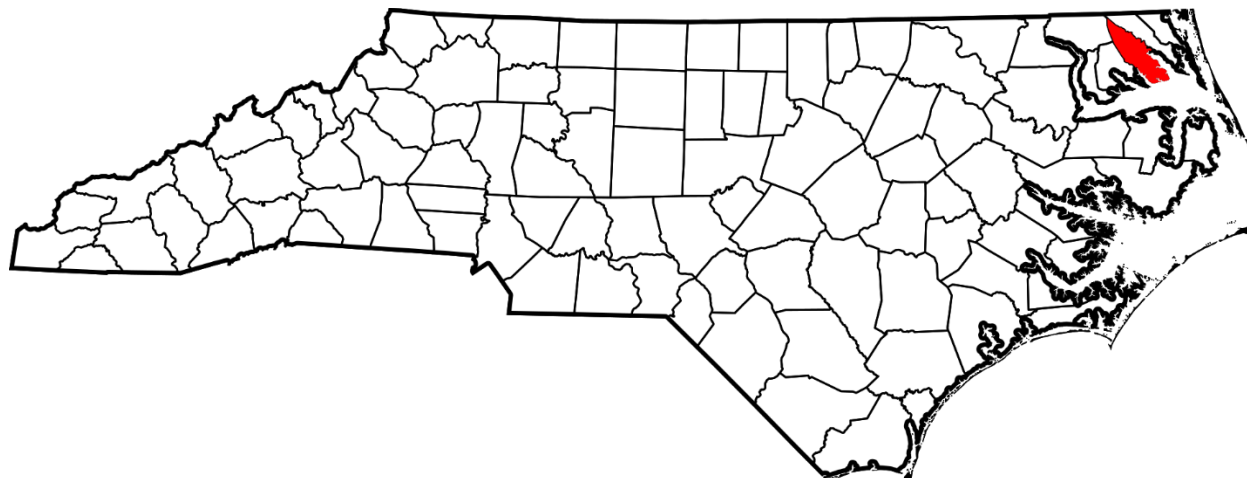


Figure 1. Map of North Carolina with Pasquotank County shaded red.

We used sea level rise projections from leading international organizations (see Appendix G) and geospatial data provided by Pasquotank County and Elizabeth City to conduct a vulnerability assessment for the county. We focused largely on the potential for rising water to permanently submerge land and for flooding to occur more frequently and with more intensity.

In developing our mitigation strategies, we talked with several hazard mitigation experts (see Appendix G) and examined the efforts of communities similar to Pasquotank in terms of geographic location and economic and social conditions. We considered the costs and benefits of possible policy recommendations in addition to their feasibility and generated the group of recommendations found in this report.

The results of our project will ideally better inform policy decisions and encourage elected officials to take present and future steps to mitigate against current and future risks of sea level rise. Enhancing the county’s resilience to future disasters is a high priority for local leaders and our project gives policymakers the information and the time they need to take actionable steps to prepare for sea level rise.

2. BACKGROUND OF PASQUOTANK COUNTY

As one of North Carolina’s first colonial settlements, Pasquotank County was founded in 1663 as a part of the greater Albemarle County in the northeast corner of the state. Its recognizable geographical shape along with those of its neighboring counties—Currituck, Camden, Perquimans and Chowan—has collectively earned the five counties the nickname, ‘the finger counties’ (see *Figure 2*). The counties owe their unique geography to the various rivers cutting across the region towards the Albemarle Sound. The importance of the region’s rivers to Pasquotank County dates back in time to the settling of the area and the naming of the county itself. The origin of the county’s name can be traced back to its first colonizers, the Algonquian Indians, and means ‘where the current of the stream divides’ (Shields 2000). Pasquotank County is bounded on the east by the Pasquotank River and on the west by the Little River. These rivers were of particular significance to its early settlers as a means of defining transportation. In fact, the county’s first settlement, Nixonton, was founded along the shores of Little River. As the county’s only official incorporated city in 1785, Nixonton served as the primary commercial center until the construction of the Dismal Swamp Canal in 1793. The canal connected the Elizabeth River in Norfolk, Virginia to Elizabeth City in Pasquotank County. This commercial water passageway transformed Elizabeth City into the county’s new economic hub, thus earning its appointment as Pasquotank’s county seat.



Figure 2. Old map of northeastern North Carolina's finger counties.

More than two centuries later, the waterways of Pasquotank County continue to maintain their role in shaping the county's geography, land use and development planning, and economy. Currently, the county has a population of slightly less than 40,000 people (USCB 2015) and a total land area of 289 square miles. This makes Pasquotank County the fifth-smallest county in North Carolina by land area. Of this area, nearly half of it is agricultural land and one third is either water or wetlands (PCMJHMP 2010). The county's economy relies on the service industry, government and public administration, retail trade, health care services, educational services, agriculture, and other industries (USBLS 2015).

Although the majority of the county's residents no longer rely on the rivers for transportation, their livelihoods are still intertwined with the waterways. The county has an average annual rainfall of 50 inches and the Pasquotank and Little Rivers are prone to frequent flooding that often impacts day-to-day life (PCMJHMP 2010). The county is susceptible to these frequent floods not only because of its geographical situation between two rivers, but also because of the county's low average elevation of only 12 feet above sea level (PCMJHMP 2010). Accelerating sea level rise may pose a significant threat to the county due to its coastal characteristics.

3. VULNERABILITY ASSESSMENT

Pasquotank County is currently vulnerable to flooding, severe thunderstorms, and tropical system events like tropical storms and hurricanes. As outlined in the county's 2010 Hazard Mitigation Plan, the county has experienced one or more natural hazards on annual basis. In addition, sea level rise poses another threat to the county.

Sea level rise is perhaps the most significant long-term threat to U.S. coastal communities over the next century. Not only will sea level rise inundate low-lying areas, it will lead to more frequent flooding, increase the chance of extreme floods (Strauss et al. 2014), and alter existing ecosystems (Maier 2013; Craft et al. 2009). In other words, while sea level rise is a coastal hazard by itself, the more important aspect of sea level rise is that over time it "exacerbates existing coastal hazards such as flooding from rain or tide, erosion, and storm surge" (Ruppert 2014).

3.1. Relative Sea Level Rise (RSLR) Projections

Global sea levels have been rising persistently for decades and are expected to continue rising well beyond the end of this century. Based on sea level gauge data from around the world, the rate of global mean sea level rise has continued to increase since the early 20th century. Between 1901 and 2010 the rate of sea level rise was 1.7 millimeters per year (mm/yr), but the rate for the two most recent decades is nearly double that at 3.2 mm/yr from 1993 to 2010 (Church et al. 2013, p. 1139), as is shown in *Figure 3*.

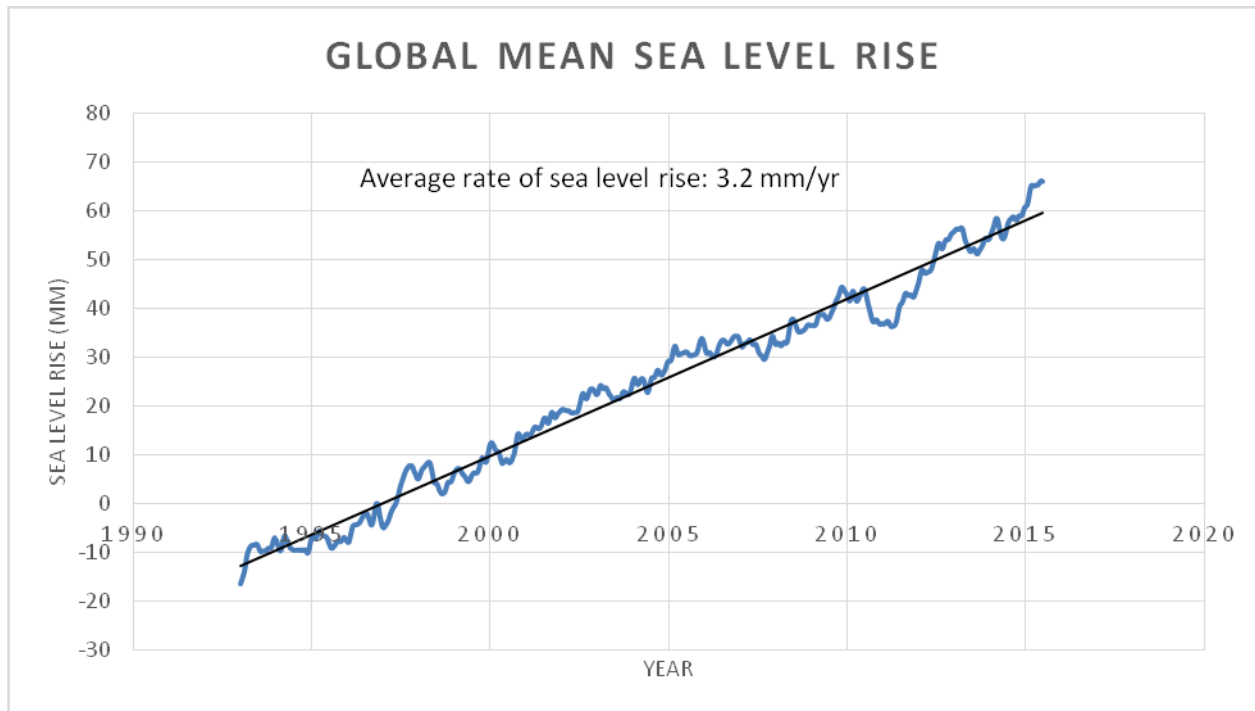


Figure 3. Global mean sea level rise since 1993. The average rate of sea level rise over this period, determined from the slope of the black regression line, was 3.2 millimeters per year (Beckley et al. 2010).

When studying sea level rise at the local scale, researchers focus on the relative rise of sea level, which is the height of the sea with respect to a specific point on land. This measurement is used because vertical land movement (subsidence or uplift) and ocean dynamics vary across regions (Parris et al. 2012). Northeastern North Carolina, including Pasquotank County, is located in a subsidence zone known as the Albemarle Embayment (see *Figure 4*) which is characterized by a high rate of relative subsidence of 1.00 ± 0.10 mm/yr (Engelhart et al. 2009, 2011; Kemp et al. 2009, 2011). Relative sea level rise in North Carolina is measured at five NOAA tidal gauge stations located in Duck, Oregon Inlet, Beaufort, Wilmington, and Southport. Based on this tidal gauge data, vertical land movement at the Duck Station is -1.49 ± 0.39 mm/yr, meaning that the land is subsiding about 1.5 millimeters every year. Along the North Carolina coast, relative sea level rise trends north of Cape Hatteras are higher than the global trend and substantially higher than trends from the stations south of Cape Hatteras (Overton et al. 2015). This disparity is due in large part to the subsidence of northeastern North Carolina. The Duck station demonstrates the highest rate of relative sea level rise at 4.62 mm/yr since 1978 (shown in *Figure 5*).

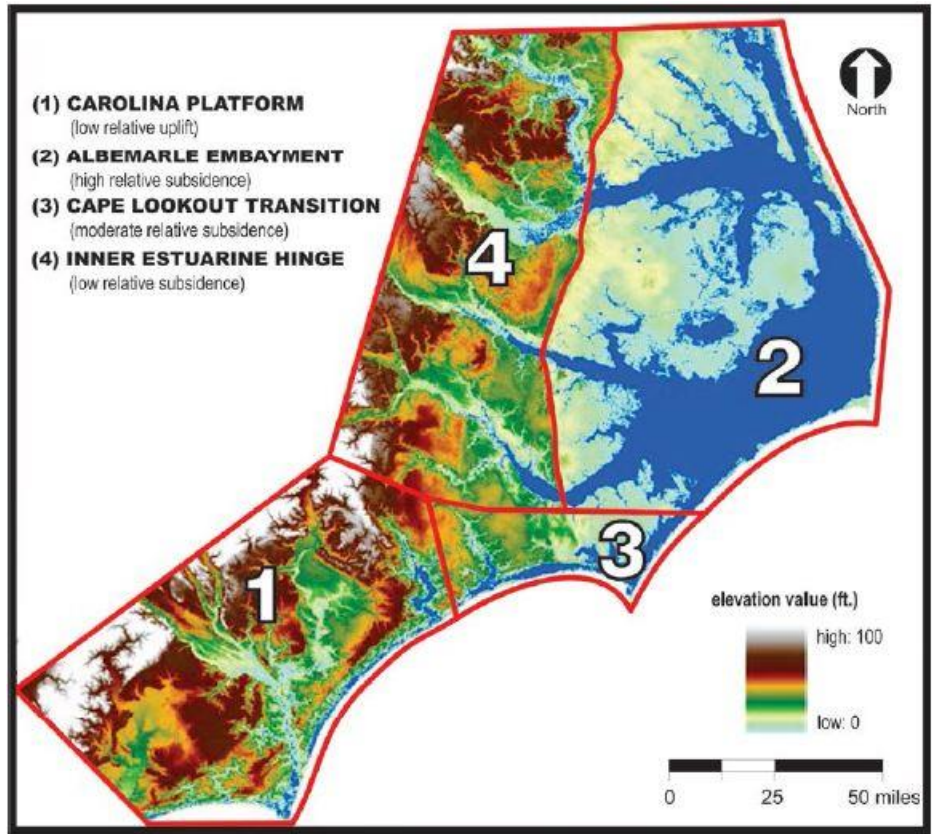


Figure 4. Zones of uplift and subsidence across coastal North Carolina. Note that Pasquotank County is located in the Albemarle Embayment zone, which is characterized by high relative subsidence (Overton et al. 2015).

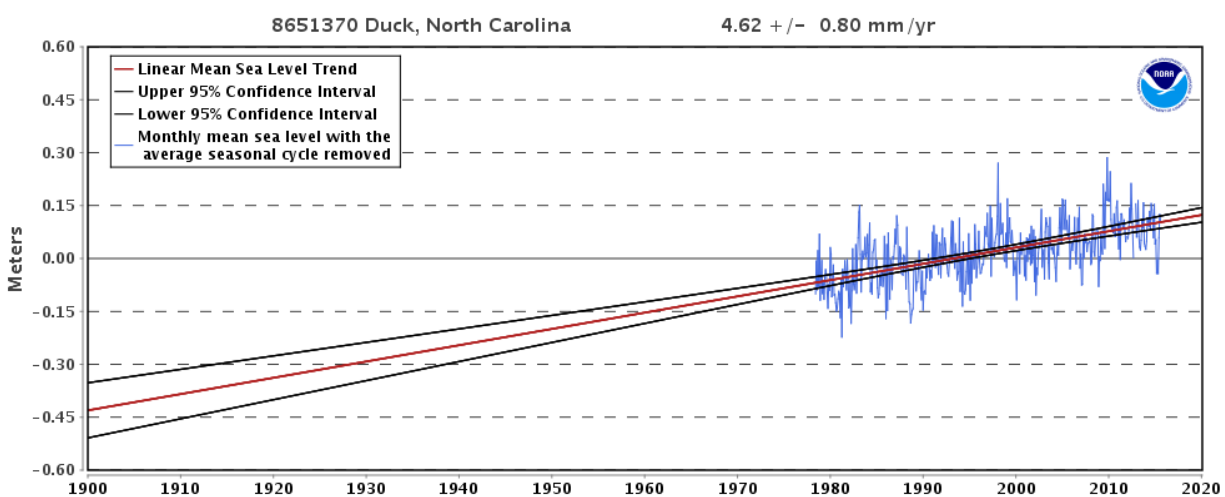


Figure 5. Sea level rise trend at Duck, NC station. The mean sea level trend is 4.62 millimeters/year with a 95% confidence interval of ±0.80 mm/yr based on monthly mean sea level data from 1978 to 2014 which is equivalent to a change of 1.51 feet in 100 years (NOAA 2014b).

If historic trends continue, Pasquotank County can expect to see relative water levels rise 5.4 inches (with a range between 4.4 and 6.4 inches) over a thirty year time frame (Overton et al. 2015). By the end of the century, relative sea level rise would be 15.5 inches (with a range between 12.8 and 18.1 inches).

However, using existing rates of sea level rise to project future sea level rise is scientifically unfounded. It is very likely that the rate of sea level rise during this century will exceed the rate observed during last century (Church et al. 2013). Various reports and research papers attempt to project global sea level rise during the 21st century. For the purposes of analyzing the effects of sea level rise on Pasquotank County, NC we consider two sets of projections: (1) the 30-year forecast given in the 2015 update to the North Carolina Sea Level Rise Assessment Report (Overton et al. 2015) and (2) “North Carolina and the Surging Sea” by Strauss et al. (2014).

Overton et al. (2015) use the Fifth Assessment Report (AR5) from the Intergovernmental Panel on Climate Change (IPCC), the leading international authority on climate change, in combination with local tidal gauge data to develop their projections of relative sea level rise. Unfortunately, the NC Sea Level Rise Update report is limited to only forecasting through 2045 despite the IPCC report containing projections through 2100. The authors of NC report (Overton et al. 2015) conclude that relative sea level rise at the Duck Station will be between 4.8 and 10.6 inches by 2045. Based on this report, we consider a maximum of one foot relative sea level rise by 2050 for Pasquotank County.

However, this report may be somewhat optimistic, as both the United States Army Corps of Engineers (USACE) and the National Oceanic and Atmospheric Administration (NOAA) project between 0.5 to 3 feet of relative sea level rise for northeastern North Carolina by 2050 (USACE and NOAA 2015).

The report by Strauss et al. (2014) provides another set of projections that are similar to those produced by USACE and NOAA. These are projections are based on a comprehensive review of sources including the IPCC AR5 report, the NOAA-led technical report to the National Climate Assessment (Parris et al. 2012), recent research about the West Antarctic Ice Sheet, and local tidal gauge data to make their sea level rise projections (Strauss et al. 2014). They make projections for three different scenarios depending on the amount global temperature rise that occurs.

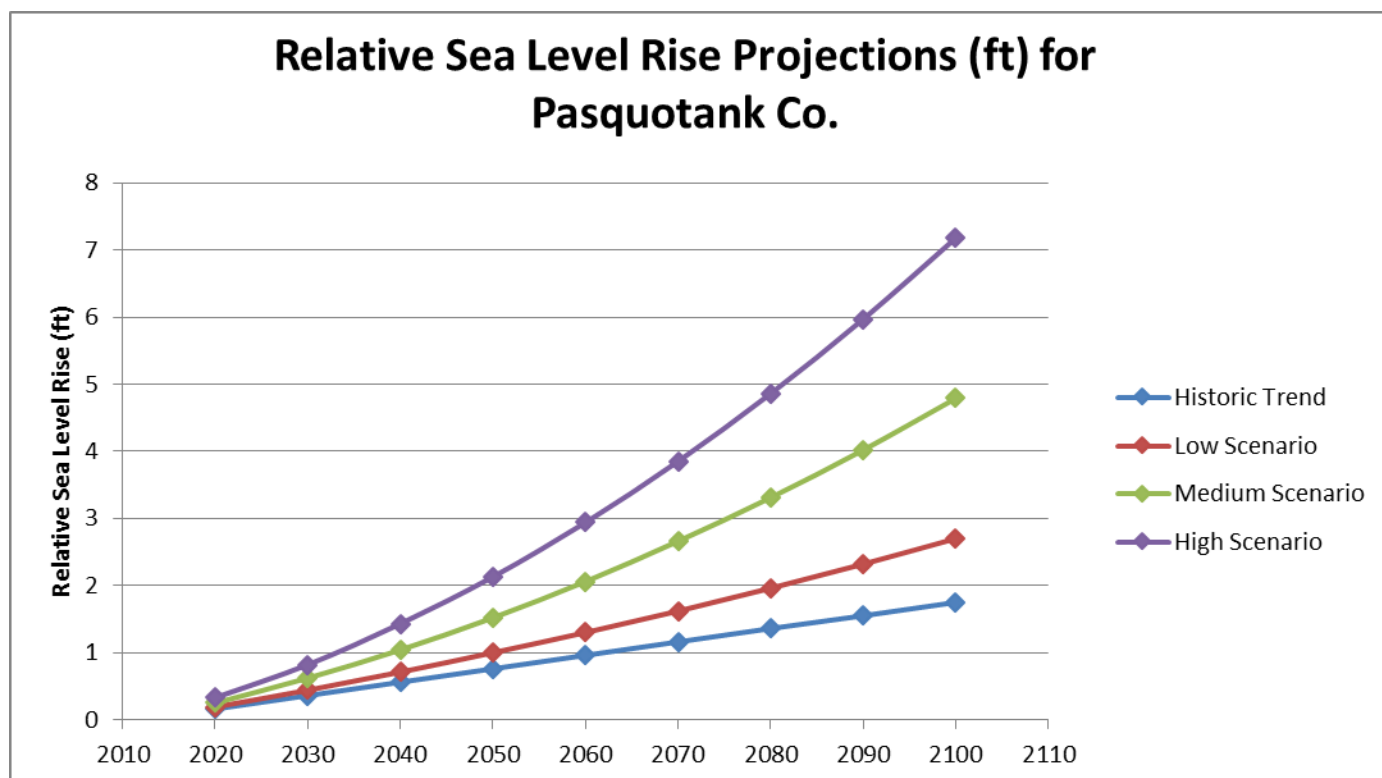


Figure 6. Relative sea level rise projections for Pasquotank County, NC from Climate Central (2014) using gauge data from the Chesapeake Bay Bridge Tunnel. The data for this chart can be found in Table 7 of Appendix A.

From the chart we can see that it is reasonable to expect local water level to rise between one and two feet by 2050 and between two and seven feet by 2100. For consistency with the NC Sea Level Rise Update, we use a one foot sea level rise for our 2050 projection. We also consider scenarios of three, four, and five feet of sea level rise by 2100. For years between 2050 and 2100, we look at scenarios of two and three feet sea level rise. Furthermore, it is important to note that it is “virtually certain that global mean sea level rise will continue to occur for many centuries beyond 2100” (IPCC 2014, p.16).

3.2. Inundation (Land Submersion) due to Sea Level Rise

The most visible threat of sea level rise is the inundation of currently dry land by rising water. With a projected one-foot rise in relative sea level by 2050, most of the county will remain dry, although the chance of flooding will greatly increase (see section 3.3). In order to determine the areas that will be most affected, we used GIS models of sea level rise produced by NOAA using the best available LIDAR-based elevation data. We also examined the North Carolina Sea Level Affecting Marsh Model (SLAMM) provided by Dr. Tom Allen, Associate Professor in the Department of Geography at East Carolina University. For more information about how we created our maps, see our detailed Mapping Methodology in Appendix B.

3.2.1. Extent of Impact

Figures 8-20 display the impact on Pasquotank County of one to four feet of relative sea level rise. The effects of an additional foot of water become more significant as the amount of sea level rise that has occurred increases. The southern part of the county is the lowest-lying area and will be the first area to be submerged due to sea level rise.

