SEA LEVEL RISE STRATEGIC PLAN UPDATE, PHASE 1 VULNERABILITY & RISK ASSESSMENT

Anne Arundel County, Maryland

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Anne Arundel County: Sea Level Rise Strategic Plan Update

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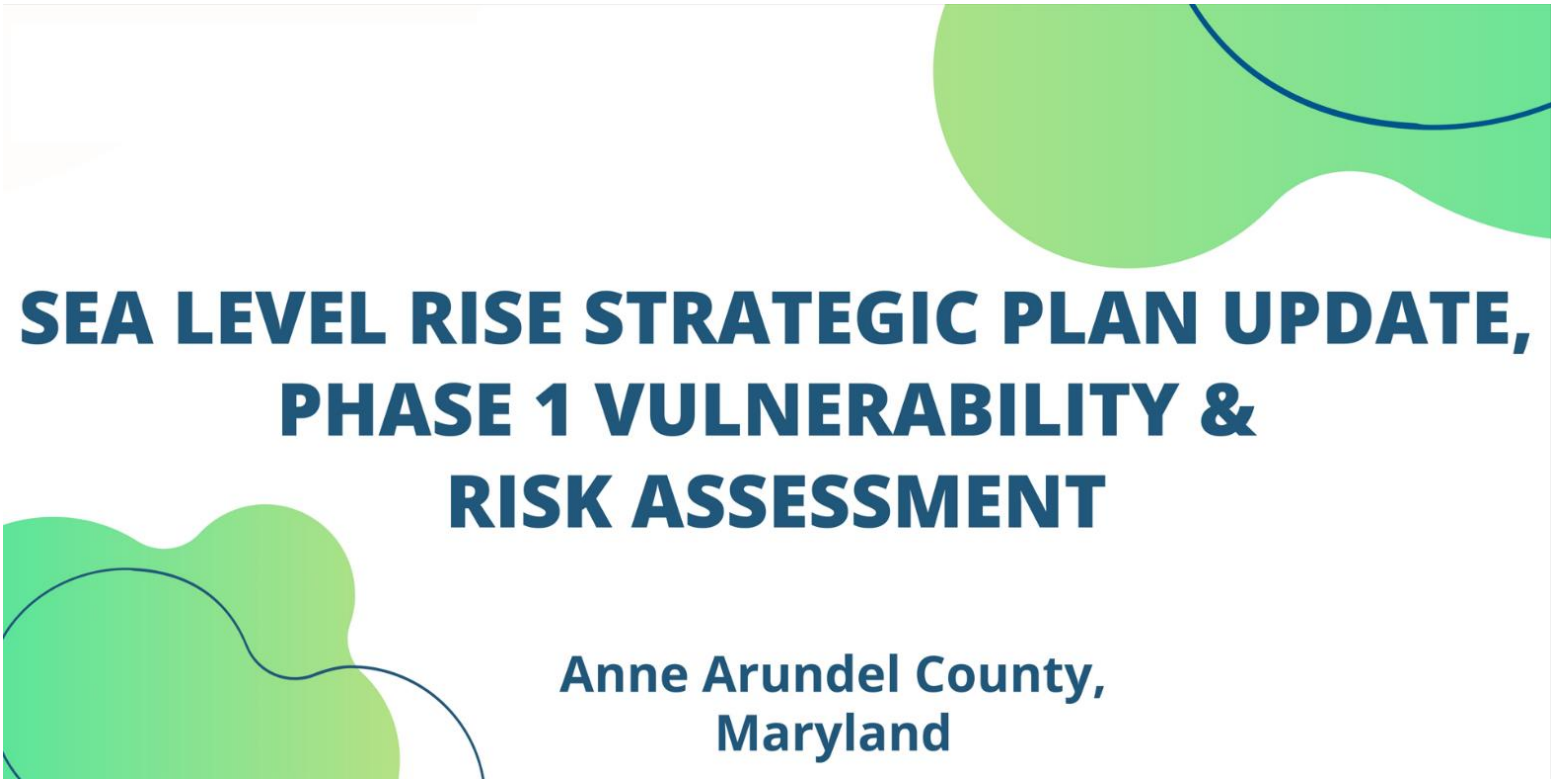
- Office of Planning and Zoning
- Office of Emergency Management
- Department of Public Works
- Bureau of Watershed Protection and Restoration.

Table of Contents

Table of Maps

Table of Tables



PART 1 - BACKGROUND

1A. Introduction

Anne Arundel County, surrounded by more than 530 miles of shoreline, is vulnerable to increased flooding as a result of relative sea level rise. Historic maps and aerials over the past century showing increasingly visible changes to the County shoreline demonstrate that relative sea level rise is happening in our past and present and will happen in our future. It is evident that the Chesapeake Bay is moving further inland, since the relative rise of sea level to any existing land surface at a particular location is exacerbated by a combination of changing climate and natural land subsidence. Today, rising temperatures from human-induced greenhouse gas emissions is affecting the volume of the sea by both warming the oceans and also increasing the melting of glaciers and ice sheets. These factors taken with the occurrence of heavier, more severe precipitation events in tandem with a sinking coastal land mass will accelerate future rates of relative sea level rise.

In 2011, Anne Arundel County began addressing this issue of increasing coastal inundation by partnering with the Maryland Department of Natural Resources (DNR) through the Coastal Communities Initiative Program to conduct a study of potential relative sea level rise (RSLR) impacts and to develop adaptation strategies. The resulting Sea Level Rise Strategic Plan (Nov. 2011) provided the first assessment of RSLR vulnerability in Anne Arundel County and made recommendations for improving the community's coastal climate resilience. Since that original study over a decade ago, scientists further refined global and regional models for RSLR projections to include factors such as greenhouse gas emission pathways, ocean dynamics, and glacial melting.

The most recent projections for the State of Maryland can be found in the document named, Sea Level Rise Projections for Maryland 2018, developed by the Maryland Commission on Climate Change and the University of Maryland Center for Environmental Science, which was subsequently followed by the 2022 Guidance for Using Maryland's 2018 Sea Level Rise Projections. The most recent federal projections can be found on the NOAA website in its 2022 SLR Technical Report, Global and Regional Sea Level Rise Scenarios for the United States (Sweet et al 2022).

> "The level of Chesapeake Bay water with respect to the land is **now rising about three times as fast as it was during Colonial times**, threatening more densely built communities and infrastructure that developed over the interim."
>
> -SLR Projections for Maryland 2018 (Boesch et al.): Page 1

In 2022, the County obtained NOAA grant funding from Maryland's DNR through its Community Resilience Grant Program to update the spatial model in the 2011 SLR Strategic plan and to reassess its vulnerability to relative sea level rise. This document provides an updated County-wide vulnerability assessment using the current RSLR projections and methods, as well as a cross-section of current planning initiatives for coastal resiliency in the County. Additionally, it provides a case study for a higher resolution vulnerability assessment for one of the more vulnerable areas of Anne Arundel County – Region 9. The County shares contiguous boundaries with federal lands, such as the U.S. Naval Academy, Fort Meade, and the U.S. Coast Guard, and the resulting spatial model for this study was developed to align with neighboring jurisdictional efforts, so this study is informed by current federal projections for the "Intermediate-High" RSLR projection, which calculates an estimated 1.64 feet to 5.35 feet of increased inundation between years 2050 to 2100.

The County recognizes that strategic planning for RSLR will be an ongoing and evolving process as more research, analysis and guidance becomes available from State and Federal agencies and the scientific and academic communities. While the intent of this strategic plan is to identify steps that can be initiated by the County in both the near and long term, it is anticipated that this plan will build upon and be revised in future years as the topic evolves. The County is taking a phased approach to building coastal resilience to anticipated RSLR risks.

➡ **Phase 1: Vulnerability and Risk Assessment and Case Example – Region 9 Coastal Resiliency Toolkit**

Phase 2: Feasibility Study of Potential Actions *(future phase)*

Phase 3: Implementation of Priority Actions *(future phase)*

This report presents the results of Phase I, which provides a 2023 update to the RSLR vulnerability and a risk assessment for the entire County and presents more detailed analysis for Region 9 as a case example. Region 9 includes the southern portion of the County along Chesapeake Bay including the communities of Edgewater, Mayo, Galesville, West River, Shady Side, Churchton, Deale, Tracys Landing, and North Beach. As a low-elevation area with peninsulas and extensive shoreline, this area has been identified as being the largest part of the County with significant coastal flooding and SLR risk. Subsequent phases will include feasibility analysis of resilience actions and identification of preferred options through a process that incorporates engineering analysis and community involvement. When complete, the compiled SLR Strategic Plan will provide the County a regional framework to implement recommended policy and projects to increase coastal resiliency to risks associated with relative sea level rise.

Near Term Steps

The current analysis updated the spatial model from the 2011 SLR Strategic plan and provides a County-wide vulnerability assessment using current RSLR projections and methods. Based on this assessment, the Technical Team on this project provided several recommendations that the County should implement which follow in the body of this report, including the below examples:

- ***Coastal Ecosystems*** - Continue and expand County efforts to restore living shorelines. Incorporate SLR projections into design of these projects.
- ***Existing and Future Development*** - Target flood-prone properties, including areas at risk from SLR as priorities for conservation easements or fee simple acquisition.
- ***Transportation Infrastructure*** - Conduct feasibility study to prioritize roads and bridges for improvements to reduce flood risk and to evaluate the most effective design options.
- ***Wells*** - Expand efforts to educate private well owners on flood risk and actions they can take to protect their wells.
- ***Septic Systems*** - Continue and expand technical and financial support for property owners to upgrade septic systems or connect to public sewer.
- ***Cultural Resources*** - Increase and prioritize survey, documentation, and preservation efforts on flood-prone areas, and provide for the support, staffing, resources, and financial means to conduct professionally-led, emergency salvage archaeology and historic site documentation for significant sites.

Long Term Steps

The County needs to develop a regional framework to implement recommended policy and projects to increase coastal resiliency to risks associated with relative sea level rise.

2011 SLR Strategic Plan Summary

Anne Arundel County's first and only vulnerability study from over a decade ago resulted in the 2011 Sea Level Rise Strategic Plan. The original strategic plan from 2011 presents the analysis of projected SLR impacts under two scenarios, 2-ft. and 5-ft. increments of projected sea level rise. The plan addresses potential impacts to seven key sectors and assets:

- Loss of **ecologically significant land**
- Impacts on **private properties and property values**
- Impaired **road access**
- Impaired **public utility infrastructure**
- **Private well and septic systems**
- Damage or loss of **archeological and cultural resources**
- Impacts on the **maritime industry**
- **Shoreline erosion**

The final section of the 2011 plan is dedicated to seven primary adaptation goals and recommendations that were developed for the County:

1. Incorporate SLR planning into all related County functions.
2. Protect coastal ecosystems to reduce the impacts of SLR, coastal flooding and shoreline erosion.
3. Reduce SLR impacts to existing and future development.
4. Reduce potential impacts to public infrastructure serving existing communities and future development.
5. Ensure safe and adequate water supply and wastewater management for communities vulnerable to SLR impacts.
6. Protect significant cultural resources from loss or damage due to SLR impacts.
7. Ensure that citizens in the County are educated and informed about SLR and have access to current information and resources.

Recommended actions that were identified in the 2011 SLR Strategic Plan were evaluated further for Region 9 during this study, in addition to a County-wide assesment. A detailed discussion of each adaptation goal and recommendation as they relate to Region 9 priority impact areas is presented in the "Part 3 – Region 9 Risk Assessment" section of this document. The analysis identified several major topics that are the most crucial in terms of future vulnerability to SLR in the County.

Current SLR Planning, Data, & Public Outreach

Inclusion of sea level rise factors into local planning builds resilience into plans and projects to protect communities and public investments. Recently, Anne Arundel County has taken a proactive stance to address coastal resiliency. The attached report demonstrates the County's implementation of goals BE 16.1 and BE 4.1.b in the County's Plan 2040 (General Development Plan), which are to consider vulnerability to sea level rise during land use, development, and zoning process. This project implemented this goal by developing new County-wide inundation spatial data, updating and assessing RSLR vulnerabilities for the County, and providing up-to-date planning recommendations (articulated below). Additionally, the County has begun actively to incorporating SLR considerations into its planning processes, including the design of capital projects, such as designs for bridges and living shorelines. For example, the Bureau of Watershed Protection and Restoration and the Department of Recreation and Parks have implemented shoreline protection projects in locations such as Beverly Triton Park and Jack Creek Park to prevent future impacts associated with sea level rise. In addition to supporting internal County planning actions, this document shall be provided as a tool to inform the Region Plan Stakeholder Committees, the County Council, and the Anne Arundel County & Annapolis Resilience Authority.

Through this effort, the County has established a StoryMap that will provide an online location to store and present the current data and findings of this study, including the Phase I analysis for Region 9. The StoryMap will be used as a platform to build out the SLR Strategic Plan in other regions of the County. Additionally, the new sea level rise data layers shall be available on GeoCortex for planning analytics and also through OpenData in the County GIS portal.

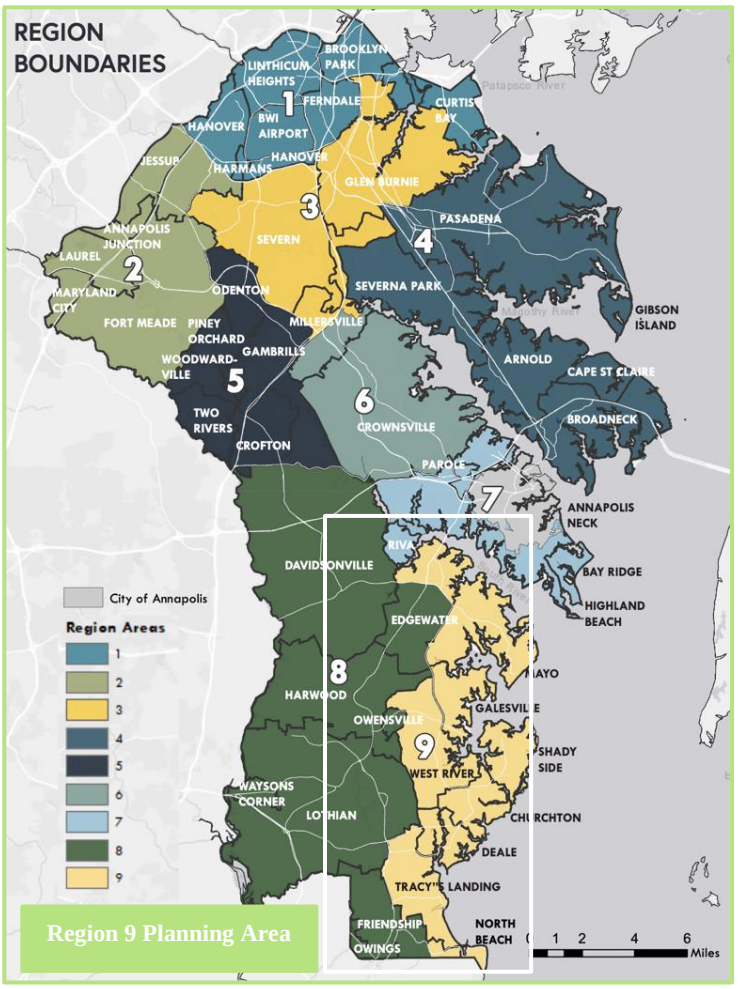
1B. Geographic Scope

This study included an evaluation of risks associated with sea level rise for all of Anne Arundel County with a special focus on the Mayo, Shady Side, and Deale peninsulas referred to as Region 9 in County plans. The boundaries of the nine Region Planning areas were defined in Plan2040, the Anne Arundel County Development Plan, based on input from a series of community open house meetings and comments from the Citizen Advisory Committee (see Region Boundaries Figure). The Region boundaries are different from the Small Area Plan boundaries used in the past as they were revisited and ultimately changed to reflect the geographic, environmental and development diversity and needs of different parts of the County. Region 9 was identified as a highly vulnerable region of the County in the 2011 Sea Level Rise Strategic Plan, and again in the 2018 update to the County's Hazard Mitigation Plan and was therefore selected for this detailed SLR study. The 2011 Strategic Plan specifically highlighted vulnerable areas in Deale/Shady Side and the Mayo peninsula. Anne Arundel County is fortunate in that its areas of potential vulnerability to sea level rise are not expansive,

Anne Arundel County - Location Information

Anne Arundel County comprises approximately 415 square miles (265,000 acres) in central Maryland. The Patapsco River and the Chesapeake Bay form the County's northern and eastern boundaries and the Patuxent River extends for about 30 miles from Laurel to Calvert County and serves as part of the western boundary. To the south, the Anne Arundel-Calvert County line extends across rolling farmland from the Patuxent River to the Chesapeake Bay. The County has approximately **530 linear miles of tidal shoreline** with picturesque waterfront communities scattered along the Chesapeake Bay and its tributaries. The County's scenic frontage along the Chesapeake Bay offer dramatic vistas and recreational opportunities.

Based on the most recent land cover data (using 2020 satellite images) indicate that 53 percent of the County land is resource lands and 47 percent is developed lands – mostly residential.



Map 1. **County Region Planning Areas.**

and the number of public and private facilities and structures that could be at risk is relatively small. In terms of future development, the vulnerable areas are generally not within the County's planned growth areas. Nevertheless, **the value of properties, infrastructure, and natural resources that could potentially be damaged or rendered unusable is significant, and to this end the County should take preventive planning measures and actions to minimize any damages or loss of important resources.** It is recognized that strategic planning for sea level rise will be an ongoing and

transitioning process as more research, analysis and guidance becomes available from State and Federal agencies and the scientific and academic communities. While the intent of the strategic plan is to identify steps that can be initiated by the County in both the near term and longer term, it is anticipated that this plan will be built upon and revised in future years as the topic progresses.

Anne Arundel County lies in the physiographic province known as the Atlantic Coastal Plain. Elevations in the County range from sea level along the shore of the Chesapeake Bay to more than 300 feet in the northwestern part of the county near Laurel. Nearly level or gently sloping areas occupy large areas north of the Severn and Magothy Rivers, on the Deale-Shadyside flats and in the southwestern part of the County in the Patuxent River. The steepest areas are in a north-south section that runs through the central part of the County, where many small streams have cut deep-shaped valleys into the soft unconsolidated materials of the coastal plain. Broad alluvial terraces border large streams and rivers that flow into the Chesapeake Bay.

The County is laced by a network of streams that carry runoff from different land uses to the waters of its many creeks and rivers. Because of its topography, with an extensive shoreline and numerous peninsulas, the County's streams tend to be short, first- and second order, slow moving, low gradient waterways. All of Anne Arundel County's streams originate within the County except for the Patapsco and the Little Patuxent Rivers. There are 12 major watersheds in the County, which are part of three larger tributary watersheds in the State: Patapsco/ Back River, Lower Western Shore, and Patuxent. The largest watersheds entirely within the County are the Severn River and South River watersheds.

More than two-thirds (69 percent or 5,872 acres) of Deale/Shady Side areas are designated as "Critical Area" under the State of Maryland's Critical Area Program. Of the total acreage within the Critical Area, more than half (3,081acres) has been designated as a Resource Conservation Area. This area is characterized by many small tributaries and low-lying peninsulas woven into the landscape. The uneven ratio of shoreline to land acreage creates a situation in which land use has a disproportionate effect on water quality.

The Maryland Inventory of Historic Properties lists over 800 historic resources within Anne Arundel County Government's jurisdiction, most of which are privately owned and fewer than a dozen are open to the public. Additionally, the County database counts more than 500 historic cemeteries. Anne Arundel County offers protection to these historic sites via Federal and State regulations as well as County legislation. A recent study completed by the Cultural Resources Section (Poulos et. al 2018) indicates that a number of potential, undocumented historic districts in the County (dating from the end of the 19th into the early 20th century) are waterfront beach communities located in vulnerable areas along the Chesapeake shoreline.

In addition to the documented historic resources and cemeteries, Anne Arundel County has more recorded archaeological sites than any other county in Maryland, with many more sites still to be discovered. Over 1700 archaeological sites are recorded to date, the majority of which fall into the County's jurisdiction. These sites span the entire 13,000 years of human presence in the area and represent a unique and non-renewable piece of cultural heritage. The assessment of archaeological potential for unknown sites is generally based on topographic and environmental settings, including proximity to local watersheds. Many of the archaeological sites in the County fall into both coastal and riverine flood zones and are vulnerable to sea level rise, shoreline erosion, and flooding.

1C. Planning Process

The Coastal Resiliency Toolkit was developed through a three-step planning process. First a computer model of future SLR was developed based on the 2022 SLR Technical Report, *Global and Regional Sea Level Rise Scenarios for the United States* (Sweet et al 2022). Next, an analysis of risks associated with SLR was conducted. Finally, conceptual measures were identified that could mitigate those risks. This study was guided by a technical team including representatives of multiple County Departments including Office of Planning and Zoning, Office of Emergency Management, Department of Public Works, and the Bureau of Watershed Protection and Restoration. The technical team and consulting team of Maryland Environmental Services, Michael Baker International, and Smith Planning and Design met on a monthly basis through the planning process.

Starting in June the County's Technical Team met on a monthly basis to discuss project development. The first meeting was held virtually on June 9, 2022. This meeting was scheduled to introduce key members of the contracting team, discuss project schedule, and contractor expectations. A data request was also made at this time and filled by County GIS resources.

A second Technical Team meeting was held on July 14, 2022. This meeting was held to discuss the work schedule and proposed timeline that was dependent on receiving information from an Annapolis SLR study that that is being conducted concurrently. Facilitation of multijurisdictional and inter-departmental coordination was needed to obtain details of the Federal SLR benchmarks decided upon by the City of Annapolis US Naval Academy for application in their Military Installation Resiliency Review (MIRR) project. Merits of using their proposed numbers versus what we proposed earlier based on State guidelines were discussed and decided on during this meeting.

During the August 11, 2022 Technical Team meeting, the results of the plan review were shared with committee members. A total of 17 County documents were reviewed for relevant SLR plans, projects or incentives. In developing the Digital Elevation Model (DEM) two LIDAR datasets were presented and reviewed: the Anne Arundel County 2020 Bare Earth Raster's and the Continuous Updated Digital Elevation Model (CuDEM).

An initial hydrodynamic model was completed by propagating daily water levels from the Annapolis National Oceanic and Atmospheric Administration (NOAA) gauge station (Station ID: 8575512) into Anne Arundel County model. The resulting water surface elevations in selected tidal gauges were validated against NOAA stations in Maryland's coastline and showed offsets and can be refined by adjusting model parameters.

During the September 7, 2022 Technical Team meeting, results of the 2050, 2065, and 2100 SLR scenarios were presented using both bathtub models. Model results were compared to NOAA SLR Viewer scenarios for Region 9 as part of the selection process. Two Digital Elevation Models (DEM) were considered for the analysis: *Anne Arundel County 2020 Bare Earth DEM* and Continuously Updated Digital Elevation Model (CUDEM). Ultimately the 2020 County provided DEM was chosen because of its resolution, coverage area, and date of collection. The differences between the two models were about +/- 1m and were located near waterbodies. A detailed description of the modeling process is included in Section 1E of this document.

Initial findings of the Hazus for the 2050 SLR scenario was provided to the Technical Team during the October 2, 2022 meeting. Region 9 vulnerability analysis was adjusted to include 2050 SLR combined with a 1% chance flood only. Final product design and layout samples were provided for review at the December 5 meeting with the focus of the meeting on the findings of the Hazus. Additional discussion centered around areas where stormwater analysis could be integrated, impacts to private wells, and shoreline erosion. Priority area analysis and possible mitigation measures were discussed at the January 11, 2023, meeting. During the February 6 meeting elements of the draft Toolkit was presented and a draft copy of the Region 9 Coastal Resiliency Toolkit was delivered to the Technical Team for review on March 4, 2023.

1D. Relationship to Other County Plans and Policies

County departments, decision-makers, project managers, and everyone in between need to align their plans and programs on the basis of the County's recommended sea level rise strategies. These strategies includes using up-to-date sea level rise science and data models and integrating targeted policy recommendations into planning efforts, permitting regulations, implementing both mitigation and preventative actions, while monitoring vulnerable shorelines and emphasizing public outreach and education. The Anne Arundel Office of Planning and Zoning (OPZ) is at the core of this alignment, offering a space to collaborate and share information.

Unlike most of the County policy documents mentioned below, the Sea Level Rise Strategic Plan of 2011 is not a formally adopted plan as recognized by the County Council, but rather a research document presenting strategic recommendations and results of a vulnerability assessment. Since the release of the 2011 SLR Strategic Plan, this document was referenced repeatedly over the past decade to inform subsequent formal plans. The County's Office of Emergency Management's internal working groups routinely acknowledge the dangers of climate change and sea level rise vulnerabilities, resulting in more recent recommendations in the updated 2018 Hazard Mitigation Plan, as well as other emergency plans (such as for long term resiliency functions and core operating procedures). Additionally, the County integrates sea level rise policy into many of its master plans, including its most recent General Development Plan known as Plan2040 (formally adopted in 2021).

In addition to these County-specific documents, cross-jurisdictional coordination with County departments and other stakeholders is a necessary part of establishing resiliency to these coastal hazards. In 2020, University of Maryland partnered with Anne Arundel County to establish a County-specific Resilience Action Strategy Work Group, resulting in the draft of a *Climate Resilience Action Strategy* for internal review. This document is not yet a formalized document available for public distribution, but rather laid out the steps for developing plans and recommendations related to climate change. The top hazards identified in this 2020 document were as follows:

1. **Catastrophic/major storm events**
2. **Tidal (nuisance) flooding**
3. **Temperature**
4. **Sea level rise**

All of these elements are interconnected and overlap in planning documents produced since the 2011 SLR Strategic Plan. Multidisciplinary teams with interjurisdictional collaboration and projects that offer multiple benefits should continue to be prioritized. In the case of this update to the 2011 Sea Level Rise Strategic Plan, the County is working with the United States Naval Academy and the City of Annapolis to ensure synchronicity with their planning efforts. The OPZ will leverage information in this document to inform its interagency partners, as well as the newly instated Resilience Authority of Annapolis and Anne Arundel County (established Oct. 25, 2022 for the purpose of developing, financing, and supporting infrastructure projects on behalf of both the County and Annapolis).

A review of County plans and policies for SLR strategies was conducted as a part of this update to ensure that a mutually supportive resilience framework exists throughout all County planning efforts. The results and recommendations of the Region 9 Coastal Resiliency Toolkit are consistent with State policies and regulations including the 2018 Sea-Level Rise Projections for Maryland Report, the 2022 Guidance for Using Maryland's 2018 SLR Projections, and the 2018 Maryland Historical Trust's Flood Mitigation Guide: Maryland's Historic Buildings, County plans and policies including the 2018 Anne Arundel County Hazard Mitigation Plan Update and the 2021 General Development Plan, Plan2040 have also be integrated into the development of the Region 9 Coastal Resiliency Toolkit. A detailed plan review is included in Attachment 2. Each County plan was reviewed using 7 criteria: 1.) Relevant Values, Goals, Objectives, Priorities; 2.) Useful Data Sources or Maps; 3.) Relevant Projects (related to SLR and/or in focus areas); 4.) Discussion of SLR; 5.)

Relevant Current Policies or Policy Incentives; 6.) Ways SLR can be Integrated into SLR Strategic Plan; and 7.) Other relevant information.

Plans, policies, and ordinances reviewed as part of this project included the following documents.

County Plans that Incorporate SLR

- **Green Infrastructure Master Plan** (2022)
- **Land Preservation, Park, and Recreation Plan** (2022)
- **Plan2040** (2021)
- **Climate Resilience Action Strategy** (2020, *not available on- line*)
- **Nuisance Flooding Plan** (2020)
- **Move Anne Arundel! County Transportation Plan** (2019)
- **Emergency Operations Plan** (2019)
- **Hazard Mitigation Plan** (2018)
- **Implementation Plan for Achieving Energy Efficiency and Conservation** (2013)
- **SLR Strategic Plan** (2011)

A few examples of how SLR is integrated into recent strategic planning initiatives in County documents are below:

- ✓ The **Hazard Mitigation Plan (2018)** summarizes the results and recommendations of the 2011 SLR Strategic Plan to provide context for the County's ongoing and emerging efforts to address climate change and SLR.
- ✓ **Plan2040** includes a goal specifically focused on climate change (BE16) and integrates climate related policies and strategies across multiple topics including shorelines, transportation, emergency response, and infrastructure.
- ✓ The goal of the **Climate Resilience Action Strategy** is to accelerate resilience planning and financing in three Chesapeake Bay communities. The approach identifies and leverages the linkages between water quality restoration and protection and climate change resilience
- ✓ The **Land Preservation, Park, and Recreation Plan (2022)** reviewed County properties to see where there are opportunities to address impact associated with SLR. Particular attention to area of coastal park improvements and acquisition of flood prone properties. The Green Infrastructure Master Plan establishes a goal to conserve an additional 5,000 acres of land in the Network by 2030, representing 30% of the County land area. It also includes recommendations to prioritize conservation of flood prone properties.