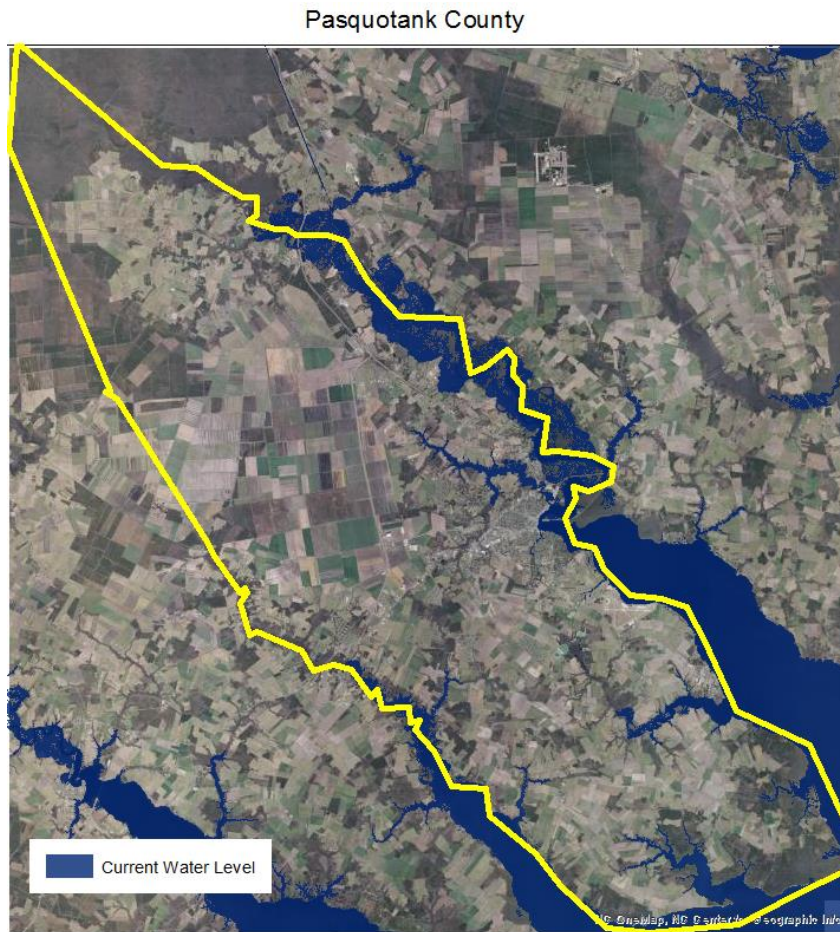


Figure 7. Map of Pasquotank County as it is today.

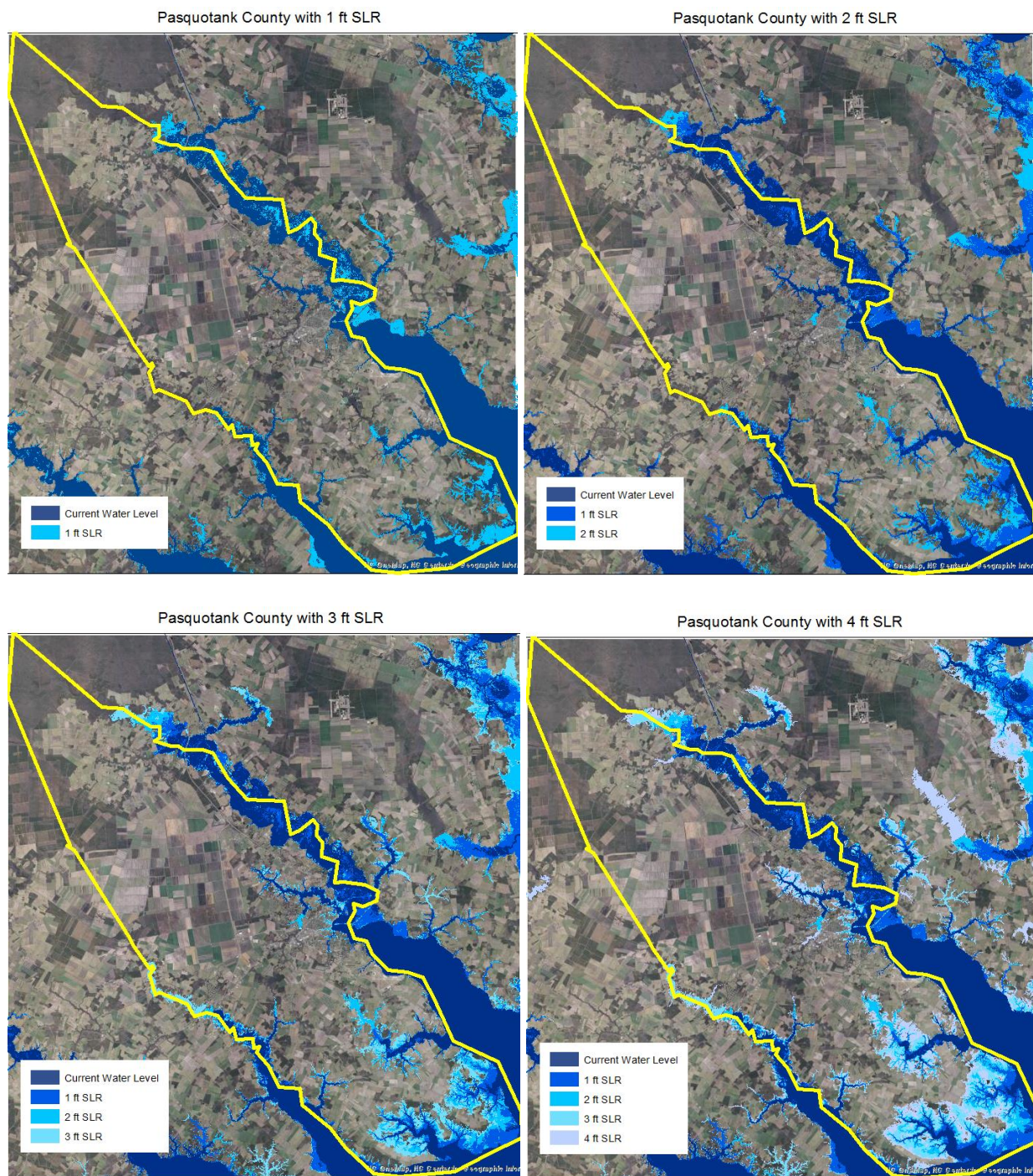


Figure 8. Maps of Pasquotank County with one to four feet of sea level rise. *Top left:* Pasquotank County can expect a one foot rise in sea level by 2050 that will submerge the areas shown in light blue. *Top right:* Two feet SLR can be expected by 2060-2080. *Bottom left and right:* By 2100, the county should be prepared for scenarios of at least three feet SLR.

3.2.2. Climate Central Study

A study conducted by researchers at Climate Central¹ (2014b) assessed sea level rise and coastal flood exposure in Pasquotank County as a part of an ongoing project called Surging Seas. Rather than attempt to calculate county-wide effects of sea level rise on our own, we rely on data collected by these researchers. This section summarizes some of the major results of that study; the full results are in the Appendix. We only use these results for overall, county-wide data. The data used in the rest of our report was created by our team or obtained from another source.

By the year 2050, when sea levels have risen one foot, the county will have lost \$51 million in property value, 27 miles of roads will be submerged, and about 1,600 people will be affected by water on at least a portion of their properties. More than 17,500 acres of currently dry land (about 12 percent of the county's total acreage) could be inundated due to a one foot rise in sea level. For two feet of sea level rise, \$139 million worth of property, 52 miles of roads, and nearly 24,000 acres (16.5 percent of total land acreage) could be submerged. Over 3,000 people could be affected (Climate Central 2014b). The numbers are even larger for three and four feet of sea level rise. These numbers are displayed in *Table 1*.

	Unit	< 1 ft	< 2 ft	< 3 ft	< 4 ft
Property value	\$ Million	51	139	270	394
Population	Count	1644	3188	6082	10351
Roads	Miles	27	52	93	146
Land	Acres	17698	23860	31246	39372

Table 1. Data of sea level rise vulnerability for Pasquotank County from Climate Central (2014b). The complete table of statistics is found in Appendix H.

These numbers are meaningful in several ways. The loss of property value will affect the county's and city's property tax base—reducing the total amount and value of taxable property will reduce property tax revenues. Displacing the population is problematic because some people may not be able to afford to relocate and others may choose to relocate outside of Pasquotank County. Losing valuable farmland, especially in the southern part of the county, due to sea level rise will hurt farmers in the area. The length of the roads affected by sea level rise is important because these roads must either be elevated or closed and some government entity will bear those costs depending on the type of roads they are (federal, state, or local). See Appendix H for the length of roads affected by type of roads. The city and county should be most concerned about the local roads since those are what they will be responsible for maintaining. A few specific areas will be hardest hit, as summarized below.

3.2.3. Matthews Acres

Matthews Acres, a subdivision off of Creek Road in northern Pasquotank County, is at risk of partial inundation over the next several decades. The entire subdivision is located in a 100-year

¹ Climate Central is a nonprofit, nonpartisan research and news organization that analyzes and reports information on climate science.

flood zone, indicating that this area is already subject to flooding due to its low elevation and proximity to the surrounding wetlands.

A one-foot rise in sea level could begin to threaten properties in Matthews Acres. While no property will be submerged, the entire subdivision will be at a greater risk of flooding. Similarly, two feet of sea level rise will not submerge a significant amount of property, but it will submerge portions of property along the edges of the subdivision. With three feet of sea level rise, shown in the bottom left quadrant of *Figure 9*, the total value of property submerged could potentially exceed \$10 million. This scenario is likely to occur by 2100. The properties most at risk are those to the east of Birdie Lane and those to the west of Matthews Drive. The lots in the center of the development are elevated enough to avoid submersion until sea level rise reaches four feet. If sea levels rise four feet or more, nearly the entire subdivision will be submerged. Furthermore, access to Matthews Acres could be limited with as little as two feet rise because parts of Creek Road may be submerged or subject to frequent flooding.

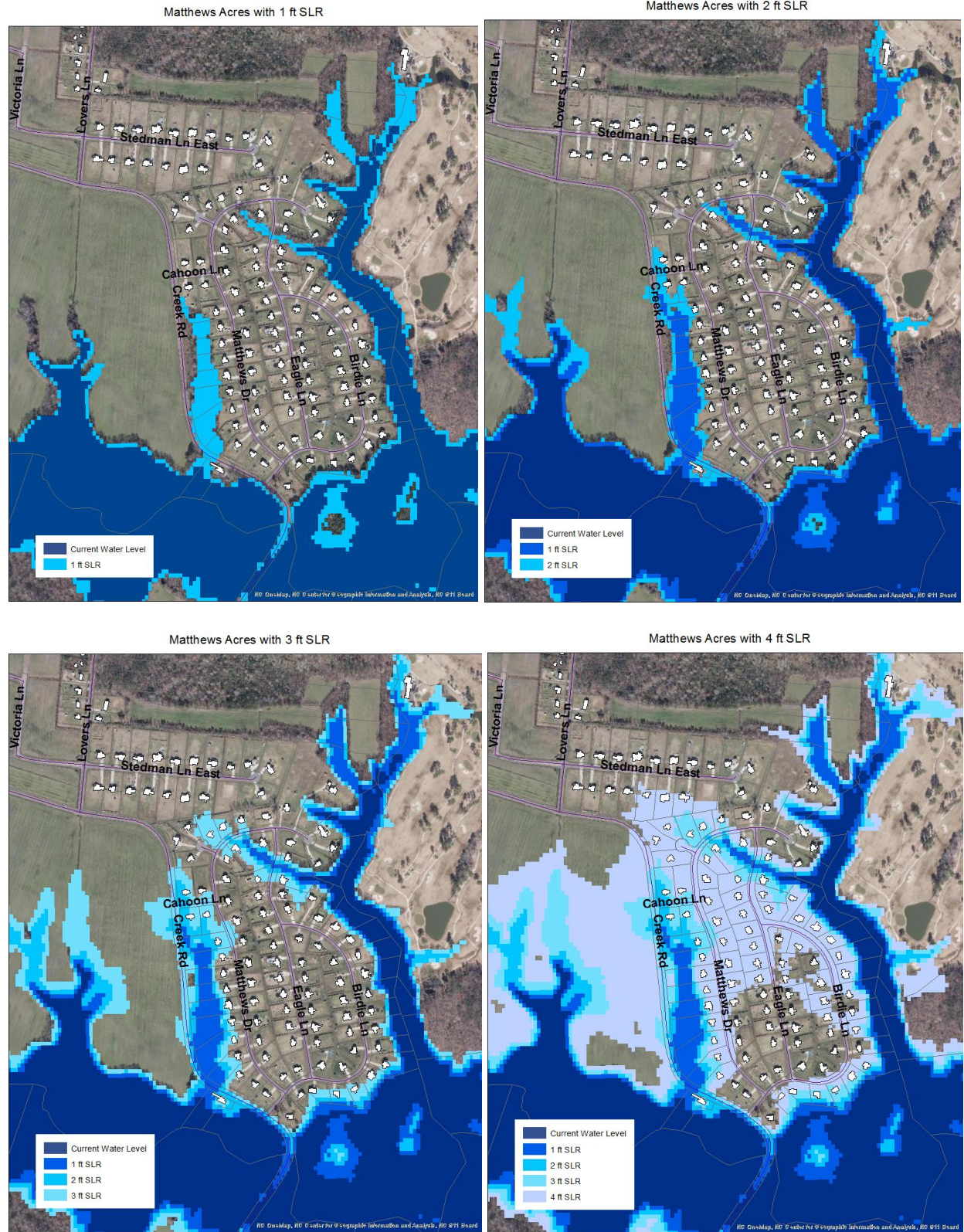


Figure 9. Sea level rise scenarios for Matthews Acres.

3.2.4. Bray's Estates

Bray's Estates is a subdivision on Scott Road in the northern part of the county, not far from Matthews Acres. Like Matthews Acres, Bray's Estates is located entirely in the 100-year flood zone; in fact, part of Bray's Estates is actually located in a designated flood way, which is classified as non-developable, meaning that no new construction can occur there. This is shown in *Figure 10* below.

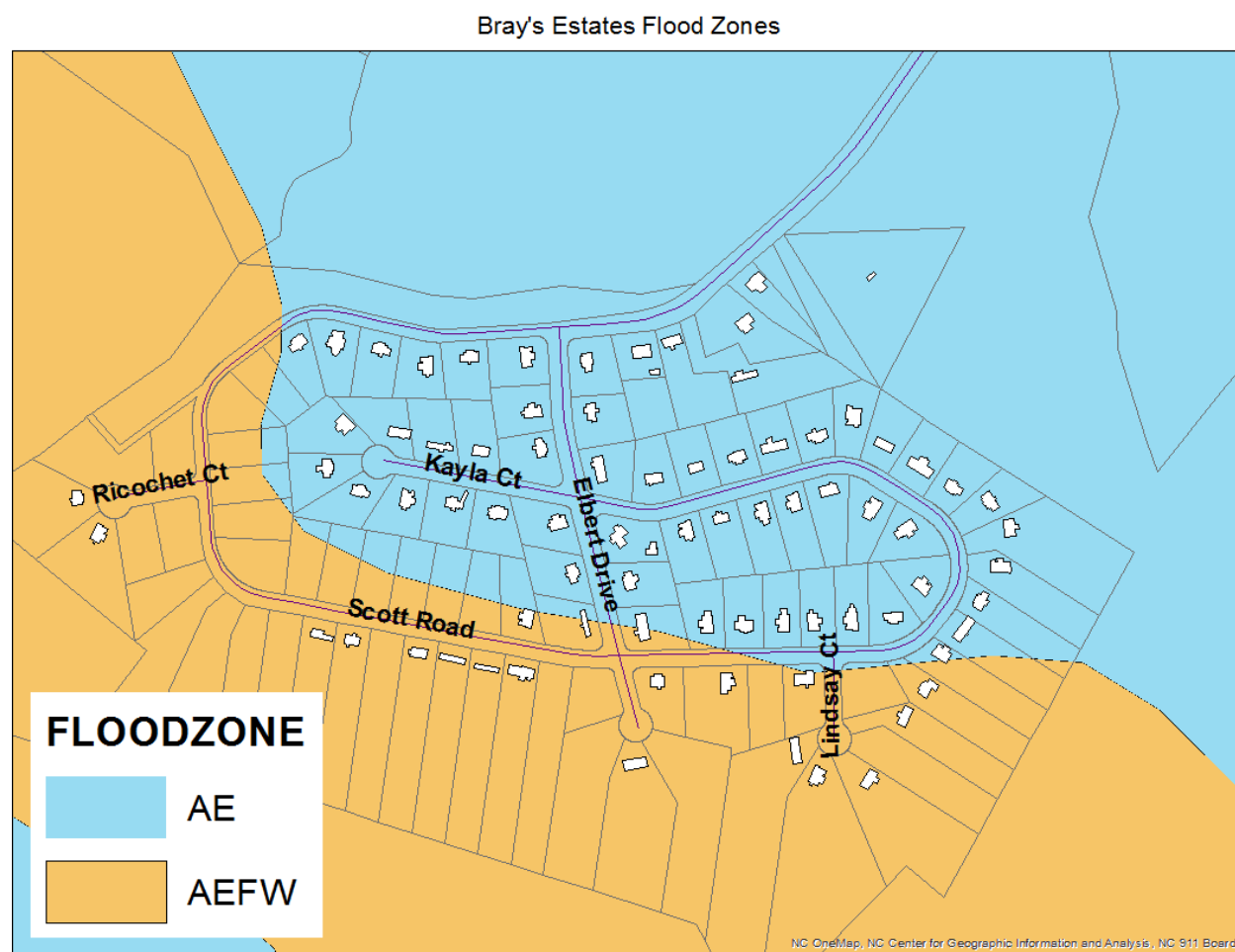


Figure 10. Bray's Estates is located partially in the flood way (AEFW) and partially in the 100-year flood zone (AE).

Bray's Estates is nearly surrounded by water and currently experiences flooding following most major precipitation events. As shown in *Figure 11*, one foot and two feet of sea level rise, expected by 2050 and 2060-2080 respectively, will begin to encroach on the southernmost properties. Beyond two feet of rising water levels, Bray's Estates will start to look remarkably different. Parts of Scott Road will be submerged and several lots will be inaccessible. The value of property that will be submerged or inaccessible due to three feet of sea level rise is almost \$4 million. Four feet of sea level rise will engulf the entire subdivision, rendering it uninhabitable.

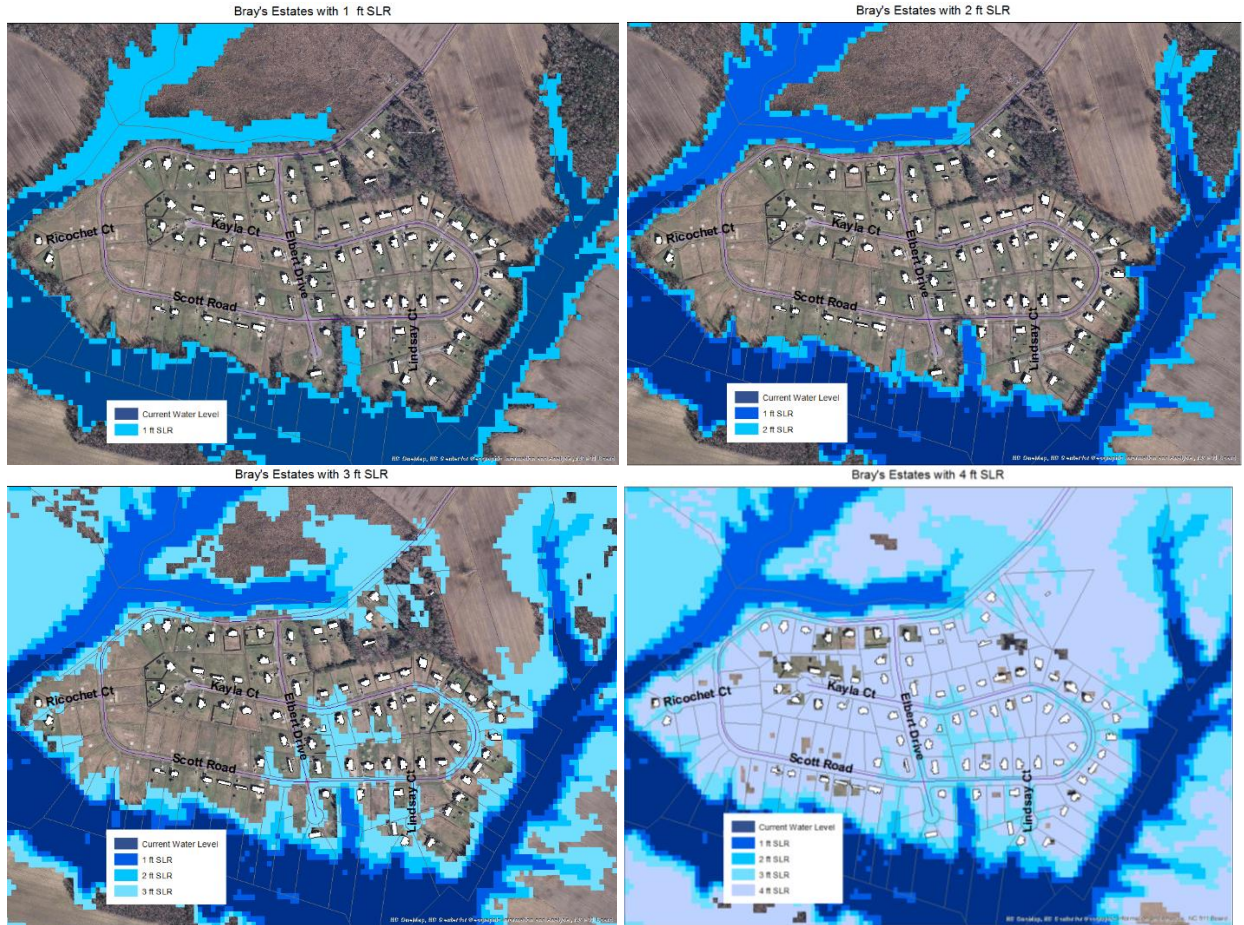


Figure 11. Sea level rise scenarios for Bray's Estates.

3.2.5. Southern Pasquotank County

The southern portion of Pasquotank County, where elevations are very low, will suffer the greatest amount of property loss (total acreage) in the county. Agricultural land will be the most affected, as much of this land will become marsh.

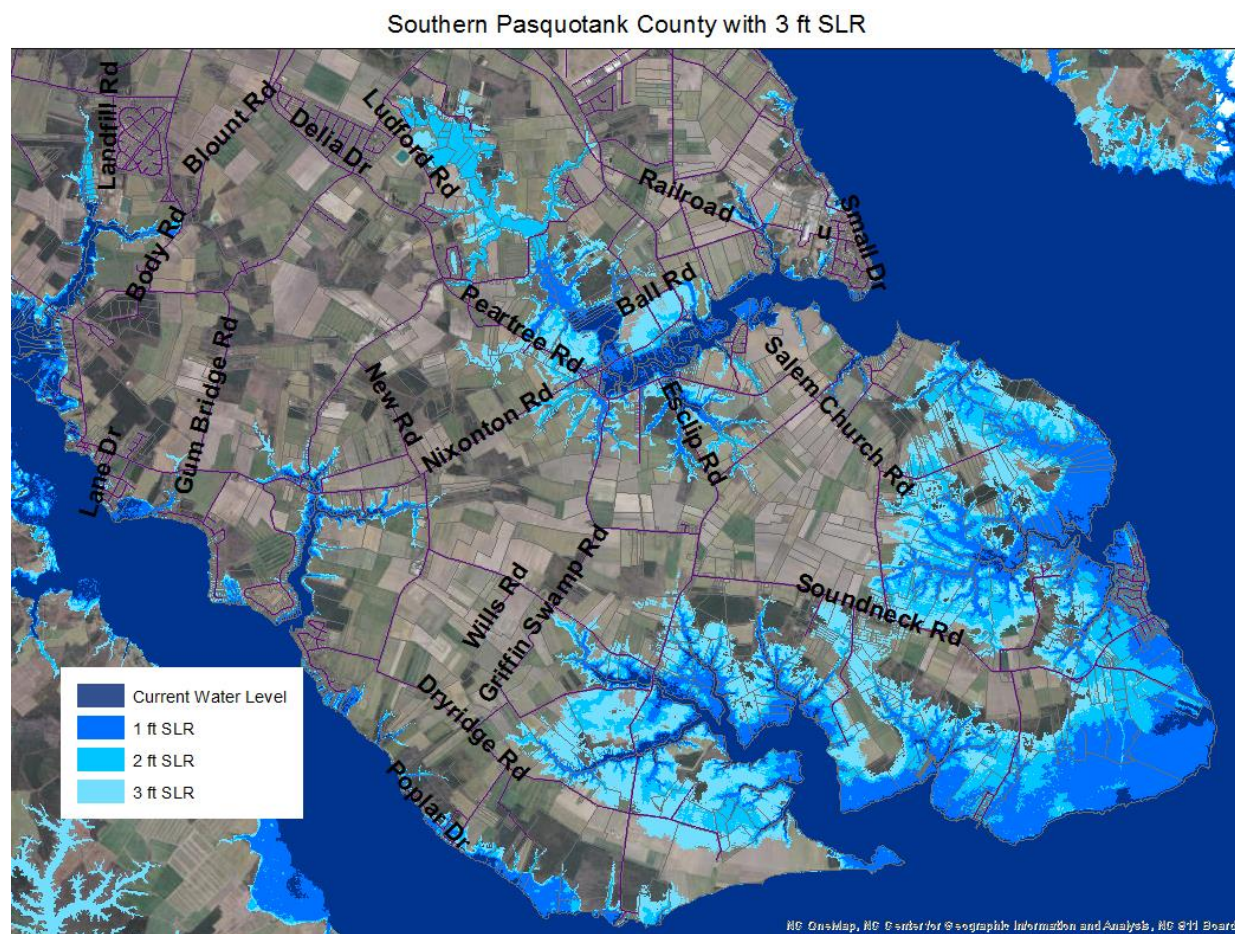


Figure 12. The southern portion of Pasquotank County with up to three feet of sea level rise. The black dots represent homes and other structures and the purple lines represent roads.

3.2.6. Glen Cove

Glen Cove, a subdivision on the Pasquotank River in the southeastern portion of the county, faces the greatest risk of submersion due to sea level rise. Several lots and homes could be submerged by 2050, when we can expect sea levels to have risen by one foot. When sea level rise has reached 2 feet, nearly the entire development will be under water. The parts of Vickie Drive and Driftwood Drive that remain dry will be completely inaccessible by land because all other roads will be flooded. The value of property loss that is expected to occur with two feet of sea level rise could approach \$15 million. More than two feet of sea level rise will simply increase the water level on already submerged land.

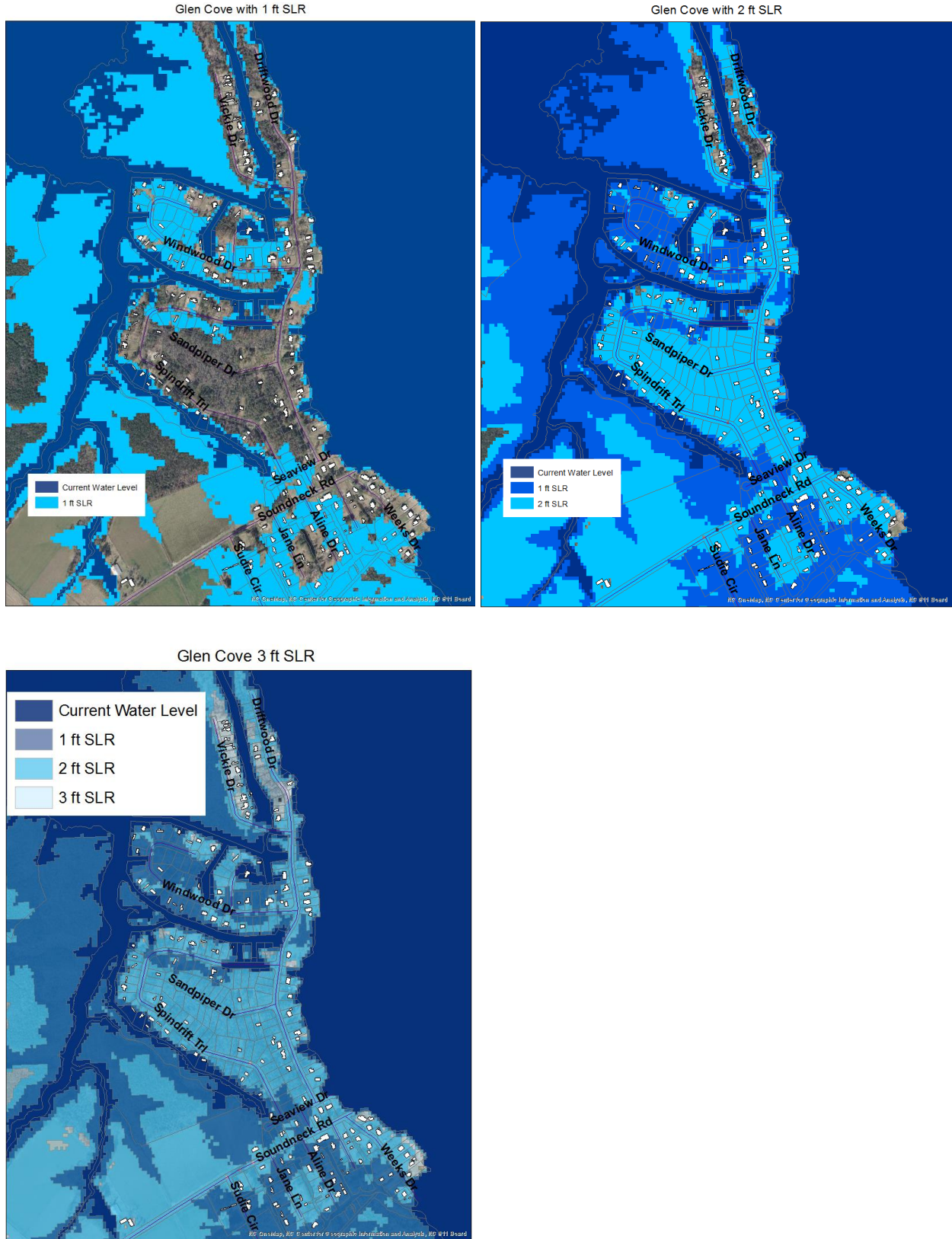


Figure 13. Sea level rise scenarios for Glen Cove.

3.2.7. Elizabeth City

As old maps of Elizabeth City illustrate (see *Figure 14*), the downtown was built between two creeks—Tiber Creek and Poindexter Creek—and then later those creeks were filled in to create the downtown we know today. Tiber Creek was located where Grice Street currently is. Poindexter Creek flowed under what is currently Elizabeth Street and forked just before reaching Martin Luther King, Jr. Drive. The southern fork continued down Elizabeth Street, flowing underneath the downtown tennis courts, and ended at Harney Street. The northern fork stretched behind the old Elizabeth City Middle School building and then became swamp land behind Sheep Harney where the fire station is located. The sea level rise models we use project that these historic creeks will be the first places to be inundated in the event of rising water levels. *Figure 15* shows the old map of Elizabeth City overlaid onto aerial imagery of Elizabeth City as it is today with a projected sea level rise of three feet.



Figure 14. Map of Elizabeth City from 1893.

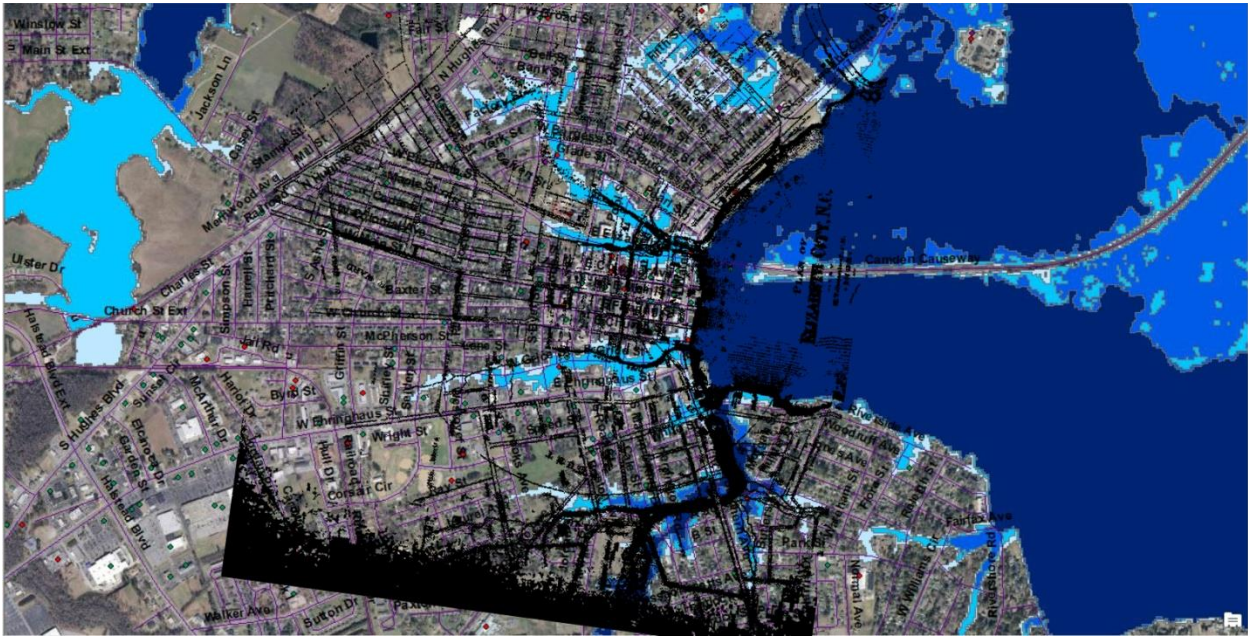


Figure 15. Old map of Elizabeth City (black) overlaid onto current imagery of Elizabeth City with three feet of sea level rise. The historic creeks accurately predict the location of future water.

The section of downtown Elizabeth City north of Elizabeth Street, shown in *Figure 16*, will begin to be submerged when sea level rise reaches two feet. Properties will remain intact through 2050, but beyond then homeowners just south of Ward Street and along the path of the old Poindexter Creek (see *Figure 14*) should be prepared to see water creep onto their properties. Homes in these locations will face severe risk of submersion by 2100, when we can expect three to four feet of sea level rise. The vulnerability of this area is of particular importance because the majority of people living here are economically disadvantaged. Submersion of this area would disproportionately affect minority, low-income households. These people will likely find it difficult to relocate in the event their property becomes inundated with water.

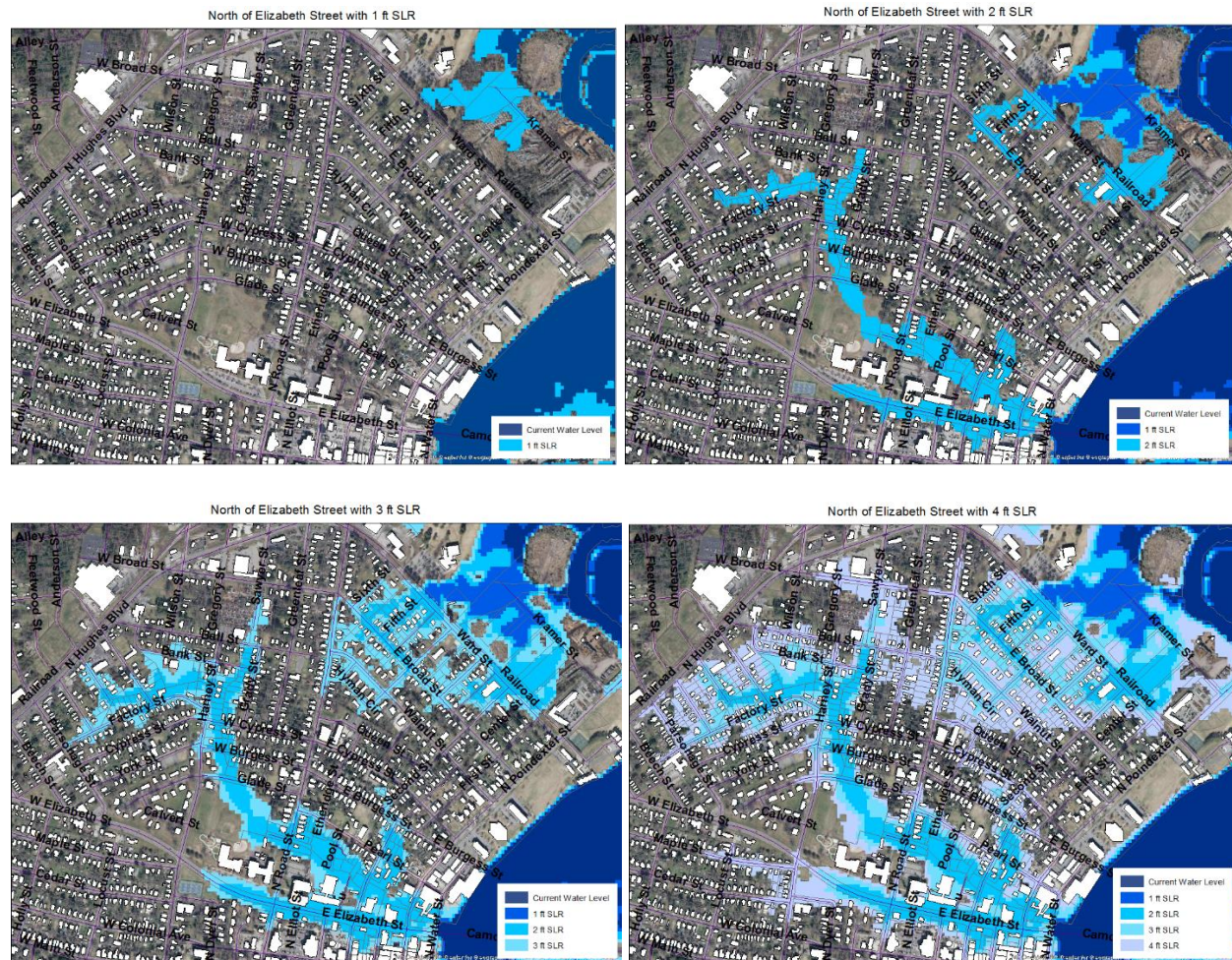


Figure 16. Sea level rise scenarios for downtown Elizabeth City north of Elizabeth Street.

The situation south of Elizabeth Street is very similar (see *Figure 17*). One foot of sea level rise will not impact the area, in terms of land submersion. Two feet or more will cause significant permanent flooding along Grice Street and the block of Church Street closest to Water Street. While the area north of Elizabeth Street is mostly residential, the area south of Elizabeth Street has many local businesses. Businesses in locations that may be submerged will ultimately have to relocate or close, which would negatively affect the business climate and the economic development efforts for downtown. Places that could be inundated include the Daily Advance, the Chamber of Commerce, First South Bank, Coastal Office Equipment, the building of the former White & Brite Grocery, and several others.

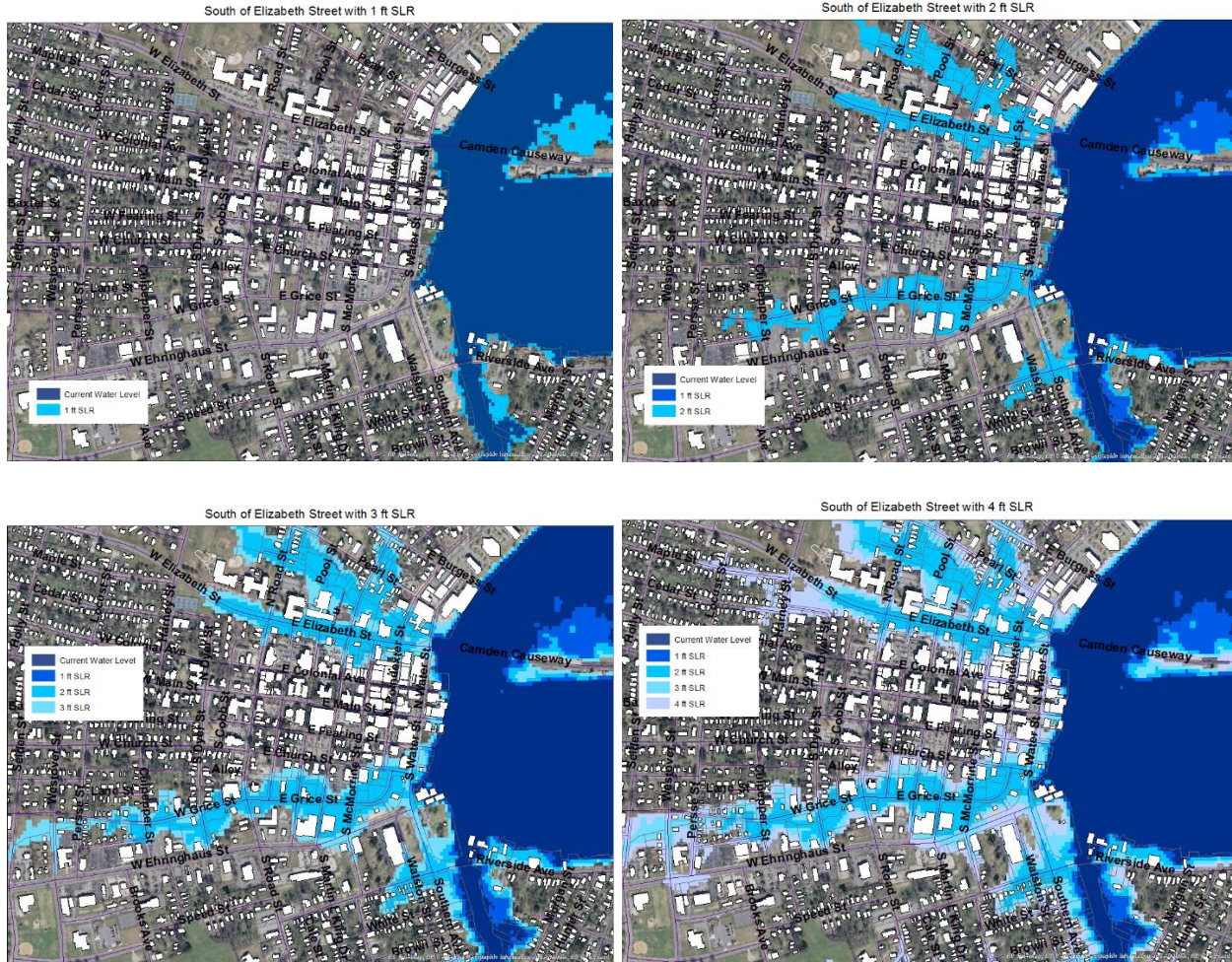


Figure 17. Sea level rise scenarios for downtown Elizabeth City south of Elizabeth Street.

Just a bit farther south, we can expect to see residential areas become submerged as sea levels rise (see *Figure 18*). This area is populated largely by low-income minority citizens who likely do not have the financial means to move or to prepare for rising waters. Furthermore, Herrington Road and Southern Avenue are two heavily trafficked roads leading to both Elizabeth City State University and the Coast Guard base. Cutting off traffic flow on these two roads could shift a significant amount of traffic to Halstead Boulevard, which turns into Weeksville Road, and lead to major congestion issues.

As little as one foot of sea level rise, expected by 2050, could cause water to come across Southern Avenue between Edge and Dawson Streets. When three feet of sea level rise has occurred by 2100, that portion of Southern Avenue would certainly be submerged, as would many surrounding homes and streets, as shown in the figure.

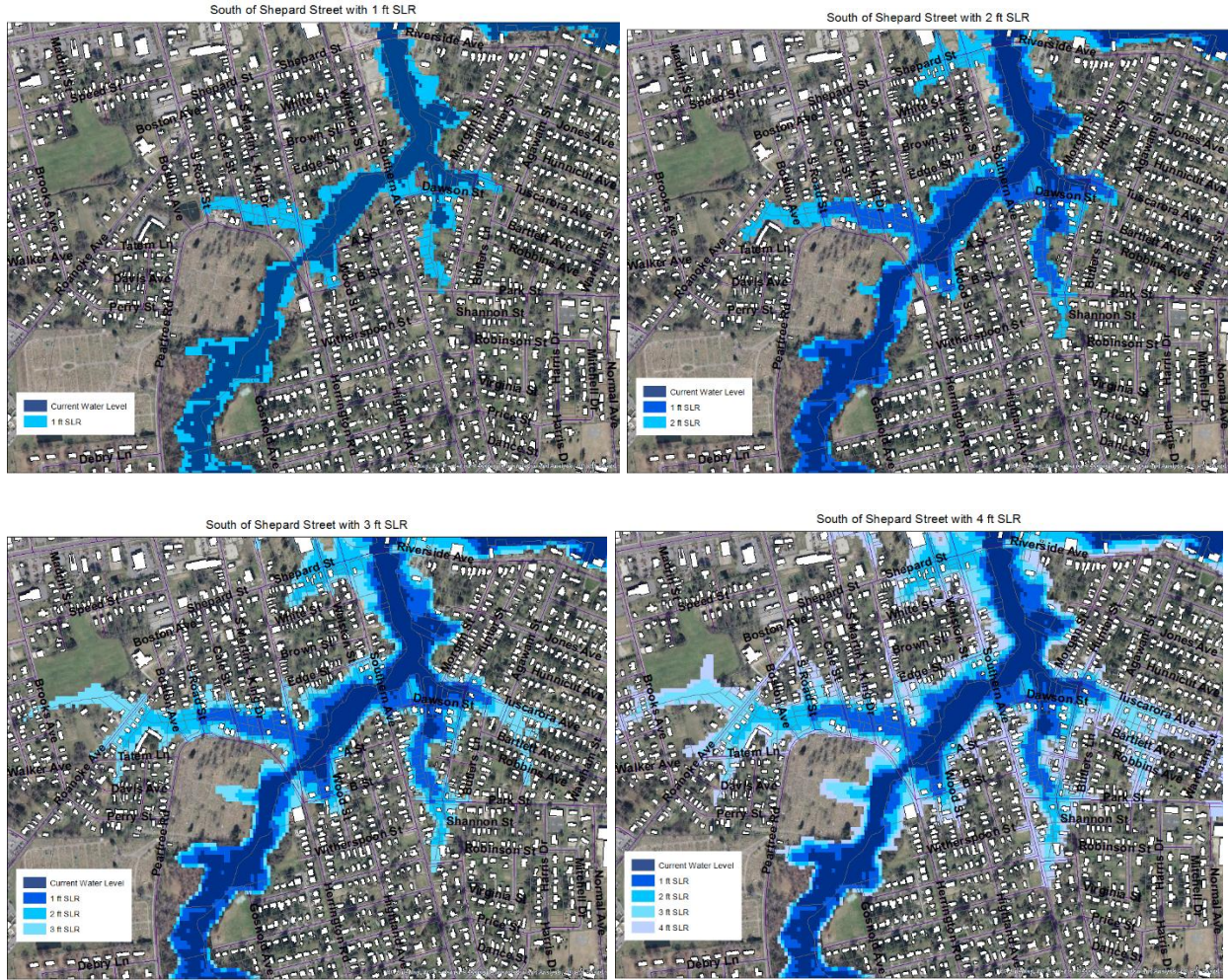


Figure 18. Sea level rise scenarios for Elizabeth City south of Shepard Street.