Based on the analysis and conclusions to date before this study, the County established that its **immediate focus for sea level rise planning efforts** will be more on **reducing impacts and future losses to existing development and resources (see the 2018 Hazard Mitigation Plan, page 3-44)**. Most recently, consideration for **limiting or restricting the extent of future development in areas subject to flooding and to sea level rise** were included in **Plan2040**, which includes **increased investments in habitat protection and restoration** along with a number of integrated policies targeting sea level rise vulnerabilities. This recently updated general development plan identifies new policy and resource sensitivity areas that classifies all of the County's peninsulas, including Shady Side, Mayo, Edgewater, Broadneck, and Pasadena, as areas requiring shoreline protection, sea level rise adaptations, and improved stormwater management, along with limitations on further development.

1E. Methodology & Model Development

The SLR model scenario year and water level projections were selected to align with SLR risk assessment being conducted by the US Navy, City of Annapolis, and Anne Arundel County as part of the Military Installation Resilience Review (MIRR). The project team reviewed the SLR Projections for Maryland, prepared by the University of Maryland Center for Environmental Science (Boesch et al. 2018) and the Global and Regional Sea Level Rise Scenarios for the United States prepared by a coalition of federal agencies and universities (Sweet et al. 2022). Both of these studies provide a range of SLR estimates based on differing assumptions of model inputs, such as future rates of greenhouse gas emissions and system responses, such as global temperature change and rates of glacial melt. The projections in both of these reports were similar in the near term (year 2050), but deviated somewhat in the long term (year 2100). For consistency with Department of Defense requirements for military installations, the County selected three time horizons, 2050, 2065, and 2100, and relied on the 2022 SLR projections in the federal agency study (Sweet et al 2022).

The 2022 study provides five Global Mean Sea Level scenarios: Low, Intermediate-low, Intermediate, Intermediate-high, and High, each predicated on different future emission pathways and global warming trends. The water elevations for each year were selected from a range of projections based on statistical likelihood. The project team based the SLR model on the "Intermediate-high" curve for RSLR, a conservative projection, but not the most extreme. The projection of water level elevations take into consideration local factors including subsidence.

Regional rates of SLR deviate from global trends as a function of regional factors such as vertical land movement, changes in ocean currents, and changes in gravitational forces from ice mass loss. The 2022 report projections provide a range of regional SLR values for each of the five global scenarios; the report provides a low, medium, and high value representing the 17th, 50th, and 83rd percentile. This risk assessment applies the medium value for all cases and selected the values from the NOAA tidal gauge located at Annapolis, MD (station ID 8575512). All future SLR values are relative to a base year of 1992 (representing the middle of the current tidal epoch). Table 1 provides both the SLR increment (how much the sea level is projected to rise),and the water surface elevations at Mean Higher High Water, a well as during an extreme event representing the 1-percent-annual chance storm. The elevations are relative to the NAVD88 vertical datum.

In order to properly assess Anne Arundel County's Vulnerability to SLR the following dataset were considered.

1. SLR Scenarios:
2. Table 1 shows the water surface elevations at Mean Higher High Water for this station relative to NAVD88 vertical datum, as discussed above. Although higher projections are important for long term risk planning, simulating lower sea level rise that have a shorter time frame (such as 2050 scenario) will help us locate areas that are prone to flooding even at lower inundation depths.

Table 1. **SLR Inundation Levels at Mean Higher High Water.**

		Water Surface Elevation Relative to NAVD88 (feet)	
Time Frame	**SLR Increment (ft)**	**Elevation of MHHW**	**Elevation of 1% Annual Chance Storm Surge**
2050	1.6	2.31	8.11
2065	2.54	3.21	9.01
2100	5.35	6.02	11.82

3. ***Modeling Technique***: Two commonly used SLR risk assessment techniques for coastal flood inundation modeling are the *Hydrodynamic modeling* and the *Bathtub Flood modeling*.

   - ***Hydrodynamic Models*** such as ADCIRC, Delft3D, MIKE modeling suite, etc., simulates coastal flooding by solving water depth equations through complex numerical methods. These numerical models are more adaptive by allowing users to dynamically add parameters such as meteorological conditions or sediment movement. This type of model also allows users to add different flooding sources as well if necessary to better replicate physical phenomena on a local scale, without having to build or test physical models. However, this added complexity makes hydrodynamic models very resource intensive to run.

     Initial testing was done using ~100ft (30m) ADCIRC resolution mesh to simulate tidal harmonic propagation in the model. However, after simulating 30 days of only tidal processes, it was shown that several tidal stations in the model have 0.70 ft (~20cm) offset from NOAA tidal gauges along the coast. These differences are due to physical interactions within the model and can be resolved through model adjustments, but it will add complexity to the objective of the project that is beyond the grant budget.

   - ***Bathtub Flood Modeling*** on the other hand are more straightforward, and only needs the Digital Elevation Model (DEM) and GIS software to run. Since the only source of flooding for this risk assessment comes from the coastal waters and there are no other external factors such as meteorology, waves, riverine flow or hydraulics , that can promote or impede the flow of water besides topography, the bathtub model was chosen for this project. This method is also called Static Bathtub Model will be discussed in the next section

4. ***Digital Elevation Model***: DEMs represent the elevation of an area without vegetation, structures, or other objects. There were two available DEMs that were considered for the analysis: *Anne Arundel County 2020 Bare Earth DEM* and Continuously Updated Digital Elevation Model (CUDEM) for Chesapeake Bay. Ultimately the 2020 County provided DEM was chosen because of its resolution, coverage area, and date of collection. Most of the differences between the two were about +/- 1m and were mostly located near waterbodies. Summarized in Table 2 below are the differences of two DEMs. The comparison of these DEMs were presented during the August 11, 2022 consultation meeting.

Table 2. **Comparison of 2020 vs. 2019 DEM Resolution for Model Development.**

Water Surface Elevation Relative to NAVD88 (feet)		
Parameters	**Anne Arundel County Bare Earth DEM**	**CUDEM**
Publication Date	2020	2019
Resolution	1 ft	3.28 ft
Area Covered	Anne Arundel County	Areas along the Chesapeake Bay

Sea Level Rise Assessment Methodology

Static bathtub modeling approach was used for this project. It is a passive mapping approach that is used to identify areas at risk to flooding by simulating the effects of a hypothetical SLR event. The approach is based on the idea that a flood can be thought of as a "bathtub" filling up with water, and its walls represent the topography and other physical features that can contain or channel the floodwaters. To simulate flood inundation, we first defined three SLR scenarios and used them to identify areas vulnerable to rising coastal waters. Using ArcGIS map algebra function we selected areas in the DEM connected to the coastal waters that were lower than the SLR elevation and identified them as inundated communities or flooded areas. Since the flooding source for this model is coastal waters of the Chesapeake Bay, low lying areas that were selected but were disconnected or were far from the shore were removed. After applying these selections, we isolated the flooding extents and the flood depths for each given SLR scenario.

This flood model produced several SLR scenarios assessing both the extent and depth of SLR (depth grids). The static bathtub model developed for this study used various input files, including:

- Digital Elevation Model in raster format
- Study Area
- Coastline
- SLR Projections

Detailed methodology and discussion of the resulting GIS datasets is below.

Step 1: Setting up the bathtub model

- Merge high resolution Topography Digital Elevation Model (DEM) 2020 Bare Earth Model from Anne Arundel County into seamless tiff.
- Process seamless DEM for any large sinks or fills within study area
- Develop a coastline using the generate contour option at 0 feet in ArcGIS platform

Step 2: Establish SLR scenario elevations

- Review SLR guidelines to develop the SLR values, as discussed in previous section
- Apply a vertical datum adjustment for converting from mean sea level to Mean Higher-High Water (MHHW)
- Use NOAA tide station for vertical adjustment.
    - i.e. MHHW is 0.71 feet above the MSL at Annapolis

5. Add vertical adjustment to chosen SLR value (see

- Table 1 above). The resultant number will be the final elevation for static bathtub modeling.

Step 3: Simulate Flooding Scenarios in bathtub model

- Load seamless DEM in ArcGIS
- Perform “map algebra” in ArcMap to extract raster pixel values equal and smaller than the prescribed SLR elevation,
    - i.e., "DEM.tif” <= float(“SLR_elevation”)
- Reclassify extracted raster into pixel values of 1 where it is lower than SLR elevation and No data where it is higher.
- Now clip the raster to the coastline of the study area to remove areas found in Ocean
- Convert clipped raster to polygon shapefile using “raster to polygon” process in ArcMap
- Now run “select by location” process in ArcMap to extract all polygons connected to ocean. Figure 1 provides an illustration of 4-point connectivity used for flooding analysis of areas below SLR in this process.

Step 4: Extract Flooding Extent and Flood Depth Grids

- The resulting polygon shapefile will be the extent of flooding due to a given SLR elevation.
- In order to calculate the flood depths, take the reclassified raster created in step 3 and multiply by the SLR elevation
- Subtract multiplied raster from the original DEM to extract flood depth grid.

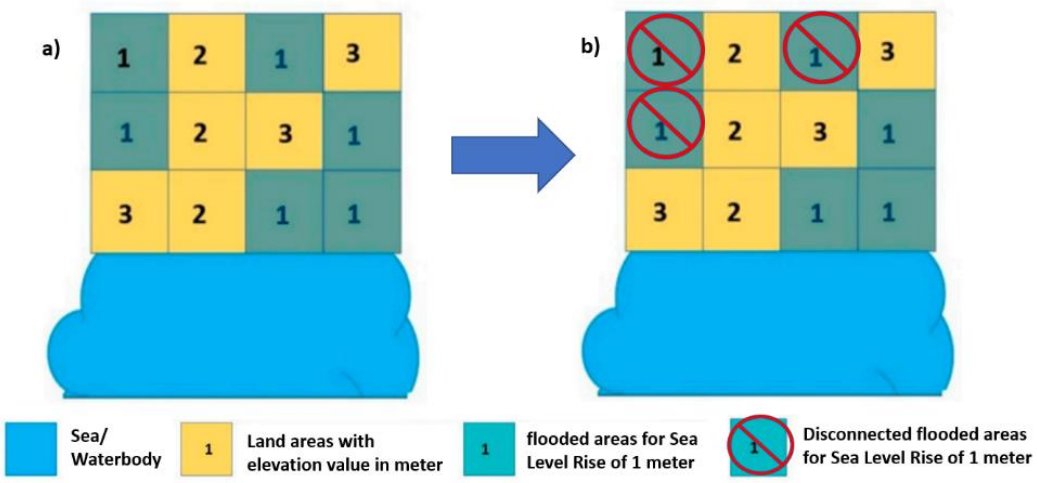
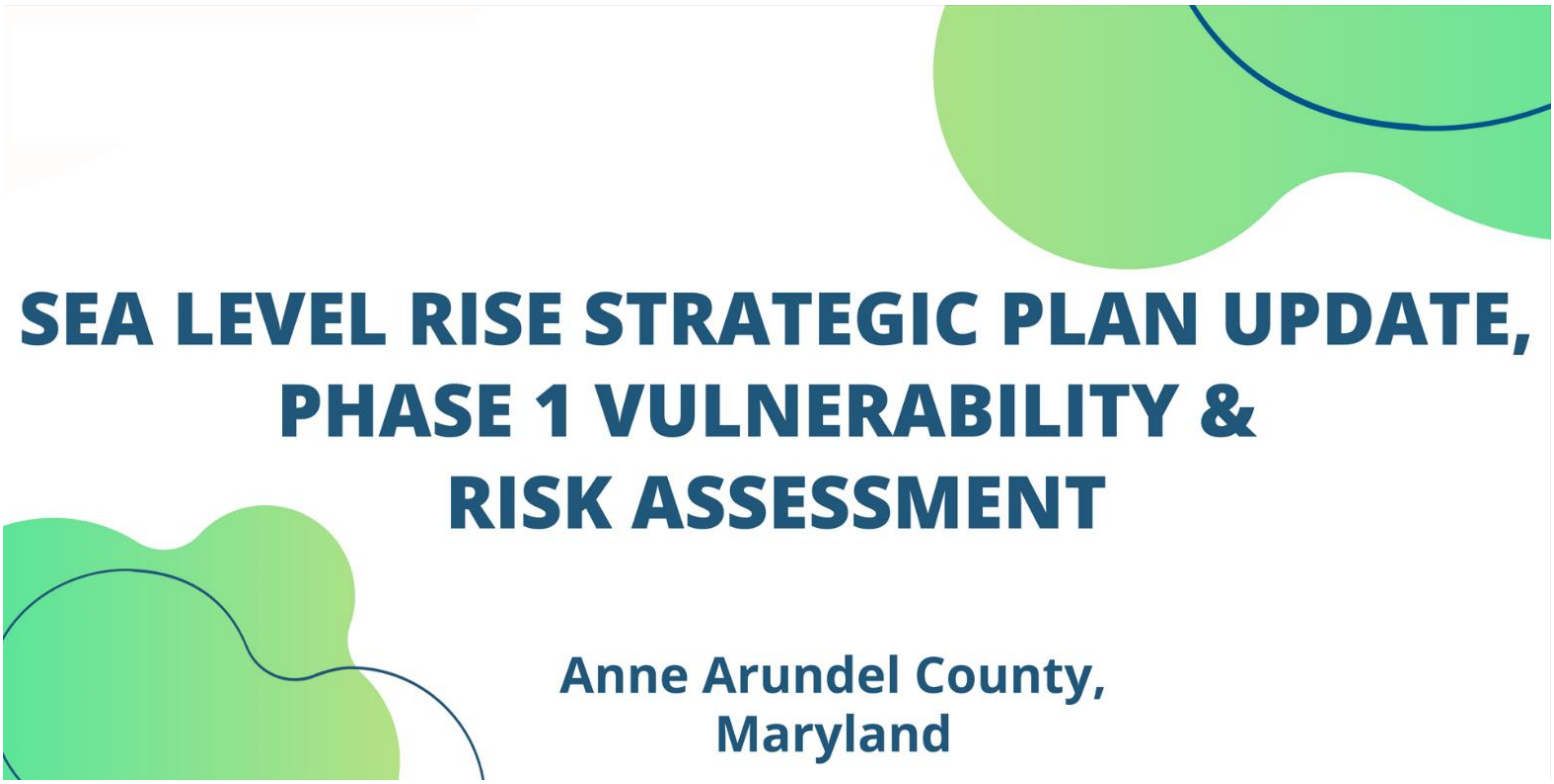


Figure 1. **Bathtub SLR modeling using four-point connectivity.**



PART 2 - COUNTY-WIDE RISK ASSESSMENT

2A. Risk in 2011 and 2023

In 2011, the County partnered with the Maryland Department of Natural Resources (DNR) through the Coastal Communities Initiative Program to conduct a study of potential SLR impacts and develop adaptation strategies. The project included four major components:

1. A vulnerability assessment to identify potential areas impacted by SLR and develop inventories of resources at risk.

2. Development of a framework for interagency strategic planning.

3. Development of a strategic plan.

4. Public outreach and education to promote public awareness of SLR issues.

The *2011 SLR Strategic Plan* is the outcome of that study. The 2011 Plan summarizes the State's research and planning efforts related to SLR; discusses the key findings from the vulnerability assessment and other planning analysis; identifies the major planning issues for Anne Arundel County as related to SLR; and recommends future actions to protect resources and minimize impacts.

Key Conclusions of the 2011 Analysis

The key conclusions of the 2011 analysis that guided the strategic planning process are summarized below:

• In terms of land cover, some of the most significant impacts of a rise in sea level will **be a loss of wooded areas and open wetlands** which are valuable components of the coastal ecosystem.

• A majority of the developed land in vulnerable areas is used for residential purposes, with **primarily single family detached homes**. Some homes may require elevation or relocation.

• With a sea level rise of less than two feet, impacts to principal structures may be relatively small. **If a rise in sea level between two and five feet** should occur, impacts may be much more significant with **as many as 2,400 structures** that could be damaged or require relocation.

• **Structures at risk** are located in mostly coastal communities, but the majority is located on the **Deale/Shady Side peninsula**.

• **Local roads** in many coastal communities may be impacted, particularly on the Lake Shore, Annapolis Neck, Mayo, and Deale peninsulas. However, the total amount of road miles is not large. Impacts would occur at a neighborhood level but could render some properties inaccessible.

• **Impacts to public utility infrastructure are difficult to assess.** Even if the surface land area is not permanently inundated, the higher water table associated with a rise in sea level may cause underground infrastructure including water supply and sewer lines and storm drains to malfunction or collapse. In terms of the quantity of public utility infrastructure, the amount that may be at risk is not large. But it is located in a more scattered pattern amongst almost all coastal communities, making planning for retrofits or alternatives more complex.

• **Sewer pump stations** in four of the County's public sewer service areas (Broadneck, Annapolis, Mayo, Glebe Heights, and Broadwater) are located in potential inundation areas under a sea level rise of between two feet and five feet.

• Several thousand properties that rely **on individual water supply wells and onsite septic systems** could be impacted by rising sea level causing septic systems to fail and wells to become contaminated by saltwater intrusion. In many cases, these properties are not within a feasible distance for connection to a public utility system, and may not be concentrated enough in density to allow installation of community well or septic systems as a viable alternative. This makes mitigation planning for such situations even more difficult.

• The **marina industry** will likely be the most impacted segment of the local economy since virtually every marina business could be impacted by a rise in sea level.

• As many as **46 County parks** could be at least partially inundated in the future. Park development plans will need to take into consideration these potentially vulnerable areas.

• Over 400 archaeological sites may be susceptible to loss or damage due to sea level rise, as well as 80 historic properties. This is of particular concern to the County given the extremely high value of some of the archaeological finds discovered to date in the County. Strategic planning to prevent loss of these irreplaceable resources is a priority.

• **Shoreline erosion** has generally been slight along most of the County's coast, although many shoreline miles have experienced some degree of erosion. Very small areas of shoreline have experienced moderate to high rates of erosion. Significant areas of shoreline have protection mechanisms in place, but identification of additional areas in need of future protection is needed

Data tables from the ***2011 SLR Strategic Plan (SLRSP)*** were updated for this planning effort. New data tables within this section include:

- Land and Property Value
- Principle Structures
- Utility Infrastructure
- Cultural Resources
- Well and Septic Systems

Each new table includes data from the *2011 SLR Strategic Plan,* which used 0-2 feet SLR inundation and new SLR scenario data for 2050, 2065, and 2100. The 2023 planning effort included the development of a bathtub model that generated SLR inundation for the new SLR scenarios. It is important to note, comparison between 2011 and 2023 findings that the 0-2 feet SLR inundation used in 2011 is similar to the 2050 SLR scenario used in 2023, which is 0-2.31 feet. Please refer to the chart below for each new SLR scenario used in 2023 and included on Table 3 through Table 12.

Land and Property Value

The 2011 SLRSP stated nearly 2,200 acres of land are vulnerable under a 0–2-foot SLR. Almost two-thirds of this area (62%) consists of woodlands and open wetlands. The 2023 analysis results indicated that over 3,100 acres of land are vulnerable to the 2050 SLR scenario. Over half, 57%, of lands vulnerable to the 2050 SLR scenario consist of forested wetlands, open wetlands, and woodlands. A total of 391 acres (12%) of residential land are vulnerable to the 2050 SLR scenario. A relatively small portion of land area is used for commercial, industrial, open space or agricultural uses.

A total of 4,462 acres of land could potentially be impacted by the 2065 SLR scenario, however this amount nearly doubles when the inundation area is expanded under the 2100 SLR scenario.

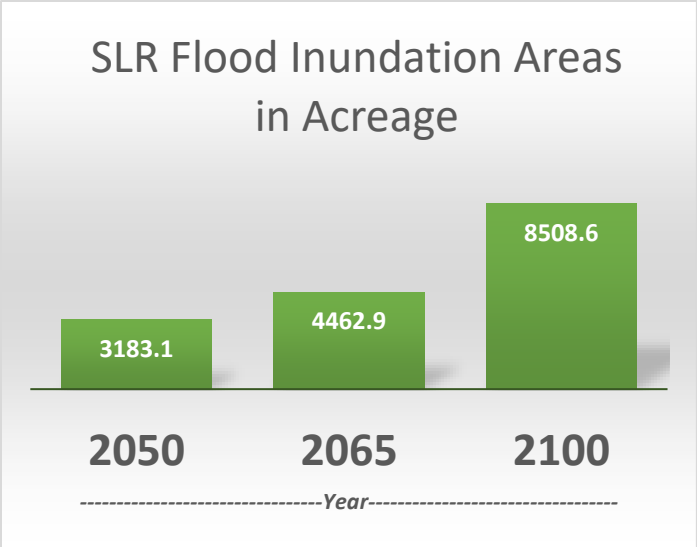


Table 3. **Land Cover.**

Land Cover (in Acres)				
Type of Land Cover	**2011 SLRSP 0-2 ft Inundation**	**2050 SLR Scenario 2.31 ft Inundation**	**2065 SLR Scenario 3.21 ft Inundation**	**2100 SLR Scenario 6.02 ft Inundation**
Commercial	13	27.5	68.4	326.9
Forested Wetland	5	114.2	216.4	499.5
Industrial	4	4.6	7.7	35.1
Open Space	262	72.3	141.3	379.6
Open Wetland	622	1,192.1	1,362.4	1,503.9
Pasture/Hay	1	3.0	6.3	35.7
Residential 1/2-acre	24	87.6	161.6	442.9
Residential 1/4-acre	44	126.5	264.1	838.0
Residential 1/8-acre	66	50.0	106.2	440.3
Residential 1-acre	68	46.2	80.5	231.9
Residential 2-acre	78	80.7	145.6	416.1
Row Crops	1	0.92	4.6	52.2
Transportation	7	7.8	20.5	75.1
Utility	1	0.58	1.7	3.4
Water	234	859.0	1,000.7	1,143.8
Woods	743	510.1	874.9	2,084.2
Total	**2,193**	**3,183.1**	**4,462.9**	**8,508.6**

Data used for 2023 Analysis:

- *2020 Land Cover dataset for Anne Arundel County, MD:*
  - *Anne Arundel County, Maryland is interested in monitoring its changing land cover for planning, zoning, and environmental protection purposes. The county is under increasing development pressure and needs to maintain an accurate land cover database so it may guide development in a sustainable way from both economic and environmental perspectives. The land cover layer was designed and built as a continuation of hand-digitized layers compiled in the 1990s. The current layer was completed using primarily automated methods and current high-resolution aerial imagery (6-inch resolution, leaf-off), as a comparison for cost and accuracy to the earlier automated and manually produced datasets. This version was updated in 2020 using 4-band aerial imagery collected in the spring of 2020 by the State of Maryland.*
- *2023 Bathtub Model - Anne Arundel County 2020 Bare Earth DEM*

  Please note that the 2011 data was based on period data (shown in blue) where the columns for 2050, 2065, and 2100were based on a revised 2023 bathtub model. While these totals were compared in the table above, data sources were disparate and cannot be compared on a one-to-one basis.

The average, median, and total assessment values of the properties at risk from the 2011 SLRSP and the 2023 planning effort are shown in Table 4. Properties at risk include those that fall fully or partially within the inundation area, as well as both improved and unimproved properties. According to the 2011 SLRSP, the total value of properties at risk to the 0–2-foot scenario was nearly $3 billion. Whereas the total value determined in the 2023 analysis for properties at risk the 2050 sea level scenarios was over $10.6 billion. Total assessment values for the 2065 sea level rise scenario was $11.4 billion, while the total assessment values for the 2100 sea level rise scenario were over $14.0 billion. These values are based on Anne Arundel County 2017/18 Edition of the Maryland Tax Assessment and are considered current as of early April 2022.

Table 4 was divided in order to provide assessment values for land only, structures only and totals (land and structure values combined) for the new sea level rise scenarios. The 2011 SLRSP results are included with the new 2050 sea level rise scenario section for comparison to the 2023 analysis results. It is to be noted that the 2011 and 2023 sea level rise scenarios differ in methodology and geographic extent, therefore an exact data comparison could not be completed. Also, a decrease in average and median assessment values decrease over time as the distance increases from the shoreline, whereas the total assessed value for all properties increases over time.

Table 4. **Properties at Risk and Assessment Values.**

Properties at Risk and Assessment Values – 2050 (0-2.31 ft Inundation) Sea Level Rise Scenario				
	2011 SLRSP 0-2 ft Inundation*	Structure Value**	Land Value***	Structure & Property Values****
# of Properties at Risk	11,607	-	-	10,295
Average Assessment Value	$223,854	$378,256	$656,466	$1,034,722
Median Assessment Value	$143,027	$212,400	$456,300	$716,700
Total Assessment Value	**$2,904,959,889**	**3,894,145,200**	**6,758,314,390**	**$10,652,459,590**

Properties at Risk and Assessment Values – 2065 (3.21 ft Inundation) Sea Level Rise Scenario			
	Structure Value**	Land Value***	Structure & Property Values****
# of Properties at Risk	-	-	11,665
Average Assessment Value	$357,601	$624,330	$981,931
Median Assessment Value	$204,700	$436,300	$681,600
Total Assessment Value	**$4,171,411,400**	**$7,282,810,790**	**$11,454,222,190**

Properties at Risk and Assessment Values – 2100 (6.02 ft Inundation) Sea Level Rise Scenario			
	Structure Value**	Land Value***	Structure & Property Values****
# of Properties at Risk	-	-	16,654
Average Assessment Value	$311,166	$532,345	$843,510
Median Assessment Value	$181,100	$369,550	$569,650
Total Assessment Value	**$5,182,153,200**	**$8,865,664,990**	**$14,047,818,190**

**Data sources for the 2011 SLRSP Table 4 were not provided, therefore a planning assumption was made that the numbers provided in the 2011 report on Table 4 represent structure values only.*
***This column provides information on parcels that contain an assessment value for structures only.*
**** This column provides information on parcels that contain an assessment value for land only.*
***** This column provides information on all parcels (land + structures) impacted by the sea level rise scenario.*
Data used for 2023 Analysis: MD Property View - Anne Arundel County 2017/18 Edition; For Anne Arundel County, the 107 property maps are current as of January 2021, the information contained in the Parcel dataset (Maryland Tax Assessment) is current as of early April 2022.

Principle Structures

According to the 2011 SLRSP, 140 principal structures were determined to be vulnerable in the 0–2-foot scenario. A total of 167 principal structures were determined to be vulnerable in the 2050 SLR scenario for the 2023 planning effort. The majority of these are residential, primarily single family detached dwellings. Results increased to 699 principal structures being potentially vulnerable to the 2065 SLR scenario. However, principal structures vulnerable to the 2100 SLR scenario significantly increased to 4,270. Of these, approximately 92% are residential structures and are primarily single family detached homes.

The location of structures at risk in the 2011 SLRSP and the new 2023 analysis are similar. The principal structures at risk are located all along the shoreline from Pasadena in the north down to South County. The Deale peninsula, which includes the communities of **Deale, Shady Side, Churchton,** and **Galesville**, is particularly vulnerable to the 2100 SLR scenario with almost 4,000 structures. The Shady Side area also contains fairly large numbers of structures at risk.

Table 5. **Principal Structures at Risk.**

Principal Structures at Risk (# of structures)				
Building Use Type	**2011 SLRSP 0-2 ft Inundation**	**2050 SLR Scenario 0-2.31 ft Inundation**	**2065 SLR Scenario 3.21 ft Inundation**	**2100 SLR Scenario 6.02 ft Inundation**
Commercial	13	51	82	254
Educational	0	0	0	2
Fire Station*	-	0	0	1
Government*	-	4	11	63
Other Institutional	2	5	10	17
Place of Worship	0	1	1	4
Residential	125	106	595	3,929
Total	**140**	**167**	**699**	**4,270**

** Not included in the 2011 SLR Strategic Plan Analysis*
Data used for 2023 Analysis:

- *Current address point GIS layer for Anne Arundel County, MD. Updated: 04-20-2022*
- *Buildings in Anne Arundel County Item Updated: 11-14-2019*

Utility Infrastructure

Water lines within vulnerable areas are located all along the coastal areas, but there are small concentrations of sewer lines at risk in Glen Burnie, Green Haven, Pasadena, Severna Park, Gibson Island, and Edgewater.

Sewer lines potentially vulnerable to the new SLR scenarios are in the same location as the water lines, with additional areas of higher concentration in the Highland Beach area, Mayo, and Deale. The majority of sewer pump stations are at-risk to the 2100 SLR scenario and mostly located in Edgewater, Highland Beach area, Mayo, Shady Side, and Deale.

Storm drainpipes are found in all of the SLR scenarios along the coastline. The 2100 SLR scenario potentially could have the greatest impact on the storm drainpipes.

Table 6. **Public Utility Infrastructure at Risk.**

Public Utility Infrastructure at Risk				
Facility Type	**2011 SLRSP 0-2 ft Inundation**	**2050 SLR Scenario 0-2.31 ft Inundation**	**2065 SLR Scenario 3.21 ft Inundation**	**2100 SLR Scenario 6.02 ft Inundation**
Water Lines (pipe length in feet)	26,684	23,874	27,762	77,169
Water Hydrants	2	0	2	16
Sewer Mains (pipe length in feet)	21,602	48,816	115,139	412,809
Sewer Manholes	36	4	8	70
Sewer Pumping Stations	1	1	5	36
Storm Drainpipes (pipe length in feet)	22,880	25,086	35,981	84,544
Stormwater Manholes*	-	4	8	70
Stormwater Inlets*	-	12	69	406
Stormwater Outfalls*	-	1	5	36

** Not included in the 2011 SLR Strategic Plan Analysis*

Data used for 2023 Analysis:

- *Anne Arundel County Water Mains. Updated quarterly. Updated 3-10- 2022*
- *Anne Arundel County Water Hydrants. Updated quarterly. Updated 3-10- 2022*
- *Anne Arundel County Sewer Mains. Updated quarterly. Updated 3-10- 2022*
- *Anne Arundel County Sewer Pump Stations. Updated quarterly. Updated 3-10- 2022*
- *Countywide Stormwater Pipes layer for Anne Arundel County. Updated 12-14- 2021*
- *Anne Arundel County Stormwater Manholes. Updated 12-14- 2021*
- *Countywide Stormwater Inlets layer for Anne Arundel County. Updated 1-14-2021*
- *Countywide Stormwater Outfalls layer for Anne Arundel County. Updated 1-14-2021*

Wells and Septic Systems

Individual septic systems in the County are susceptible to impacts of SLR, either due to surface inundation or to high water tables associated with a rise in sea level. This may cause septic systems to fail and can result in contaminated wells due to floodwaters and saltwater intrusion. Table 7 and Table 8 indicate the number of properties with wells and septic facilities that are located in vulnerable areas. Septic systems on properties susceptible to the new SLR scenarios are primarily concentrated along the coastal portions of the Lake Shore peninsula, the Broadneck peninsula, Annapolis, and the coastal areas in South County including Deale/Shady Side peninsulas. Wells at risk are found in the same general locations with septic systems at risk. These locations are consistent with the findings in 2011 SLRSP.

Table 7. **Wells.**

Wells at Risk (# of properties)				
Primary Use	**2011 SLRSP 0-2 ft Inundation**	**2050 SLR Scenario 0-2.31 ft Inundation**	**2065 SLR Scenario 3.21 ft Inundation**	**2100 SLR Scenario 6.02 ft Inundation**
Agriculture	Private and Community Wells	85	89	98
City (Annapolis)		5	7	8
Industrial		5	15	20
Marina		14	143	160
Natural Resource & Passive Park Lands		21	21	26
Office		1	1	1
Other Institutional		9	9	12
Public Institutions		5	6	8
Recreation and Entertainment		43	43	47
Retail Commercial		16	17	27
Single-Family Detached		5,201	5,924	7,995
Townhouse Residential		1	1	1
Undeveloped		26	29	38
Utility		2	4	7
Totals	**4,787**	**5,434**	**6,309**	**8,448**

Data used for 2023 Analysis:

- *Two datasets of GPS located wells shared by the County. Isabel submerged wells (1,171) and GPS 2021 wells (9,262).*

Table 8. **Septic Systems at Risk.**

Septic Systems at Risk (# of properties)				
Land Use Code	**2011 SLRSP 0-2 ft Inundation**	**2050 SLR Scenario 0-2.31 ft Inundation**	**2065 SLR Scenario 3.21 ft Inundation**	**2100 SLR Scenario 6.02 ft Inundation**
Agriculture	Septic Systems	106	108	115
Commercial		87	88	95
Commercial Condominium		11	11	11
Commercial Residential		20	20	22
Exempt		56	61	68
Exempt Commercial		13	13	14
Industrial		6	7	8
Apartments		2	2	2
Marsh Land		1	1	1
Residential		4,066	4,388	5,233
Residential Commercial		1	1	2
Residential Condominium		2	2	2
Total	**5,206**	**4,371**	**4,702**	**5,573**

Data used for 2023 Analysis:

- *Septic Inventory*

Cultural Resources

Anne Arundel County is home to thousands of significant historic sites, archaeological sites, cemeteries, and Scenic & Historic Roads that warrant preservation. The County provides protections to these cultural resources through its Code (see Article 17-6-501 to 504). Over the centuries, human settlement has been focused on the shorelines and watersheds of the Chesapeake Bay, so hundreds of these sites are vulnerable to sea level rise. Documentation and survey efforts continuously add to the inventories of these sites, which is demonstrated by the increased number of documented vulnerable cultural resources since 2011.

Table 9. **Cultural Resources at Risk.**

Cultural Resources at Risk				
Resource Type	**2011 SLRSP 0-2 ft Inundation**	**2050 SLR Scenario 0-2.31 ft Inundation**	**2065 SLR Scenario 3.21 ft Inundation**	**2100 SLR Scenario 6.02 ft Inundation**
Archaeological Sites	371	318	361	427
Historic Sites & Districts	47	67	71	84
Cemeteries**	10	10	12	23
# Scenic & Historic Roads (Linear feet)	n.d.	2 (91.38 = 0.017 miles)	4 (120.9 = 0.023 miles)	11 (3004.2= 0.57 miles)
Total Count of Resources	**464**	397	448	545

*** This data count reflects only verified cemeteries. A large number of unverified and reportedly moved cemeteries requiring further condition assessment and evaluation are not included in this tally.*

Data used for 2023 Analysis:

- *Historic Resources Inventory Dataset from Cultural Resources*
- *Archaeological Site Datasets*
- *Historic Cemeteries Layer*
- *Scenic & Historic Roads*

The majority of **archaeological sites** at risk are Native American, pre-contact sites, as well as early colonial and 19th century. Additionally, it should be considered that many unsurveyed areas of high archaeological potential are also endangered. A recent study by the Cultural Resources Section (see Poulos et al. 2018) of archaeological sites vulnerable to flooding in the Pasadena and Shady Side areas also included an assessment of unsurveyed areas and provided a predictive model for archaeological potential. There is a high probability that flood-prone areas of high archaeological potential will result in a loss of significant archaeological information if survey efforts are not increased in these areas.

By far, the majority of endangered and documented **historic sites and districts** are found in Region 9 and Region 4, including National Register sites like Historic **Londontown**, **Hancock's Resolu**tion, and **Normans Retreat**. Notable historic districts included **Fort Smallwood**, **Galesville**, **Sherwood Forest**, **Gibson Island**, **Bay Ridge**, **Columbia Beach**, and the **Cumberstone Road Historic Area**. It should be emphasized again that these numbers only reflect documented sites. A recent study by the Cultural Resources Section (see Poulos et al. 2018) of vulnerable, flood-prone areas in Pasadena and Shady Side shed light on the number of undocumented, potential historic districts and structures from the boom of late 19th-early 20th century beach resort settlement in areas vulnerable to flooding, including the historic areas of **Cedarhurst, Alpine Beach, Cottage Grove, Orchard Beach, Bayside Beach, Venice on the Bay. Fairview,** and **Riviera Beach**,

Vulnerable **cemeteries** in the County are primarily historic family cemeteries dating to the 19th century or even earlier, but the SLR flood scenarios also include a few church cemeteries (including Galesville UM Church Cemetery, St. Matthews UM Church Cemetery, and Asbury Town Neck UM Church). More than half of the cemeteries identified at risk are located in Region 9. Region 7 and Region 4 also have cemeteries at risk (although three of the cemeteries in the database should be noted as outside of County jurisdiction within the City of Annapolis – USNA Cemetery, Cedar Bluff Cemetery, and St. Anne's Cemetery).

Scenic and historic roads of immediate concern were in Regions 4 and 6, but later scenarios also include Region 9. The Sea Level Rise bathtub inundation model shows only two Scenic and Historic roads being impacted by 2050, St. Margarets Rd. on Pleasant Plains and Defense Hwy. Concerns in 2065 are drawn to **River Road**. in Region 6, with models suggesting increased flooding impacts along the edge of Round Bay in Herald Harbor. In Region 4, significant inundation may be seen by 2100 in a small residential subdivision in Severna Park on the other side of Round Bay, which contain Riverview Rd., Ridout Rd., and Round Bay Rd.

Four of the vulnerable roads are classified as a Category 1 roads due to their high historic integrity, meaning that they maintain their historic character. The rest are Category 2 roads, which are also a high level although they may have some alteration here and there. Both are marked as warranting historic preservation. Treatment methods should be sensitive to the historic alignment and view shed and involve consultation with the County's Cultural Resources Section.

Linear Feet of Scenic/Historic Roads at Risk				
Road Name (Category)	**REGION**	**2050 SLR Scenario 0-2.31 ft Inundation**	**2065 SLR Scenario 3.21 ft Inundation**	**2100 SLR Scenario 6.02 ft Inundation**
Riverview Road (2)	4	-	-	245.96
Ridout Rd (2)	4	-	-	267.144
Round Bay Road (2)	4	-		155.44
Saint Margarets Road (2)	4	71.80	72.11	76.9
Whitehall Rd (1)	4	-	2.33	104.28
River Road (1)	6	-	21.1	797.38
Defense Hwy (2)	6,8	19.58	25.36	362.98
Contees Wharf Rd. (1)	9	-	-	35.48
Town Point Rd. (1)	9	-	-	130.37
Friendship Rd. (2)	9		-	377.10
Swamp Circle Rd. (1)	9	-	-	451.17
Total Linear Feet	-	**91.38**	**120.9**	3004.2

Data used for 2023 Analysis:

- *Scenic & Historic Roads*

Sea Level Rise Scenarios – Maps of Flooding Extents

Map 2 through Map 4 show the extent of SLR flooding in all 3 scenarios. These areas are at risk to local flood depths of at least 2ft. Consultants on this project provided interactive County-wide webmaps for expected SLR in 2050, 2065, and 2100, which can be viewed electronically on the SLR Strategic Plan StoryMap. Additionally, County GIS datasets for the inundation layers used in this study can be obtained through Anne Arundel County OpenData and also viewed on the County's GeoCortex system**. Map 2 through Map 4 below can be viewed on the StoryMap, which also allows zooming in and out for a more detailed perspective.**

Map 2. County-wide SLR Impacts for 2050.

Map 3. **County-wide SLR Impacts for 2065.**

Map 4. **County-wide SLR Impacts for 2100.**

The Big Picture in Anne Arundel County

The current analysis confirmed again that the level of flood risk to **Region 9** (identified as having some of the most vulnerable communities such as **Shady Side, Churchton**, and **Mayo** in the 2011 analysis) is among the highest in the County. Region 9 was a focus of this study for higher level analysis (see Part 3 in this document) due to the evidence over the past decade of increased flood risk from climate change factors such as extreme weather events and relative sea level rise. The current 2023 model informing this report continues to show a significant rise in sea level risk (i.e., shoreline changes and increased flood extents) from 2050 to 2100 in Region 9 (see Table 10).

Additionally, **Regions 4** and **7** also demonstrate high risk levels in the model. Communities such as **Pasadena**, **Broadneck**, and **Annapolis Neck** show significant acreage could be inundated by 2100 (see Table 11). It is recommended that neighborhoods in these regions, such as **Lake Shore, Gibson Island, Pinehurst Harbor, Bay Ridge, Highland Beach, Round Bay,** and **Fishing Creek Farms**, to name only a few examples, undergo further planning for coastal resiliency actions.

Region 6, the **Crownsville** area, is also noteworthy in the various SLR scenarios, particularly in the lower lying shoreline areas of **Indian Creek** and **Herald Harbor**. Shoreline portions of the Davidsonville area, as well as Glen Burnie, Ferndale, and Curtis Bay, overlapped multiple regions and also presented potential vulnerabilities under these scenarios. Region 2 and Region 5 were the only regions that did not present significantly in the flood extents for the sea level rise scenarios (although riverine flooding due to extreme weather events exacerbated by climate change is still a factor for consideration in those areas outside of this study).

Table 10. **Graph of Flood Extents for each Relative SLR Scenario in the Region Planning Areas.**

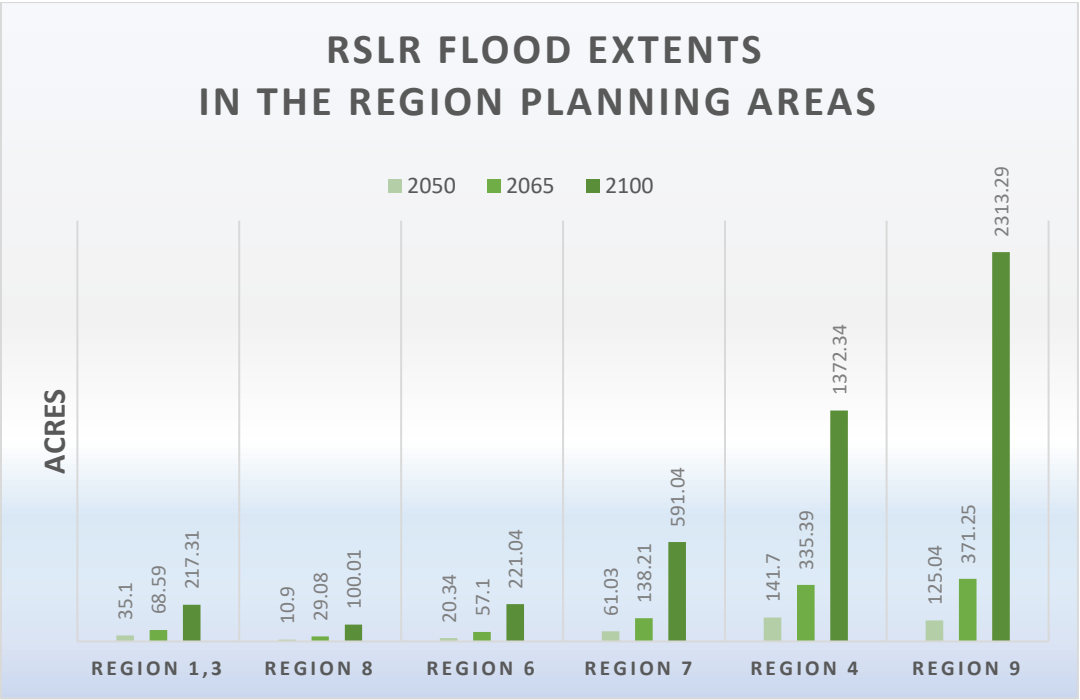


Table 11. **SLR Flood Extents in County Communities for each Scenario.**

REGION PLANNING AREA	COMMUNITY	Acreage of Flood Extent		
		2050 SLR Scenario	2065 SLR Scenario	2100 SLR Scenario
9	**MAYO**	**32.88**	**79.47**	**497.55**
	SHADY SIDE	20.81	62.87	465.03
	CHURCHTON	11.99	42.18	390.62
	GALESVILLE	14.58	53.87	228.88
	DEALE	15.13	39.36	268.32
	WEST RIVER	8.19	29.49	164.27
	TRACYS LANDING	7.09	19.52	124.05
	EDGEWATER	12.47	28.45	109.36
	NORTH BEACH	1.73	15.69	61.15
	FRIENDSHIP	0.17	0.35	4.06
4	**PASADENA**	**68.02**	**145.73**	**598.43**
	BROADNECK	23.36	66.63	358.38
	SEVERNA PARK	15.91	37.10	128.33
	ARNOLD	11.62	25.97	101.85
	GIBSON ISLAND	8.28	28.36	82.16
	CAPE ST CLARE	10.54	22.48	69.30
	MILLERSVILLE	3.97	9.12	33.89
7	**ANNAPOLIS NECK**	**38.27**	**77.25**	**328.43**
	BAY RIDGE	8.39	28.11	144.10
	ANNAPOLIS	10.59	23.75	87.29
	RIVA	3.48	7.48	24.82
	HIGHLAND BEACH	0.3	1.62	6.40
6	CROWNSVILLE	20.34	57.10	221.04
8	DAVIDSONVILLE	10.9	29.08	100.01
1,3	GLEN BURNIE	23.31	43.55	124.96
	CURTIS BAY	11.79	25.04	92.19
	FERNDALE	0.00	0.00	0.16
3	SEVERN	0.00	0.00	0.40

2B. Recommendations & Mitigation Measures

This section presents an overview of typical measures to mitigate the risks of coastal flooding and SLR. The mitigation measures are organized under the same recommendation categories of the *2011 SLR Strategic Plan*.

- **Protect coastal ecosystems**
- **Reduce SLR impacts to existing and future development**
- **Reduce potential impacts to public infrastructure**
- **Ensure safe and adequate water supply and wastewater management**
- **Protect significant cultural resources from loss or damage due to SLR impacts**

Feasibility study of mitigation measures in specific locations will be conducted in future phases of work. The County will take the approach of conducting feasibility studies of mitigation measures at the community scale. This will support collective action of the public and private sectors to analyze and implement projects that can generate community-level benefits. The County has received a Federal Emergency Management Agency (FEMA) Building Resilient Infrastructure and Communities (BRIC) grant through the State of Maryland to conduct analysis and prepare a community level plan for coastal resilience for the Deale-Shady Side Peninsula. As this report describes, the Deale-Shady Side Peninsula faces significant risk from SLR. The risk assessment in this report will inform that upcoming study.

Cost estimates for specific mitigation measures will be prepared in future feasibility studies. The following graphic illustrates the relative order of magnitude of different types of mitigation measures. As mitigation actions are proposed in the future, the County will partner with the Resilience Authority of Annapolis and Anne Arundel County to develop funding strategies.

Protect Coastal Ecosystems

Coastal ecosystems provide key functions including flood wave attenuation, coastal erosion protection, habitat for fish and wildlife, as well as recreation and tourism opportunities. Implementing flood mitigation and coastal resilience measures to minimize the loss of these critical ecosystems will also provide additional protection to inland areas.

The County and its private sector partners have implemented a number of physical shoreline projects that reduce erosion and flood risk while also enhancing natural habitat and public waterfront access. Examples include shoreline projects at: Fort Smallwood Park, Beverly-Triton Nature Park, Franklin Point Park, and Jack Creek Park. The County has also provided funding for living shoreline projects on private lands such as at West River United Methodist Camp and Cape St. Claire.

Recommendations for Coastal Ecosystems:

1. Continue and expand County efforts to restore living shorelines. Incorporate SLR projections into design of these projects.
2. Expand outreach and education efforts for waterfront property owners and homeowner associations on shoreline restoration.
3. Increase funding and technical support for communities to design and implement living shoreline projects with a focus on areas at greatest risk of SLR impacts.

Protection of Coastal Ecosystems	
Areas of Mitigation Interest	**Actions to Reduce Flood Risk**
Coastal Wetlands **Tidal Marshes** **Mudflats** **Submerged Grasses** **Beaches**	• Increase coastal setbacks for construction • Habitat restoration programs • Wetland restoration and mitigation banking programs • Living and hybrid shorelines • Conservation easements
Shoreline Erosion	• Natural vegetation • Erosion control structures • Beach nourishment

Reduce Impacts to Existing and Future Development

There are multiple mitigation measures that coastal communities are beginning to implement to protect existing development and minimize SLR risks to future development. These include structural measures, such as living shorelines and levees as well as policy changes, such as requiring houses to be built at higher elevations.

The County has also revised the development requirements in County Code (Article 17-6-102) to make natural vegetation the preferred shore erosion control measures unless it is demonstrated to be ineffective. If natural vegetation is not effective, the Code establishes an order of preference for use of nature-based solutions before resorting to rip-rap and bulkheads.

Recommendations for Existing and Future Development:

1. Review and revise as necessary, County Code requirements and design standards for shoreline erosion control projects to require living shoreline techniques unless demonstrated to be infeasible and to establish design elevations that account for SLR.
2. Target flood-prone properties, including areas at risk from SLR as priorities for conservation easements or fee simple acquisition.
3. Review and evaluate potential changes to Planned Land Use and Zoning designations in areas at risk from SLR as part of Region Plans and Comprehensive Zoning.
4. Review development requirements in areas at risk from SLR as part of update to County's Critical Area program and amend relevant County Code sections as needed to implement recommendations.

Protection of Existing / Future Development	
Areas of Mitigation Interest	**Actions to Reduce Flood Risk**
Coastal Structures	• Property Acquisition • Habitat restoration programs • Wetland restoration and mitigation banking programs • Living shoreline • Groins and jetties
Land Use Policy	• Higher regulatory standards • Transfer of development rights • Conservation easements • Tax Incentives/credits

Reduce Impacts to Public Infrastructure: Transporation

Priority areas for road infrastructure mitigation measures include roads and bridges that are important to sustaining Community Lifelines but are inundated in present day flood events and those that are projected to be vulnerable to SLR. Of particular concern are major roadways that provide network connectivity and community sustainment, and those primary ingress/egress roads on peninsulas where access to entire neighborhoods may be cut off during flood events or are projected to be vulnerable to SLR.

In the Nuisance Flood Plan, the County identified 15 roads where flooding at high tides unrelated to particular storm events has been observed. Computer modeling identified 154 road segments at risk of 'sunny day flooding' under current conditions. As described in that plan, County response to 'sunny day flooding' includes notifying the public, documenting impacts, and mitigating impacts.

Recommendations for Transportation Infrastructure:

1. Conduct feasibility study to prioritize roads and bridges for improvements to reduce flood risk and to evaluate the most effective design options.
2. Plan for appropriate maintenance and post-flood recovery for at-risk roads and bridges.
3. Develop evacuation plans for vulnerable peninsula areas during flood events.

Protection of Public Infrastructure-Transportation	
Areas of Mitigation Interest	**Actions to Reduce Flood Risk**
Roadways	• Elevate road profiles • Increase coastal setbacks • Bridge structure upgrades and strengthening • Groins, jetties, seawall adjacent to roads
Stream Flow Constrictions	• Stormwater BMPs (Constructed stormwater wetlands, wet ponds) • Wetland creation restoration • Green infrastructure

Reduce Impacts to Public Infrastructure – Water & Wastewater Systems

None of the County public water or sewer treatment plants are located in areas projected to be inundated under any of the SLR scenarios. However, pumping stations, final effluent pumps, and discharge pipes from sewer treatment plants could be impacted by flooding. The Military Installation Resilience Review for the US Navy-Annapolis facility recommended that the final effluent filter pumps at the Annapolis Water Reclamation Facility be replaced with pumps that will not be damaged if under water.

Recommendations for Water and Wastewater Systems:

1. Review pumping stations and discharge systems at County wastewater treatment plants to identify vulnerabilities to SLR and development and implement recommendations to increase resiliency.
2. Replace final effluent filter pumps at Annapolis Water Reclamation Facility.

Protection of Public Infrastructure-Water & Wastewater Systems	
Areas of Mitigation Interest	**Actions to Reduce Flood Risk**
Wastewater / Water Treatment Facilities	• Extension of public service • Elevate pump stations and facility electronic systems • Structure upgrades and strengthening • Stormwater BMPs (Constructed stormwater wetlands, wet ponds)

Wells and Septic Systems

The County has developed several programs to address the vulnerability of private wells and septic systems to flooding. Design requirements for new private wells within the 100-year floodplain and coastal areas prone to flooding follow State regulations to terminate 24 inches above ground floor elevation and to be fitted with flood resistant caps to minimize the risk of floodwater contaminating wells. The Department of Public Works *Our wAAter* program is proactively engaging communities in septic problem areas to connect to public sewers or upgrade septic systems. This program should continue and include focused efforts in areas where SLR and rising groundwater will exacerbate septic problems.

Recommendations for Wells and Septic Systems:

1. Continue to participate in regional efforts to monitor and protect groundwater resources, including monitoring of saltwater intrusion into aquifers.
2. Expand efforts to educate private well owners on flood risk and actions they can take to protect their wells.
3. Continue and expand technical and financial support for property owners to upgrade septic systems or connect to public sewer.
4. Evaluate the impact of increasing precipitation events and sea level rise on septic system function and develop strategies to ensure adequate percolation and functionality.

Protection of Wells and Septic Systems	
Areas of Mitigation Interest	**Actions to Reduce Flood Risk**
Private Property	• Floodproof well cap and heighten standpipe • Community well systems • Collect and treat septic waste at treatment facility • Extension of public services • Acquisition / Relocation
Land Use Policy	• Higher regulatory standard • Tax incentives/credits

Historic and Archaeological Resources

Anne Arundel County contains thousands of **historic properties**, **archaeological sites**, and **cemeteries**, as well as **scenic and historic roadways** that are afforded some protection through the Anne Arundel County Code. Over the past decade, with the support of competitive grant funding when available, the Cultural Resources Section has provided vulnerability assessment studies for flooding and sea level rise hazards, as well as conducted a few instances of salvage archaeology. These studies focused on historic structures and archaeological sites, identifying endangered cultural resources and providing priority action lists based on their significance and level of threat.

Recommendations for Cultural Resources

1. Review existing local laws and policies in order to strengthen protections and preservation assistance for endangered cultural resources.
2. Foster interdepartmental coordination during feasibility studies for coastal resiliency and adaptation between the Cultural Resources Section and other County departments, such as DPW and OEM.
3. Identify strategies for integrating historic site preservation and other cultural resource considerations with natural resource conservation through County shoreline protection projects and other resiliency plans and actions, including environmental monitoring.
4. Increase and prioritize survey, documentation, and preservation efforts on flood-prone areas, and provide for the support, staffing, resources, and financial means to conduct professionally-led emergency salvage archaeology/historic site documentation for significant sites.
5. Expand public outreach and education in flood-prone communities to provide guidance on flood mitigation for historic structures, to establish volunteer site stewardship monitoring programs, and to encourage community investment into preservation actions for significant, endangered cultural resources.
6. Develop guidelines and requirements for the potential displacement and destruction of vulnerable historic resources and archaeological sites when shoreline stabilization is not a feasible strategy for permanent protection.

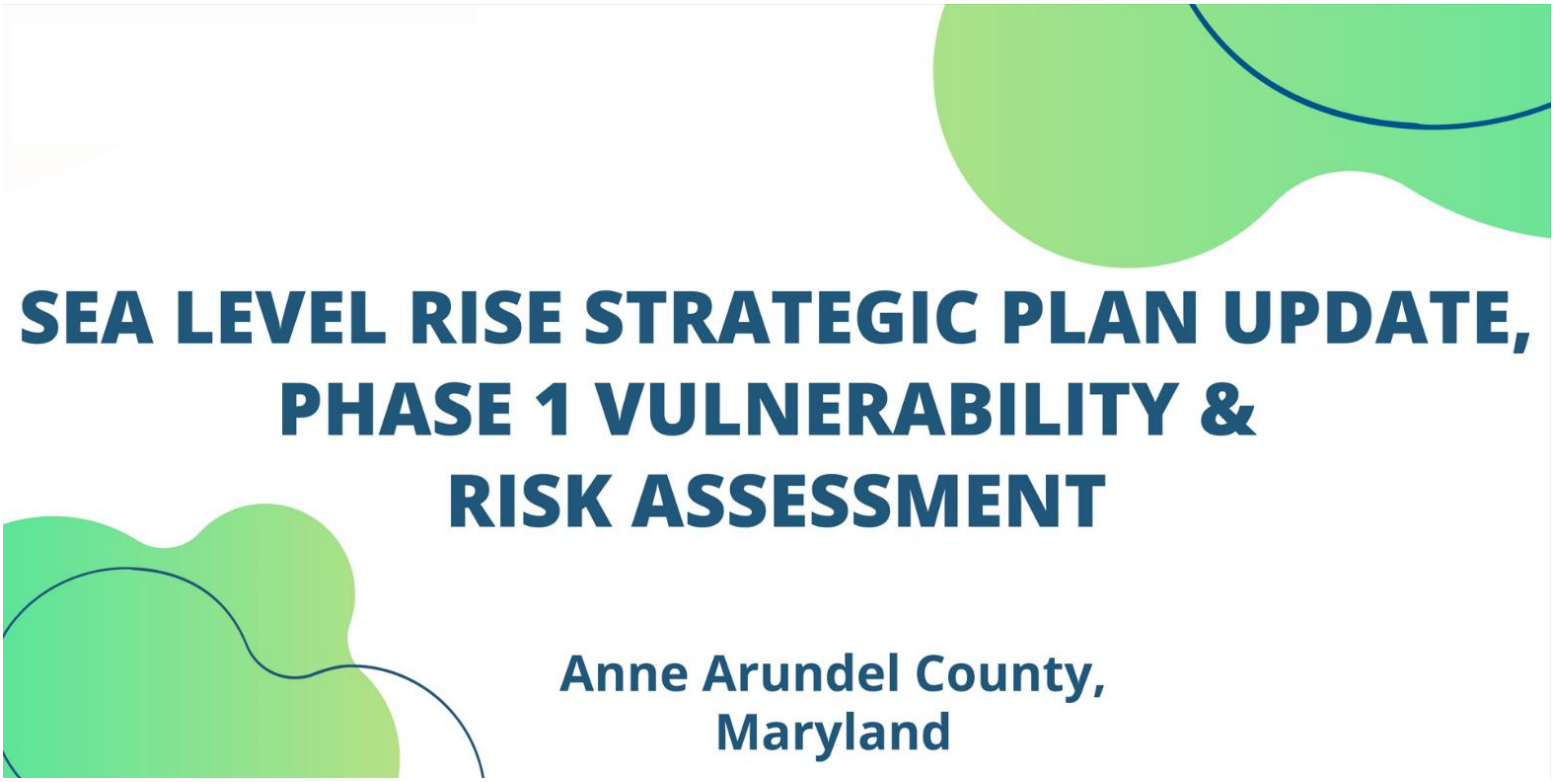
State/Federal Guideline References:

- Planning for Maryland's Flood Prone Archeological Resources
- Flood Mitigation Guide: Maryland's Historic Buildings
- NPS Cultural Resources Climate Change Strategy

Areas of Mitigation Interest	Actions to Reduce Flood Risk
Coastal Historic Structures & Sites (Flooding & Shoreline Erosion)	• Groins, jetties, seawall, and other structural barrier solutions. • Incorporate site preservation considerations into shoreline restoration methods (i.e., archaeological site capping/burial or sensitive landscape plantings to increase site stability) • Salvage archaeology & historic site documentation • Site Monitoring
Private Property	• Acquisition • Elevation • Relocation • Wet/dry floodproofing • Improve stormwater management and drainage systems • Perimeter Barriers • Survey/Documentation
Land Use Policy	• Higher regulatory standards • Standards for compensatory storage and equal conveyance of water • Tax incentives/credits

Previous Anne Arundel County Vulnerability Studies (on-file in the archives at the Cultural Resources Section, OPZ, Anne Arundel County):

- *Sea Level Rise Strategic Plan, Anne Arundel County, Phase 1 Report, Part 2: Vulnerability Assessment for Cultural Resources* (2010)
- *Phase I Hazard Mitigation Planning for Anne Arundel County's Cultural Resources: Maryland City/Laurel/Jessup, Pasadena, & Shady Side/Deale* (2018) by Poulos et al.