3.2.8. Wastewater Treatment Plant

The Elizabeth City Wastewater Treatment plant located on Knobbs Creek Drive is located in a unique position along the river. The plant itself is elevated high enough to remain dry in the event of up to nearly five feet of sea level rise. However, the access roads to the plant will be submerged with as little as one foot of sea level rise. In other words, the plant may be inaccessible by 2050. Plant facility operational staff and maintenance crews would be unable to reach the plant, which could prove extremely costly in the event of some type of plant failure.

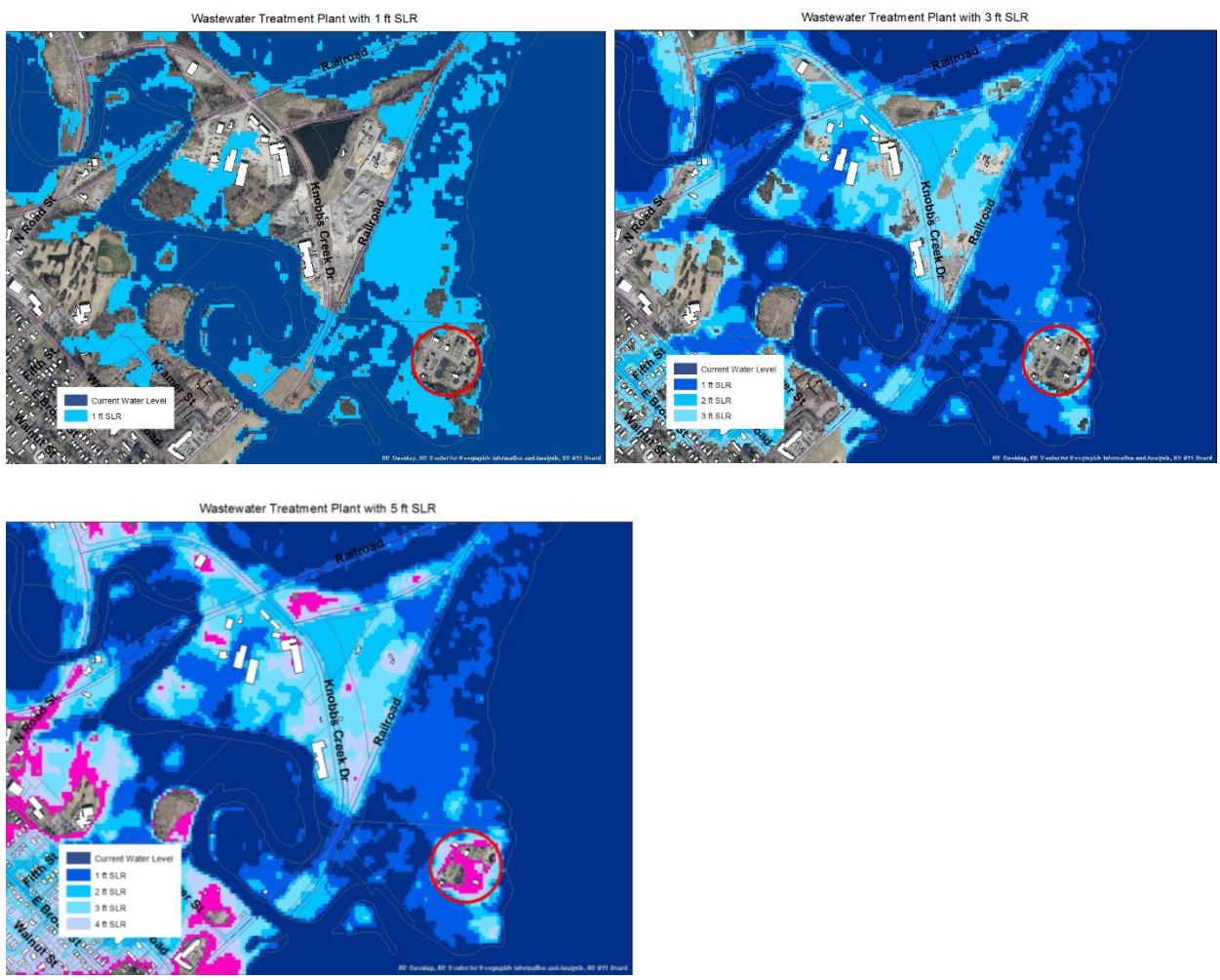


Figure 19. Sea level rise scenarios (one foot, three feet, and five feet) for Elizabeth City’s wastewater treatment plant (circled in red).

3.2.9. Flood Zones

With a sea level rise of three or more feet, which is expected no later than 2100, all of the floodways in Pasquotank County will be submerged. Large parts of the current 100-year flood zone (AE) will be submerged, as well. Homes and other structures built in the floodways or the flood zone will be at risk of significant property damage.

Current Flood Zones with 4 ft SLR

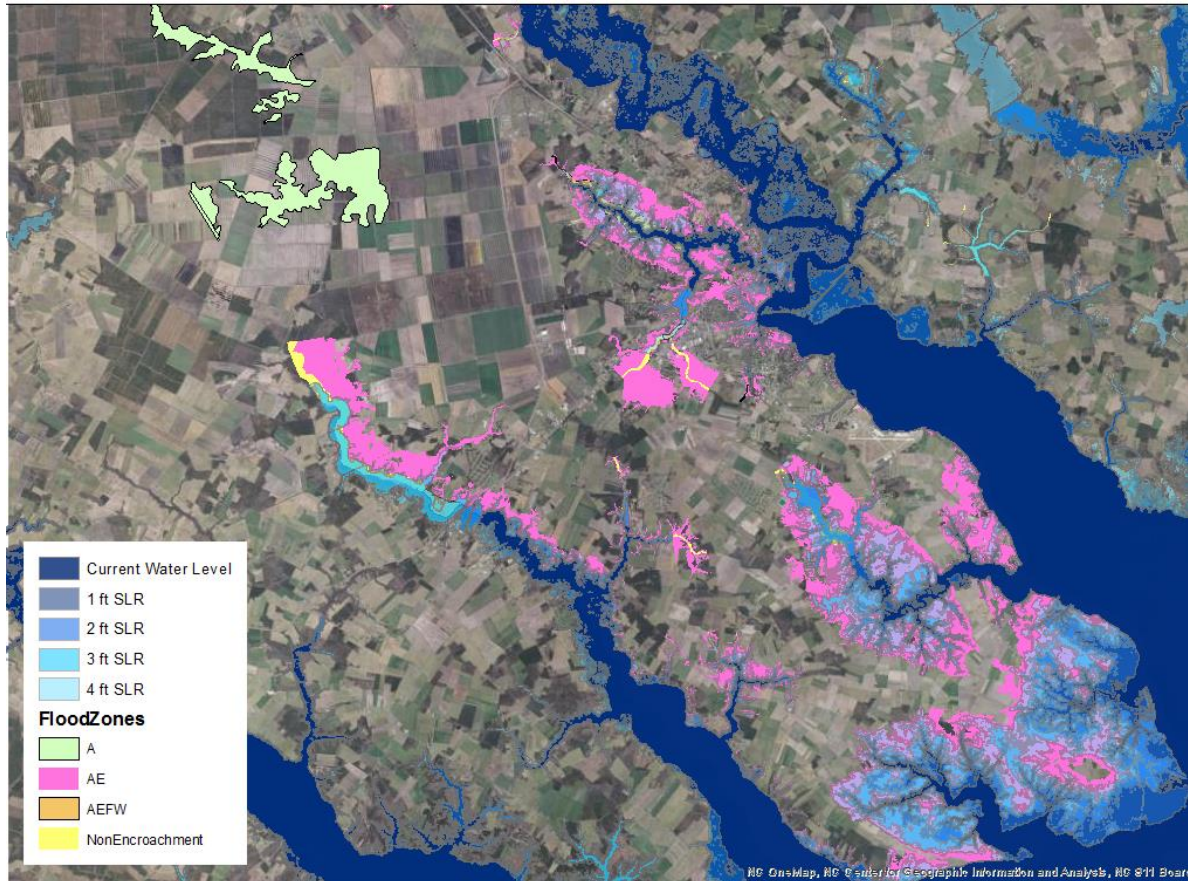


Figure 20. Pasquotank County's current flood zones with overlays of sea level rise scenarios.

3.2.10. Comprehensive List of Impacted Locations (including critical facilities, local businesses, schools, churches, etc.)

We have attempted to compile a comprehensive list of locations that will be at least partially submerged by each additional foot of sea level rise (this list can be found in Appendix E).

3.3. Increased Flooding Risk

Sea level rise will augment the base water level from which floods occur and thus extend the reach of floodwaters. This means that even land that will not be permanently submerged due to sea level rise will face a much higher probability of being flooded. While the entire county is not at risk of submersion, the entire county will be at greater risk of experiencing a flood.

Furthermore, the current one-hundred year floodplain will expand to include much more of the county. The county will also likely see floodwaters reach progressively new heights (Tebaldi et al. 2015). The frequency of flooding will increase, as precipitation events and tidal events that previously did not cause flooding will cause flooding in the future.

According to one projection, by 2050, today's one-hundred year flood event will occur every five years in Pasquotank County (Tebaldi et al. 2012). In other words, a flood that has a 1% chance of occurring in any given year today will have a 20% chance of occurring in any given year by 2050. Other projections have this likelihood anywhere from 5% to 50% by 2050 (Climate Central 2014a). The one-year flood mark could be two feet higher than the current mark by 2050 (Climate Central 2014a), so the AE flood zone will grow much larger. According to Pasquotank County's 2010 Multi-Jurisdictional Hazard Mitigation Plan, approximately 38% of the county's land area is within the one-hundred year floodplain. About half of the county's land area could be within the one-hundred year floodplain by 2050.

Figure 21 shows a map of Pasquotank County's flood zones, where the pink color signifies the one-hundred year floodplain. This pink area is expected to increase significantly by 2050. It will probably cover the majority of the southern part of the county within the next few decades. Homeowners with federally financed loans whose homes are located in this flood zone are required to purchase flood insurance. Most mortgage companies also require homeowners in flood zones to buy flood insurance. As the flood zone expands in the future, more homeowners will be forced to buy flood insurance, causing their disposable income to decrease. A drop in disposable income will likely cause a reduction in county sales tax revenues since people have less money to spend on consumption. This will be an important consideration for local officials when crafting mitigation strategies. A strategy such as participation in the Community Rating System (CRS), outlined in Section 5.1, which encourages flood hazard mitigation by reducing National Flood Insurance Program (NFIP) premiums, is an attractive option to consider. Lowering insurance rates for homeowners causes an increase in disposable income. More money to spend leads to more consumption and an increase in county sales tax revenues. Thus, participation in the CRS could partially pay for itself through sales tax revenues.

Pasquotank County Flood Zones

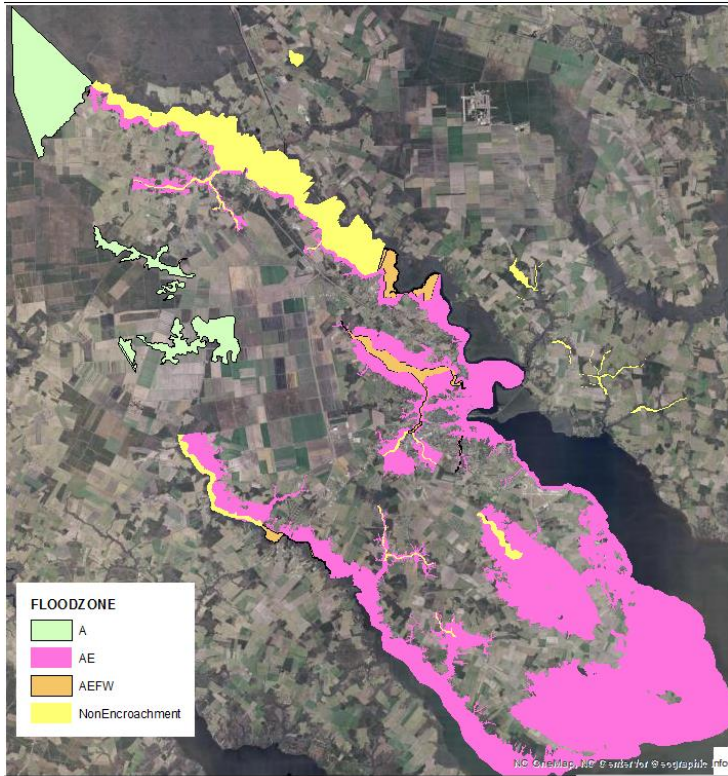


Figure 21. Pasquotank County's flood zones.

3.4. Land Use Planning

Elizabeth City and Pasquotank County have adopted future land use plans that adequately address the challenges of sea level rise over the next few decades. For example, land designated for conservation in the future land use plans is the land most likely to be submerged first as the sea level rises. Beyond 2050, however, water will begin to extend beyond these conservation areas. This is shown in *Figure 22* for Elizabeth City. When the next land use planning process takes place, the city and the county should attempt to enlarge the conservation areas of the previous plan.

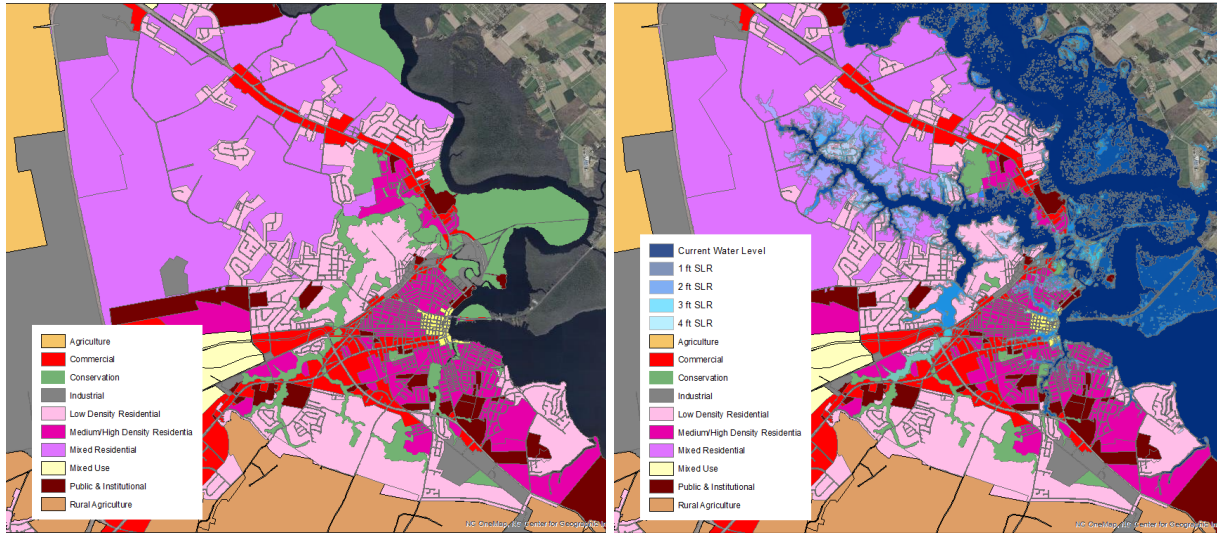


Figure 22. The map on the left shows the future land use plans for downtown Elizabeth City. The map on the right shows sea level rise (in blue) overlaying future land use. Sea level rise follows the conservation areas pretty closely but extends beyond them as it becomes more severe.

The southern part of the county is particularly vulnerable to sea level rise, as shown in *Figure 23*.

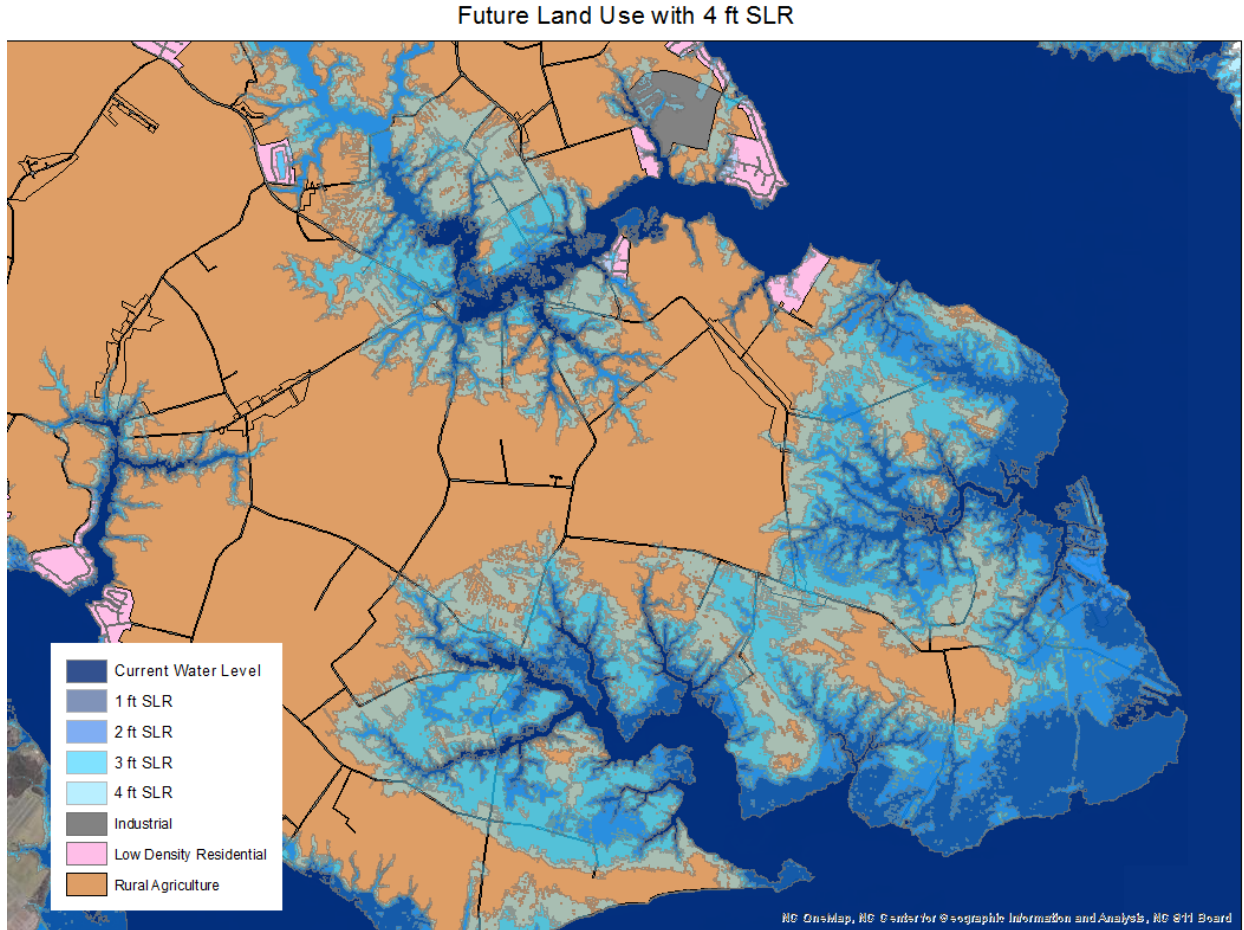


Figure 23. The southern portion of the county is designated predominantly as rural agricultural land in the county’s future land use plan. This map shows that sea level rise will submerge much of this farmland.

3.6. Social and Economic Vulnerability

Sea level rise will affect people in the county, regardless of income, but low-income people will have the hardest time adjusting. High, middle, and low income families are all affected, as are white, black, and Hispanic people. However, in Elizabeth City, low-income African American families may be more vulnerable than others. The area north of Elizabeth Street bounded by Hughes Boulevard and Ward Street is a predominantly black community, and it is projected to be critically impacted by sea level rise (see section 2.2.7). Similarly, homes in the community south of Shepard Street are at risk due to rising water. The majority of people living in these homes have limited financial resources and will face greater challenges with the threat of sea level rise.

4. CASE STUDIES

As a part of our research, we studied five other communities that also are grappling with the challenge of sea level rise and have created mitigation strategies of their own. The communities include small coastal towns (Plymouth, NC and St. Mary's GA), large coastal cities (Norfolk, and Chesapeake, VA), and a poor, low-lying coastal county (Hyde County, NC). Each of these places are summarized below.

In selecting the five communities, we sought those that shared a number of features in common with Pasquotank County and Elizabeth City, such as population size, rurality, elevation, geographical setting, median household income, and/or the fact that their community is subsiding. These communities have also taken steps to address the impacts of sea level rise on their citizens. We hope that these case studies will provide insights into the strategies other municipalities have adopted to address sea level rise.

4.1. The City of Chesapeake, Virginia

The City of Chesapeake has been selected as a case study for Pasquotank County because of its similar geographical location, low-lying elevation, subsidence, natural hazards, and industries. Chesapeake is located in the southeastern part of Virginia and is bordered to the south by Currituck and Camden Counties in North Carolina. Like Pasquotank County, Chesapeake does not directly border the Atlantic Ocean. The city is 20 miles inland and has an average elevation of 12.2 feet above sea level, but it is sinking lower due to subsidence. Most residents are employed by the military and service related industries.

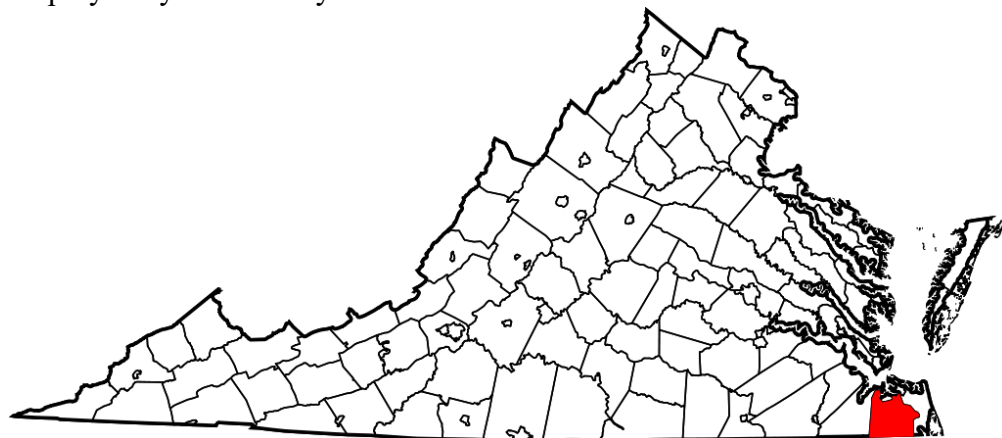


Figure 24. Map of Virginia's Counties highlighting the City of Chesapeake.