PART 3 - REGION 9 RISK ASSESSMENT

This section provides a detailed vulnerability and risk assessment for Region 9, the Southern portion of Anne Arundel County along the Chesapeake Bay. The region stretches from Edgewater to North Beach and is bound my MD 2 to the west. It includes the Mayo Peninsula, Galesville, West River, Shady Side, Churchton, Deale, Tracy's Landing, North Beach, and parts of Edgewater and Friendship. As a low-elevation area with peninsulas and extensive shoreline, this area has been identified as being the largest part of the County with significant coastal flooding and SLR risk. Communities in Region 9 vary in the vulnerability to SLR based on their location and elevation. Table 12 summarizes the extent of potential flooding under SLR scenarios in the years 2050, 2065, and 2100.

Table 12. **Vulnerable Areas in Region 9.**

Vulnerable Areas (in acres)			
Region 9 Communities	**2050 SLR Scenario**	**2065 SLR Scenario**	**2100 SLR Scenario**
Churchton	13	42	82
Davidsonville	1	3	15
Deale	12	27	236
Edgewater	47	100	556
Friendship	1	2	0
Galesville	1	3	11
Harwood	26	63	228
North Beach	1	15	78
Shady Side	23	59	722
Tracys Landing	10	29	179
West River	15	36	152
Total	150	381	2,258

Data used for 2023 Analysis:

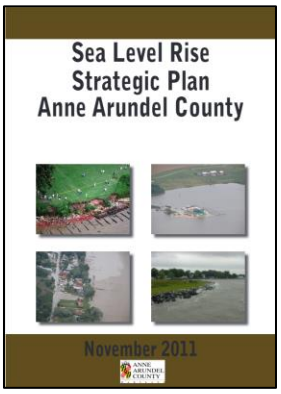
- *Maryland Coastal Resiliency Assessment - Priority Shoreline Areas, updated August 27, 2019*

In terms of calculating the total area that is vulnerable to SLR, Edgewater will be the most affected community in 2050 with 47 acres, and Shady Side will have the greatest vulnerable area by 2100 with 722 acres. This modeling approach shows that in Region 9:

- While flooding is minimal in the 2050 scenarios, areas that are at risk in the 2100 SLR scenario increase significantly.
- Edgewater is the most affected by 2050, but Shady Side will be the most vulnerable in 2100
- No critical facilities will be flooded; however, road access may be impaired.
- Areas identified as Moderate and High for shoreline erosion are predominantly located in designated Resource Conservation Areas in the Chesapeake Bay Critical Area.
- Open Wetlands are the most at risk in all SLR scenarios
- Many of the areas most vulnerable to flooding are conserved lands, such as Franklin Point State Park and the Smithsonian Environmental Research Center.

Recommended actions that were identified in the 2011 SLR Strategic Plan were evaluated further for Region 9 and are discussed in the following section. The analysis identified several major topics that are the most crucial in terms of future vulnerability to SLR in the County. Details and full descriptions of impacts are presented for each recommended action.

3A. Ecologically Significant Areas of Region 9



The *2011 Sea Level Rise Strategic Plan* stated that the most significant impacts of a rise in sea level at the countywide level will be a loss of wooded areas and open wetlands which are valuable components of the coastal ecosystem. Over 1,600 acres of such lands are potentially vulnerable under the 0–2-foot sea level rise scenario, with over 4,500 vulnerable acres under higher levels of sea level rise. While the acreage may not be large at any one specific location, the benefits of forest and wetlands are significant in terms of their ability to reduce coastal erosion, offer protection against storm surges, and absorb coastal flooding.

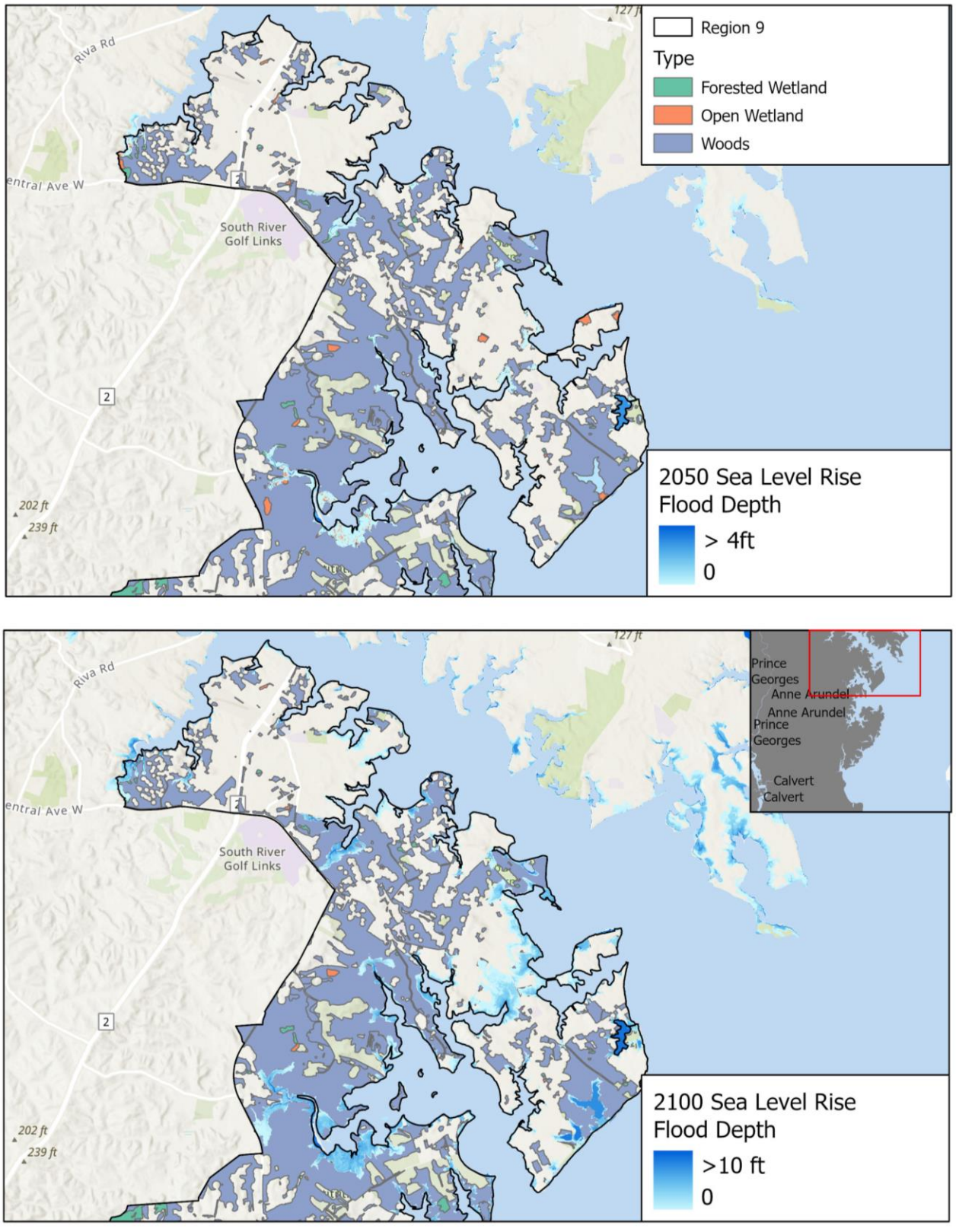
Region 9 has a total of 27,563 acres of land classified into different land cover categories. Using the three (3) sea level rise scenarios, less than 1% of land cover will be under 2 feet of coastal waters in 2050 sea level rise scenario, over 1% in 2065 sea level rise scenario, and a jump to over 8% by 2100 sea level rise scenario. Ecologically significant areas such as Forested Wetland, Open Wetland, and Woods will be very vulnerable to all sea level rise scenarios. These areas make up (54 acres) 36% of inundated areas in 2050 sea level rise scenario and (1,488 acres) over 65% by 2100 sea level rise scenario and will suffer potential damage due to an increase of salinity due to coastal flooding. Ecologically significant areas are primarily located in Edgewater, Deale, and Shady Side. Locations of these ecologically significant areas subjected to 2050, 2065, and 2100 sea level rise scenarios are highlighted in Table 13 below and in Map 5 through Map 7.

Table 13. **Land Cover in Region 9.**

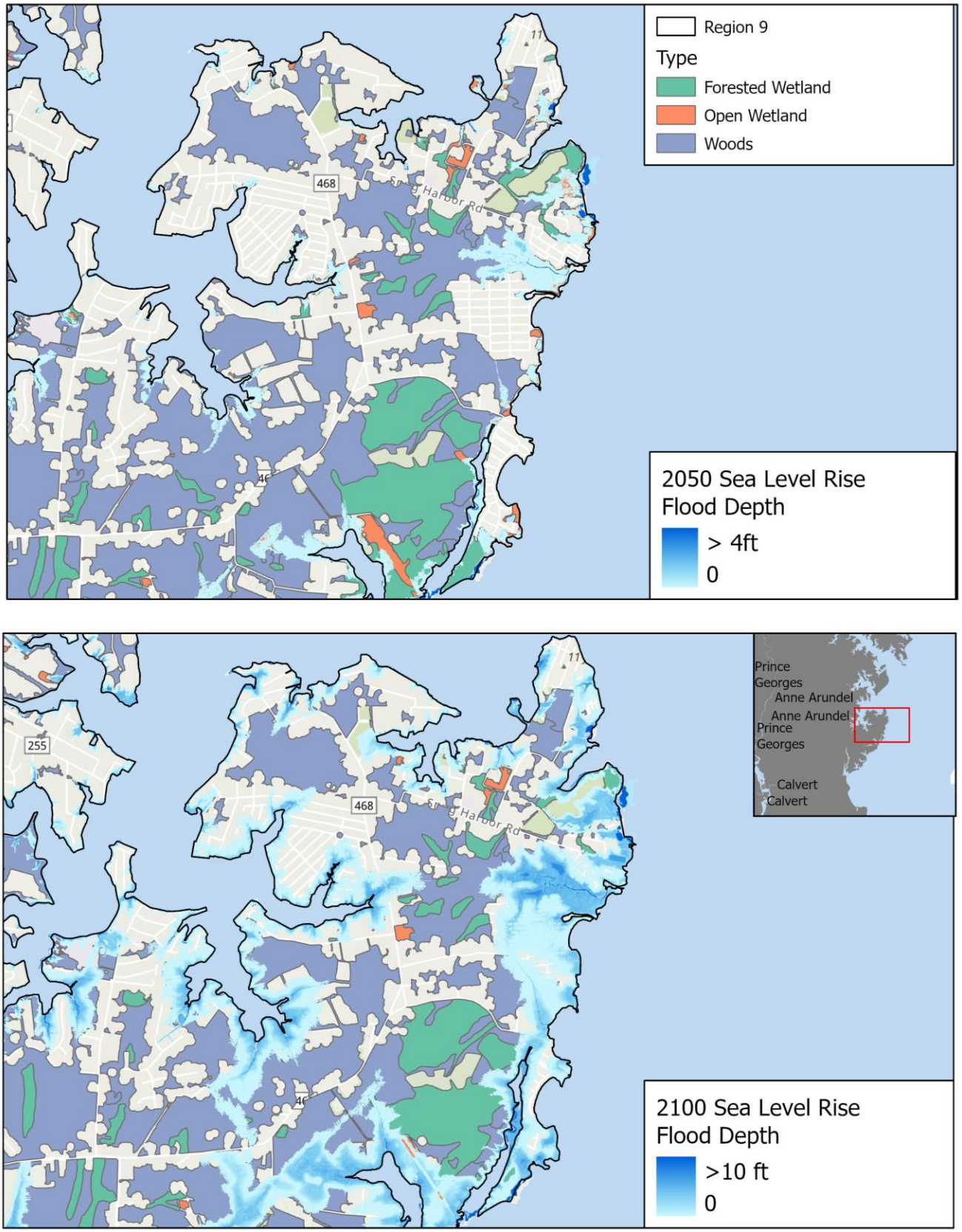
Land Cover (in Acres)			
Type of Land Cover	**2050 Sea Level Rise Scenario**	**2065 Sea Level Rise Scenario**	**2100 Sea Level Rise Scenario**
Commercial	2	3	53
Forested Wetland	2	6	124
Open Space	2	4	64
Open Wetland	35	190	808
Pasture/Hay	0	0	8
Residential 1/2-acre	2	3	48
Residential 1/4-acre	4	6	66
Residential 1/8-acre	4	7	134
Residential 1-acre	1	3	121
Residential 2-acre	4	8	98
Row Crops	0	0	11
Transportation	0	0	17
Utility	78	99	152
Water	2	3	53
Woods	17	50	556
Total	**150**	**381**	**2,258**

Data used for 2023 Analysis:

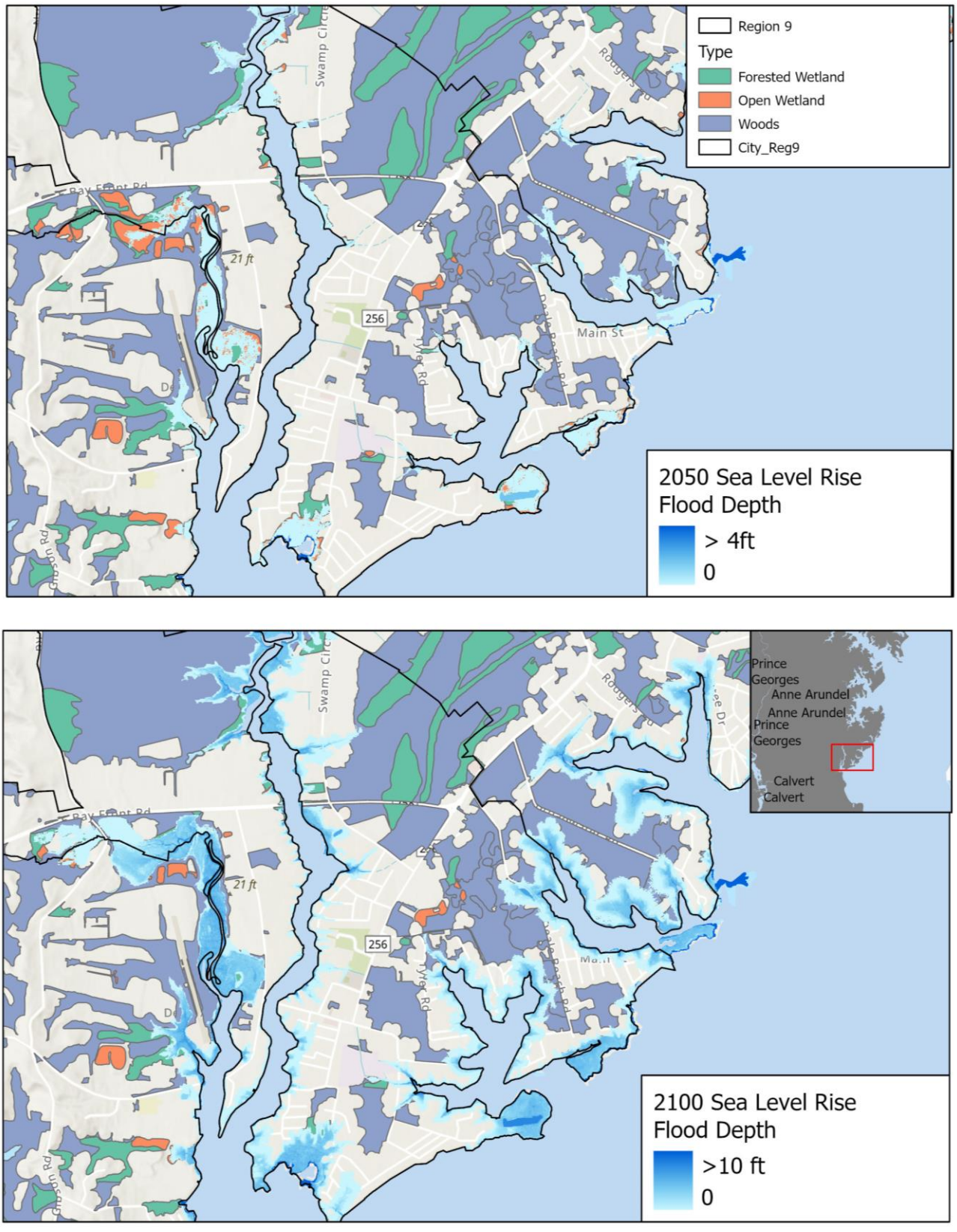
- *2020 Land Cover dataset for Anne Arundel County, MD*



Map 5. **Edgewater's ecologically significant areas vulnerable to 2050 and 2100 sea level rise.**



***Map 6*. Shadyside ecologically significant areas vulnerable to 2050 and 2100 sea level rise.**



Map 7. **Deale ecologically significant areas vulnerable to 2050 and 2100 sea level rise.**

Further assessment in Region 9 identified a significant number of recently constructed non-structural shoreline protection features along the Region 9 coastline that protect ecologically significant land. These nonstructural, living shorelines were predominantly located in Shady Side and Deale as illustrated in Map 7.

Critical Areas Commission Regulated Lands

State Critical Area regulations impose restrictions on development within 1,000 feet of Maryland's tidal waters and tidal wetlands. Most areas of sea level rise vulnerability in the county fall within the Critical Area overlay.

In Region 9, there are 13,643 acres of land designated as critical areas and nearly half of these areas are classified as Resource Conservation Areas (RCA). Each of the three (3) sea level rise scenarios were overlayed with the Critical Areas. Critical areas located within the three (3) sea level rise scenarios were selected.

Map 8. **Location of nonstructural shoreline protection measures in Region 9.**

Results of the analysis indicates that by 2050, less than 1% of the critical areas will be under 2 feet or more of coastal water due to sea level rise, however in 2100, over 15% of these areas will be impacted. For both 2050 and 2065 sea level rise scenarios, the most impacted Critical Area was the Resource Conservation Areas with more than 70% being impacted. However, in 2100 the Limited Development Areas comprised 21% of the vulnerable area identified as subject to sea level rise. These vulnerable areas are largely found in **Edgewater**, followed by **Churchton, Shady Side**, and **Deale**. Results of this analysis are presented in Table 14.

Table 14. **Region 9 Potential Inundation Areas.**

Region 9 Areas of Potential Inundation (acres)			
Critical Areas Classes	**2050 Sea Level Rise Scenario**	**2065 Sea Level Rise Scenario**	**2100 Sea Level Rise Scenario**
FED – Federal Land	9.40	45.31	195.98
IDA – Intensely Developed Area	2.30	4.13	100.17
LDA – Limited Development Area	10.22	20.22	435.33
RCA – Resource Conservation Area	51.35	220.41	1,366.38
Total (in acres)	**73.27**	**290.07**	**2,097.86**

Data used for 2023 Analysis:

- *Critical Areas in Anne Arundel County, MD: updated December 9, 2021*

FEMA Flood Zones

Region 9 has a total of 3,628.09 acres of land that FEMA has designated into different flood zones. Areas that have 1% annual chance of flooding are categorized as AE, A, or AO; VE are coastal high hazard areas, and areas with 0.2% annual chance of flood. To identify these at-risk areas to sea level rise, the flooding extents from all three (3) sea level rise scenarios were overlayed with 2015 Anne Arundel County FEMA flood zones. The FEMA flood zone land area was analyzed for potential sea level rise inundation based on three (3) scenarios. These zones presented in Table 12 below will be under 2ft or more of coastal waters as indicated under each of the three (3) sea level rise scenario columns. Although a small area of the FEMA floodplain will be affected in 2050 at 4%, it will increase significantly to 60% by 2100. More than half of flood zone AE in 2050 and 2100 are located in Edgewater, Harwood, and Shady Side.

Table 15. **FEMA Flood Zones in Region 9.**

Region 9 Areas of Potential Inundation (acres)			
FEMA Floodplain Designation	**2050 Sea Level Rise Scenario**	**2065 Sea Level Rise Scenario**	**2100 Sea Level Rise Scenario**
Zone AE	120.79	331.46	1,957.26
Zone A	4.11	12.34	75.66
Zone AO	0.00	0.00	1.62
Zone VE	22.95	32.30	84.23
0.2% Annual Chance	0.48	0.98	63.27
Total	**148.32**	**377.07**	**2,182.05**

Data used for 2023 Analysis:

- *FEMA Floodplain in 2015 for Anne Arundel County, MD: updated November 15, 2022*

Park Lands in Region 9

There are twenty-nine (29) parks covering 4,393.15 acres of land in Region 9 designated as:

- County Park – 25 parks
- Federal Park – Smithsonian Institution
- State Park – Franklin Point
- Other Preserved Open Space – Rockhold Creek Farm and Camp Letts

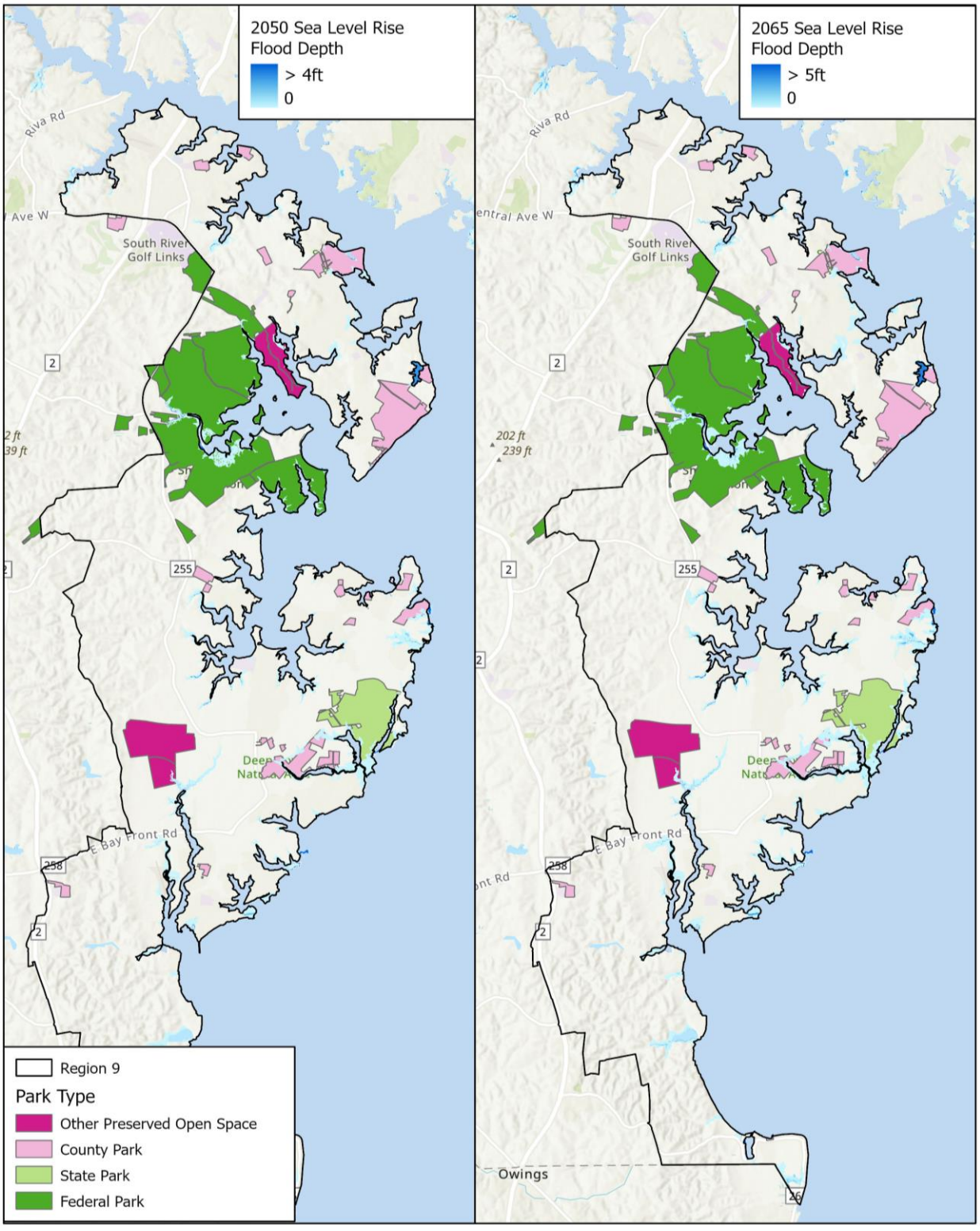
Although only 12% of the total park land could potentially be inundated by 2100, these lands still need to be considered under future planning. The most vulnerable in all three (3) sea level rise scenarios is the Smithsonian Institution which makes up half of the affected park land in the region. About 20% acres of County Parks may experience coastal flooding of more than 2 feet in 2100. Approximately 5.8 acres of Franklin Point State Park will have flooding in 2050 and this will increase to 93.57 acres in 2100. County parks such as Deep Cover Natural Area and Beverly Triton Natural Park will have over 50 acres in flooded areas by 2100. Results of this analysis are presented in Table 16 and illustrated in Map 9 for 2050 and 2065 sea level rise scenarios and Map 10 for 2100 sea level rise scenario.

Table 16. **Region 9 Park Land at Risk.**

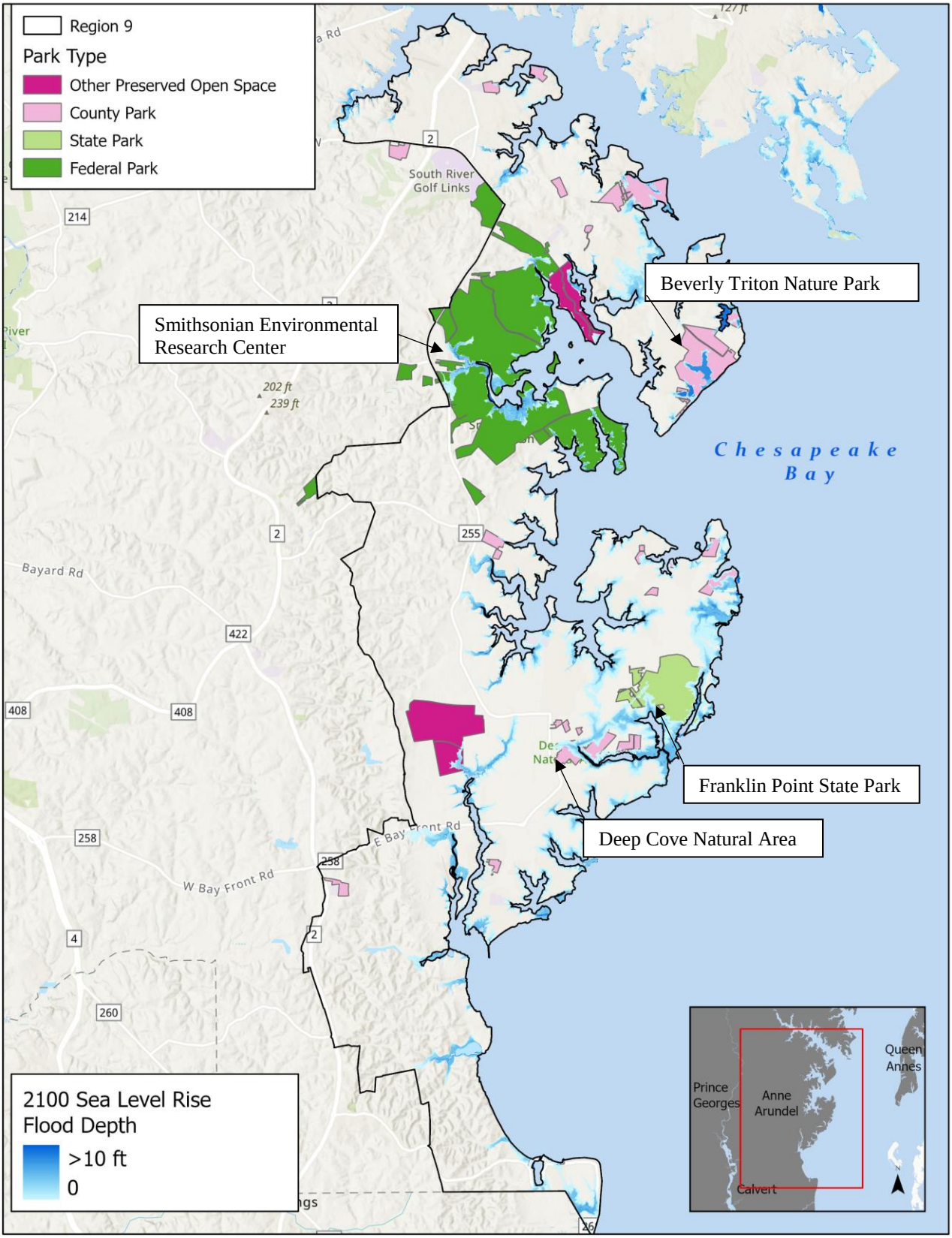
Region 9 Park Land at Risk (acres)			
Park Type	**2050 Sea Level Rise Scenario**	**2065 Sea Level Rise Scenario**	**2100 Sea Level Rise Scenario**
County Park	12.32	23.94	182.91
Federal Park	25.22	65.14	229.86
State Park	5.84	12.38	93.57
Other Preserved Open Space	3.40	8.27	39.48
Total	**46.77**	**109.74**	**545.82**

Data used for 2023 Analysis:

- *2020 Land Cover dataset for Anne Arundel County, MD*



Map 9. **Region 9 Park and Open Space Area vulnerable to 2050 and 2065 sea level rise.**



Map 10. **Region 9 Park and Open Space Areas vulnerable to 2100 sea level rise.**

3B. Existing and Future Development in Region 9

The 2050 sea level rise projection plus the 1% annual chance flood scenario was used for the Region 9 Hazus analysis. Results produced by this analysis included both building and content loss estimations, debris generation, and shelter needs. A total of **5,387 at-risk structures, 5,291 residential, are within the 2050 sea level rise projection plus the 1% annual chance flood scenario**. At-risk structures are divided into three (3) Hazus occupancy types, commercial, other, and residential.

As presented in Table 17building and content loss under the 2050 sea level rise projection plus the 1% annual chance flood scenario for Region 9 total is $1,208,819,588 of which 94% or $1,143,893,603 were anticipated losses from single family homes. High loss estimation risk areas were determined by extrapolating structures with loss estimates greater than $100,000. Using this method, high-risk areas include:

- Shelby Heights Area, especially along the Shelby Bay, Cub Neck Creek, and Whitemarsh Creek
- Chalk Point and Back Bay Area, especially along West River and South Creek
- New Deale Beach Area, especially along Parker Creek and Carrs Creek
- Franklin Manor Beach and Cape Anne Area
- Cedarhurst Area

Table 17. **Region 9 Structures at Risk (Loss Estimation).**

Region 9 At-Risk Structures Loss Estimations					
General Occupancy	**Hazus Specific Occupancy Type**	**Building Loss**	**Contents Loss**	**Inventory Loss**	**Total Loss**
COM - Commercial	COM1-Retail Trade	$2,783,024	$9,237,330	$20,876,070	$32,896,423
	COM2-Wholesale Trade	$1,496,247	$3,909,064	$4,766,395	$10,171,706
	COM3-Personal and Repair Services	$27,414	$105,068	$0	$132,481
	COM4-Professional/Technical Services	$1,450,179	$1,823,976	$0	$3,274,155
	COM8-Entertainment & Recreation	$1,158,352	$4,856,972	$0	$6,015,324
OTH - Other	EDU1-Grade Schools	$86,512	$572,336	$0	$658,848
	GOV1-General Services	$62,561	$472,884	$0	$535,445
	IND2-Light	$324,457	$949,184	$792,124	$2,065,766
	IND5-High Technology	$34,027	$123,110	$946,711	$1,103,849
	REL1-Churches and Other Non-profit Org.	$581,384	$4,028,127	$0	$4,609,511
RES - Residential	RES1-Single Family Dwelling	$763,390,772	$380,502,831	$0	$1,143,893,603
	RES3B-Triplex / Quads	$29,175	$13,657	$0	$42,832
	RES3D-Multi-dwellings (10 to 19 units)	$637,095	$408,381	$0	$1,045,477
	RES4-Temporary Lodging	$900,038	$1,474,130	$0	$2,374,168
	Total	$772,961,237	$408,477,050	$27,381,300	$1,208,819,588

3C. Public Infrastructure: Transportation in Region 9

The *2011 Sea Level Rise Strategic Plan* reported that major transportation infrastructure in the county does not appear to be significantly vulnerable to sea level rise impacts, and even local and collector roads were found to be minimally impacted (in terms of total road miles) under a sea level rise of 0-2 feet. Under the 0–5-foot scenario, there are approximately 35 miles of local and collector roads that are potentially at risk countywide. Local roads in Region 9 that were identified at risk are found primarily on the Mayo peninsula (communities of Turkey Point, Selby on the Bay, Ponder Cove); the Deale peninsula (communities of Shady Side, Galesville, Churchton, Deale), and in South County (communities of Fairhaven on the Bay, Rose Haven).

Street centerlines intersected with flood extents were used to identify roads that will under at least 2 feet of water in the three (3) sea level rise scenarios. The results in

Table 18, below, show the length of the roads in miles that will have impaired access due to segments of it being flooded due to the three (3) sea level rise scenarios. Street centerline lengths may seem almost insignificant in 2050 and 2065 with less than 2 miles being affected, however the 2100 sea level rise scenario impairs almost 32 miles of roads. Portions of Walnut Avenue potentially impacted by the 2100 sea level rise scenario will impair access to houses in North Beach. In Shady Side, Columbia Beach Road will be inundated and impair access to several local roads that lead to residential areas east of Franklin Point State Park. In Edgewater, parts of Turkey Point Road that connects areas east of Selby Bay may also have accessibility issues. Potentially impaired roads and loss of access to areas under the 2100 sea level rise scenario are illustrated in Map 11.

Table 18. **Region 9, Impaired Roads.**

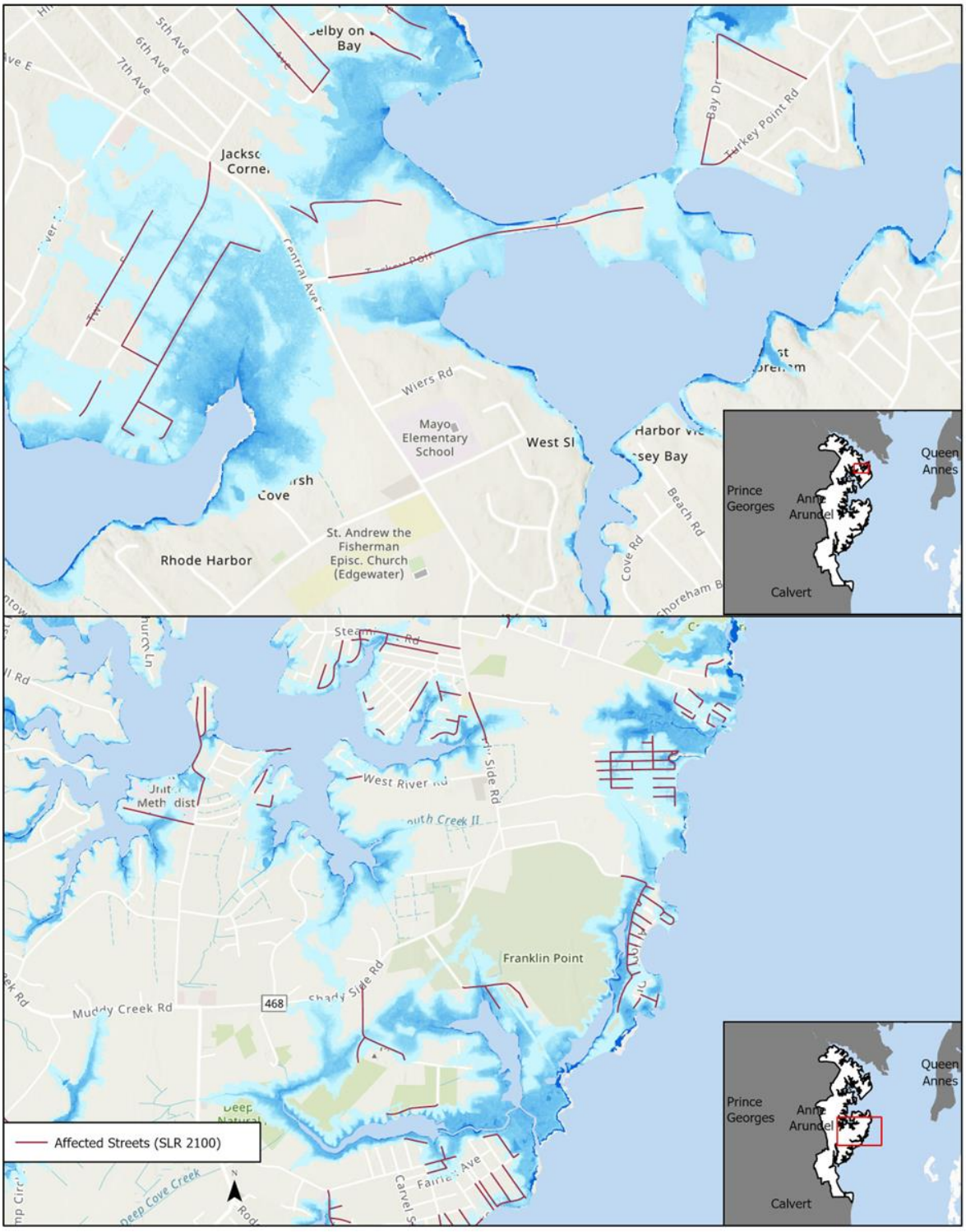
Region 9 Impaired Roads by Type (miles)			
Road Type	**2050 Sea Level Rise Scenario**	**2065 Sea Level Rise Scenario**	**2100 Sea Level Rise Scenario**
Collector	0.51	0.64	7.24
Local	0.11	0.55	23.00
Minor Arterial	0.14	0.23	1.12
Principal Arterial	0.47	0.47	0.47
Total	**1.23**	**1.90**	**31.83**

Data used for 2023 Analysis: Road Functional Classification dataset for Anne Arundel County, MD; Updated Dec 9, 2021

The following statements from the *2011 Sea Level Rise Strategic Plan* remain true:

- Most of the local roads that appear vulnerable are individual segments right along the coast, and their potential inundation would not result in cutting off an entire community.
- Partial inundation of MD 214 could impact access to the lower end of the Mayo peninsula.

- There are several local roads in the communities of Arundel on the Bay, Oyster Bay, and Shady Side that could become completely inundated.



Map 11. **Potentially impaired roads and loss of access under the 2100 SLR Scenario.**

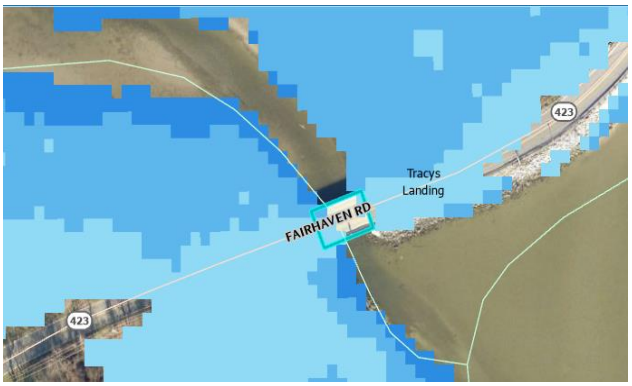
The total length of impacted road miles is not significant, and impacts may occur mainly at a neighborhood level but could render some properties inaccessible. Local roads in many coastal communities may be impacted, particularly on the Mayo and Deale peninsulas.

Results from this analysis also determined numerous bridges in Region 9 may be affected by flood waters from the three (3) sea level rise scenarios. As presented in
Table 19, pedestrian/bike only bridge crossings over smaller creeks and tributaries are the most affected by the sea level rise scenarios. However, portions of bridges connecting major roads over larger creeks may also be impacted. The **Solomons Island Road Bridge** in Edgewater over South River and two bridges over **Rockhold Creek** are vulnerable to the 2050 sea level rise scenario. The **Turkey Point Road Bridge** that goes over a crossing in Selby Bay could be potentially impacted by the 2050 sea level rise scenario, however, impacts from the 2100 sea level rise scenario will isolate the community east of it. Smaller bridges in **Edgewater** and **Deale** that are over tributaries to Chesapeake Bay will also be affected. Bridges that are affected with least 2 feet of water by 2100 sea level rise scenarios are shown in Map 13 through Map 16.

Table 19. **Region 9 Impaired Bridges.**

Region 9 Impaired Bridges			
Road Type	**2050 Sea Level Rise Scenario**	**2065 Sea Level Rise Scenario**	**2100 Sea Level Rise Scenario**
Pedestrian / Private	3	10	25
Vehicular Bridge	6	6	9

Data used for 2023 Analysis: Bridges dataset for Anne Arundel County, MD. Updated December 9, 2021

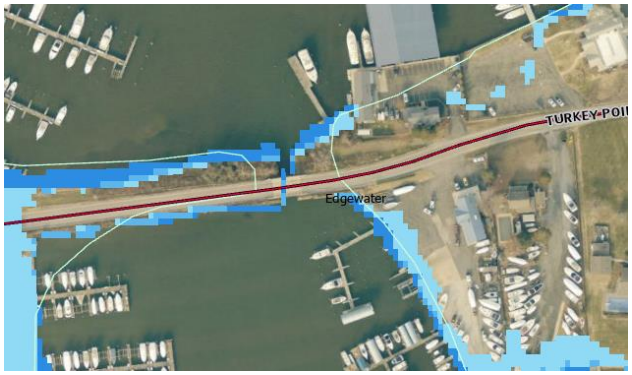


Map 13. **Bridge on Fairhaven Rd. in Tracy's Landing**

Map 12. **Deale Rd. over Rockhold Creek.**

Map 15. **Deale Road over Tracy's Creek.**

Map 14. **East Bay Rd. over Rockhold Creek.**



Map 17. **Turkey Point Rd in Edgewater over Selby Bay.**

Map 16. **Solomons Island Rd., Rt. 2 over South River.**

3D. Public Infrastructure: Water & Wastewater Systems in Region 9

Water and wastewater systems were analyzed by identifying the length of pipeline and inline facility counts that intersect each of the three (3) sea level rise scenarios. These facilities were identified to be in areas with at least 2 feet of sea level rise. **Edgewater is the most vulnerable community having the greatest numbers of sewer pump stations, storm inlets, storm outfalls and storm manholes impacted by 2100 sea level rise scenarios.** Also noteworthy is the increase from two sewer manholes affected by 2050 sea level rise scenario to 286 in 2100; more than 30% of these are in **Shady Side** and 28% are **Edgewater**. The number of sanitary and storm sewer inline facilities that are impacted by each sea level rise scenario - are presented in Table 20 and Map 18 to Map 20.

Table 20. **Sanitary/Storm Sewer Inline Facilities.**

Region 9 Impaired Sanitary/Storm Sewer Inline Facilities (count)			
Facility	**2050 Sea Level Rise Scenario**	**2065 Sea Level Rise Scenario**	**2100 Sea Level Rise Scenario**
Storm Manhole	0	1	14
Storm Inlet	0	0	88
Storm Outfall	7	17	84
Sewer Manhole	2	2	286
Sewer Pump Station	0	0	3
Hydrants	0	0	1

Data used for 2023 Analysis: Anne Arundel County Water & Wastewater facilities. Updated quarterly. Updated 1-14-2021 & 3-10- 2022

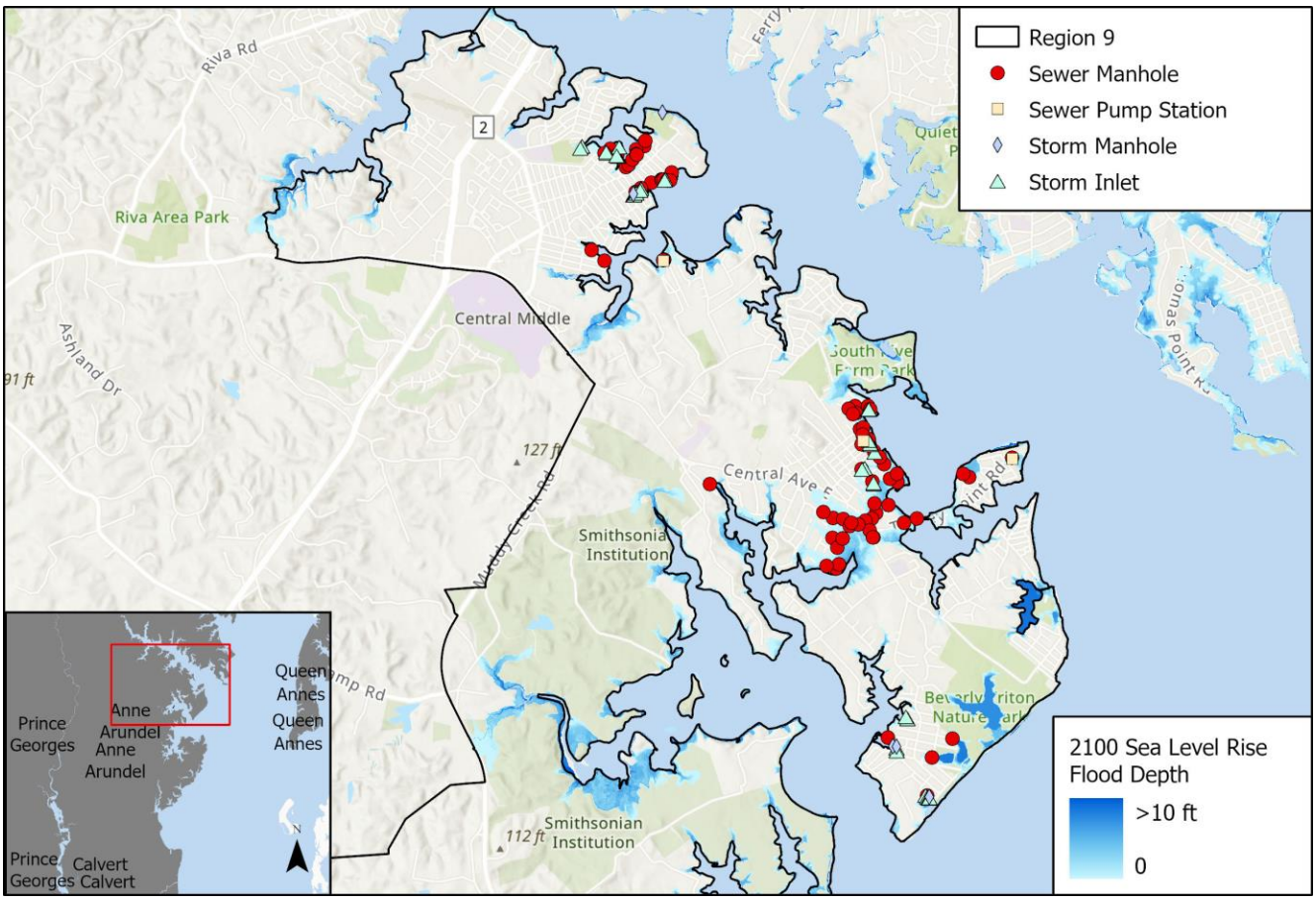
There are two water treatment facilities in Region 9, the **Broadwater Water Recovery Facility (WRF)** in **Shady Side**, and the **Rose Haven Water Treatment Plant** in **North Beach**. Both plants will not be impacted by anticipated 2100 SLR. However, there will be an increasing length of pipes under the 2100 scenario that will be exposed to standing water and through direct inflow or groundwater infiltration will place an additional load on the system conveyance and treatment. Water Service Lines impacted by anticipated 2100 SLR are located primarily in North Beach. On the other hand, water main under the 2050 and 2065 scenario primarily impact connecting areas of Edgewater to Riva and Annapolis, outside Region 9.

The most vulnerable areas to SLR on public sewer service in Region 9 are located within portions of **Mayo, Shady Side, Edgewater** and **Deale**, all other areas in Region 9 are on septic. There is an anticipated increases of 108,106 linear feet of impacted sewer line (force main and gravity) between 2050 and 2100, an increase from 7,831 linear feet impacted by 2050 SLR to 115,937 linear feet in 2100. Impacts to storm sewers are similar with an anticipated increase of 15,086 linear feet of impacted storm sewer line between 2050 and 2100. The results in Table 21 and Map 21 to Map 23 show the length of the sanitary sewer, storm sewer and water lines in feet that may be impacted by SLR.

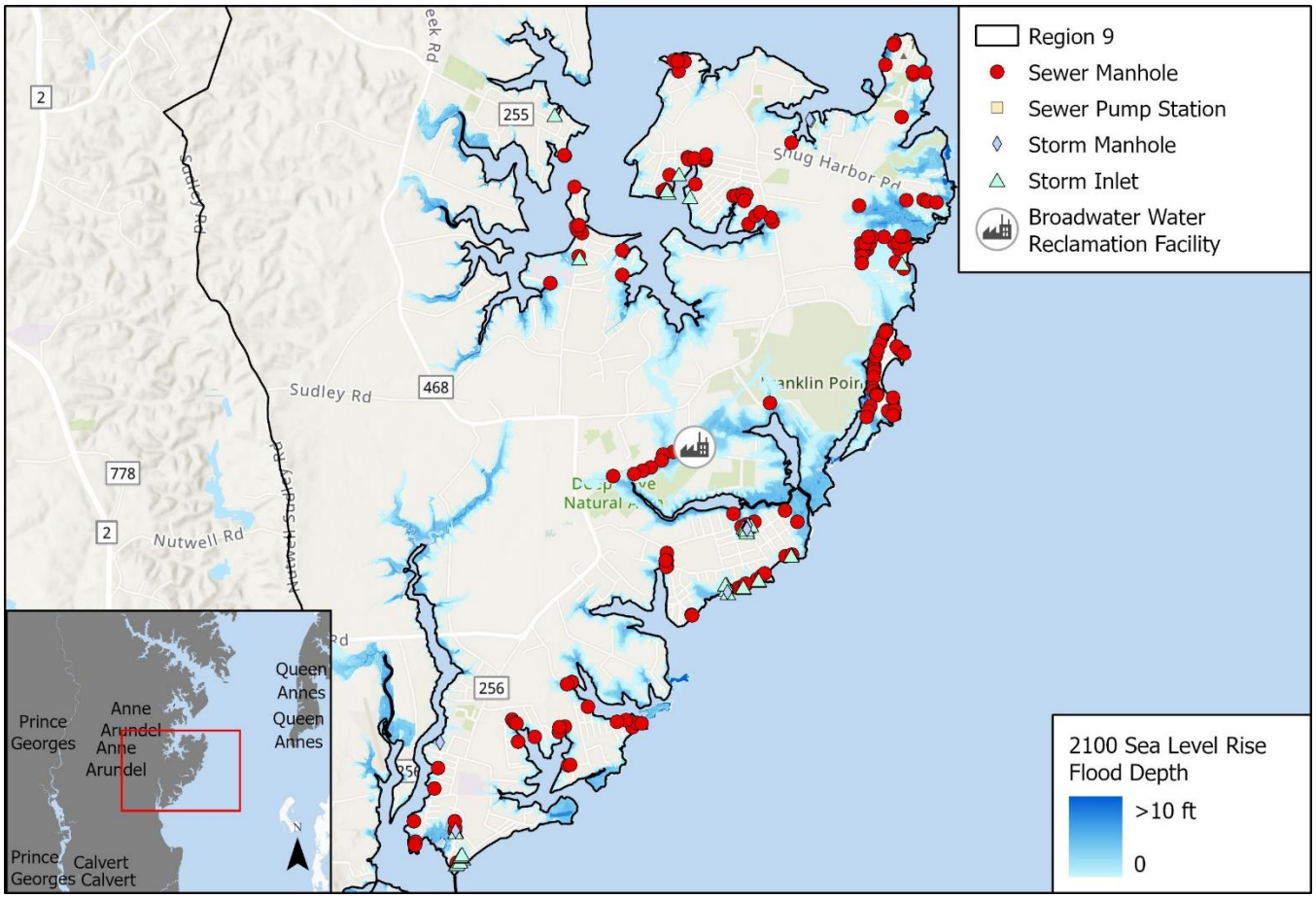
Table 21. **Sanitary, Sewer, & Water Lines.**

Region 9 Sanitary, Storm Sewer, and Water Lines (pipe length, ft)			
Conveyance Type	**2050 Sea Level Rise Scenario**	**2065 Sea Level Rise Scenario**	**2100 Sea Level Rise Scenario**
Sewer Mains (Force Main)	7,654	8,534	32,982
Sewer Mains (Gravity)	177	913	82,955
Storm Pipe	1,173	2,187	16,259
Water Main	5,413	5,413	6,115
Water Service Lines	0	0	236

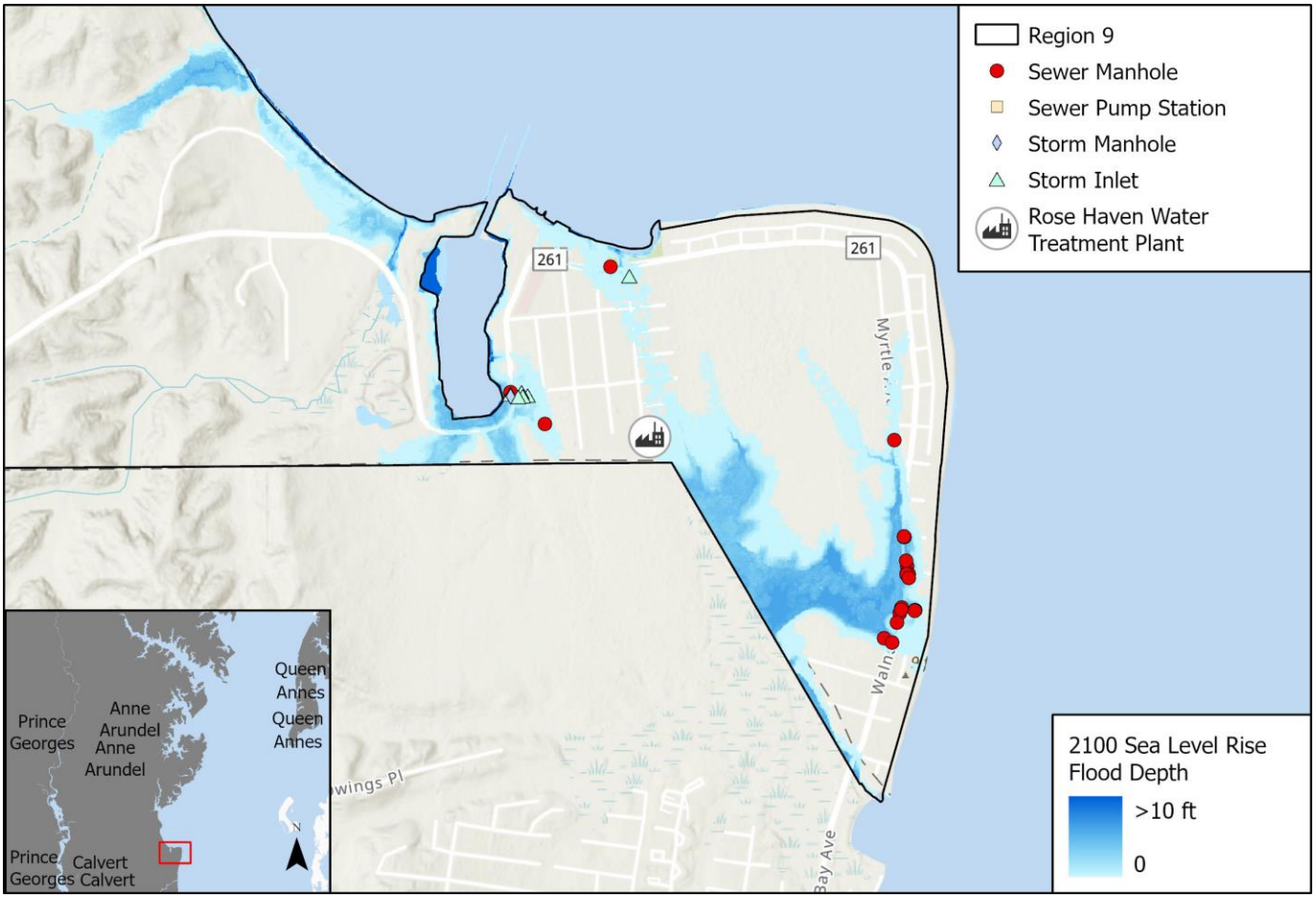
Data used for 2023 Analysis: Anne Arundel County Water & Wastewater facilities. Updated quarterly. Updated 1-14-2021 & 3-10- 2022