4.1.1. Current Strategies

The City of Chesapeake has numerous mitigation strategies set in place to cope with potential natural hazards. These include a Hazard Mitigation Plan, a Disaster Recovery Plan laid out by the Regional Catastrophic Planning Team, a Comprehensive Land Use Plan mandated by Virginia state law, and continued participation in the National Flood Insurance Program.

4.1.2. Recommendations

While the City of Chesapeake's Hazard Mitigation Plan is not updated annually, the planning process is ongoing to improve upon its current report. To do so, the city continues to facilitate discussion and brainstorming sessions with all interested parties (i.e. community, local government, environmental organizations, etc.). It also considers strategies undertaken by other cities within the region, such as the *Southside Hampton Roads, Virginia Hazard Mitigation Plan*. In doing so, the city is able to learn from its neighbors, identify effective strategies, and implement changes as needed. This makes its Hazard Mitigation Plan adaptable and better suited to handle its most current threats.

The city plans to further capitalize on its proximity to similarly situated cities by participating in the annual Hamptons Roads Planning District Commission Mitigation Funding Workshop. The goal of the workshop is to provide no-cost assistance to the communities to help satisfy reporting requirements, make progress on mitigation actions, and apply for mitigation grant funding (CNEMAC 2014). As a suggestion for receiving mitigation funding, the city's plans include reinforcing its involvement in the Community Rating System (CRS). Prioritizing CRS would lead to increased insurance coverage, improved hazard awareness and reduced flood insurance premiums for the residents of Chesapeake (CNEMAC 2014).

In addition to CRS, the city is preparing to complete a detailed vulnerability assessment of critical facilities in accordance with FEMA's new 100-year floodplain elevations and repetitive flood loss areas. This will entail reviewing structural or facility vulnerability to flood and wind hazards using flood-frequency information and building elevation data (CNEMAC 2014). Aside from these physical recommendations, the Hazard Mitigation Plan includes innovative communication strategies.

The Hazard Awareness Program is a low-cost program to be completed in conjunction with the city's Plan for Public Information (PPI). Both programs individually focus on assessing the public's information needs and identifying outreach projects to convey messages regarding natural hazards. Combining both programs will be beneficial because it minimizes the need to repeat messages, involves outreach and marketing professionals within the city, investigates regional partnerships to cut costs through cost sharing, and to use existing programs and resources to the fullest potential (CNEMAC 2014). To communicate quickly and effectively in the event of a natural hazard, the city plans to support and maintain their new Reverse-911 system. This will entail preparing messages to release to citizens before and after a natural hazard.

4.2. Norfolk, Virginia

Norfolk, Virginia provides a useful case study for Elizabeth City because of its similar geographical location, low-lying elevation, subsidence, natural hazards, and industries. However, Norfolk is significantly larger than Elizabeth City in terms of population size. Norfolk is located in southeastern Virginia and is bordered to the west by the Elizabeth River and to the north by the Chesapeake Bay. These surrounding waterways are integral to the city's economic vitality.

Besides serving as an import-export hub, Norfolk is home to naval stations and several private shipyards. The city's residents are primarily government employees or in the service industry.

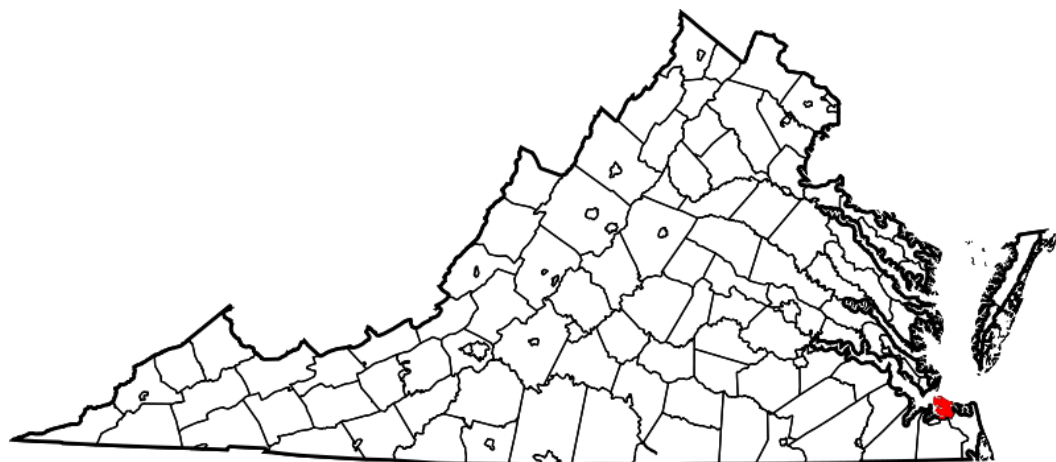


Figure 25. Map of Virginia's counties highlighting the City of Norfolk.

4.2.1. Current Strategies

Norfolk has a mixed portfolio of mitigation strategies in place to handle the threat of natural hazards. These strategies include land use regulations, stormwater control regulations, Hazard Mitigation Plan, enrollment in FEMA's Hazard Mitigation Assistance, and participation in the Rockefeller Foundation's 100 Resilient Cities Challenge.

4.2.2. Recommendations

Norfolk's participation in the 100 Resilient Cities Challenge has instilled a strong commitment to reduce the city's overall risk to sea level rise. The 100 Resilient Cities Challenge identifies cities that are ready to build resilience to the social, economic, and physical challenges that cities face in light of our changing climate (100 Resilient Cities Challenge 2015). An appointed Chief Resilience Officer for the city of Norfolk facilitates the challenge. Some of their most successful resiliency initiatives are grounded in creating a collective vision for the city's future. The Launch Vision 2100 is a citizen-led long-term planning initiative that will work with the city's Planning and Neighborhood Development departments to encourage resilient thinking in communities, map community assets, and facilitate discussions about where and how the city should make long-term investments for future growth (Norfolk Resilient City 2015).

Norfolk also plans to partner with the U.S. Army Corps of Engineers on a comprehensive flood risk study. The two organizations will conduct a comprehensive study of flooding in Norfolk beginning in 2016 with the intent of evaluating options to reduce the city's flooding risk. Additionally, the Chief Resilience Officer has recommended an ambitious plan to have Norfolk implement the most resilient zoning code in America. Starting in 2014, this project has involved the cooperation of several organizations, including Clarion Associates, the Renaissance Planning Group, Herd Planning and Design, and the City of Norfolk (Norfolk Resilient City 2015). The

new code will be a user-friendly document that incorporates current best practices, encourages resilient development, and promotes environmentally friendly development.

4.3. Hyde County, North Carolina

Hyde County in North Carolina was selected because it has several parallels to Pasquotank County. The median household incomes in Hyde and Pasquotank County are similar, about \$40,000 according to 2013 census data. They are both located at comparable elevations. Additionally, Hyde County is not located directly on the ocean but borders the Pamlico Sound similar to how Pasquotank borders the Albemarle Sound.

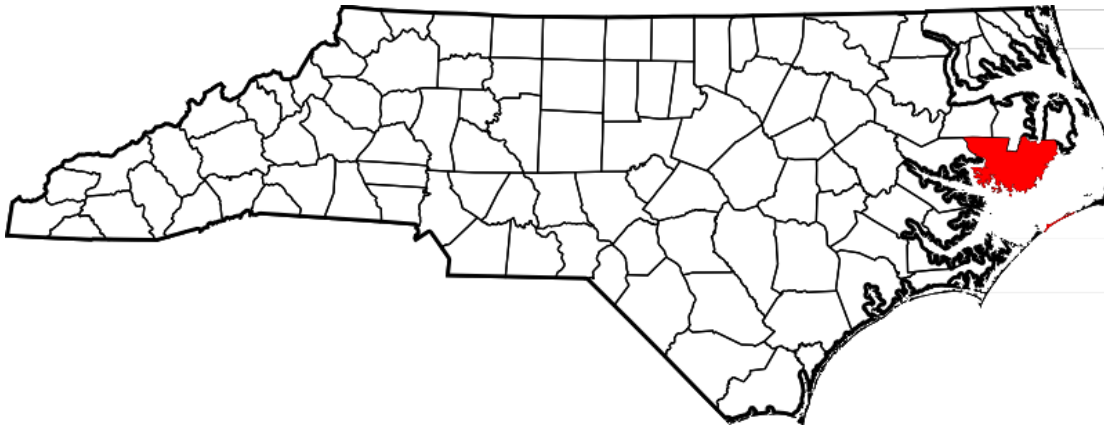


Figure 26. Hyde County, NC is located on the Pamlico Sound.

4.3.1. Current Strategies

Hyde County has several plans that address flood hazards. The *Pamlico Sound Regional Hazard Mitigation Plan* contains information pertaining specifically to Hyde County. Additionally, through a collaboration between Georgia Sea Grant, North Carolina Sea Grant, and the University of Georgia's Carl Vinson Institute of Government, the proposal *Sea Grant Climate Adaptation Initiative 2013: Comprehensive Community Resilience Planning* was developed for Hyde County and several other eligible municipalities.

4.3.2. Recommendations

Hyde County is still working with Georgia Sea Grant, North Carolina Sea Grant, and the University of Georgia to develop a comprehensive flood resilience program. They will be able to use Vulnerability Consequences and Adaptation Planning Scenarios (VCAPS) to brainstorm and adopt adaptation strategies. VCAPS works to bring together local and expert knowledge to diagram the outcomes and consequences of climate-related hazards.

A major recommendation made for Hyde County was its incorporation into the Community Rating System (CRS) (Holland Consulting Partners 2015). Through cost/benefit modeling, where reductions in damages would equate to the benefit and the dollars spent on adaptation actions are the cost, the team involved will be able to show the benefits of joining the CRS. In

the future, local planning and policy recommendations will be explicitly linked to the Community Rating System.

The final goal of the adaptation strategies that Hyde County will undertake is to make the city resilient to climate related hazards like flooding, storm surge, and sea level rise. Although it has not yet completed its flood resiliency plan, it will be a valuable resource for Pasquotank County in the future (Sea Grant 2013).

4.4. St. Marys, Georgia

St. Marys, GA was chosen as a case study for several reasons. Like Elizabeth City, it is not located directly on the ocean. St. Marys is located on the St. Marys River in Georgia. Additionally, its current population is about 17,000 people, roughly similar to Elizabeth City. St. Marys is located in rural Camden County, Georgia. Additionally, the city is located adjacent to the U.S. Navy Kings Bay Naval Submarine Base, a large military base. Elizabeth City similarly has the East Coast's largest Coast Guard base.

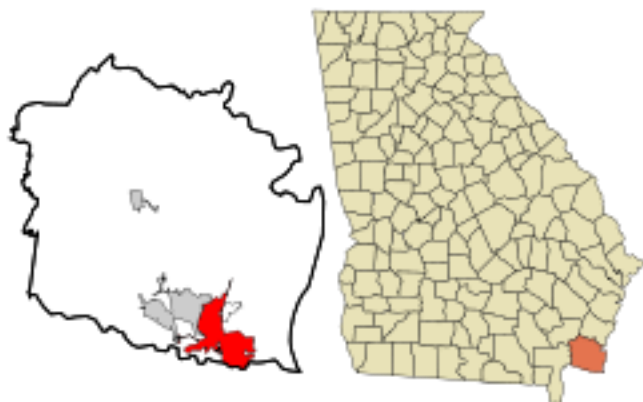


Figure 27. St. Marys, GA is located on the Southern coast of Georgia on the St. Marys River.

4.4.1. Current Strategies

St. Marys has adopted several plans. The county in which it is located created the *Camden County Hazard Mitigation Plan* (CCHMP 2009). A joint venture between Georgia Sea Grant, North Carolina Sea Grant, and the University of Georgia's Carl Vinson Institute of Government resulted in the creation of the *Sea Grant Climate Adaptation 2013: Comprehensive Community Resilience Planning*, a project proposal, and the *St. Marys, GA Flood Resiliency Plan*, the final project outcome.

4.4.2. Recommendations

Through a collaboration with North Carolina Sea Grant, Georgia Sea Grant, and the University of Georgia's Carl Vinson Institute of Government, St. Marys was able to use Vulnerability Consequences and Adaptation Planning Scenarios (VCAPS) to brainstorm and adopt adaptation strategies. VCAPS works to bring together local and expert knowledge to diagram the outcomes

and consequences of climate-related hazards. Their goal was to make the city “resilient” to climate-related hazards like flooding, storm surge and sea level rise.

A major recommendation made for St. Marys was its incorporation into the Community Rating System (CRS). Through cost-benefit modeling, where reductions in damages would equate to the benefit and the dollars spent on adaptation actions are the cost, the team involved was able to show the benefits of joining the CRS. Specifically, they chose to address the sections of the CRS related to public information, regulations, flood preparedness, and flood damage reduction. In regards to public information, the team in St. Marys chose to advise their citizens of flood hazards, flood insurance, and methods to reduce flood damage. The specific regulations put into place related to open space preservation or guaranteeing that currently vacant floodplain parcels will be kept from development (Sea Grant 2013).

Other recommendations were based on specific vulnerabilities that the city of St. Marys faces. After several focus groups and polls, the city decided to focus on the impact of episodic flood events, like heavy rainstorms and storm surge, and long-term flood events, like sea level rise, on their stormwater infrastructure, wastewater treatment structure, and private properties.

When addressing the effects of episodic flooding on stormwater infrastructure and the wastewater treatments plant, two major concerns were a decrease in water quality caused by sewage spills and power outages. A mitigation strategy to prevent sewage spills is to increase drainage capacity by regularly cleaning drainage ditches, planting more vegetation by the ditches, and using permeable pavement. These measures prevent the wastewater treatment from receiving water in excess of the amount it is capable of safely retaining. The city also decided to educate the public on the effects of littering and uncovering sewer drains, both of which can lead to clogged drainage outlets and poor drainage capacity. Several ideas were suggested for addressing potential power outages in the wastewater treatment plant. The lift station pumps could be flood-proofed. Back-up generators could be placed in strategic locations at higher elevations. The lift station pumps themselves could be raised to reduce their vulnerability to floods. Finally, it was suggested that the city could partner with the US Navy King’s Bay Naval Submarine Base to interconnect wastewater systems.

In order to manage risks to properties in St. Marys, the main causes of flooding damage were identified as being surface water runoff and wind damage. The public decided at a town hall meeting that they valued their historic properties because they increase tourism, attract potential future investors, and boost the morale of the community. Consequently, in order to protect these buildings, the building codes must be altered to allow for flood-proofing. In case any irreparable damage occurs, detailed photographs will be taken to preserve the memory of these buildings in their current state. In order to protect other properties, the town considered passing height regulations on their buildings and raising existing buildings to reduce vulnerability to floods. The town also considered beginning educational campaigns about protecting building and properties and the benefits of these measures, like lower flood insurance premiums.

4.5. Plymouth, North Carolina

Plymouth, North Carolina is similar to Elizabeth City in that it is located on the Albemarle Sound, specifically on the Roanoke River leading to the sound. Additionally, Plymouth has a similar median household income to Elizabeth City.



Figure 28. Plymouth, NC is located in Washington County, which is located on the Albemarle Sound.

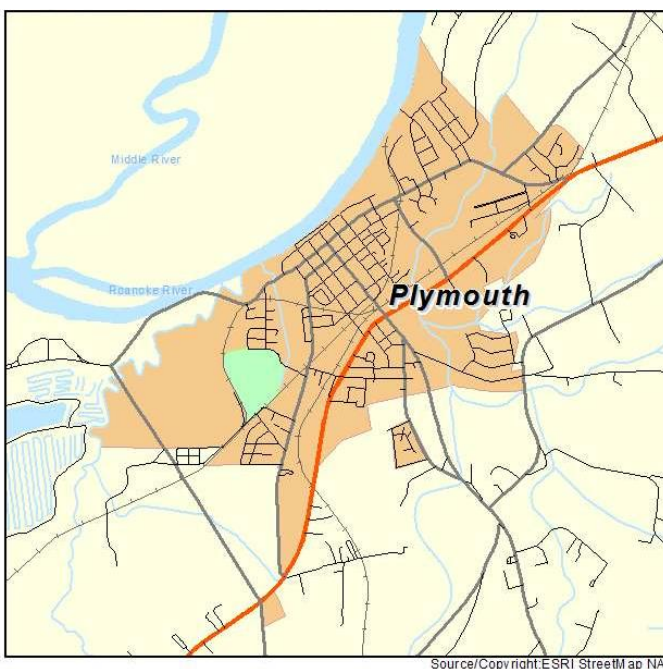


Figure 29. Plymouth, NC is located on the Roanoke River, which empties into the Albemarle Sound.

4.5.1. Current Strategies

A student group from the University of North Carolina in Chapel Hill assisted in developing the *Plymouth Vulnerability Assessment*. Additionally, a collaboration between the North Carolina

Sea Grant, East Carolina University's Renaissance Computing Institute, and the Social and Environmental Research Institute culminated in the creation of *Facing the Future in Plymouth, NC: Preparing for Increased Flood Risks*.

4.5.2. Recommendations

Local leaders in Plymouth used the Vulnerability Consequences and Adaptation Planning Scenarios (VCAPS) to brainstorm and adopt adaptation strategies. VCAPS works to bring together local and expert knowledge to diagram the outcomes and consequences of climate-related hazards like flooding, storm surge and sea level rise (Johnson 2010). Local officials decided to focus on the impact of localized flooding on the town's stormwater and wastewater collection and treatment systems.

Due to aging stormwater management infrastructure, in the past, discharges from the wastewater treatment were not up to regulatory standards. Additionally, Plymouth is especially concerned about nutrient levels in the river as they depend on fishing as a major source of tourism. Major changes in nutrient levels can lead to fish kills. In order to address these concerns, the town pinpointed weaknesses in their existing systems. They noted that during flood events, accessing the water treatment plant and pumping stations would be difficult. While no specific mitigation strategies were suggested for this issue, roads to these plants could be elevated. There was also concern about inflow and infiltration into the wastewater treatment system. In other words, the increase in groundwater table heights would prevent sewage from draining properly, creating a possible public health hazard and property damage. Additionally, if pumping stations received too large a volume of water, there would be increase wear and tear on the system, electricity costs, and labor costs. In order to mitigate this threat, it was proposed that the local government educate the public about the disposal of fats and grease through the sewer system and the importance of using grease traps in order to reduce unnecessary wear and tear on sewer lines. Additionally, it was suggested that while current infrastructure should be properly maintained, a certain amount of money should be regularly set aside so that in the future, the government could move beyond doing point repairs.

Other possible effects of flooding that were mentioned were the risks associated with standing water and changes in nutrient levels in the river. Bodies of standing water can become breeding grounds for mosquitos. A possible mitigation strategy for this issue is an educational campaign about eliminating standing water or spraying these bodies of water with pesticides (Covi 2012).

5. MITIGATION STRATEGIES

The following subsections of our report contain a host of recommendations for mitigating and reducing the hazards of flooding and sea level rise. We compiled these strategies after analyzing the specific vulnerabilities of Pasquotank County and Elizabeth City. We also studied communities in similar situations to Pasquotank County and Elizabeth City in order to see what others are doing to address the issue of sea level rise and an increase in flood risk (for further information, refer to Section 4. Case Studies). Several hazard mitigation and sea level rise experts offered advice and recommendations, as well. (For a list of names, see the Acknowledgements section).

Our strongest recommendation is that both Pasquotank County and Elizabeth City participate in the Community Rating System (CRS), which is explained in section 5.1. Additional strategies can be found in sections 5.2 through 5.5. We have included very broad cost estimates for each strategy. Our methodology for these cost estimates is included in Appendix D. *Table 2* is a summary of potential mitigation strategies. In order to learn more about a specific strategy, refer to its corresponding section in the report.

Primary Strategy: Participation in the Community Rating System (Section 5.1)		
Additional Strategies		
Low Cost	Medium Cost	High Cost
5.3.1. Creating a Flood Awareness Focus Group	5.4.2. Maintenance of existing drainage systems	5.4.3. Elevate vulnerable roads
5.3.2. Advising local homeowners on how to prevent flood damage.	5.3.3. Creating and posting signs and markers that show the height of previous flooding, storm surge events, and projected sea level rise as well as signs that warn drivers of roads vulnerable to flooding.	5.4.4. Elevation of existing public and private buildings in flood-prone areas.
5.2.3. Revision of zoning and subdivision ordinances to increase lot sizes in areas with poor soils		5.4.1. Establishment of parks in frequently flooded areas.
5.2.2. Revision of zoning ordinances to include regulations for underground chemical and gasoline storage		5.4.6 Construction of levees (not recommended)
5.2.1. Revision of buildings codes for new developments to include a heightened freeboard relative to previous requirements		5.4.5. Construction of living shorelines
5.2.4. Limit development in flood-prone areas.		
5.2.5. Increase setback requirements		
5.2.6. Identify potential homes for buyout		
5.3.4. Reverse-911		

Table 2. Potential mitigation strategies for Pasquotank County and Elizabeth City. The primary strategy, CRS, is listed at the top. Other strategies are categorized based on estimated cost in no particular order.

5.1. Community Rating System

Our first and strongest recommendation is the adoption of the Community Rating System, a system under which members of a community receive reduced National Flood Insurance Program (NFIP) premiums in exchange for the adoption of flood mitigation strategies that go beyond the minimum required under the NFIP (FEMA 2015). For more information on the NFIP see Appendix E.

The Community Rating System operates on a basic point scaling system. By engaging in any of the nineteen activity categories outlined by the CRS, communities will be given an overall “credit points” score (FEMA 2015). Activities that can contribute points come in a wide variety, ranging from making public information available on a website to more physical strategies like flood-proofing buildings. The score then determines the discounted rate your community will receive on all NFIP flood insurance premiums. *Table 3* below shows the different rate classes and their points required, as well as the discounts given for each class.

Community Rating System Rate Class Requirements and Discounts			
Rate Class	SFHA* Discounts	Non-SFHA* Discounts	Credit Points Required
1	45%	10%	4,500 +
2	40%	10%	4,000 – 4,499
3	35%	10%	3,500 – 3,999
4	30%	10%	3,000 – 3,499
5	25%	10%	2,500 – 2,999
6	20%	10%	2,000 – 2,499
7	15%	5%	1,500 – 1,999
8	10%	5%	1,000 – 1,499
9	5%	5%	500 - 999
10	0%	0%	0 - 499

Table 3. “How Much Discount Property Owners In Your Community Can Get” (FEMA 2015).

*Special Flood Hazard Area

** Preferred Risk Policies are available only in B,C, and X Zones for properties that are shown to have a minimal risk of flood damage. The Preferred Risk Policy does not receive premium rate credits under the CRS because it already has a lower premium than other policies. Although they are in SFHAs, Zones AR and A99 are limited to a 5% discount. Premium reductions are subject to change.