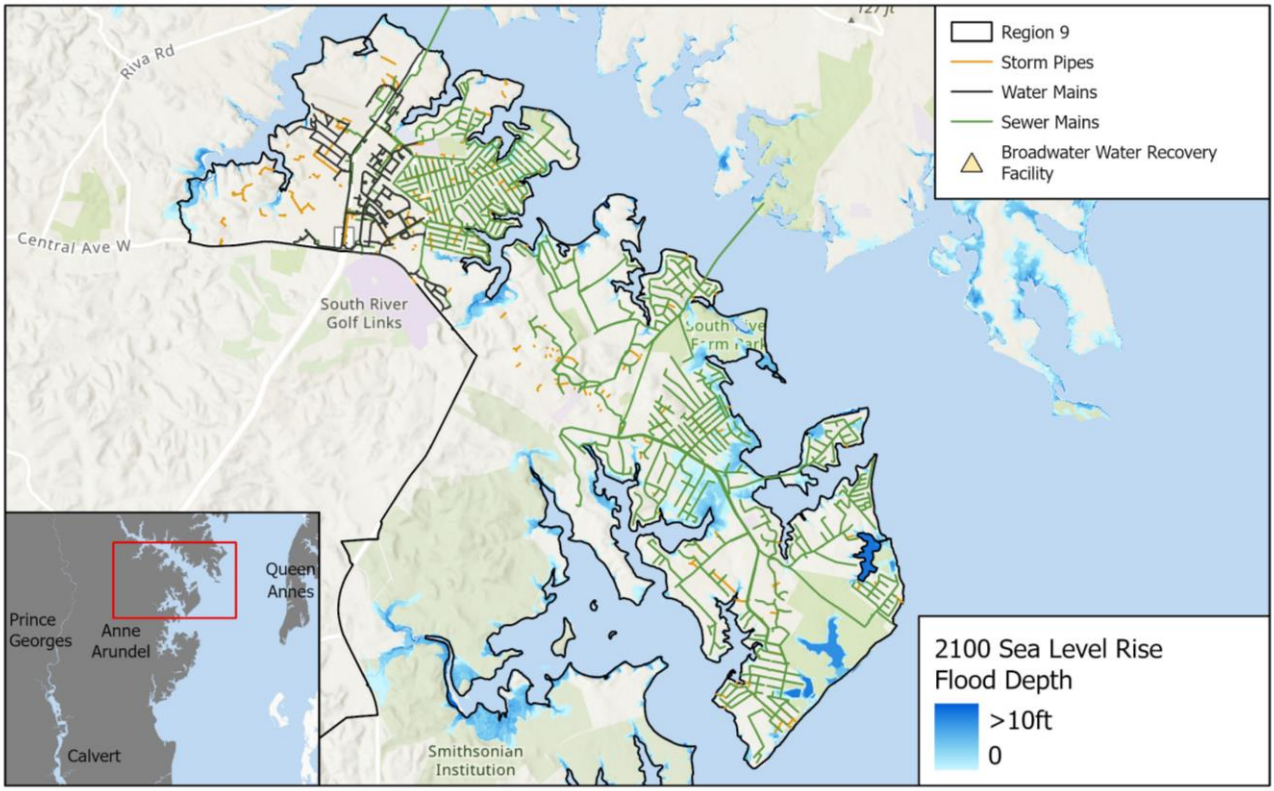
Map 18. **Edgewater Water / Wastewater Facilities.**



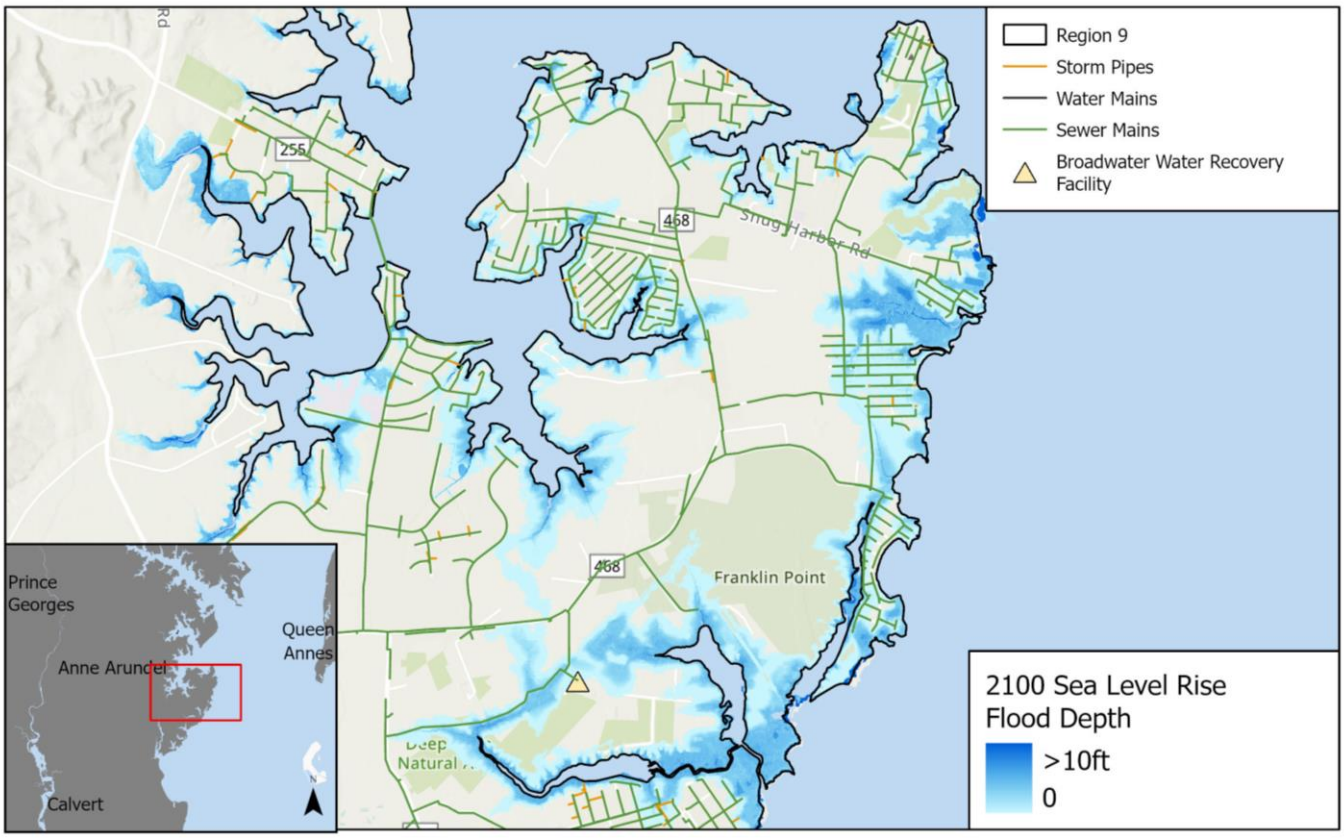
Map 19. **Shady Side Water/Wastewater Facilities.**



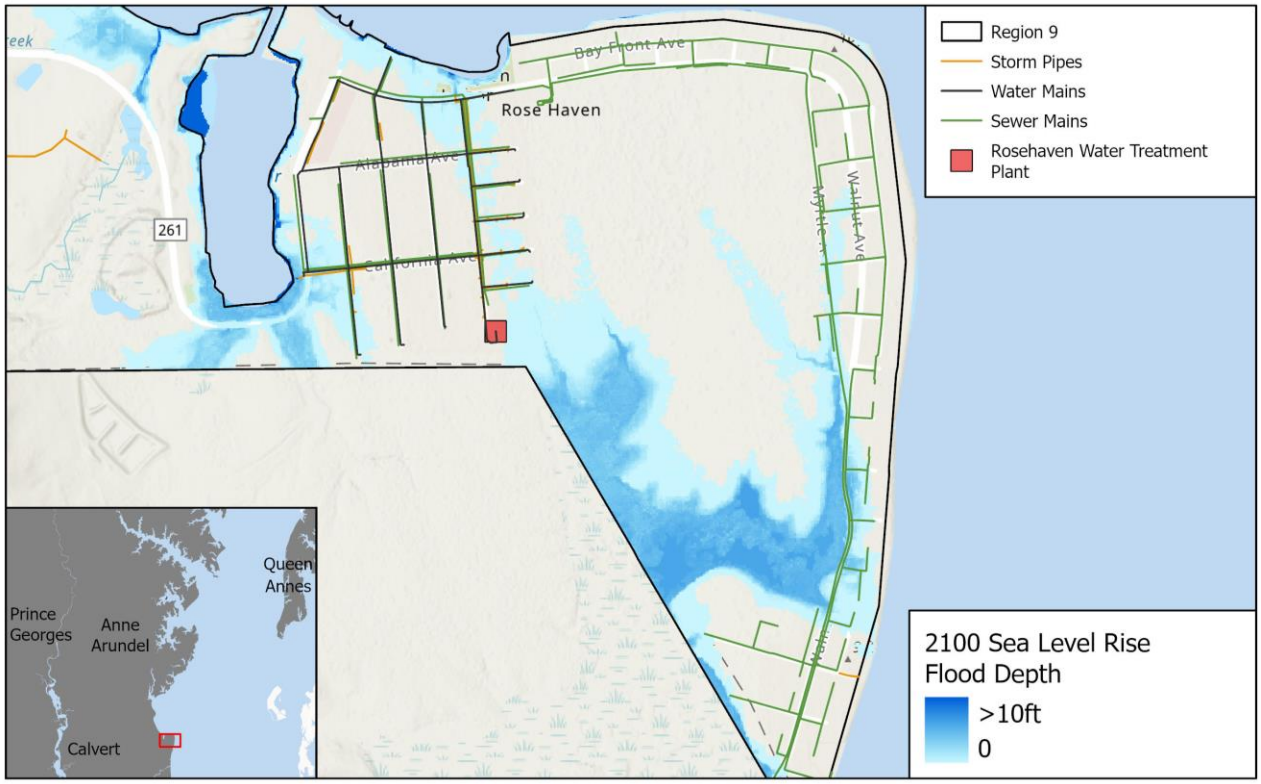
Map 20. **Rose Haven Water/ Wastewater Facilities.**



Map 21. **Edgewater Stormwater, Water Mains, and Sanitary Lines.**



Map 22. **Shadyside Stormwater, Water Mains and Sanitary lines.**



Map 23. **Rosehaven Stormwater, Water Mains and Sanitary lines.**

3E. Wells and Septic Systems in Region 9

Both well water supplies and septic systems are at risk for saltwater contamination from rising flood waters or groundwater intrusion from higher water tables. Residential properties are at most risk in all three (3) scenarios for Region 9. Vulnerable wells are located mostly in Edgewater, followed by Shady Side and Deale. Edgewater, Deale and Churchton are most vulnerable to septic system failure in all three (3) sea level rise scenarios.

Table 22 shows the number of properties served by well water while Table 23 shows the properties with septic system at risk.

***Table 22*. Wells at risk in Region 9.**

Region 9 Wells At-Risk (# of properties)			
Primary Use	**2050 Sea Level Rise Scenario**	**2065 Sea Level Rise Scenario**	**2100 Sea Level Rise Scenario**
Agriculture	59	62	70
Industrial	1	1	4
Marina	26	28	34
Natural Resource & Passive Park Lands	9	10	13
Other Institutional	-	-	1
Public Institutions	2	3	5
Recreation and Entertainment	5	7	9
Retail Commercial	2	2	6
Single-Family Detached	635	733	1,530
Undeveloped	2	11	17
Utility	0	0	1
Totals	**745**	**857**	**1,690**

Data used for 2023 Analysis:

- *Two datasets of GPS located wells shared by the County*
- *Anne Arundel County Existing Land Use 2021. Updated 11-19-2021*
- *Anne Arundel County Water Mains. Updated 3-10- 2022*
- *Anne Arundel County Water Service. Updated 2-1- 2022*

Table 23. **Septic Systems at Risk in Region 9.**

Region 9 Septic Systems At-Risk (# of properties)			
Primary Use	**2050 Sea Level Rise Scenario**	**2065 Sea Level Rise Scenario**	**2100 Sea Level Rise Scenario**
Agriculture	47	48	51
Industrial	0	0	2
Marina	20	21	24
Natural Resource & Passive Park Lands	10	10	10
Other Institutional	0	0	0
Public Institutions	1	1	1
Recreation and Entertainment	1	1	1
Retail Commercial	1	1	2
Single-Family Detached	318	361	459
Transportation	0	1	1
Undeveloped	10	10	12
Utility	0	0	1
Totals	**409**	**454**	**564**

Data used for 2023 Analysis: Anne Arundel County Septic Inventory

Methodology for Analysis

Two GPS well location shapefiles (*GPS 2021 Wells*: 9,262 and *Isabel Submerged Wells*: 1,171) were shared by the County; these were incomplete. The reported number of wells in the *2011 Sea Level Rise Report* was approximately 45,500. In order to estimate and account for wells that have not been identified via GPS, the following methodology was used:

1. Using *Existing Land Use* data, removed parcels that intersect with *Water Service* and *Water Main lines*.
2. Removed areas that do not have GPS well points and have Primary Use equal to "Natural Resource & Passive Park Land" or "Water" or "Transportation".
3. Removed areas that do not have GPS well points and have Secondary Use equal to "Road/Rail ROW" or "'Cemetery' or "Cemeteries"
4. ***Total Estimated Wells*: 48,430**

This new shapefile consists of property parcels that assumes well use. An at-risk well is assumed when the sea level rise extent (flooding of ≥2 feet) intersects with any part of the parcel property.

3F. Critical Facilities in Region 9

In addition to the actions that were identified in the *2011 Sea Level Rise Strategic Plan*, the steering committee suggested that the results of the sea level rise assessment include at risk critical facilities.

As defined in the Anne Arundel Hazard Mitigation Plan, critical facilities are those assets and operations that are essential to a jurisdiction maintaining functionality, especially during and after emergencies or significant natural hazard events. There is a range of facilities that can be categorized as critical, including:

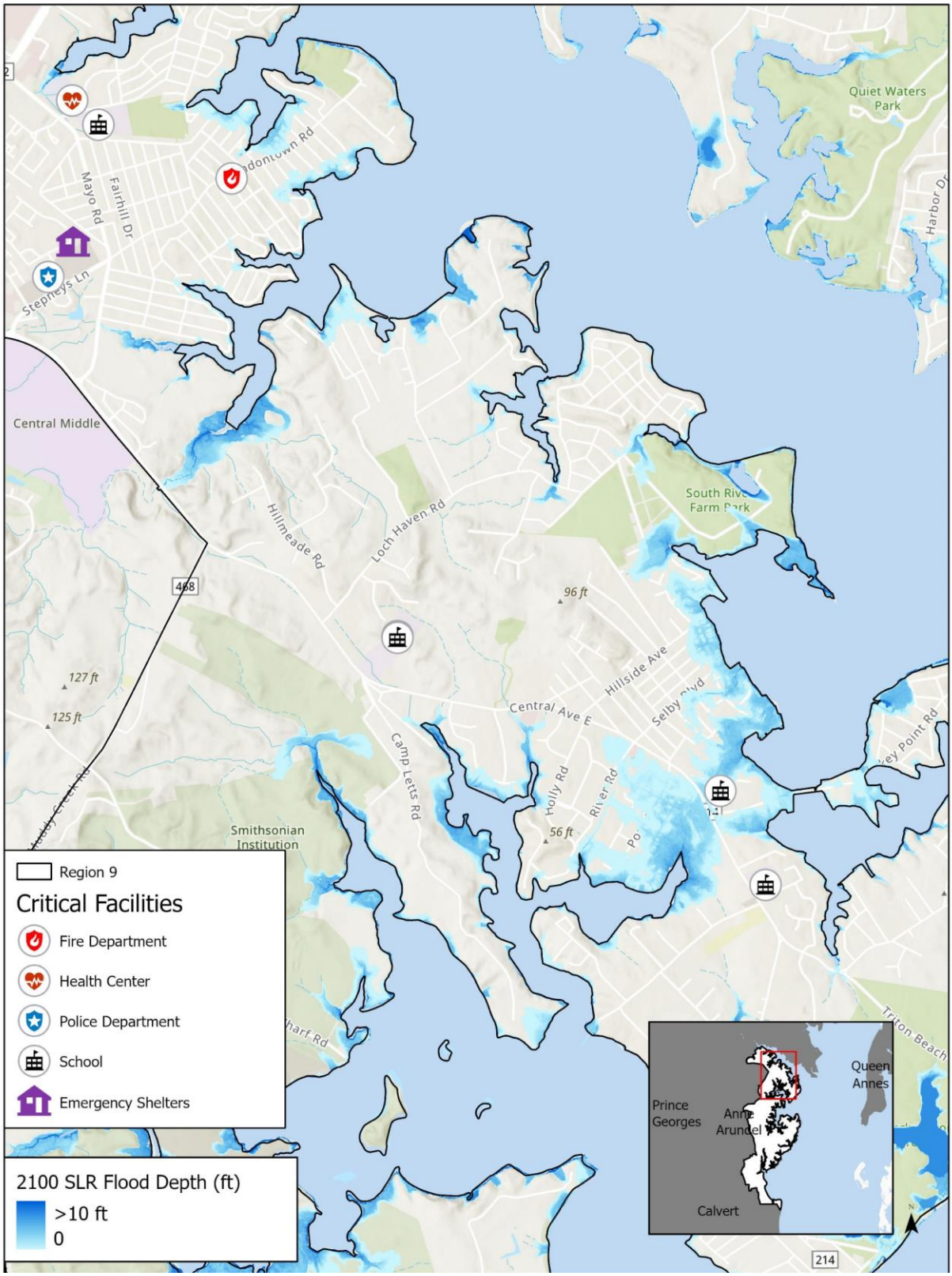
- Police and Fire Stations
- Schools
- Shelters
- Hospitals or Health Centers

Table 24 summarizes Region 9 structures that were identified as at-risk critical facilities. Building footprints were overlayed with flood extents from the three sea level rise scenarios (2050, 2065, and 2100). There are no critical facilities under the sea level rise scenarios plus 2 feet of water. Map 24 to Map 26 show the location of these structures in relation to anticipated 2100 sea level rise scenario. Although the simulations show that no critical facility will directly be flooded due to sea level rise but access to the **Avalon Shores Fire Company 41** and **Bay Community Health Center** in **Shady Side** may be impaired.

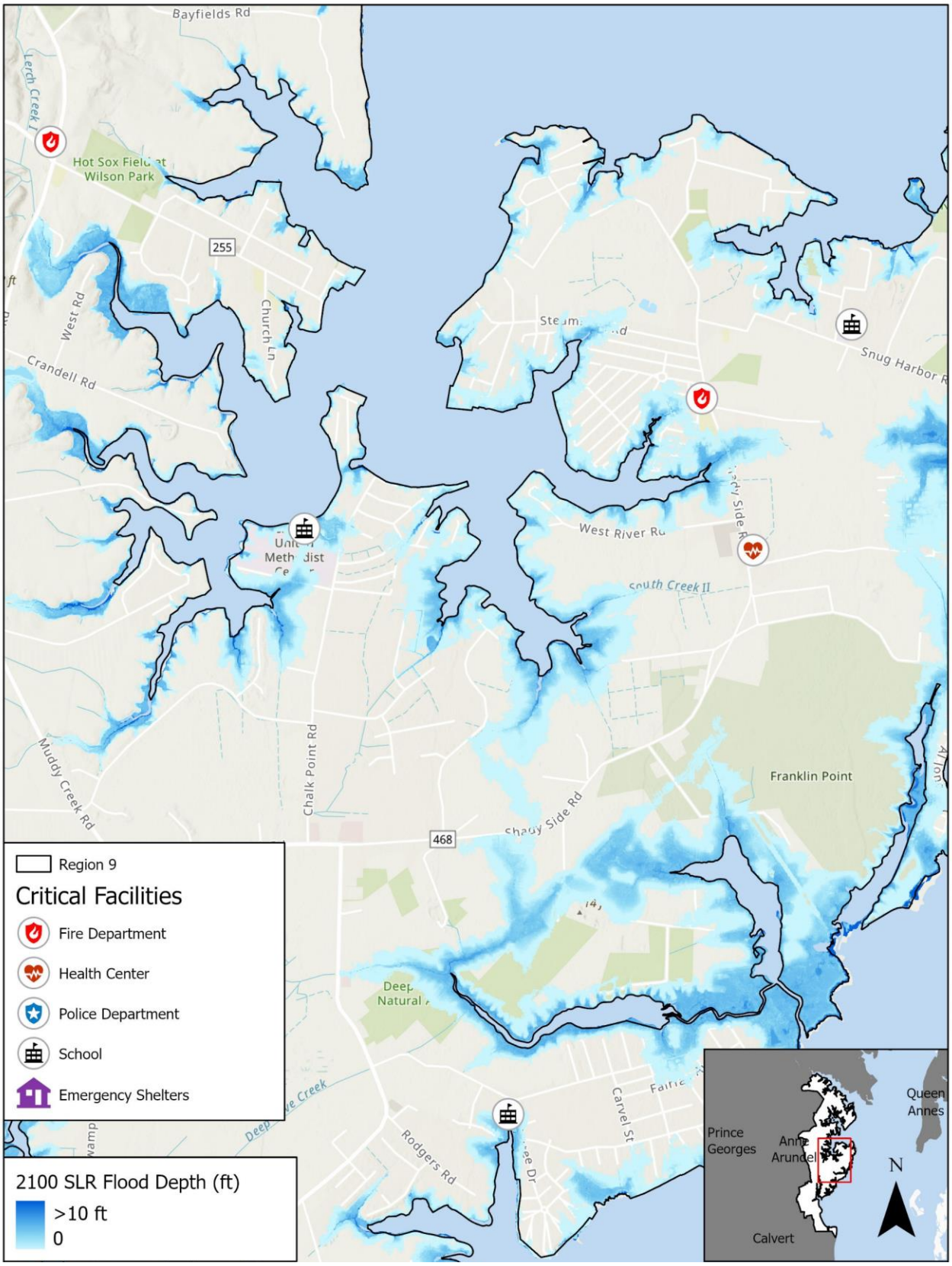
Table 24. **Critical Facilities at Risk in Region 9.**

Region Critical Facilities At-Risk to 2100 Sea Level Rise Scenario	
Critical Facility	**# of Facilities**
Emergency Shelter	1
Health Center / Hospital	2
Fire Department	4
Schools	10
Police Department	1

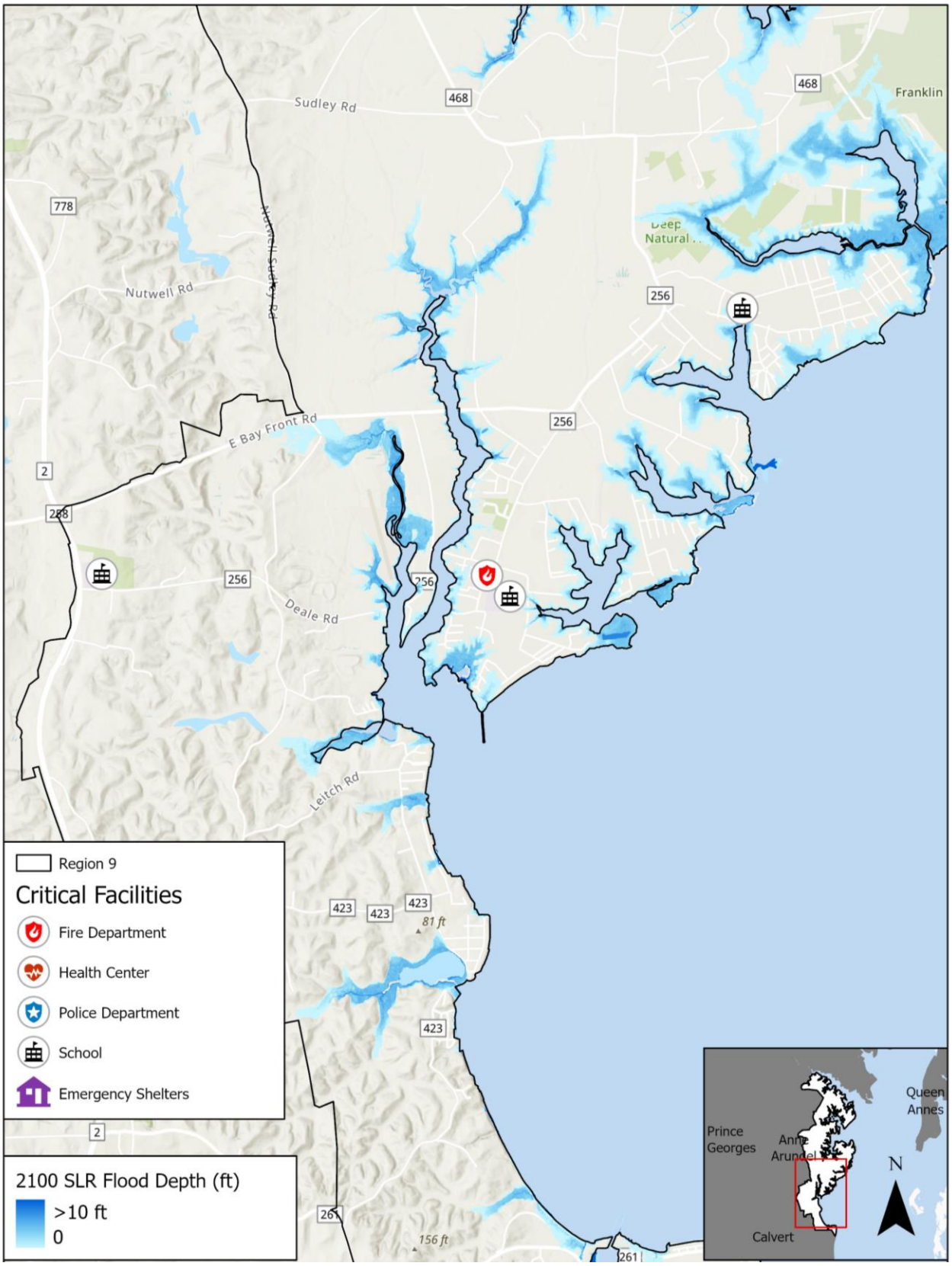
Data used for 2023 Analysis: Anne Arundel Critical Facilities



Map 24. **Critical Facilities in Edgewater, Mayo.**



Map 25. **Criticial Facilities in West River, Shady Side.**



Map 26. **Critical Facilities in Deale, Tracys Landing, and Churchton.**

3G. Historic and Archeological Resources in Region 9

Anne Arundel County has a rich cultural heritage, and settlement here has long focused on the shorelines. The *2011 SLR Strategic Plan* listed over 400 archaeological sites that may be susceptible to loss or damage due to SLR, as well as over 70 historic properties county-wide. This is of particular concern to the County given the extremely high value of some of the archaeological finds discovered to date in the County.

There are 932 parcels in Region 9 that are registered to the Maryland Inventory of Historic properties, one-third of which (no. = 332) show varying degrees of vulnerability to sea level rise flood extents. Parcels from the Historic Resource Inventory in Anne Arundel County were overlaid with three (3) SLR scenarios to identify properties that will be flooded by at least 2 feet of coastal waters.

Parcels in the **Columbia Beach Survey District**, **Town of Galesville, West Benning Road Historic District, Chesapeake Instrument Corporation Complex,** and **Cumberstone Road Rural Historic District** are vulnerable to SLR. Historic roads are also at risk to SLR and in most cases, even if some parts of these roads are flooded, it will still impair access to certain areas (including **Swamp Circle Rd., Friendship Rd., Town Point Rd**., and **Lake Shore Rd**.). Table 25 indicates five (5) historic districts that are potentially vulnerable to SLR (**Cumberstone Road, W. Benning Road, Columbia Beach**, **Ivy Neck**, and **Galesville**). The number of individual buildings and landscape features that are within those districts comprise of many structures having a greater threat between 2050 and 2100. Significant historic properties that may be impacted include **Norman's Retreat, Londontowne Publik House, Tulip Hill, Cedar Park,** and the **Lula Scott Rosenwald School.** The location of these resources are presented in Map 27.