The Community Rating System is unique among mitigation strategies in that, for Pasquotank County and Elizabeth City, engaging in participation is not only low-cost, but will actually result in a net gain in savings for the area. Because of this, 37 out of the 51 largest NFIP communities in North Carolina already participate in the Community Rating System, including Currituck County, Dare County, and Morehead City.

We estimate that upon initial entrance to the CRS, Pasquotank County and Elizabeth City are likely to fall into either Class 9 or Class 8, resulting in 5% or 10% insurance premium reductions respectively. Admission into the CRS under these two classes would save a significant amount of money for residents. For policies held in Elizabeth City, the total amount spent on flood insurance premiums could be reduced by \$48,339 under a Class 9 designation, or by \$96,678

under a Class 8 designation. Pasquotank County homeowners would see similarly large savings, amounting to \$36,267 under a Class 9 designation, or \$72,534 under a Class 8 designation. For the total premium reduction in Pasquotank County (including Elizabeth City), savings are estimated to be around \$84,606 under Class 9 or \$169,212 under a Class 8 designation. This information is summarized in *Table 4* below.

Pasquotank County CRS Discounts			
	Pasquotank County	Elizabeth City	Both Pasquotank County and Elizabeth City
CRS Class 9	\$36,267	\$48,339	\$84,606
CRS Class 8	\$72,534	\$96,678	\$169,212

Table 4. This table shows the projected annual savings for NFIP flood insurance policy holders in Pasquotank County and Elizabeth City.

The county is already performing several activities that will earn CRS points. These are shown in *Table 5* and described in Appendix F. Our three additional activity recommendations for reaching a Class 9 CRS rating are: 330 (Outreach Projects), 350 (Flood Protection Information), and 540 (Drainage System Maintenance). By our estimates, the implementation of these three activities along with the seven activities already being carried out by Pasquotank County will secure a Class 9 classification in the Community Rating System. *Table 5* summarizes the specific activity recommendations and their corresponding point estimates.

Recommended Activities for Class 9 Certification			
Activity #	Estimated Points	Morehead City Points	Cost Indication (Free, Low, Med, High)
310 Elevation Certificates	~46-56	56	Already Implemented
320 Map Information Service	~60-140	140	Already Implemented
340 Hazard Disclosure	~10-15	10	Already Implemented
360 Flood Protection Assistance	~50	0	Already Implemented
440 Flood Data Maintenance	~50-90	86	Already Implemented
450 Storm-Water Management	~30-120	33	Already Implemented
630 Dam Safety	~58	58	Already Implemented
No-Cost Points:	~304 – 529		
330 Outreach Projects	~100-200	212	Low Cost
350 Flood Protection Information	~40-60	56	Low Cost
540 Drainage System Maintenance	~100-170	170	Medium Cost
Total:	~544 – 959	821	

Table 5. Activities that we recommend Pasquotank County do in order to reach Class 9 Certification. The Estimated Points column gives a range of possible point values the county might earn for performing each activity. The Morehead City Points column indicates how many points Morehead City earned for implementing each strategy.

Achieving a Class 8 CRS ranking for Pasquotank County will prove to be a higher-cost endeavor that may take several years to achieve, but will result in doubling the annual savings for NFIP flood insurance policy-owners. *Table 6* below includes a summary of recommendations for Pasquotank County should the county decide to pursue a Class 8 Certification. Strategies such as a flood warning system and higher regulatory standards should be noted for their flood hazard mitigation benefits. For a detailed explanation of our recommendations, see Appendix F.

Recommended Activities for Class 8 Certification			
Activity #	Estimated Points	Morehead City Points	Cost Indication (Free, Low, Med, High)
410 Additional Flood Data	~10-60	11	Low
420 Open Space Preservation	~40-150	48	Medium
430 Higher Regulatory Standards	~120-215	165	Medium
510 Floodplain Management Planning	~70-125	99	Medium
610 Flood Warning Program	~40-140	60	Medium
530 Flood Protection	~60-160	0	High
Total Class 8:	~340-850	383	
Grand Total (Class 9 & Class 8):	~884-1809	1204	

Table 6. Activities that we recommend Pasquotank County do in order to reach Class 9 Certification. The Estimated Points column gives a range of possible point values the county might earn for performing each activity. The Morehead City Points column indicates how many points Morehead City earned for implementing each strategy. The Grand Total row is of most importance to the county: the county will need 1,000 total points to reach Class 8 certification.

When estimating points, we rarely exceeded the average points per activity, a value provided by the National Flood Insurance Program. The range of our point estimation is quite wide; where the low-bounded number can be seen as an underestimation, with the high-bounded number likewise, an overestimation. Lastly, we would like to mention that expanding the efforts of an activity will increase the amount of points given.

To conclude, the Community Rating System will not be a comprehensive solution in the short term, but rather is an excellent way to open the door to flood mitigation strategies while saving money for the community at the same time. The savings acquired by participating in the CRS provide a strong incentive for initial involvement, while also consolidating an important framework of mitigation strategies that will ease the implementation of long-term strategies. To enter the Community Rating System, communities first appoint a CRS coordinator to handle the application and serve as a primary contact with FEMA. From there, the CRS coordinator will receive a CRS Application, containing “all necessary instructions and procedures” for applying (FEMA 2015). After applying, the community’s CRS coordinator will be in contact with the state’s ISO/CRS Specialist, who outlines point delegation for strategies implemented and collaborates with the community on working towards obtaining the insurance discounts.

5.2. Revise Local Codes and Ordinances

5.2.1. Revision of buildings codes for new developments to include a heightened freeboard relative to previous requirements

Description: This strategy would decrease economic and property losses due to flooding in new developments. As these buildings have not yet been constructed, the incremental costs to build a heightened freeboard are minimal.

For example, Norfolk, Virginia recommended that citizens elevate their homes to three feet above the current standard to account for potential sea level and subsidence of the city. While it is costly to elevate existing buildings, the *Coastal Sensitivity Guide* states that "...building a new house on pilings one meter higher only increases construction cost by about one percent" (CCSP 2009).

For Pasquotank County, the new freeboard requirement could vary across the county, based on the risk of sea level rise and flooding. Refer Section 3 for specific portions of the county that are especially vulnerable to sea level rise and consequently should have higher freeboard requirements.

Relation to the Community Rating System (CRS): This action would earn Pasquotank County points in the CRS through Activity 430: Higher Regulatory Standards.

Cost estimate: Low cost

5.2.2. Revision of zoning ordinances to include regulations for underground chemical and gasoline storage

Description: This recommendation was listed in the 2005 Hazard Mitigation Plan as a suggested mitigation measure to protect groundwater resources. By regulating the underground storage of possible hazardous chemicals, both Elizabeth City and Pasquotank County as a whole can ensure that their groundwater remains uncontaminated by any accidental spills.

Cost estimate: Low cost

5.2.3. Revision of zoning and subdivision ordinances to increase lot sizes in low-lying areas and in areas with poor soils

Description: This recommendation was listed in the 2005 Hazard Mitigation Plan as a recommended mitigation measure to minimize the economic and property losses due to flooding. Since flooding worsens when soils cannot adequately absorb water, it is recommended that development not occur on lands with poor soils. By having low-density developments and increasing the sizes of lots within subdivisions, there will be more soil in which flood water can absorb thus decreasing damage to nearby properties.

Relation to the Community Rating System (CRS): This action would earn points in the CRS through Activity 450: Stormwater Management and Activity 430 High Regulatory Standards.

Cost estimate: Low cost

5.2.4. Limit development in flood-prone areas

Description: According to Pasquotank County's 2010 Hazard Mitigation Plan, filling and construction is prohibited within the floodway and non-encroachment zones. We recommend that the county continue to ensure that this requirement is enforced. As the floodway and non-encroachment zones expand under new FEMA maps in the future, it is important to ensure that new development is not allowed to occur in these areas. Furthermore, the county should consider efforts to limit development in places that are particularly vulnerable to inundation due to sea level rise over the next century. While the county cannot completely prevent private property owners from building on their property, the county can attempt to limit the scale of development projects and encourage developers to preserve the natural environment. The county can also increase lot size, as suggested in Section 5.2.3 above, and increase setback requirements, as suggested in Section 5.2.5 below. Ensuring that flood-prone areas are not zoned for commercial or industrial use is also very important.

For example, the southern part of the county is particularly vulnerable to sea level rise. Currently, this land is used for agriculture, but as water levels rise, much of it will be submerged. This is depicted in *Figure 23*. As the area becomes inundated and wetlands form, it will be important for the county to limit future development there in order to slow erosion and protect the land.

Relation to the Community Rating System (CRS): This strategy can contribute to Activity 430 Open Higher Regulatory Standards and to Activity 420 Open Space Preservation. For example, Morehead City has received 48 CRS points for preserving approximately 22 acres in the SFHA as open space.

Cost estimate: Low cost

5.2.5. Increase setback requirements

Description: The 2010 Pasquotank County Multi-Jurisdictional Hazard Mitigation Plan states that the county currently requires a 30 foot undisturbed vegetative buffer adjacent to all watercourses, water bodies, or wetlands. In addition no filling or construction within the floodway or non-encroachment zones is allowed (PCMJHMP, 2010). This setback requirement is important in that it prevents people from investing in development in flood-prone areas, areas where their investments could easily be washed away.

We believe that it is important to increase this setback requirement in low-lying areas. As areas close to bodies of water are prone to flooding, this vulnerability increases greatly if this area is low-lying. Flood waters can cover distances greater than 30 feet in lower elevated areas. For this

reason, it is important that setback requirements be revised and increased for low-lying areas in order to prevent property damage.

Relation to the Community Rating System (CRS): This action may earn points through Activity 430: Higher Regulatory Standards. We recommend that governmental officials consult with the state ISO/CRS specialist for this strategy.

Cost estimate: Low cost

5.2.6. Identify potential homes for buyout

Description: The county should identify homes in vulnerable areas for buyout when federal funds make themselves available under the Hazard Mitigation Grant Program (HMGP) or the Flood Mitigation Assistance Program. Buying out homes using grant money will prevent people from being displaced due to sea level rise and coastal storms and will limit the amount of damage.

Relation to the Community Rating System (CRS): The strategy could potentially apply to Activity 520 Acquisition and Relocation.

Cost estimate: Low cost (with grant funding)

5.3. Communication Strategies

5.3.1. Community Flood Awareness Forum

Description: A Community Flood Awareness Forum would regularly bring together local citizens, governmental officials, and experts on sea level rise and flood mitigation strategies to evaluate the current opinion of the public on flood-related issues and discuss possible strategies to address any concerns. This collaborative effort is a catalyst for the exchange of information and ideas, and for problem solving. Additionally, a regular open forum raises and maintains public interest in flood-related issues and sea level rise.

Several groups have created similar task forces in order to combine expert and local knowledge and thoroughly address the issue of flooding in coastal communities. The City of Norfolk, Virginia regularly meets with its citizens to discuss flood related issues. Additionally, the City of Beaufort and the Town of Port Royal have a Sea Level Rise Task Force to encourage their citizens to take action at the local level. For more information, go to <https://bprsealevelrise.wordpress.com/>. North Carolina Sea Grant, Georgia Sea Grant, and the University of Georgia Carl Vinson Institute of Government work together to use the Vulnerability Consequences and Adaptation Planning Scenarios (VCAPS) to create flood resiliencies plans for their partner cities. Holding regular town-hall style meetings with locals allows for citizen-input into flood hazard mitigation strategies. See the case studies section above for further details.

Cost estimate: Low cost

Sources of Funding: Funding and guidance for these sessions can come from North Carolina Sea Grant. If there is sufficient interest in creating comprehensive flood resiliency plans, Dr. Jessica Whitehead, a Coastal Communities Hazards Adaptation Specialist from North Carolina Sea Grant. She can be contacted at j_whitehead@ncsu.edu.

5.3.2. Advising local homeowners and business owners on how to prevent flood damage

Description: It is important that citizens be empowered with the knowledge to protect their property from flood damage. Flood-safety information can be compiled from a variety of reputable organizations like the National Oceanic and Atmospheric Administration (www.floodsafety.noaa.gov) or the Red Cross (www.redcross.org/prepare/disaster/flood) and made available to homeowners and business owners. This information can be displayed on both Elizabeth City and Pasquotank County's respective websites and in other areas, such as the library, so that the public has easy access to this information.

An example of this type of display of flood damage prevention information can be found on the city of Norfolk's website: www.norfolk.gov/index.aspx?NID=1061.

We have also created a brochure that the county could print for citizens and display on the county website. That brochure located in Appendix H.

Relation to the Community Rating System (CRS): This strategy can contribute to Activity 350: Flood Protection Information and Activity 360: Flood Protection Assistance of the CRS.

Cost estimate: Low cost

5.3.3. Creation of signage.

Description: Signs can be created to be placed in frequently flooded areas to warn drivers of any possible risks during storms. Additionally, markers can be placed around the county and/or the city to show flood levels from previous storms. These markers can also show projected levels of sea level rise in order to raise awareness in the community.

Cost estimate: Medium cost

5.3.4. Reverse-911

Description: In the event of a natural hazard, a Reverse-911 system allows residents to be promptly alerted via text message. A Reverse-911 system would entail preparing messages to release to residents before and after the natural hazard. The initiative would be headed by emergency management. AtHoc is the recommended operator for the Reverse-911 system.

Relation to the Community Rating System (CRS): This action would earn points for Pasquotank County under Activity 610: Flood Warning and Response.

Cost estimate: Low

Sources of Funding: Staff time

5.4. Physical Mitigation Strategies

5.4.1. Establishment of parks in frequently flooded areas

Description: Parks can range from a small area containing a playground and picnic table to large swathes of natural space that contains hiking paths or areas for fishing. The establishment of parks in frequently flooded areas not only prevents the construction of residential housing or vital infrastructure in flood-prone areas, but also can serve as buffers to protect already existing buildings. These parks can also help preserve the wetlands habitats that are unique to the area. Wetlands are particularly useful to communities like those found in Pasquotank County and Elizabeth City because they assist in preventing flooding. These new parks could also increase tourism in the area and in Elizabeth City and the county as a whole.

Relation to the Community Rating System (CRS): The creation of parks could contribute to the amount of land that qualifies for the Open Space Preservation section of the CRS (Activity 420).

Cost estimate: High cost

Sources of Funding: The North Carolina Department of Environment and Natural Resources: Parks and Recreation Trust Fund provided dollar-for-dollar matching grants for local governments to acquire land and develop a park or recreational project to serve the general public. For more information, visit the North Carolina State Park's website page, 'Parks and Recreation Trust Fund' (<http://www.ncparks.gov/more-about-us/parks-recreation-trust-fund>). Additionally, the National Coastal Wetlands Conservation Grant Program, run through the federal Department of the Interior, provides grants to acquire, restore, and enhance wetlands. For more information, visit the U.S. Fish & Wildlife Service's Website (https://www.fws.gov/coastal/CoastalGrants/pdfs/2016NCWCGP_NOFO.pdf).

Finally, this strategy may qualify for the Flood Mitigation Assistance Grant from the Federal Emergency Management Agency (FEMA). This grant provides funding for projects that reduce or eliminate long-term risk of flood damage to structures insured under the National Flood Insurance Program (NFIP). For more information, go to FEMA's website (<https://www.fema.gov/flood-mitigation-assistance-grant-program>).

5.4.2. Maintenance of the existing drainage system

Description: This type of maintenance would include regular inspections of drainage ditches and other drainage infrastructure to ensure there is nothing obstructing the flow of stormwater. The issue of decreased drainage capacity due to infrequent maintenance was identified in the *2004 Advanced Core Land Use Plan for Pasquotank County and Elizabeth City*. Regular maintenance would reduce the harmful effects of flooding on public and private properties by increasing the drainage capacity of the existing infrastructure. The City of St. Marys, Georgia recommended

that its drainage infrastructure be regularly inspected and cleared of debris in order to protect its citizens from the harms of flooding (Alfonso et al. 2014). In general, it is less expensive to clean a ditch than to pay for the damages caused by flooding that could have been prevented with maintenance of existing infrastructure.

Relation to the Community Rating System (CRS): This action would qualify for points under Activity 540: Drainage System Maintenance of the Community Rating System.

Cost estimate: Medium cost. However, it is worth noting that retrofitting or rebuilding a drainage system can cost 10 to 20 times as much as including larger pipes in the initial construction. Thus, it is advised that any new constructions include larger pipes or ditches in the initial construction.

Sources of Funding: This strategy may qualify for the Flood Mitigation Assistance Grant from the Federal Emergency Management Agency (FEMA). This grant provides funding for projects that reduce or eliminate long-term risk of flood damage to structures insured under the National Flood Insurance Program (NFIP). For more information, visit FEMA's website (<https://www.fema.gov/flood-mitigation-assistance-grant-program>).

5.4.3. Elevate vulnerable roads

Description: Knobbs Creek Drive which leads to the Rogerson Wastewater Treatment Facility, the wastewater treatment plant for Elizabeth City, has been identified as being vulnerable to flooding and sea level rise. Inundation of this road would prevent maintenance workers from accessing the facility during times when it is most vulnerable to damage and accidental spills. These spills can contaminate surface waters and lead to fines from the federal government. Elevating this road to several feet above expected flood height levels will ensure that workers will be able to access this vital piece of infrastructure at all times.

The roads in Bray's estates could also be elevated so that properties could still be accessible by vehicle in the future. However, raising the height of the roads in Bray's Estates would cause additional flooding problems. While the roads would be less susceptible to flooding, floodwaters would be displaced into people's yards and homes that would be lower than the elevated roads.

Additionally, the portion of Creek Road around Matthews Acres and the bridge could be raised to guard against the possibility of being inundated.

Cost estimate: High cost. However, cost can be minimized if roads are rebuilt several feet higher during routine reconstruction.

Sources of Funding: The Rural Grant Program through the North Carolina Department of Commerce is a possible source of funding. More information can be found on the North Carolina Department of Commerce's website (<http://www.nccommerce.com/ruraldevelopment/rural-grants-programs>). Additionally, a Technical Assistance Grant (TAG) from the North Carolina Department of Environmental Quality Division of Water Infrastructure could contribute to the elevation of this road. For more information on TAGs, visit the website for North Carolina's Division of Water Infrastructure (<http://portal.ncdenr.org/web/wi/sgp>).

5.4.4. Elevate existing public and private buildings in flood-prone areas

Description: Buildings that are currently located in flood-prone areas are especially vulnerable to frequent flood damage. Thus, while it is costly, it may be prudent to elevate these buildings to minimize economic and property damage over the long term. Doors, windows and walls can be flood-proofed if it is not possible to elevate the home.

Relation to the Community Rating System (CRS): This strategy would earn points for Pasquotank County through the CRS under Activity 530: Flood Protection.

Cost estimate: High cost

Sources of Funding: The United States Department of Agriculture runs the Rural Development Housing Program. This program provides loans and grants to not only assist rural Americans buy housing but also make health and safety repairs. For more information, visit the U.S. Department of Agriculture's Rural Development webpage (<http://www.rd.usda.gov/about-rd/agencies/rural-housing-service>).

This strategy may qualify for the Flood Mitigation Assistance Grant from the Federal Emergency Management Agency (FEMA). This grant provides funding for projects that reduce or eliminate long-term risk of flood damage to structures insured under the National Flood Insurance Program (NFIP). For more information, visit FEMA's website (<https://www.fema.gov/flood-mitigation-assistance-grant-program>).

5.4.5. Construct living shorelines

Description: Living shorelines use natural elements like wetland plants, submerged aquatic vegetation, coir fiber logs, sand fill, and stone to absorb wave energy and protect against shoreline erosion. Not only do living shorelines stabilize vulnerable shores, they protect the surrounding riparian and intertidal environment, provide a filtration system for upland water runoff thus improving water quality, and enhance breeding and feeding habitats for local fish and other aquatic life (NOAA 2015).

Unlike hard structures such as bulkheads and seawalls, which do not allow the vertical accretion of sediment on shorelines, living shorelines slow erosion by weakening wave action and providing a buffer for wetlands to either vertically accumulate sediment (vertical accretion) or retreat (horizontal relocation). Vertical accretion of sediment along shorelines allows wetlands to keep pace with sea level rise (PDE 2012).

Living shorelines are not simply natural shorelines, however. Living shorelines are specifically engineered to control erosion and particular plants and vegetation are chosen for their ability to absorb wave energy (PDE 2012). A report titled *New Jersey Living Shoreline Possibilities* prepared by the Partnership for the Delaware Estuary contains much more information about living shorelines. That report can be found here:

<https://s3.amazonaws.com/delawareestuary/pdf/Living+Shorelines/Dodge+Final+Report.pdf>.

Relation to the Community Rating System (CRS): This action may contribute to the CRS through Activity 420: Open Space Preservation and Activity 430: Higher Regulatory Standards. We recommend that governmental officials consult with the state ISO/CRS specialist for this strategy.

Cost estimate: High cost

Sources of Funding: This strategy may qualify for the Flood Mitigation Assistance Grant from the Federal Emergency Management Agency (FEMA). This grant provides funding for projects that reduce or eliminate long-term risk of flood damage to structures insured under the National Flood Insurance Program (NFIP). For more information, visit FEMA’s website (<https://www.fema.gov/flood-mitigation-assistance-grant-program>).

5.4.6. Construct levees

Description: A levee is a constructed, earthen wall that runs parallel to rivers or coastline. Levees can protect communities from storm flooding and, in the case of the levee system of Netherlands, can even reclaim land that was once several feet underwater.

While levees are a possible strategy, our group **strongly recommends against** them. Levees encourage a false sense of security and entice people to develop close to them. However, levees can fail, with devastating consequences. For example, in 1999, Princeville, North Carolina was hit by Hurricane Floyd. This storm caused the Tar River to swell, breaching the levees and flooding the town for nearly two weeks as the levee prevented the stormwater from draining (“History of Princeville, North Carolina”). Again, while levees are a potential strategy for addressing flood hazards, we caution against them.

Cost estimate: High cost

5.5. Long-term monitoring and planning

As a final recommendation, we encourage the county to begin routinely monitoring signs of sea level rise and staying up to date with research and publications on sea level rise and climate change. Changes in flooding patterns, including more frequent flooding, higher flood levels, floods in historically dry, well-drained areas, etc. are potential indicators of rising sea levels. The IPCC is an international authority on climate change that assesses the available information about climate change, giving priority to peer-reviewed literature, and prepares comprehensive assessment reports on the latest climate science. We used information from the most recent IPCC report, Assessment Report 5, which was published in 2014, in our research. However, when the next report is released, the county should pay special attention and use the findings to update the projections given in our report. Additionally, the North Carolina Coastal Resources Commission Science Panel will conduct a reassessment of sea level rise in North Carolina every five years. The next update should occur in 2020, and it will be important to use this report as a guide because it is specific to North Carolina. Climate Central is also a reliable source of information that the county should take advantage of. Revising the sea level

rise projections for the county at least every five years will give the county its best chance to mitigate against future effects.

6. CONCLUSION

Pasquotank County is vulnerable to sea level rise over the next century and beyond. While the areas projected to be permanently inundated are limited to certain parts of the county, particularly the southern portion, the entire county will experience increased flooding risks.

In this report, we have presented a wide array of potential mitigation strategies that Pasquotank County should consider adopting. These mitigation strategies range from policy options to communication efforts to physical projects. Our main recommendation is that the county participate in the Community Rating System (CRS). This program will reward the county's residents for actions taken by the county to mitigate against flooding and sea level rise.

It is our hope that county officials will use the findings of this report to make informed policy decisions. At the very least, the vulnerability assessment of our report should provide county leaders with a better understanding of how sea level rise is likely affect the county over the next several decades. The case studies and mitigation strategies in our report give policymakers relevant information about what other places are doing to guard against sea level rise and potential options to consider implementing in Pasquotank County.

We appreciate the opportunity to conduct this assessment on Pasquotank County, and we hope that the results of our study can be used to the betterment of the county in the future.

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APPENDIX A. SEA LEVEL RISE PROJECTION DATA

Year	Historic Trend	Low	Medium	High
2020	0.16	0.19	0.25	0.33
2030	0.36	0.44	0.62	0.82
2040	0.56	0.71	1.04	1.43
2050	0.76	1.00	1.52	2.13
2060	0.96	1.30	2.06	2.94
2070	1.16	1.62	2.66	3.85
2080	1.36	1.96	3.31	4.86
2090	1.55	2.32	4.02	5.97
2100	1.75	2.70	4.79	7.18

Table 7. Local sea level rise projections at Chesapeake Bay Bridge Tunnel, VA (Climate Central 2014).

APPENDIX B. MAPPING METHODOLOGY

The GIS layers of sea level rise we used to create our maps came from the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center (2014a). This data from NOAA contains seven layers: a baseline layer for the current water level and then six layers for sea level rise in one foot increments (one to six feet) above the local high tide line called Mean Higher High Water (MHHW). NOAA used a modified bathtub approach modeling hydraulic connectivity and locally adjusted MHHW levels to create its inundation model. The first step is to add the desired sea level rise amount to the current tidal surface elevation, for which NOAA has data. Then the elevation values were subtracted from the new water surface to derive the inundation depth grid. Several more steps were taken to evaluate and analyze the data. For more information about how NOAA's model was created, see https://coast.noaa.gov/slr/assets/pdfs/Inundation_Methods.pdf and https://coast.noaa.gov/digitalcoast/_pdf/SLRViewerFAQ.pdf. To view the model and explore sea level rise scenarios online, visit NOAA's Digital Coast Sea Level Rise and Coastal Flooding Impacts Viewer at <https://coast.noaa.gov/slr/>.

We have attempted to compile a comprehensive list of locations that will be at least partially submerged by each additional foot of sea level rise. While we made every effort to include every location affected, we undoubtedly missed some. Therefore, use this list only as a guide.

APPENDIX C. COMPREHENSIVE LIST OF IMPACTED LOCATIONS

We have attempted to compile a comprehensive list of locations that will be at least partially submerged by each additional foot of sea level rise. While we made every effort to include every location affected, we undoubtedly missed some. Therefore, use this list only as a guide.

One foot SLR (expected by 2050):

- Wastewater treatment plant accessibility (FID 88 in critical_facilities)
- Pumping Station (FID 80 in critical_facilities)
- St. James AME Zion Church (FID 101 in EC_Businesses)
- Grouper's Restaurant (FID 28 in EC_Businesses)
- Pump Station on Grace Drive (FID 85 in critical_facilities)
- Symonds Creek Boat Dock (FID 74 in critical_facilities)
- Hobbs Landing Boat Dock (FID 76 in critical_facilities)
- Wildlife Boat Dock (FID 75 in critical_facilities)
- Frog Island Marina (FID 73 in critical_facilities)
- Bethel AME Zion Church (FID 100 in EC_Businesses)
- Parts of Ward Street
- Creek Road around bridge
- Part of Eagle Lane in Matthews Acres
- Telephone 330 Exchange (FID 105 in critical_facilities)
- Utilities NC Power (FID 101 in critical_facilities)
- Parts of S Martin L King Drive, Cale Street, and Herrington Road
- Part of Southern Avenue
- Dawson Street

Two feet SLR (expected between 2060 and 2080):

- Wades Point Cell Tower (FID 27 in critical_facilities)
- New Salem Baptist Church (FID 115 in EC_Businesses)
- Pump Station on Church Street Extended (FID 81 in critical_facilities)
- Pump Station on Grice Street (FID 84 in critical_facilities)
- Pump Station (Harbor Place) (FID 87 in critical_facilities)
- Elizabeth Street from Water Street to tennis courts
- Former White & Brite's Grocery (FID 213 in EC_Businesses)
- Pump Station on Glade Street (FID 82 in critical_facilities)
- Eastern Star Church (FID 176 in EC_Businesses)
- Daily Advance
- Chamber of Commerce
- Pump Station Raw Water Intake (FID 91 in critical_facilities)
- Part of Broad Street
- Creek Road south of Matthews Acres
- Albemarle Electric (FID 102 in critical_facilities)
- Weeksville Volunteer Fire Department (FID 29 in critical_facilities)
- Newbegun Methodist Church (FID 162 in EC_Businesses)
- Parts of Newbegun (Small Drive)
- Coastal Office Equipment
- Flora Avenue
- Shepard Street
- Boston Avenue

Three feet SLR (expected no later than 2100):

- Parts of Church Street Extended
- Pump Station on Water Street (FID 83 in critical_facilities)
- Fire Station #2, 410 Harney Street (FID 7 in EC_CriticalFacilities)
- Clary's Grocery (FID 200 in EC_Businesses)
- Eastern Star Church of God in Christ, 403 Factory Street (FID 24 in EC_Churches)
- Quality Seafood (FID 32 in EC_Businesses)
- Part of Museum of the Albemarle
- New Life Church (FID 175 in EC_Businesses)
- Parts of Road Street between Broad Street and Queen Street
- Faithway Apostolic Church, 304 Bell Street (FID 0 in EC_Churches)
- Part of Broad Street
- Most of Fifth, Walnut, Fourth, Third, and Chesson Streets
- Nearly all of Ward Street
- Around Trade Mart (next to Todd's Northside) (FID 72 in EC_Businesses)
- Around Knobbs Creek Utility Station (FID 69 in critical_facilities)
- Part of the Pines golf course
- Part of Creek Road
- Part of Main Street Extended
- Part of Jessup Street
- Houses on Glendale Avenue, Casey Street (off of Main Street Extended)
- Parts of Scott Road, Lindsay Court, Elbert Drive, Ricochet Court (Bray's Estates)
- Colonial Cleaners
- Possibly Weeksville Elementary School (FID 27 in critical_facilities)
- Esclip Radio Tower (FID 128 in critical_facilities)
- Parts of Newbegun
- VFD Soundneck Substation
- Esclip Water Tower (FID 103 in critical_facilities)
- Leigh Farm Road
- Plant Park (across from Sandwich Market)
- Parts of Roanoke Avenue
- Part of Tatem Lane
- Tuscarora Avenue, Bartlett Avenue, Robbins Avenue
- Some waterfront homes on Riverside Avenue

Four feet SLR (possible by 2100):

- Bray's Estates (entire subdivision)
- Most of Matthews Acres
- Creek Road around Matthews Acres
- Scott Cell Tower off of Scott Road (FID 126 in critical_facilities)
- N Road Street between Ward Street and Queen Street
- Hyman Cir., Walnut Street, E Broad Street, Ward Street, Sixth Street, Fifth St, Willow Street, Fourth Street, Third Street, Chesson Street, and Second Street
- Continental Plaza Condominiums (condos behind MACU)

- Potentially MACU dormitories
- W Broad St., Bell, Sawyer, Greenleaf, Grady, Harney, Cypress, Burgess, Factory, Richardson, Anderson, Fleetwood, and Parsonage Streets
- EIC Headstart (FID 312 in EC_Businesses)
- Salvation Army (FID 19 in critical_facilities)
- Tennis courts on corner of Harney and Elizabeth Streets
- Cedar Street
- Former City Wine Cellar (FID 51 in EC_Businesses)
- Cypress Creek Grill
- Special Needs Pasquotank Health (behind tennis courts) (FID 57 in critical_facilities)
- Christ Episcopal Church (FID 155 in EC_Businesses)
- Mamasitas (FID 23 in EC_Businesses)
- Church of Jesus Christ of Latter Day Saints (FID 152 in EC_Businesses and FID 22 in EC_Churches)
- Fitness Warehouse
- Museum of the Albemarle
- White Street
- Tatem Lane
- Edge Street
- Washington Street and Laurel Avenue
- Tuscarora Avenue and Bartlett Avenue
- All waterfront properties on Riverside Avenue
- Southern Avenue
- Flooding around J.C. Sawyer Elementary School (FID 65 in critical_facilities)

APPENDIX D. CATEGORIZING MITIGATION STRATEGIES BY COST

For the purposes of this study, we have chosen to categorize the estimated costs of implementing mitigation strategies as having a low, medium, or high cost. The numerical values for each category have been assigned according to similar cost estimates found in the selected case studies. Low (< \$5,000), Medium (\$5,000-\$15,000), High (>\$15,000)

APPENDIX E. NATIONAL FLOOD INSURANCE PROGRAM

“The National Flood Insurance Program (NFIP) is aimed at reducing the impact of flooding on private and public structures. This is achieved by providing affordable insurance for property owners and by encouraging communities to adopt and enforce floodplain management regulations. These efforts help mitigate the effects of flooding on new and improved structures. Overall, the program reduces the socio-economic impact of disasters by promoting the purchase and retention of Risk Insurance in general, and National Flood insurance in particular” (FEMA, 2014).

In essence, the NFIP is a federally-subsidized insurance program designed to make available affordable flood insurance to home- and business-owners living in areas prone to flooding. Flood

insurance is required for properties in the floodplain if property owners have a home mortgage from a federally-insured bank. This encompasses many properties in Pasquotank County and Elizabeth City. Both Pasquotank County and Elizabeth City are already participating in the NFIP.

Thousands of residents and business-owners in both Elizabeth City and Pasquotank County pay a significant sum of money for federally funded flood insurance. In Elizabeth City alone, 1,458 residents and business-owners are paying a combined \$966,782 annually in flood insurance premiums in order to maintain coverage of \$268,067,100 in property value. The situation is similar in Pasquotank County, where 1,275 properties pay \$725,335 annually in order to cover collective property values of \$289,721,400. In Elizabeth City, annual flood insurance costs an average of \$663 per property, and an average of \$569 in Pasquotank County. These values are certainly not insignificant for individual homeowners. This information is summarized in *Table 8* below.

NFIP Flood Insurance Annual Premiums			
	Pasquotank County	Elizabeth City	Both Pasquotank County and Elizabeth City
Annual NFIP Flood Insurance Premiums	\$725,335	\$966,782	\$1,692,117
Average NFIP Premium Per Claim	\$569	\$663	\$619

Table 8. Annual NFIP Flood Insurance Premiums in Elizabeth City and Pasquotank County, in total \$USD as well as \$USD per claim.

Moreover, flood insurance rates are only set to increase. The Biggert-Waters Flood Insurance Reform Act of 2012 led to a drastic increase in NFIP flood insurance premiums for all residents in an effort to make the program less costly (Ferraro 2014). These increases were repealed under the Homeowner Flood Insurance Affordability Act of 2014 (HFIAA), which returned flood insurance premiums to their lower, subsidized rates, but with the stipulation that subsidies will continue to be removed more slowly over time (Ferraro 2014). This means that insurance premiums are expected to rise significantly in the years to come. Furthermore, as the flood zone expands in the future, more homeowners will be forced to buy flood insurance.

APPENDIX F. CRS ACTIVITIES AND POINTS

This appendix explores the fine details of how communities specifically achieve points for the Community Rating System. As mentioned before, the nineteen activities that grant points for the CRS are divided into four major categories: Series 300: Public Information, Series 400: Mapping and Regulations, Series 500: Flood Damage Reduction, and Series 600: Flood Preparedness. *Table 9* below gives a detailed summary of the specific activities for which communities will be granted points. In order to give a good idea of how many points one might expect from a given activity, we have included the average points given across all CRS communities, as well as the points received by Morehead City, a community that serves as a good example for Pasquotank County.

While many coastal communities in North Carolina participate in the CRS, we concluded that Morehead City would serve as an appropriate model for CRS adoption within Pasquotank County due to several similarities. Morehead City and Pasquotank County/Elizabeth City share several similarities in that they are both communities that will be affected by the ocean's rising water levels, but are not directly along the shoreline. This means that the most effective mitigation strategies are likely to be similar between the two communities. Additionally, both communities have between 1,000 and 3,000 NFIP policies, meaning the sort of cost-benefit decision-making will be similar in both instances. Morehead City, as of 2015, is listed as a Class 8 community, therefore receiving a 10% discount on NFIP flood insurance premiums.

Morehead City is also an effective model to study in terms of which activities Pasquotank County may pursue in order to achieve Class 8 status. Based on their CRS proposal, we can see that Morehead City has implemented low-cost strategies in an effort to reduce the NFIP insurance premiums while incurring as little cost to the city as possible. The strategies already undertaken by Morehead City reveal an effective model to follow in Pasquotank County and Elizabeth City. *Table 9*, shown below, includes the points given to Morehead City for each activity in order to show what Pasquotank County and Elizabeth City might reasonably expect as a new CRS community. Primarily, *Table 9* outlines the nineteen specific activities through which communities earn points. The activities listed in bold have already been at least partially implemented by Pasquotank County (Cox 2015b).

Community Rating System Activity Breakdown		
Activity	Description	Points Maximum / Average / Morehead City
Activity Series 300	Public Information	Total Possible Points: 981
310 Elevation Certificates	Maintain FEMA elevation certificates for new construction in the floodplain	Maximum: 116 Average Points Given: 46 Points Given in Morehead City: 56
320 Map Information Service	Provide Flood Insurance Rate Map (FIRM) information to people who inquire, and publicize this service	Maximum: 90 Average Points Given: 63 Points Given in Morehead City: 140
330 Outreach Projects	Send information about flood hazard, flood insurance, flood protection measures, and/or the natural and beneficial functions of floodplains to flood-prone residents or all residents of a community	Maximum: 350 Average Points Given: 63 Points Given in Morehead City: 212

340 Hazard Disclosure	Real estate agents advise potential purchasers of flood-prone property about the flood hazard	Maximum: 80 Average Points Given: 14 Points Given in Morehead City: 10
350 Flood Protection Information	The public library and/or community's website maintains references on flood insurance and flood protection	Maximum: 125 Average Points Given: 33 Points Given in Morehead City: 56
360 Flood Protection Assistance	Give inquiring property owners technical advice on how to protect their buildings from flooding, and publicize this service	Maximum: 110 Average Points Given: 49 Points Given in Morehead City: 0
370 Flood Insurance Promotion	Promote the purchasing of flood insurance for residents and businesses	Maximum: 110 Average Points Given: 0 Points Given in Morehead City: 0
Series 400	Mapping and Regulations	Total Possible Points: 5,841
410 Floodplain Mapping	Develop new flood elevations, floodway delineations, wave heights, or other regulatory flood hazard data for an area not mapped in detail by the flood insurance study	Maximum: 802 Average Points Given: 65 Points Given in Morehead City: 11
420 Open Space Preservation	Guarantee that currently vacant floodplain parcels will be kept free from development	Maximum: 2,020 Average Points Given: 474 Points Given in Morehead City: 48
430 Higher Regulatory Standards	Examples: Require freeboard, require soil tests, minimum housing lot sizes over 1 acre, require coastal construction standards in AE Zones, have regulations tailored to protect critical facilities or areas subject to special flood hazards	Maximum: 2,042 Average Points Given: 214 Points Given in Morehead City: 165
440 Flood Data Maintenance	Keep flood and property data on computer	Maximum: 222

	records ; use better base maps; maintain elevation reference marks	Average Points Given: 54 Points Given in Morehead City: 86
450 Stormwater Management	Regulate new development throughout the watershed to ensure that post-development runoff is no worse than pre-development runoff; regulate new construction to minimize soil erosion and protect or improve water quality	Maximum: 755 Average Points Given: 119 Points Given in Morehead City: 33
Series 500	Flood Damage Reduction	Total Possible Points: 4,692
510 Floodplain Management Planning	Prepare, adopt, implement, and update a comprehensive flood hazard mitigation plan using a standard planning process	Maximum: 622 Average Points Given: 123 Points Given in Morehead City: 99
520 Acquisition and Relocation	Acquire and/or relocate flood-prone buildings to that they are out of the floodplain	Maximum: 1,900 Average Points Given: 136 Points Given in Morehead City:
530 Flood Protection	Protection of existing floodplain by development by floodproofing, elevation, or minor structural projects	Maximum: 1,600 Average Points Given: 136 Points Given in Morehead City: 0
540 Drainage System Maintenance	Conduct periodic inspections of all channels and retention basins and remove debris as needed	Maximum: 570 Average Points Given: 214 Points Given in Morehead City: 170
Series 600	Flood Preparedness	Total Possible Points: 790
610 Flood Warning and Response	Provide early flood warnings to the public, and have a detailed flood response plan keyed to flood crest predictions	Maximum: 395 Average Points Given: 144 Points Given in Morehead City: 60
620 Levee Safety	Maintain existing levees not otherwise credited in	Maximum: 235

	the flood insurance rating system that provide some flood protection	Average Points Given: 0 Points Given in Morehead City: 0
630 Dam Safety	Communities in a state with an approved dam safety program that have at least one building subject to inundation from the failure of a high-hazard-potential dam receive some credit	Maximum: 160 Average Points Given: 0 Points Given in Morehead City: 58 (all Communities within NC receive these points)

Table 9. This table includes every activity outlined by the CRS, a brief description of what constitutes an activity of the given category, and lastly information regarding the point allocations for each activity.

Bold activities are those already being carried out by Pasquotank County.

As shown in *Table 9*, it is clear to see that Pasquotank County and Elizabeth City can strongly benefit from adopting the Community Rating System. Without implementing any new strategies whatsoever, it is possible, though unlikely, that Pasquotank County and Elizabeth City could receive a Class 9 designation and subsequent 5% premium discount.

We add, as a disclaimer, that it is difficult to predict the exact point values that will be given for each activity completed by a community. These recommendations are not precise in their point predictions; therefore, conservative estimates have been used.

Using conservative point estimates, we have detailed our recommendations for specific strategies to implement as a part of the Community Rating System. These recommendations have a particular emphasis on very low-cost strategies that would result in net savings through flood insurance premium discounts. This section will focus on recommendations for implementing specific activities in order to cross the point threshold into CRS Class 9 (5% discount) and CRS Class 8 (10% discount). It is important to note that our point estimates are not exact, and the North Carolina ISO/CRS Specialist should be consulted when joining the CRS. Specific instructions for joining the CRS will be included in the conclusions section.

In order to qualify as a Class 9 CRS community, a threshold of 500 points must be reached. Having spoken with Shelley Cox, Pasquotank County's planning director, it is apparent that Pasquotank County has already partially implemented seven out of nineteen CRS activities. With these activities having been implemented already, qualifying for Class 9 is easily within reach. The seven activities for which Pasquotank County already qualifies are the following: 310 (Elevation Certificates), 320 (Map Information Service), 340 (Hazard Disclosure), 360 (Flood Protection Assistance), 440 (Flood Data Maintenance), 450 (Storm-Water Management), and 630 (Dam Safety).

Here we detail all activities that Pasquotank County has already undertaken, which will result in "free" points for the CRS. Communities are given points under activity 310 merely by maintaining building certificates to prove that they are meeting or exceeding standards.

Communities receive points under activities for providing Flood Insurance Rate Map information to people who inquire, and receive additional points for publicizing this service. Points are granted for activity 340 when communities regularly practice advising potential purchasers of flood-prone property and the flood hazards associated with living in floodplains. Flood advisory is often carried out through real estate agents, who inform prospective buyers. Communities receive points under activity 360 by offering technical advice to individuals and property owners on protecting their buildings from flooding. Publicizing this service is necessary in order to receive points. Communities receive points under activity 440 by maintaining flood and property data on computer records, using base maps that are up-to-date, and maintaining flood elevation reference marks. According to Shelley Cox, Pasquotank County keeps flood and property data on computer record, and therefore would receive some points. Pasquotank County would also receive points under activity 450, which gives points from regulating new development through the watershed to ensure that there are no significant increases in water runoff. In effect, this means decreasing the amount of impervious services in a new development so that water is absorbed into the ground more easily. All of the above activities have already been implemented in Pasquotank County, making it very worthwhile to join the Community Rating System. We estimate that the activities already implemented will earn between 304 and 529 points for the Community Rating System. While the upper bound of this estimate will grant Pasquotank County a Class 9 rating, we have included three low-cost recommendations in order to ensure attaining a CRS discount.

Our three additional activity recommendations for reaching a Class 9 CRS rating are: 330 (Outreach Projects), 350 (Flood Protection Information), and 540 (Drainage System Maintenance). Implementing the first two activities should prove to be low-cost strategies that will garner a significant amount of points for the CRS.

Morehead City earned 212 points under Activity 330 by mailing a community brochure to all properties in the community on an annual basis. An outreach brochure is additionally mailed annually to all properties in the community's Special Flood Hazard Area. Additionally, Morehead City provides flood information through displays at public buildings. The primary cost incurred for this activity is the distribution of the brochures through the mail. We have included in Appendix H a "Flood Awareness" brochure than can potentially be distributed in similar fashion.

Activity 350, Flood Protection Information, is a very low cost strategy that will earn a significant amount of CRS points. Morehead City earned 56 points under Activity 350 simply by making available documents that relate to floodplain management. The selected documents were placed in their "Webb Memorial Library" as well as their website.

Activity 540, drainage system maintenance, is a relatively higher cost strategy that we recommend. Implementing strategies under this activity would almost certainly secure a Class 9 qualification for Pasquotank County. Additionally, while higher cost, the benefits of implementing drainage system maintenance strategies far exceed simply the points gained under CRS. Morehead City received 170 points under Activity 540 with the following specific strategies. Portions of the Morehead City drainage system are regularly inspected, with maintenance being performed as needed. Records are kept of both inspections and maintenance

works. The primary costs incurred under this activity include paying for regular inspections and maintenance. Keeping drainage systems properly maintained, however, can significantly reduce the impact of flooding events in flood-prone areas.

By our estimates, the implementation of these three activities along with the seven activities already being carried out by Pasquotank County will secure a Class 9 classification with the Community Rating System. *Table 10* summarizes the specific activity recommendations and their corresponding point estimates.

Recommended Activities for Class 9 Certification			
Activity #	Estimated Points	Morehead City Points	Cost Indication (Free, Low, Med, High)
310 Elevation Certificates	~46-56	56	Already Implemented
320 Map Information Service	~60-140	140	Already Implemented
340 Hazard Disclosure	~10-15	10	Already Implemented
360 Flood Protection Assistance	~50	0	Already Implemented
440 Flood Data Maintenance	~50-90	86	Already Implemented
450 Storm-Water Management	~30-120	33	Already Implemented
630 Dam Safety	~58	58	Already Implemented
No-Cost Points:	~304 – 529		
330 Outreach Projects	~100-200	212	Low Cost
350 Flood Protection Information	~40-60	56	Low Cost
540 Drainage System Maintenance	~100-170	170	Medium Cost
Total:	~544 – 959	821	

Table 10. Activities that we recommend Pasquotank County do in order to reach Class 9 Certification. The Estimated Points column gives a range of possible point values the county might earn for performing each activity. The Morehead City Points column indicates how many points Morehead City earned for implementing each strategy.