Table 25. Region 9 Impacted Historic Resources

Region 9 Historic Properties by Type			
Recorded Sites	**2050 SLR Scenario**	**2065 SLR Scenario**	**2100 SLR Scenario**
Structures / Dwellings	39	42	48
Historic Districts	5	5	5
Historic Roads	3	5	11
Cemeteries (Verified)	4	7	15
Total	**51**	**59**	**79**

Data used for 2023 Analysis:

- *Anne Arundel County Historic Resources & Cemetery data files*

Historic cemeteries notably will also be impacted, particularly in Shady Side and Tracys Landing. The counts in Table 25 only reflect the cemeteries with verified locations and fairly well understood boundaries. If the unverified cemeteries are also included, the total count of vulnerable cemeteries raises to 22.

As for archaeological resources, Region 9 has 335 identified archaeological sites, over 90% of which are within 0.5 miles from the shoreline, making them vulnerable to sea level rise and coastal erosion. Coastal flooding due to the 2050 sea level rise will affect 123 sites and will increase to 182 vulnerable sites in 2100. In other words, **37% to 54% of all archaeological sites in Region 9 will be vulnerable from 2050 to 2100**. At least 10% of the sites are known to be significant, including Native American camp sites (including the **Harrison Site, 18AN423**), colonial domestic and town sites (**Ivy Neck, London Town)**, wharf sites and one shipyard (**Stewards Shipyard**). Two of these significant archaeological sites are cemeteries, the **Norman-Richardson Cemetery (18AN832)** and the **Larrimore Family Cemetery (18AN1590),** both of which will be vulnerable in 2100. Another site, **18AN530**, is a possible Native American

burial site and is vulnerable in the 2065 SLR model. The majority of these sites have not undergone evaluation, which means there is no estimation of historic significance as of yet for those sites. Sea level rise will affect the County's oldest archaeological sites, the only tangible remains of a distant past. The majority (about 70%) of these vulnerable archaeological sites are shell middens along the Chesapeake shoreline of Region 9, most of which are pre-contact Native American sites.

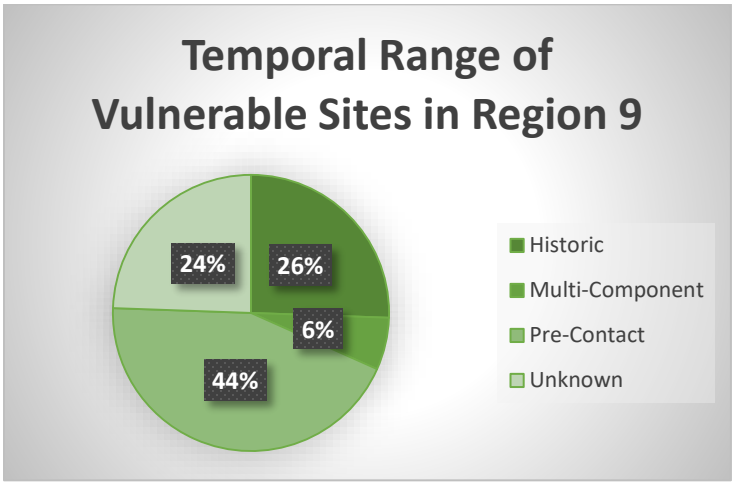
As presented in Table 26, Edgewater has the most archaeological sites vulnerable to SLR followed by Harwood. There are 9 sites that are within 20ft of shoreline that were identified having moderate to high erosion rates. And 8 of which are also vulnerable to all 3 SLR flooding scenarios. There are 5 sites that are located within 20 feet of shorelines that have been identified as vulnerable to moderate and high wave hazard.

Table 26. Archaeological Property Counts in Communities in Region 9

Region 9 Archaeological Properties in Communities			
Communities	**2050 SLR Scenario**	**2065 SLR Scenario**	**2100 SLR Scenario**
Edgewater	57	66	83
Harwood	36	41	51
Churchton	8	10	13
West River	7	8	12
Shady Side	5	7	9
Deale	4	5	6
Tracys Landing	4	5	6
Galesville	2	2	2
Total	**123**	**144**	**182**

Data used for 2023 Analysis:

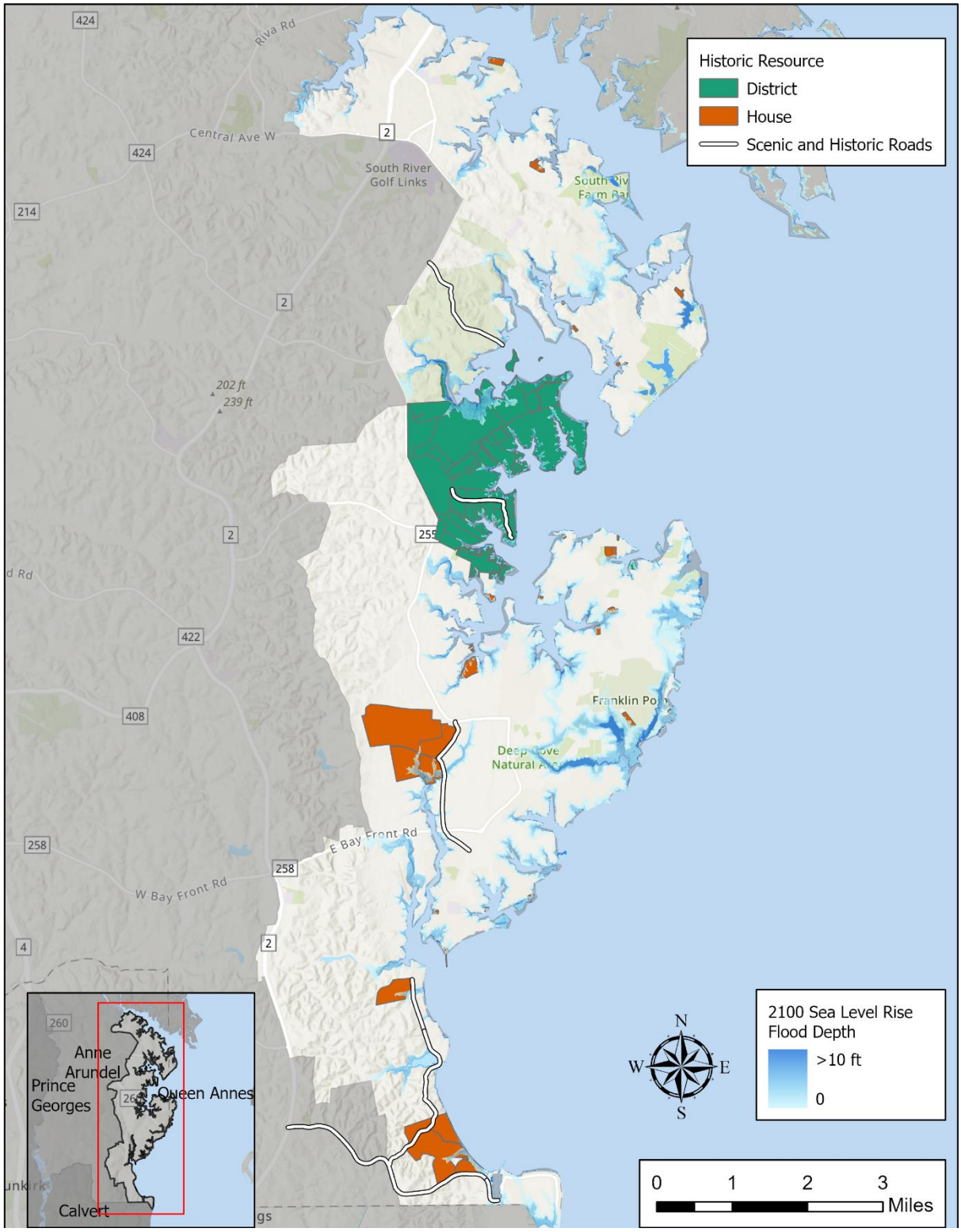
- *Anne Arundel County Archaeological data files*
- *DNR Anne Arundel County 10-yr Erosion Level (1993-2010), updated August 27, 2019*



Related Resources:

- Sea Level Rise Strategic Plan, Anne Arundel County, Phase 1 Report: Vulnerability Assessment (A.A.Co.)*
- Phase I Hazard Mitigation Planning for Anne Arundel County's Cultural Resources: Maryland City/Laurel/Jessup, Pasadena, & Shady Side/Deale (A.A.Co.)*

**Not available online; on-file in the archives of the Cultural Resources Section, Office of Planning & Zoning.*



Map 27. Historic Properties and Roads in Region 9 vulnerable to SLR in 2100.

PART III - Region 9: Social Vulnerability

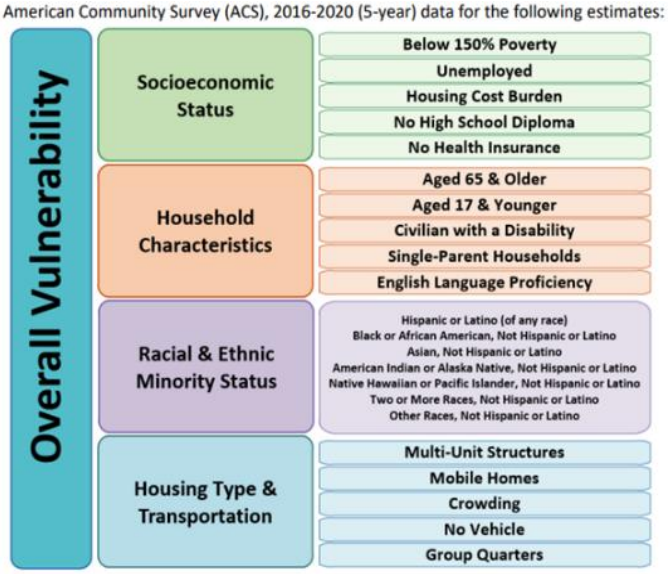
The most recent CDC's Social Vulnerability Index (SVI) uses U.S. Census (ACS 5-year estimates, 2016-2020) data to determine the relative social vulnerability of every census tract. The SVI ranks each tract based on 16 social factors and groups them into four related themes. Each tract receives a separate ranking for each of the four themes, as well as an overall ranking.

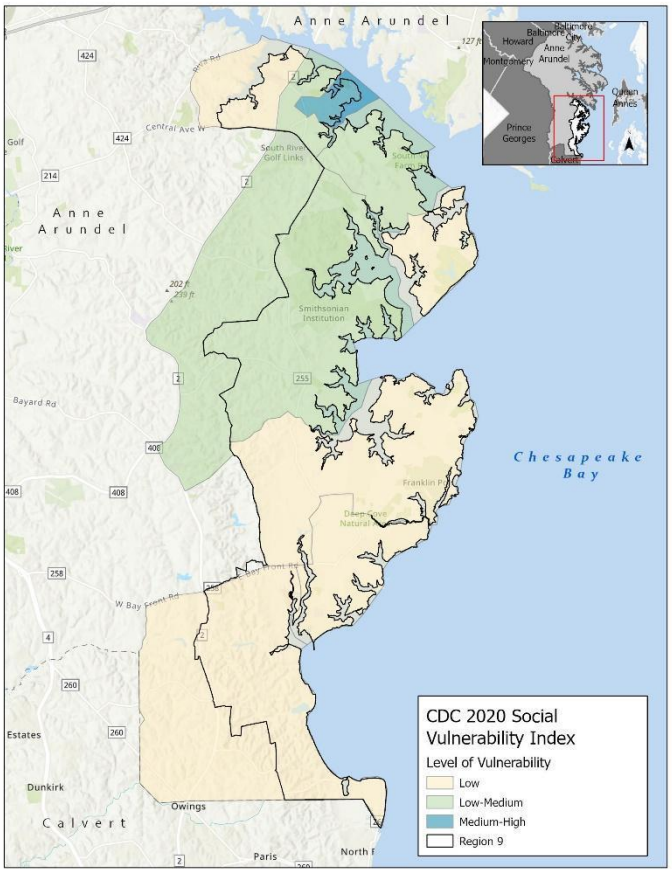
The four themes included in the SVI are:

1. Socioeconomic Status – below 150% poverty, unemployed, housing cost burden, no H.S. diploma, no health insurance.
2. Household Characteristics – aged 65 and older, aged 17 and younger, civilian with disability, single-parent household, English language proficiency.
3. Racial & Ethnic Minority Status – race, ethnicity.
4. Housing Type & Transportation – multi-unit structures, mobile homes, crowding, no vehicle, group quarters."

The CDC provides an overall ranking for each census track by totaling the sums for each theme, ordered the tracts, and then calculated overall percentile rankings. Please note taking the sum of the sums for each theme is the same as summing individual variable rankings.

Integrating the SVI with the flood risk analysis indicates that most of the areas at highest risk to SLR impacts in Region 9 are rated Low or Low-Medium. The Londontown area is identified as Medium-High on the SVI.





Map 28. CDC 2020 Social Vulnerability Index, Region 9.

3H. Shoreline Erosion Analysis of Region 9

With almost 15% of the County's shoreline located in Region 9 erosion of coastal shoreline is a major concern. Shoreline erosion is typically caused by seasonal changes in water current patterns, wind, human activity such as wakes from boats, and changing sediment flows from sources. Shoreline can also be eroded with rising water levels as well causing the coast to retreat further inland.

Using the current 10-yr shoreline erosion data for Anne Arundel County (Nunez et. al, 2021), a total of 19,505 ft of shoreline have moderate to high erosion rates in Region 9. Under SLR projections in 2050, 90% of these shorelines will be under at least 2ft of coastal waters and will increase to 95% under the 2100 scenario if no measures were taken. Table 27 below shows the length of the most vulnerable shoreline in Region 9 that are susceptible to both shoreline erosion and SLR.

Table 27. At-Risk Shoreline, moderate and high (length, feet)

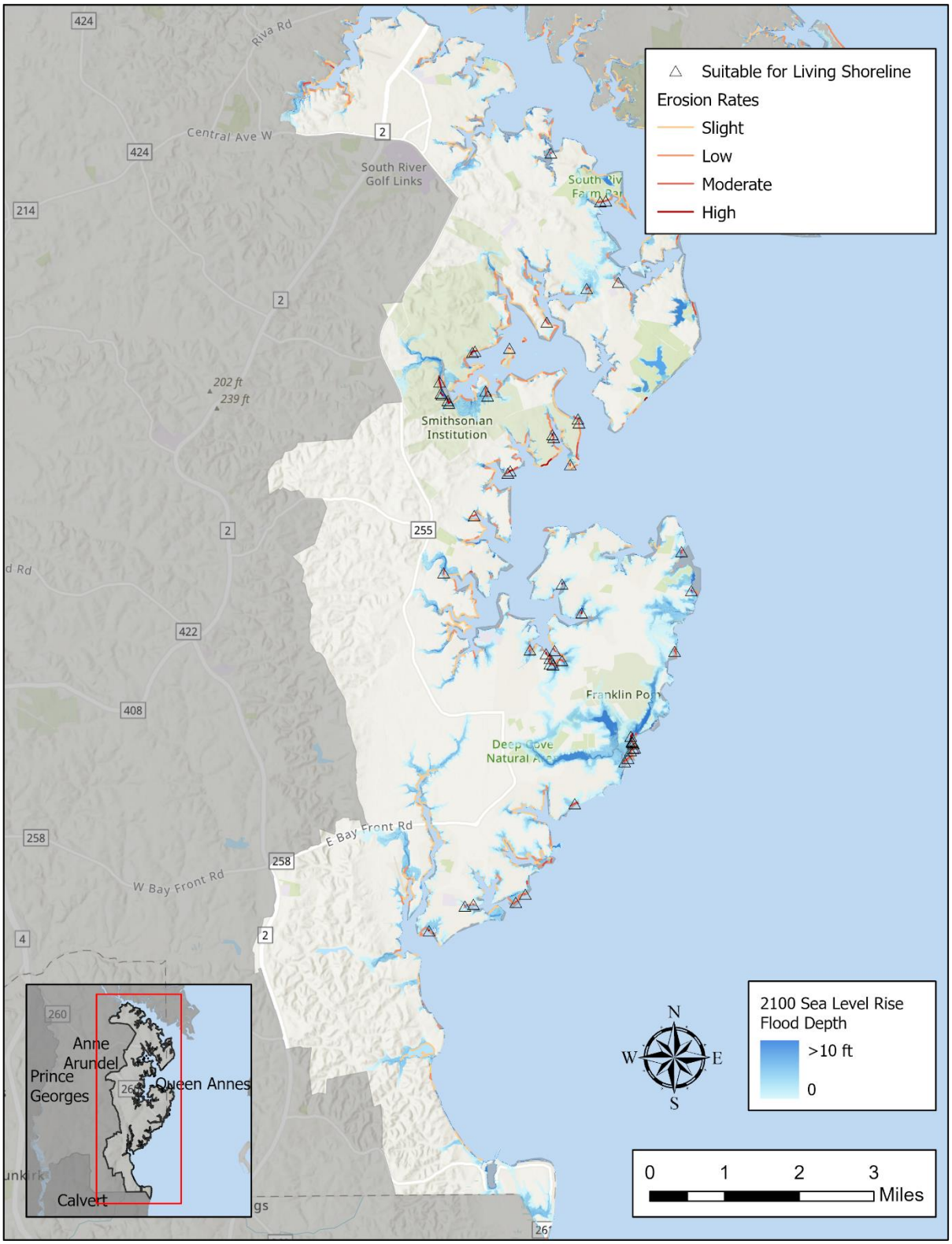
At- Risk Shoreline, moderate and high (length, feet)			
Region 9 Communities	**2050 SLR Scenario**	**2065 SLR Scenario**	**2100 SLR Scenario**
Churchton	4,692	4,692	4,692
Deale	1,077	1,077	1,152
Edgewater	3,014	3,231	3,648
Galesville	182	182	182
Harwood	6,712	6,712	7,016
Shady Side	1,286	1,286	1,338
Tracy's Landing	50	50	50
West River	627	627	627
Total (feet)	**17,641**	**17,858**	**18,705**

Data used for 2023 Analysis:

- *DNR Anne Arundel County 10-yr Erosion Level (1993-2010), updated August 27, 2019*

The Anne Arundel County Living Shoreline Suitability Model (Nunez et. al, 2022) was also used to identify which of these moderately and high eroding shorelines would be suitable for different mitigation measures. Around 14,377 ft of shoreline was found suitable for living shorelines. Map 27 below identifies areas in Edgewater and Shady Side identified suitable to Living Shoreline mitigation.

Although the best available data was used for this assessment, shorelines were assessed only qualitatively through GIS spatial techniques. The shoreline in Region 9 will continuously change not only from SLR but from storm surge, waves, winds, and development. Due to its dynamic nature, shoreline assessments should be done regularly to assess future developments.



Map 29. Areas of shoreline erosion in Region 9 that are vulnerable to SLR in 2100

3I. HAZUS Loss Estimations in Region 9

Hazus evaluates the risks associated with flooding from severe weather on top of SLR to help understand community risks in the future. While SLR in 2050 is not expected to directly impact a large number of buildings, the impacts dramatically increase when coupled with a severe weather event. For this reason, the Hazus analysis for Region 9 included the extent and depth of flooding due to SLR under the 2050 scenario in conjunction with FEMA's 1 percent annual chance flood scenario.

Loss estimations, along with debris generation , and projected shelter needs from 2050 sea level rise projection plus the 1% annual chance flood scenario were determined for the Region 9 Coastal Resiliency Toolkit. Results produced by this analysis include both building, content loss estimations, debris generation, and shelter needs. Detailed results produced by this analysis can be found in Attachment 3.

What is Hazus?

Hazus is a nationally standardized risk modeling methodology. Hazus is used to determine potential losses from disasters. The Hazus flood model calculates physical damage and economic loss due to coastal and/or riverine inundation. Losses are calculated using functions that relate the depth and type of flooding to the degree of damage for various categories of buildings.

FEMA's Hazus 6.0 was utilized for this analysis. FEMA's Hazus 6.0 was released on November 16, 2022, and had major inventory data, methodology, and software improvements. Data improvements included incorporation of the 2020 census data.

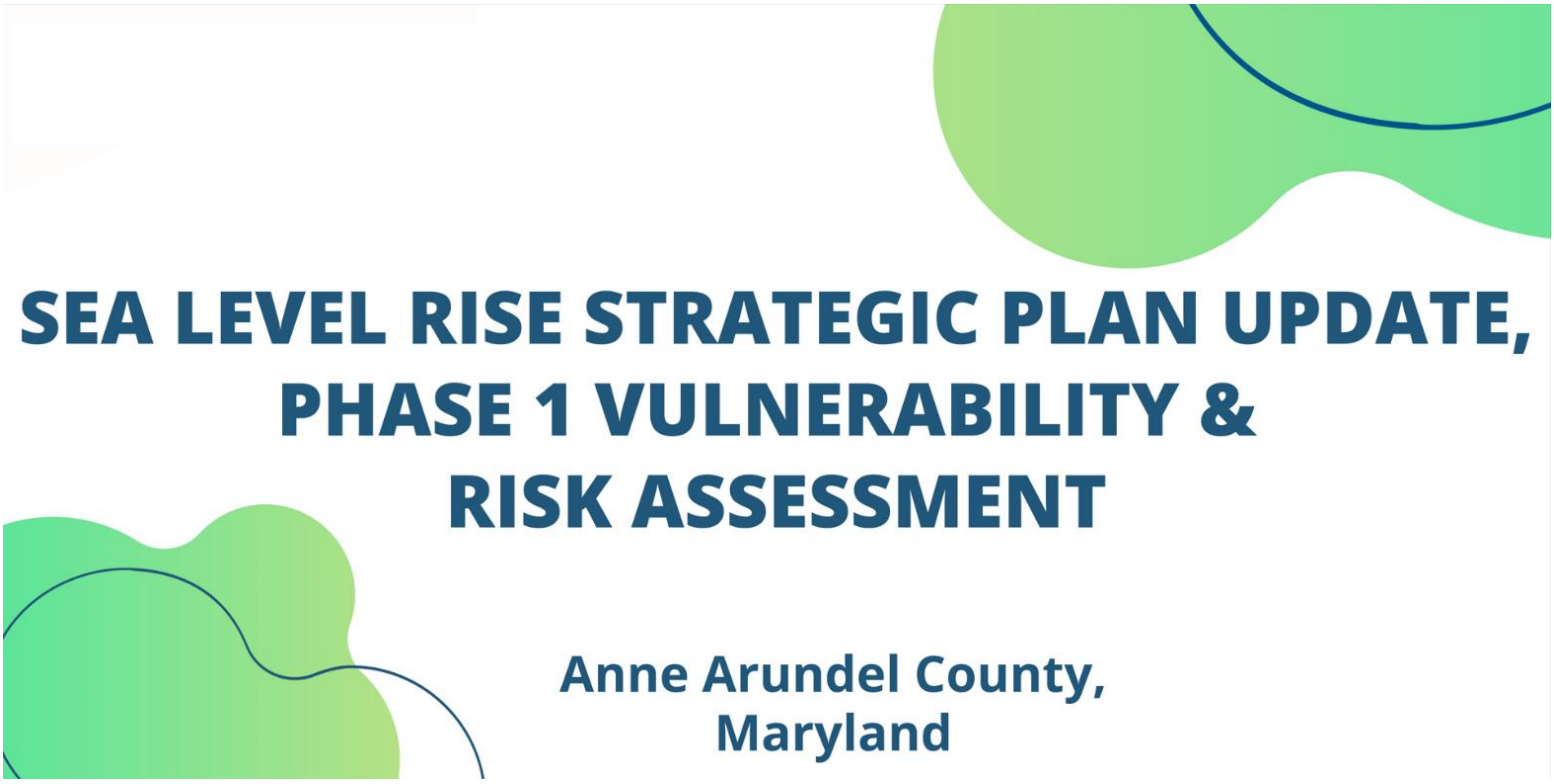
Parcel-specific information containing assessed values, land use/occupancy categories, number of stories, and additional attributes was acquired through the Maryland Department of Planning. Specific parcel attributes were combined with building footprints, which represent real-world locations for addressable structures and incorporated into the Hazus program.

A total of 5,387 at-risk structures, 5,291 residential, are within the 2050 SLR projection plus the 1% annual chance flood scenario study area. At-risk structures are divided into three (3) Hazus occupancy types, commercial, other, and residential. Building and content loss under the 2050 SLR projection plus the 1% annual chance flood scenario for Region 9 total is $1,208,819,588 of which 94% or $1,143,893,603 were anticipated losses from single family homes.

High loss estimation risk areas were determined by extrapolating structures with loss estimates greater than $100,000. Using this method, high risk areas include:

- Selby Heights Area, especially along the Selby Bay, Cub Neck Creek, and Whitemarsh Creek
- Chalk Point and Back Bay Area, especially along West River and South Creek
- New Deale Beach Area, especially along Parker Creek and Carrs Creek
- Franklin Manor Beach and Cape Anne Area
- Cedarhurst Area

The information from the Hazus report will be integrated into the Anne Arundel County Hazard Mitigation Plan update in 2024, as part of the County's ongoing efforts to integrate SLR strategies into existing plans and policies.


SEA LEVEL RISE STRATEGIC PLAN UPDATE,
PHASE 1 VULNERABILITY &
RISK ASSESSMENT
Anne Arundel County,
Maryland

NEXT STEPS

Anne Arundel County has been experiencing the impacts of a changing climate and will continue to do so over the coming decades. The priorities presented in this Update to the SLR Strategic Plan establish the basis for policy and action planning within Anne Arundel County. The continued development of a strategy, with broad public participation will determine how well the County adapts to a changing future.

Progressing from planning strategies to implementation will be an iterative process which begins now. The County's Technical Team will review programs and policies based on the information presented here and will assess their procedures to determine how the actions presented in the plan can be applied to their operations and programs. Members of the County's Technical Team will ensure that all stakeholders, including residents and those that were not part of technical team, are aware of and able to provide feedback on the plan.

Future work in Region 9 will include more specific, detailed actions which advance those that are included in this plan. The County will report to the public its successes, its challenges, and the actions needed to resolve those challenges.

Anne Arundel County recognizes the policy and operational changes, and new initiatives that will be needed to accomplish the priorities described throughout this document will all require personnel and financial resources. Understanding the amount of funding needed to implement these actions will require more detailed analysis as specific programs are modified and developed. Thus, this plan does not include cost estimates or funding plans. The County will develop a path forward which will allow equitable implementation of this Plan.

The following list includes immediate next steps for Anne Arundel County to take in the next year to accelerate the implementation of this Plan:

- Develop a work plan for members of the County's Technical Team, including issue-specific working groups
- Schedule meetings with community groups
- Conduct broad outreach and engagement with stakeholders and the public
- Initiate project development and implementation measures in priority areas – Deale/Shady Side

The findings presented in this Plan provide the framework around which future discussions will take place. Anne Arundel County looks forward to working with Maryland Department of Natural Resources to confront the challenges of building resilience into Sea Level Rise.

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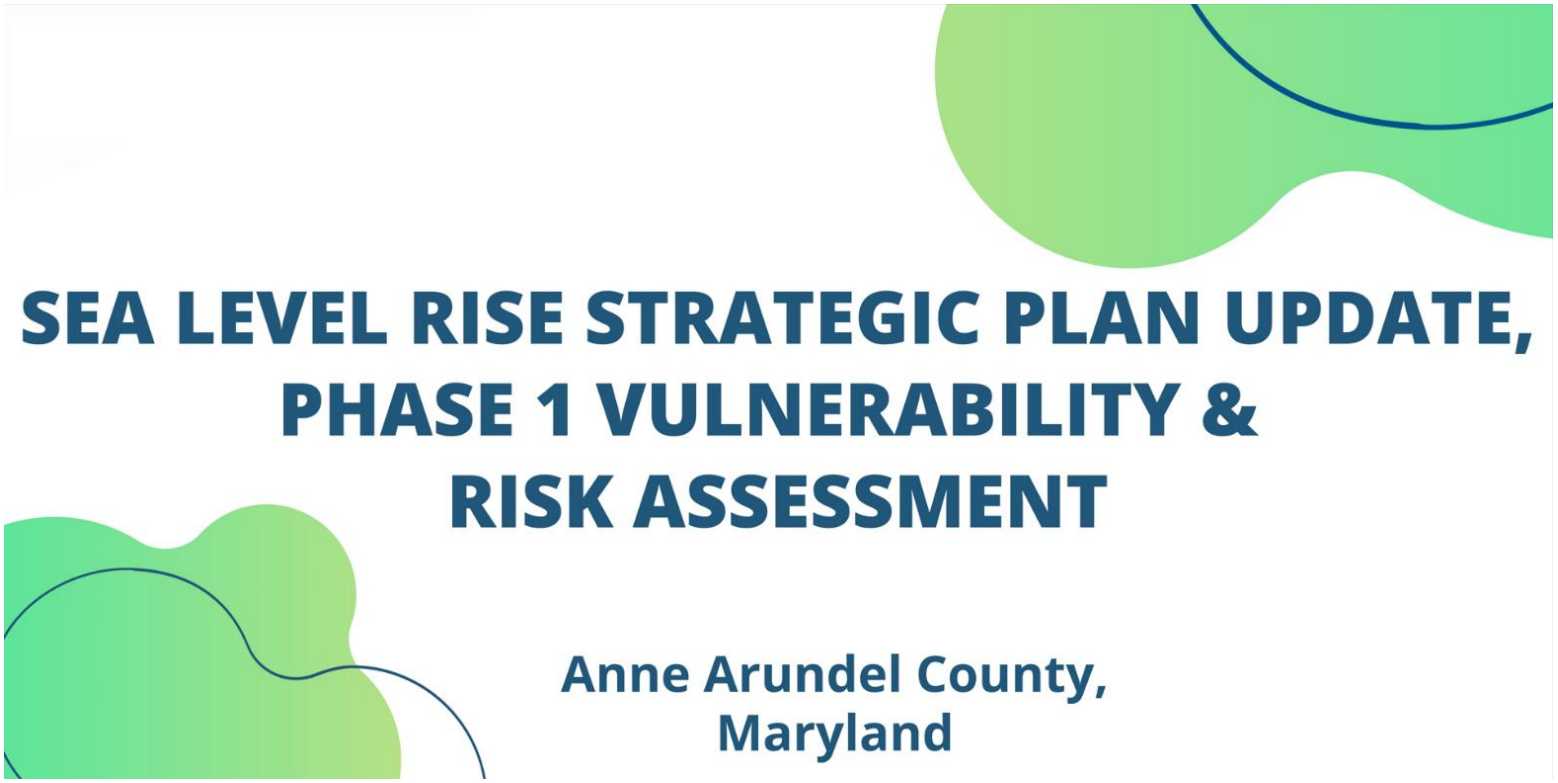


ATTACHMENT A. Plan Review Summaries & Matrix

This document provides a summary review of key County planning documents relative to SLR. This review of County plans and policies for SLR strategies was conducted to ensure that a mutually supportive resilience framework exists throughout all County planning efforts. Each County plan was reviewed using 7 criteria: 1.) Relevant Values, Goals, Objectives, Priorities; 2.) Useful Data Sources or Maps; 3.) Relevant Projects (related to SLR and/or in focus areas); 4.) Discussion of SLR; 5.) Relevant Current Policies or Policy Incentives; 6.) Ways SLR can be Integrated into SLR Strategic Plan; and 7.) Other relevant information.