Achieving a Class 8 CRS ranking for Pasquotank County will prove to be a higher-cost endeavor that may take several years to achieve, but will result in doubling the annual savings for NFIP

flood insurance policy-owners. Most of the very-low cost activities have been exhausted in the previous section, Class 9, including all of the 300 Series activities. In this section, we focus on the remaining activities that are lower cost, yet yield a high amount of points. In the 400 Series, we recommend implementing to some degree the three remaining activities: 410, Additional Flood Data; 420, Open Space Preservation; and 430, Higher Regulatory Standards.

Activity 410, Additional Flood Data, pertain to any activity that develops useful, mapped information. New maps may include information on new flood elevations, floodway delineations, wave heights, or other data not mapped in detail by the flood insurance study. Given the extensive use of GIS within Pasquotank County and Elizabeth City, implementing this strategy under the CRS would be a good fit. In their 2009 CRS report, Morehead City reported that they had begun a “cooperating technical partnership agreement with FEMA and the State of North Carolina.” For this strategy they only received 11 points, but the average points earned for communities that participate is 65 according to FIRM.

Activity 420, Open Space Preservation, grants points for communities that can prove that they have set land aside in floodplains that will remain free from development. Developing land often leads to an increase in impervious surfaces, which exacerbates flood symptoms due to higher runoff and lower ground absorption of water. By limiting the amount of impervious surfaces in floodplains, communities are indirectly protecting the existing developments as well as reducing the impact of flooding overall. To give an indication of how many points a community may receive, we once again turn to Morehead City. Morehead City has committed to leaving 22 acres of property within the floodway undeveloped, resulting in 48 points with the CRS. If Pasquotank County can show that they are committed to keeping floodplain parcels from being developed, they will gain a significant amount of points with the CRS.

Activity 430, Higher Regulatory Standards, encompasses a wide range of policy implementations. Policies that fall under this activity include requiring new developments to build freeboard space (elevate the building) a certain amount above the base flood elevation, requiring minimum lot sizes in new developments, or adopting and enforcing certain building code regulations. Certain measures such as requiring freeboard are relatively inexpensive, outsource the cost of mitigation strategy to developers, and very often save properties from the bulk of expensive repairs in flooding events. Morehead City requires freeboard for new and substantial improvement construction, protection of natural formations, and compliance with International Building and Residential Codes, for which they receive an impressive 165 points.

Activity 510, Floodplain Management Planning, gives points to communities that create and adopt a “comprehensive flood hazard mitigation plan.” To be more specific, Morehead City received 99 points in 2009 for several related actions. For one, they identified 17 repetitive loss properties to be purchased when funding is found. The most significant part of this activity was their creation of a Floodplain Management section within their Hazard Mitigation Plan, for which a progress report “must be submitted on an annual basis.”

Activity 610, Flood Warning Program, has the potential to be of vital importance for residents within the floodplain. Points are given under this activity for being able to provide early flood warnings to the public, particularly those living within the floodplain, and having a detailed plan

of response. Morehead City receives 60 points for identifying flood threats, warning residents in the floodplain, and for having a program outlined for coordinating responses to flooding events. Warning systems can be implemented through simple measures such as the installation of warning sirens. Additionally, flood warning initiatives can be integrated into other warning systems over radio, television, or, most practically, SMS. Not only does this activity garner a significant amount of points, the implementation of such strategies can greatly increase safety for unexpected flooding events that occur.

Activity 530, Flood Protection, is a higher-cost strategy implementation that involves the protection of existing floodplain development by flood-proofing buildings and other minor structural projects. Morehead City has not implemented any strategies under Activity 530, as they have a keen focus on participating in the CRS while spending little. While these recommendations are founded on a similar basis, we wanted to include this recommendation due to the direct and immediate effects of this strategy. Additionally, we included this strategy as a reminder that keeping and providing proof for any strategy, project, or policy implemented is likely to gain points for the Community Rating System. CRS communities, on average, receive 136 points under Activity 530. *Table 11* below contains a summary of the above recommendations for achieving a Class 8 rating in the CRS. Please note that the upper-bound estimate is 1809, which would qualify Pasquotank County for a Class 7 rating, earning the community a 15% discount on NFIP premiums.

Recommended Activities for Class 8 Certification			
Activity #	Estimated Points	Morehead City Points	Cost Indication (Free, Low, Med, High)
410 Additional Flood Data	~10-60	11	Low
420 Open Space Preservation	~40-150	48	Medium
430 Higher Regulatory Standards	~120-215	165	Medium
510 Floodplain Management Planning	~70-125	99	Medium
610 Flood Warning Program	~40-140	60	Medium
530 Flood Protection	~60-160	0	High
Total Class 8:	~340-850	383	
Grand Total (Class 9 & Class 8):	~884-1809	1204	

Table 11. Activities that we recommend Pasquotank County do in order to reach Class 9 Certification. The Estimated Points column gives a range of possible point values the county

might earn for performing each activity. The Morehead City Points column indicates how many points Morehead City earned for implementing each strategy. The Grand Total row is of most importance to the county: the county will need 1,000 total points to reach Class 8 certification.

APPENDIX G. EXPERT CONSULTANTS AND SEA LEVEL RISE ORGANIZATIONS

We consulted with several hazard mitigation experts and researchers on sea level rise. They include Tom Allen at East Carolina University; Gavin Smith, Anna Schwab, and Donald Hornstein at the University of North Carolina, and Jessica Whitehead from North Carolina State University. We also obtained sea level rise projections from the National Atmospheric and Oceanic Administration (NOAA), the United States Army Corps of Engineers (USACE), the Intergovernmental Panel on Climate Change (IPCC), and Climate Central.

APPENDIX H. ADDITIONAL DOCUMENTS

Additional documents are presented in the following several pages.

SEA LEVEL RISE AND COASTAL FLOOD EXPOSURE IN PASQUOTANK COUNTY, NC										
FILE DETAILS										
Format: Excel xls										
File creation date: July 14, 2014										
File name: NC_Pasquotank_County-total.xls										
Download page URL: ssrf.climatecentral.org/#p=L&state=North Carolina&location=NC_County_37139										
File URL: ssrf.climatecentral.org/states/NC/downloads/analysis_total_tables/County/NC_Pasquotank_County-total.xls										
SOURCES AND METHODS										
Findings from Surging Seas (SurgingSeas.org), a project of Climate Central (climatecentral.org)										
Original data sources and methods detailed on download page and more widely at SurgingSeas.org, including linked reports and scientific papers.										
CITATION										
Climate Central (2014). Sea level rise and coastal flood exposure in Pasquotank County, NC, in Surging Seas Risk Finder. Retrieved from ssrf.climatecentral.org/#p=L&state=North Carolina&location=NC_County_37139										
DISCLAIMER										
All content found herein is provided solely for personal informational purposes and is provided "AS-IS." You acknowledge and agree that your use and possession of this content is subject to, and you agree to the provisions set forth in, Climate Central's Terms of Use and Privacy Policy (both at http://www.climatecentral.org/about/legal) and Surging Seas Disclaimer (http://sealevel.climatecentral.org/about/disclaimer).										
NOTES										
- Results based on the elevation of land that structures sit on, relative to local high tide (MHHW). Results do not factor in structure elevation or details.										
- Results based on tidally referenced elevation only. These results do not factor in potential protection from levees, sea walls, or other engineering, or natural features.										
- Land elevation values are based on high-accuracy laser ("lidar") measurements, but still include errors.										
- Summary or total exposure results, such as the ones in this table, average elevation errors over wide areas, so are more reliable than results for individual facilities or locations.										
- Unit COT means "count over threshold." Certain features are counted as affected when at least 25% of their area or length is affected, such as military bases or airports (runway length).										
- If present, a value of N/A indicates missing data for the denominator, so a percentage cannot be computed.										
- If an exposure category from the online tool is not listed, this indicates that the analysis identified no exposure for that category below 10ft in Pasquotank County.										
TABLE: SEA LEVEL RISE AND COASTAL FLOOD EXPOSURE IN PASQUOTANK COUNTY, NC ON LAND BELOW 1-10 FT										
Elevation relative to local high tide line (Mean Higher High Water)										
Unit	< 1ft	< 2ft	< 3ft	< 4ft	< 5ft	< 6ft	< 7ft	< 8ft	< 9ft	< 10ft
BY TOTALS										
High social vulnerability population	Count	219	498	1110	2110	3414	4639	5478	6384	6947
Medium social vulnerability population	Count	688	1255	2286	3720	5125	7328	9937	11965	14575
										16913

	Unit	Elevation relative to local high tide line (Mean Higher High Water)									
		< 1ft	< 2ft	< 3ft	< 4ft	< 5ft	< 6ft	< 7ft	< 8ft	< 9ft	< 10ft
Low social vulnerability population	Count	737	1435	2687	4521	6473	7882	10242	11479	11878	12533
Property value	\$Million	51	139	270	394	471	538	603	685	769	851
Population	Count	1644	3188	6082	10351	15012	19849	25657	29828	33400	36593
Caucasian population	Count	1028	1953	3676	6242	9017	11879	14813	16910	19124	21227
Population of color	Count	642	1282	2490	4253	6214	8271	11250	13401	14838	15995
African-American population	Count	573	1144	2218	3791	5521	7356	10087	12052	13349	14397
Asian population	Count	29	50	85	145	235	325	428	508	575	621
Hispanic population	Count	81	162	327	530	730	934	1172	1331	1449	1539
Native American population	Count	15	28	52	94	145	190	243	281	319	358
Homes	Count	802	1535	2878	4873	6997	9106	11232	12791	14192	15396
Schools	Count	0	0	0	1	2	3	6	7	8	9
Colleges and Universities	Count	0	0	0	0	0	0	0	2	2	2
Libraries	Count	0	0	0	0	1	1	1	1	1	1
Theater, music & arts buildings	Buildings	0	0	0	0	0	0	0	0	1	1
Museums	Count	0	0	0	0	0	0	0	0	1	1
Houses of worship	Count	2	7	11	16	26	40	42	52	54	58
Government buildings	Count	0	1	2	4	9	11	12	13	17	20
Roads	Miles	27	52	93	146	199	252	300	338	385	428
Federal roads	Miles	1	1	2	3	5	7	9	13	18	22
Local roads	Miles	11	21	41	72	100	128	151	168	189	211
Secondary roads	Miles	4	7	10	14	17	20	24	29	33	35
State roads	Miles	16	30	51	71	94	117	140	157	177	195
Passenger stations	Count	0	0	0	0	0	0	0	0	1	1
Intercity bus stations	Count	0	0	0	0	0	0	0	0	1	1
Heliports	Count	0	0	0	1	2	3	4	4	4	4
FM radio transmitter sites	Count	0	0	0	0	0	0	3	3	3	3
EPA listed sites	Count	4	9	11	19	27	34	40	45	46	50
Biennial Reporters	Count	0	0	0	0	0	1	1	1	1	1
NPDES sites	Count	3	7	7	8	10	11	12	12	12	13
RADINFO sites	Count	0	1	2	9	14	18	21	25	26	27
RMP sites	Count	1	1	2	2	2	2	2	2	2	2
SSTS sites	Count	0	0	0	0	0	1	2	2	2	3
TRI sites	Count	0	0	0	0	0	0	0	0	0	1
Hazardous materials facilities	Count	1	1	2	2	2	3	4	4	4	6
Extreme hazmat facilities	Count	1	1	2	2	2	2	2	2	2	2
Pesticide facilities	Count	0	0	0	0	0	1	2	2	2	3
Hazardous waste sites	Count	0	1	2	9	14	18	21	25	26	27
Major hazwaste source sites	Count	0	0	0	0	1	1	2	2	2	2
Minor hazwaste source sites	Count	0	0	1	5	7	10	12	14	15	15
Unspecified hazardous waste sites	Count	0	1	1	4	6	7	7	9	9	10

	Unit	Elevation relative to local high tide line (Mean Higher High Water)														
		< 1ft	< 2ft	< 3ft	< 4ft	< 5ft	< 6ft	< 7ft	< 8ft	< 9ft	< 10ft					
Landfills	Count	0	0	0	0	0	0	0	0	0	0	1	2	2	2	
Wastewater sites	Count	3	7	7	8	10	11	11	11	11	11	12	12	12	13	
Nonmajor wastewater sites	Count	3	7	7	8	10	11	11	11	11	11	12	12	12	13	
Sewage plants	Count	0	0	0	0	1	1	1	1	1	1	1	1	1	1	
Land	Acres	17698	23860	31246	39372	47593	56357	64580	71651	79795	91580					
Protected land	Acres	4	6	9	18	47	173	404	473	521	602					
Federal protected land	Acres	0	0	0	0	0	0	6	18	32	49					
BY PERCENTAGE																
High social vulnerability population		3.0%	6.9%	15.5%	29.4%	47.6%	64.6%	76.3%	89.0%	96.8%	99.6%					
Medium social vulnerability population		3.5%	6.3%	11.5%	18.7%	25.8%	36.8%	49.9%	60.1%	73.2%	85.0%					
Low social vulnerability population		5.4%	10.6%	19.8%	33.4%	47.8%	58.2%	75.7%	84.8%	87.7%	92.6%					
Property value		3.1%	8.5%	16.4%	24.0%	28.6%	32.7%	36.7%	41.6%	46.8%	51.7%					
Population		4.0%	7.8%	15.0%	25.5%	37.0%	48.9%	63.2%	73.4%	82.2%	90.1%					
Caucasian population		4.3%	8.2%	15.5%	26.3%	38.0%	50.0%	62.4%	71.2%	80.6%	89.4%					
Population of color		3.6%	7.3%	14.2%	24.2%	35.3%	47.0%	63.9%	76.2%	84.3%	90.9%					
African-American population		3.6%	7.2%	14.0%	23.9%	34.8%	46.3%	63.5%	75.9%	84.1%	90.7%					
Asian population		4.4%	7.6%	12.8%	22.1%	35.6%	49.3%	64.9%	77.0%	87.1%	94.2%					
Hispanic population		5.0%	9.9%	19.9%	32.3%	44.5%	56.9%	71.4%	81.1%	88.3%	93.8%					
Native American population		3.6%	6.8%	12.6%	22.6%	35.0%	45.6%	58.4%	67.6%	76.7%	86.2%					
Homes		4.8%	9.1%	17.1%	29.0%	41.6%	54.1%	66.8%	76.1%	84.4%	91.6%					
Schools		0.0%	0.0%	0.0%	8.3%	16.7%	25.0%	50.0%	58.3%	66.7%	75.0%					
Colleges and Universities		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%					
Libraries		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%					
Theater, music & arts buildings		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%					
Museums		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%					
Houses of worship		3.2%	11.1%	17.5%	25.4%	41.3%	63.5%	66.7%	82.5%	85.7%	92.1%					
Government buildings		0.0%	4.8%	9.5%	19.0%	42.9%	52.4%	57.1%	61.9%	81.0%	95.2%					
Roads		4.3%	8.2%	14.7%	23.0%	31.4%	39.8%	47.3%	53.4%	60.7%	67.5%					
Federal roads		0.9%	1.1%	2.5%	4.8%	8.1%	10.4%	13.8%	20.4%	28.1%	34.5%					
Local roads		3.3%	6.2%	12.0%	21.4%	29.7%	38.1%	44.9%	49.8%	56.2%	62.6%					
Secondary roads		5.8%	9.4%	13.9%	19.0%	22.8%	26.5%	31.8%	38.4%	43.5%	47.1%					
State roads		6.7%	13.1%	21.8%	30.4%	40.5%	50.5%	60.1%	67.6%	76.3%	83.9%					
Passenger stations		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%					
Intercity bus stations		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%					
Heliports		0.0%	0.0%	0.0%	20.0%	40.0%	60.0%	80.0%	80.0%	80.0%	80.0%					
FM radio transmitter sites		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%					
Hazardous materials facilities		14.3%	14.3%	28.6%	28.6%	28.6%	42.9%	57.1%	57.1%	57.1%	85.7%					
Pesticide facilities		0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	50.0%	50.0%	50.0%	75.0%					
Extreme hazmat facilities		50.0%	50.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%					

Unit	Elevation relative to local high tide line (Mean Higher High Water)									
	< 1ft	< 2ft	< 3ft	< 4ft	< 5ft	< 6ft	< 7ft	< 8ft	< 9ft	< 10ft
Hazardous waste sites	0.0%	2.9%	5.7%	25.7%	40.0%	51.4%	60.0%	71.4%	74.3%	77.1%
Unspecified hazardous waste sites	0.0%	6.7%	6.7%	26.7%	40.0%	46.7%	46.7%	60.0%	60.0%	66.7%
Minor hazwaste source sites	0.0%	0.0%	5.6%	27.8%	38.9%	55.6%	66.7%	77.8%	83.3%	83.3%
Major hazwaste source sites	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	100.0%	100.0%	100.0%	100.0%
Landfills	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	100.0%	100.0%	100.0%
Wastewater sites	20.0%	46.7%	46.7%	53.3%	66.7%	73.3%	80.0%	80.0%	80.0%	86.7%
Nonmajor wastewater sites	20.0%	46.7%	46.7%	53.3%	66.7%	73.3%	80.0%	80.0%	80.0%	86.7%
Sewage plants	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
EPA listed sites	6.6%	14.8%	18.0%	31.1%	44.3%	55.7%	65.6%	73.8%	75.4%	82.0%
SSTS sites	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	50.0%	50.0%	50.0%	75.0%
TRI sites	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
RMP sites	50.0%	50.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Biennial Reporters	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
RADINFO sites	0.0%	2.9%	5.7%	25.7%	40.0%	51.4%	60.0%	71.4%	74.3%	77.1%
NPDES sites	20.0%	46.7%	46.7%	53.3%	66.7%	73.3%	80.0%	80.0%	80.0%	86.7%
Land	12.3%	16.6%	21.7%	27.4%	33.1%	39.2%	44.9%	49.8%	55.4%	63.6%
Protected land	0.1%	0.1%	0.2%	0.4%	1.0%	3.6%	8.4%	9.9%	10.9%	12.6%
Federal protected land	0%	0%	0%	0%	0%	0.0%	0.1%	0.5%	0.8%	1.3%

FLOOD AWARENESS GUIDE

PASQUOTANK COUNTY, NC

Flood Facts

- A car or truck can be carried away by as little as 2 feet of water.
- A person can be knocked down by as little as 6 inches of water.
- Flash flooding is the leading cause of weather-related deaths in the U.S.
- In the U.S. floods cause \$6 billion worth of damage and kill 140 people annually.
- 90 percent of all U.S. natural disasters declared by the President involve some sort of flooding.
- Just a few inches of water can cause tens of thousands of dollars in damage.
- Over 50 percent of flood-related deaths are vehicle-related.

Key Takeaways

- Flooding poses a threat to Pasquotank County.
- Homeowner's insurance policies do not cover flood damage.
- A floodplain development permit (or a building permit) and an Elevation Certificate are required to build in a flood zone.

Local Flood Hazard

Pasquotank County is a low-lying area with the potential for significant storm and flooding damage. The entire land area of the county is susceptible to flooding; however, there are several areas that are more vulnerable than others. Downtown Elizabeth City regularly experiences urban flooding issues due to heavy rainfall over short and extended periods of time. Southern portions of the county, which are low-lying and characterized by swamp land, are also at a higher risk for flooding. If a storm system causes moderate to severe flooding in the county, it can be expected that there will be damage to property and infrastructure.

The county experiences a tropical system event on an annual basis. Storm surge, the increase in water height due to a storm, poses a threat to Pasquotank County. Storm surge from Hurricane Floyd in 1999 resulted in water marks of 30 inches in businesses along the Pasquotank River.



Contact Information

Planning & Inspections (252) 335-1891
GIS (252) 331-2336
Emergency Management (252) 335-4444

What is a 100-year flood?

A 100-year flood event is not a flood that occurs once every 100 years. It is a large, damaging flood that has a 1 percent chance of occurring in any given year. If your property is located in a 100-year flood zone, then it is at risk of experiencing a flood.

Many mortgages have a repayment period of 30 years. Homes and buildings in or near a 100-year flood plain have a 26% chance of experiencing a flood during the life of the loan.

Is my property located in the floodplain?

Properties located in the purple, blue, and red areas in the map below are located in the floodplain. For more maps, visit

<http://www.co.pasquotank.nc.us/gis/fema.cfm>

or search for your address at

<http://www.co.pasquotank.nc.us/gis/taxsearch.cfm>.

Do I need flood insurance?

Flood damage is not covered under homeowner's insurance policies. Therefore, in order to be protected against flood damage, you should consider purchasing flood insurance. The National Flood Insurance Program (NFIP) provides affordable flood insurance for property owners. Flood insurance is mandatory for federally financed loans when buying, building, or improving structures in a flood zone. If you live in a flood zone, most mortgage companies will require you to purchase flood insurance. You can purchase flood insurance even if you don't live in a flood zone. There is a 30-day waiting period between when you buy the insurance and when it kicks in.

How do I protect my property?

The easiest way to avoid flood damage is to avoid construction in a flood zone. However, if building in a flood zone is the only option, steps can be taken to help minimize potential damage:

- Existing structures can be elevated in order to be above Base Flood Elevation.
- Flood vents can be installed in new and existing homes.
- Exterior walls can be sealed.

Can I build in the floodplain?

Pasquotank County allows limited development within certain areas of the floodplain. A floodplain development permit or a building permit is required for all development within a 100-year floodplain. In addition, the county requires an Elevation Certificate for buildings and substantial improvements in all identified flood zones, or Special Flood Hazard Areas (SFHAs). The Elevation Certificate is kept on file to show compliance with the floodplain management ordinance. Property owners can use the Elevation Certificate to obtain flood insurance. Contact the Planning & Inspections Department at (252) 335-1891 for more information.

Flood Safety Tips

- Do not drive through flooded areas—the water can be deceptively deep and powerful.
- Do not walk through moving water.
- Listen to local TV and radio broadcasts for severe weather information.
- Assemble a disaster supply kit.
- Bring in outdoor furniture and move essential items to an upper floor.
- If advised to evacuate, do so immediately, making sure to disconnect electrical appliances and turn off lights.

Importance of Floodplains

Floodplains are relatively low-lying areas adjacent to streams, lakes or rivers commonly prone to flooding. Floodplains are part of the natural hydrologic system, serving the important function of carrying and temporarily storing excess floodwater or dampening the energy of torrential rain or coastal storms. In addition, floodplains are useful for maintaining water quality, preserving groundwater supply, supporting natural vegetation and providing natural habitats, as well as offering many kinds of recreational and educational activities.

Drainage System Maintenance

Keeping the county's drainage system clear of obstructions and debris is vital to prevent flooding. Large debris and trash can obstruct the flow of water and lead to flooding during precipitation events. Water quality can also be significantly impacted by debris in the drainage system.