Plan2040, Volume I: Anne Arundel County General Development

Plan2040 establishes a vision, goals, policies, and strategies to guide development of Anne Arundel County over the next twenty years. It reflects the voices of thousands of residents and addresses their priorities for the future of the County. The plan builds on the foundation of the previous General Development Plans and Small Area Plans. It values, promotes, and protects what makes Anne Arundel County "the best place for all," including the Chesapeake Bay and its tributary rivers, forests, farms, quiet suburban neighborhoods, rural landscapes, and thriving economic centers.

Plan2040 lays out a policy framework that informs many of the County's future decisions on land use, environmental protection, transportation, open space, agriculture, community facilities, historic preservation, housing, economic development, and quality of life. Plan2 040 will be implemented through Region Plans, functional plans, design manuals, regulations, the capital budget, and the work programs of County departments.

Plan2040 is based on a vision and five themes that are integrated into a comprehensive set of goals and policies. The plan is based on an integrated approach to sustainable development that considers the interaction of the environment, economy, and social equity. To emphasize those connections, the plan is organized in four chapters:

- ✓ Natural Environment
- ✓ Built Environment
- ✓ Health Community
- ✓ Healthy Economy

The Office of Planning and Zoning (OPZ) have developed climate change policies and strategies that are used as a framework for discussion purposes and inclusion in the Anne Arundel County General Development Plan update, Plan2040. The policies and strategies were developed based on three County reports and initiatives including the Sea Level Rise Strategic Plan (2011), Energy Efficiency and Conservation Plans (2009 and 2013), and the Climate Resilience Action Strategy.

Diverse Landscapes and Communities

The Plan2040 recognizes and supports the diverse landscapes and communities of Anne Arundel County. The scale and character of natural features, neighborhoods, and activity centers varies across the County. While the needs and priorities of each community may vary, in general, Plan2040 takes the following approaches:

- ✓ Targeted Development, Redevelopment and Revitalization Areas: promotes public and private investment in designated Town Centers, Commercial Revitalization Areas, and Sustainable Communities.
- ✓ Neighborhood Preservation Areas: primarily limits new development with public investments in walking and biking infrastructure, parks, and schools.
- ✓ Peninsulas: supports protection of natural shorelines, road improvements, stormwater management, adaptation to sea level rise, and decreases development potential on the planned land use map.
- ✓ Rural and Agricultural: continues policies to protect rural lands, support the agricultural economy, and improve public transportation and services.

To coordinate climate resilience throughout the County, Plan2040 includes a goal specifically focused on climate change (BE16) and integrates climate related policies and strategies across multiple other areas.

Goal BE 16: Increase the County's resilience to future changes in climate and reduce emissions of greenhouse gases.

Policy BE 16.1. Establish systems in the County government to integrate climate change considerations across County functions.

> **c.** Incorporate considerations of climate change, including sea level rise, into the County's adopted plans as necessary to ensure implementation. These plans could include the Water and Sewer Master Plan; Hazard Mitigation Plan; Land Preservation, Parks and Recreation Plan; and other plans as appropriate.

Other Policies Presented in Plan2040 that Focus on Sea Level Rise

Goal NE1: Preserve, enhance, and restore sensitive areas, including habitats of rare, threatened, and endangered species, streams, floodplains, tidal and non-tidal wetlands, bogs, shorelines, steep slopes, and all applicable buffers.

Policy NE1.3: Protect, enhance, and create living shorelines and nearshore habitat.

> Require all shoreline restoration projects on County-owned properties to utilize living shoreline restoration techniques where feasible. Require designs take into account projections for sea level rise.

Goal NE3: Expand, enhance and continue to protect the County's greenways, open space, rural areas and the Priority Preservation Area.

Policy NE3.1: Increase the amount of protected land in the County

Target flood-prone properties, including non-tidal wetlands, and areas at risk from sea level rise as priorities for easement or fee simple acquisition.

Goal NE4: Improve and protect surface water quality by reducing impacts from stormwater runoff, wastewater discharge, and septic systems.

Policy NE4.3: Reduce total nutrient loads from onsite septic systems and small community-based systems (also known as "minor systems").

Evaluate the impact of increasing precipitation events and sea level rise on septic system function and develop strategies to ensure adequate percolation and functionality

Goal NE5: Ensure the safe and adequate supply of groundwater resources and wastewater treatment services for current and future generations.

Policy NE5.3: Develop a long-term public water and sewer infrastructure replacement program.

Evaluate and address the impacts of sea level rise and climate variability on the County's water and sewer infrastructure and future needs

Goal BE4: Support quality of life and economic vitality in County Peninsula Policy Areas, while preserving the environmentally sensitive areas.

Policy BE4.1: Prioritize protection of sensitive environmental features on County peninsulas during long range planning efforts.

Consider vulnerability to sea level rise, coastal flooding and nuisance flooding during land use, development, and zoning processes. Consider expansion of the Critical Area to include these areas.

Goal BE4: Support quality of life and economic vitality in County Peninsula Policy Areas, while preserving the environmentally sensitive areas

Policy BE4.2: Ensure the maritime industry remains a viable driver of economic growth and stability in the Peninsula Policy Areas.

Review Maritime use requirements to ensure environmental protection, adaptability to sea level rise, and adequacy of transportation infrastructure.

Goal HC10: Provide a high-level of emergency medical care, fire protection, police protection, emergency management and an all-hazards response to all residents and visitors of the County, including a comprehensive evacuation plan with adequate evacuation shelters.

Policy HC 10.4: Increase preparedness for weather-related emergencies including extended heat waves, urban and coastal flooding, and drought.

> Work with the local community network to assist vulnerable communities in developing action plans and improving emergency preparedness at the community level. In addition to planning for catastrophic events, promote awareness and preparedness for the longer term or more permanent impacts of sea level rise.

Anne Arundel County Hazard Mitigation Plan

The HMP focuses on mitigation strategies and actions that assess the vulnerability of coastal communities to sea-level rise, coastal flooding, and nuisance flooding; incorporates the Climate Resilience Action strategies and actions into local comprehensive plans; improves resilience of critical infrastructure to flooding and the impacts of climate change; and identifies protective measures for cultural and historic resources to flooding, erosion, and sea level rise impacts.

Section 3.4 of the plan specifically addresses Resiliency, Climate Change and Sea Level Rise Considerations and cross reference strategies and actions that are presented in county and state policies and plans.

The HMP summarizes the results and recommendations of the 2011 the Sea Level Rise Strategic Plan to provide context for the County's ongoing and emerging efforts to address climate change and sea level rise. The Plan acknowledged the information in the SLR Strategic Plan was developed about eight years ago, and various of the inputs have likely changed in the interim. Moreover, inundation projections are necessarily based on predictions about the degree of sea level rise, and this is by definition uncertain, and thus so are the results.

Based on the analysis and conclusions to date, the County has determined that its immediate focus for sea level rise planning efforts will be more on reducing impacts and future losses to existing development and resources. Consideration for limiting or restricting the extent of future development in areas subject to flooding and to sea level rise will be completed during the comprehensive planning process of the General Development Plan update and as better estimates are obtained by the County on sea level rise projections. The existence of low- density zoning and development regulations currently in place are expected to limit the future development potential in areas vulnerable to flooding and to sea level rise. While a number of infill parcels or lots still exist in these areas, the County does not anticipate a surge of new subdivisions or major development applications within these areas. The County will consider legislation and other mitigation strategies and actions in areas prone to flooding and sea level rise that reduces potential losses and damages to life and property.

The County's subdivision code, zoning ordinance, and the General Development Plan govern land use and development in areas subject to flooding and to sea level rise. The State Critical Area regulations as well as FEMA floodplain regulations provide additional controls on future construction and development in vulnerable areas. Article 17, Title 8 establishes a 100-foot buffer for development and redevelopment on properties within the Critical Area from the mean high-water line of tidal waters, tributary streams, and tidal wetlands. An expanded buffer is required if there are contiguous slopes of 15% or greater; nontidal wetlands, nontidal wetlands of special State concern, and hydric soils or highly erodible soils. The establishment of these buffers along the shoreline serves as an on-going hazard mitigation action by the County that maintains the natural environment of a stream; protects riparian wildlife; establishes and maintains an area of transitional habitat between aquatic and terrestrial communities; minimizes adverse effects on wetlands, shorelines, stream banks, tidal water and aquatic resources; and provides for the removal or reduction of sediments, nutrients, and potentially harmful or toxic substances. The County will continue to explore scientific studies and implement best management practices to enhance local mitigation efforts and reduce potential damages and losses from future disasters.

The County solicited an economic and real estate consultant to conduct a land use market analysis which was completed in 2019. The analysis assessed demographic and development trends, the real estate market, and land demand and capacity. The assessment was based on ten submarket areas that were identified as having similar real estate market and land use characteristics. Some of the key conclusions related to future development are summarized below.

- ✓ The County's average annual growth rate is slowing. During the period from 1970 - 2010 the annual growth rate averaged 2%. Between 2000 and 2010, the rate slowed to 1% annually.
- ✓ Between 2010 and 2018, growth averaged roughly 0.7%. This is in part due to the decreasing land development capacity.
- ✓ The County is still well positioned to capture its fair share of regional growth in the future, as it continues to urbanize its targeted growth areas.
- ✓ The urbanizing regional growth patterns are showing a preference for urban mixed-use and higher density developments near important transportation routes and transit lines linking residential communities to employment centers.
- ✓ Under current zoning, the County does not have sufficient land development capacity in several of the submarkets to accommodate
- ✓ A substantial amount of undeveloped land in the County is concentrated in rural areas that are not planned or zoned for future development. This preservation of rural areas will continue to be reflected in the land use policies of the new GDP to be completed in 2020.

These conclusions have several positive implications as related to hazard mitigation. First, targeted growth areas are not located along or near the County's shoreline and therefore are not in areas most vulnerable to sea level rise impacts. Secondly, the policy focus on redevelopment and revitalization will serve to protect more greenfield areas from new

development, preserving natural features, tree canopy, and other environmental features that help to reduce climate change impacts. Redevelopment also provides opportunities to provide improved stormwater management techniques and facilities in older developed areas that may have outdated or minimal stormwater management currently, which will help mitigate stream erosion, water quality impacts, and other negative consequences of stormwater runoff. Focusing on redevelopment and infill in currently developed areas also allows more opportunity for infrastructure upgrades and lessens the need for infrastructure expansions into new undeveloped areas.

Anne Arundel County recognizes the importance of assuring development within the 100-year floodplain is conducted in a manner that minimizes future risk to human life and potential damage and losses to property. To minimize current and future risk, Anne Arundel County has adopted a local floodplain ordinance and local Building and Construction Codes that ensures building standards are met for development within the 100-year floodplain. Future updates to the HMP will more closely evaluate the vulnerability of structures including historical and archaeological assets and critical infrastructure.

2011 Sea Level Rise Strategic Plan

In addition to the detailed vulnerability assessment and overall analysis, the Strategic Plan incorporates a series of goals and recommendations related to sea level rise. These are briefly summarized below, and the document is incorporated by reference. The HMP update includes an additional mitigation strategy that asserts that the County will work to incorporate these goals and strategies into that document. The County has requested that specific goals and recommendations that are included in the 2010-2011 Strategic Plan not be included in the HMP, as they have not been formally adopted or approved. The goals are by definition fairly general and focus on the need to incorporate sea level rise considerations into County policies and activities, and to further study the issue going forward. The recommendations include a very detailed series of actions and policy updates that are aimed at increasing the level of technical knowledge about sea level rise and its effects, and in mitigating such effects on existing and future development. The goals are listed below, and the recommendations may be reviewed via the Strategic Plan.

1. **Incorporate sea level rise planning into all related County functions.**
    a. Establish a sea level rise project team to implement the strategic plan. The team will be responsible for establishing a work program to implement the recommended actions, monitoring progress, reporting results, and interacting with State agency liaisons.
    b. Continue to monitor information related to sea level rise planning, data, and resources.
    c. Update the vulnerability assessment when needed.
    d. Develop an integrated monitoring system with standardized recording methods to track recent, ongoing and future flooding and/or inundation problems in impacted or vulnerable communities in the county.
    e. Account for potential fiscal impacts of sea level rise in future cost/revenue analyses.
    f. Incorporate the results and recommendations from the sea level rise planning process into the County's adopted plans as necessary to ensure implementation.

2. **Protect coastal ecosystems to reduce the impacts of sea level rise, coastal flooding and shoreline erosion.**
    a. Identify high priority sites along the County's shoreline for protection and/or restoration.
    b. Include identified high priority sites in future updates of the County's Land Preservation, Parks and Recreation Plan and General Development Plan.
    c. Highest priority sites should be targeted for acquisition using Program Open Space or other preservation funds.
    d. Develop an inventory of sites that can be targeted for wetland or forest mitigation projects by private developers where development plans propose off-site mitigation.
    e. Outreach and promote the establishment of conservation easements with tax incentives on private properties in high priority sites.
3. **Reduce sea level rise impacts to existing and future development.**
    a. Determine the remaining development holding capacity within the vulnerable areas, or within the Critical Area or FEMA districts. Incorporate this into the existing development and permit tracking system in order to better assess the number of new lots being approved and permits issued in these areas.
    b. Revise the County's development regulations to discourage the granting of variances and modifications that allow stream and wetland impacts in the Critical Area.
    c. Revise the County's development regulations to increase wetland and stream buffer setbacks in the Critical Area in accordance with State Critical Area Commission recommendations, at a minimum.
    d. Determine whether additional recommendations related to sea level rise vulnerability, both regulatory and non-regulatory, should be incorporated into the development plan review and approval process.
    e. Assess the feasibility of potential revisions to building code requirements that would minimize sea level rise impacts to existing and future development in the FEMA 100-year non-tidal and coastal high hazard flood zones.
    f. Determine the benefits and feasibility of enrolling in FEMA's Community Rating System program to reduce flood insurance premiums for property owners in the County.
4. **Reduce potential impacts to public infrastructure serving existing communities and future development.**
    a. Identify those road segments in vulnerable areas and study feasible alternatives that can be put in place in both the short term and longer term to ensure road access.
    b. Identify those segments or components of the public water and sewer infrastructure systems in vulnerable areas and determine the range of feasible alternatives that can be implemented in both the short term and longer term to ensure adequate service.
    c. Assess whether revisions are needed to current design standards for public infrastructure capital projects to reduce future operation and maintenance problems in areas vulnerable to sea level rise impacts.
    d. Establish policy directives and develop the criteria that will be used if needed to determine when, where, and under what circumstances public infrastructure in vulnerable areas would be abandoned.
5. **Protect significant cultural resources from loss or damage due to sea level rise impacts. Develop a schedule to complete investigations of all priority sites that have had little or no previous investigation.**

a. Require Phase III level mitigation (excavation) of archaeological sites by contractors, overseen by county staff, when permit or development actions not governed by existing code provisions occur on private or public land located on the prioritized list of vulnerable sites.
b. Triggering events for cultural resources review to assess and conduct mitigation should be expanded beyond the current requirements for site development plans.
c. Protect historic sites and buildings in place using shoreline stabilization measures.
d. Develop guidelines and requirements for the potential displacement of vulnerable historic resources when shoreline stabilization is not a feasible strategy for permanent protection.
e. Develop a community stewardship program to create a partnership between private property owners of culturally significant properties and the County for the purpose of monitoring periodic and ongoing occurrences of flooding, inundation and erosion of these properties and ensuring action is taken before significant resources are lost.
f. Determine the eligibility of historic properties to use historic preservation tax credit programs to offset costs of elevation or flood-proofing retrofits where those adaptation strategies are appropriate.

6. **Ensure safe and adequate water supply and wastewater management for communities vulnerable to sea level rise impacts.**
    a. Assess whether revisions are needed to current State and local construction or design regulations and standards for private wells and/or private on-site septic systems in vulnerable or flood-prone areas.
    b. Evaluate alternative wastewater treatment solutions for properties on septic systems in areas vulnerable to sea level rise.
    c. Evaluate the feasibility of new community well systems or connection to the public water system as alternatives for areas that are or may become vulnerable to private well contamination.
7. **Ensure that citizens in the County are educated and informed about sea level rise and have access to current information and resources.**
    a. Develop a network of community representatives for those communities located in vulnerable areas.
    b. Provide education and outreach opportunities for business interests, including the maritime industry.
    c. Develop and maintain a web site within the County internet system dedicated to sea level rise planning and related resources useful to the public.
    d. Work with the local community network to assist vulnerable communities in developing action plans and improving emergency preparedness at the community level. Promote awareness and preparedness for the longer term or more permanent impacts of sea level rise.

The **key conclusions** of the analysis which will help to guide the strategic planning process are summarized below.

- ✓ In terms of land cover, some of the most significant impacts of a rise in sea level will be a loss of wooded areas and open wetlands which are valuable components of the coastal ecosystem.
- ✓ A majority of the developed land in vulnerable areas is used for residential purposes, with primarily single family detached homes. Some homes may require elevation or relocation.
- ✓ With a sea level rise of less than two feet, impacts to principal structures may be relatively small. If a rise in sea level between two and five feet should occur, impacts may be much more significant with as many as 2,400 structures that could be damaged or require relocation.
- ✓ Structures at risk are located in most coastal communities, but the majority is located on the Deale/Shady Side peninsula.
- ✓ Local roads in many coastal communities may be impacted, particularly on the Lake Shore, Annapolis Neck, Mayo, and Deale peninsulas. However, the total amount of road miles is not large. Impacts would occur at a neighborhood level but could render some properties inaccessible.
- ✓ Impacts to public utility infrastructure are difficult to assess. Even if the surface land area is not permanently inundated, the higher water table associated with a rise in sea level may cause underground infrastructure including water supply and sewer lines and storm drains to malfunction or collapse. In terms of the quantity of public utility infrastructure, the amount that may be at risk is not large. But it is located in a more scattered pattern amongst almost all coastal communities, making planning for retrofits or alternatives more complex.
- ✓ Sewer pump stations in four of the County's public sewer service areas (Broadneck, Annapolis, Mayo-Glebe Heights, and Broadwater) are located in potential inundation areas under a sea level rise of between two feet and five feet.
- ✓ Several thousand properties that rely on individual water supply wells and onsite septic systems could be impacted by rising sea level causing septic systems to fail and wells to become contaminated by saltwater intrusion. In many cases, these properties are not within a feasible distance for connection to a public utility system and may not be concentrated enough in density to allow installation of community well or septic systems as a viable alternative. This makes mitigation planning for such situations even more difficult.
- ✓ The marina industry will likely be the most impacted segment of the local economy since virtually every marina business could be impacted by a rise in sea level.
- ✓ As many as 46 County parks could be at least partially inundated in the future. Park development plans will need to take into consideration these potentially vulnerable areas.
- ✓ Over 400 archaeological sites may be susceptible to loss or damage due to sea level rise, as well as 80 historic properties. This is of particular concern to the County given the extremely high value of some of the archaeological finds discovered to date in the County. Strategic planning to prevent loss of these irreplaceable resources is a priority.

- ✓ Shoreline erosion has generally been slight along most of the County's coast, although many shoreline miles have experienced some degree of erosion. Very small areas of shoreline have experienced moderate to high rates of erosion. Significant areas of shoreline have protection mechanisms in place, but identification of additional areas in need of future protection is needed.

Climate Resilience Action Strategy

University of Maryland launched the Local Resilience Financing Initiative (LRFI) works in partnership with local leaders to develop, implement, and finance robust resilience plans, with a specific focus on linking natural resource restoration and protection to community infrastructure and economic development.

The goal of the strategy is to accelerate resilience planning and financing in three Chesapeake Bay communities: Anne Arundel, Charles, and Queen Anne's counties. The approach identifies and leverages the linkages between water quality restoration and protection and climate change resilience. In addition, our strategy was to create linkages between public financings of resilience and water quality restoration with market-based investments by:

- ✓ Developing and implementing actionable, scalable, and innovative resilience and natural infrastructure planning and financing strategies.
- ✓ Incentivizing the implementation of new and innovative technologies and policies; and,
- ✓ Incentivizing efficiency, thereby ensuring that every dollar invested achieves the maximum level of water quality restoration and resilience possible.

This approach will enable communities to focus on identifying the co-benefits and connections between water quality restoration and protection and local resilience. Creating a robust and actionable resilience plan and implementation strategies creates a unique opportunity to expand investments in water quality and water resource management.

The County's resilience Imitative is being implemented in three core phases, each designed to bring our partner communities closer to long-term resilience through action and aggressive implementation and financing. The first of the three phases resulted in the creation of Climate Resilience Action Strategies. Phases 2 and 3 will result in the development and implementation of comprehensive financing systems and processes.

Implementation Plan for Achieving Energy Efficiency and Conservation

In total, the Office of Central Services, Department of Public Works and the Department of Recreation and Parks used 118,239 MWh of electricity in the 2013 baseline year to operate buildings, public works facilities, recreational areas and other facilities. As the square footage of County buildings is projected to increase to 2.903 million square feet and water production and treatment is expected to increase 2.9 percent annually.

As part of an economic plan to limit demand for energy consumption and reduce the operating cost of County government, the County has established a goal of reducing electricity consumption by 15 percent over the next five years (2013). This will require the County to reduce its annual electricity consumption by 17,736 MWh annually, to 112,427 MWh in five years. The County is also committed to exploring opportunities for utilizing renewable energy technologies to supplement its energy use. One major advantage with the use of renewable energy is that it is sustainable, as it is derived from natural and available resources.

The Implementation Plan for Achieving Energy Efficiency and Conservation is arranged in three sections. The first section provides details on existing energy usage that develops a baseline inventory. The baseline for electricity usage for Anne Arundel County buildings, facilities, water and sewer service and waste management was established for the time period from July 1, 2012 through June 30, 2013. Consumption for the Baseline Year In order to determine the County's electricity usage baseline, data tracking information from three separate County agencies was combined to set the baseline.

The second section presents a electricity reduction plan that meet the goal of reducing electricity consumption by 15 % over five years. The County planned to achieve this goal by incorporating energy saving actions into its building operation practices and facility maintenance plans. These practices include retrofitting existing building with state of-the-art energy management systems and implementing the utility company's peak demand program. The County will also achieve this goal by implementing innovative and responsible environmental practices into its substantial rehabilitation projects and all of its new construction projects. In addition, the County has implemented an energy-efficient product procurement policy.

The third section explores the application of renewable energy sources that are presented in a Renewable Energy Action Plan. The provides a structure for the County to develop, utilize and generate renewable energy resources as viable energy alternatives to supplement its increasing energy needs. While there are numerous renewable energy alternatives currently being developed that will continue to be explored , the County is committed to developing opportunities to take advantage of existing technologies for the installation of solar photovoltaic (PV), solar hot water, and geothermal systems for its owned or leased properties.

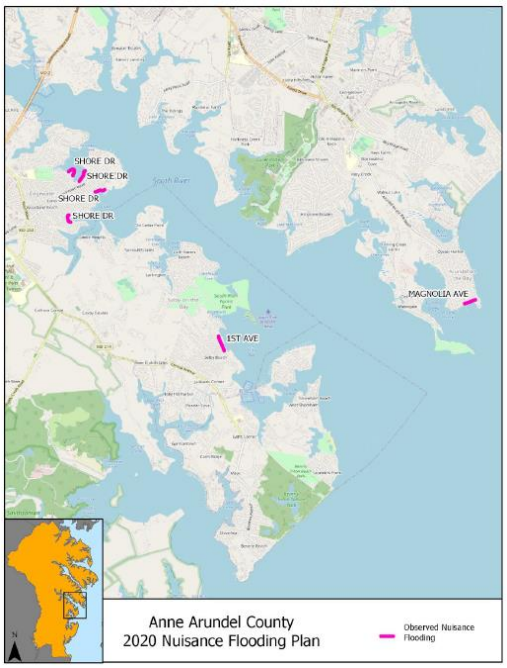
Nuisance Flood Plan

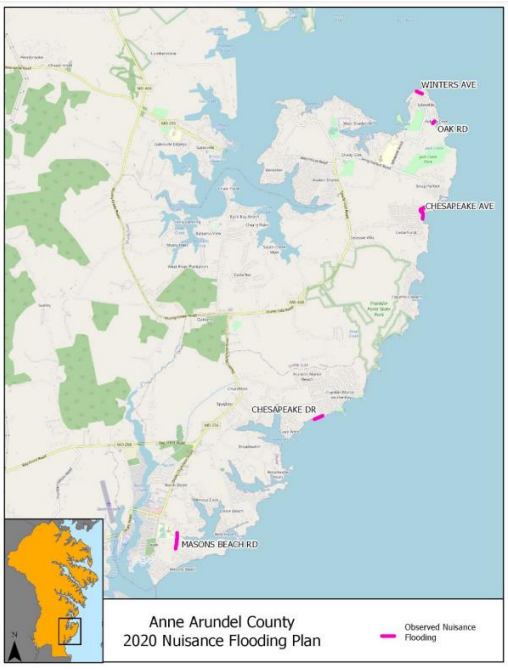
When significant nuisance flooding is expected; it is the responsibility of the Anne Arundel County OEM to disseminate information to key stakeholders to prepare for nuisance flooding impacts and respond accordingly. In extreme cases where nuisance flooding reaches such a severity that life safety, critical infrastructure, and key resources are threatened, Anne Arundel County OEM may disseminate public safety information via the Alert Anne Arundel Mass Notification System and through additional methods

As part of the nuisance flood planning process for Anne Arundel County, a thorough inventory of known flood hazard areas was created. One hundred and fifty-four (154) flood prone roads have been modeled and fifteen (15) flood prone roads have been observed through a collaborative effort by the OEM, DPW, GIS, County Fire and County Police. These areas impacted by nuisance flooding will increase gradually in the coming years as changing climatological patterns elevates water levels to new extremes; likely to accelerate gradually over time. New areas will also become impacted, leading to an increased number of businesses, residents, and critical infrastructure at risk. Public services will also be more frequently impaired as flooding increases.

Nuisance Flood Response Thresholds

Thresholds are maintained for Anne Arundel County which direct a set of actions based on a particular inundation level or frequency of flooding. These thresholds are meant to supplement actions directed by the Anne Arundel County Emergency Operations Plan.





In addition to actions specified in the HMP, the NFP includes activities which Anne Arundel County will implement or consider implementing to mitigate the impacts of nuisance flooding. These activities support the four areas of focus found in the Hazard Mitigation Plan. They also support recommendations and actions from Anne Arundel County's National Flood Insurance Program (NFIP) Flood Risk query provided by the Federal Emergency Management Agency (FEMA) and goals and strategies of the Anne Arundel County Emergency Operations Plan.

Structural

- Enact floodplain ordinance or codes which mandate the use of freeboard beyond current requirements.
- Improve stormwater management infrastructure to more effectively convey water from flood-prone areas.
- Conduct regular maintenance of drainage and stormwater control systems.
- Consider green infrastructure options rather than conventional stormwater solutions.

Nonstructural

Public Information

- Communicate the risk of nuisance flooding in non-emergency times to residents and businesses via mass mailings, social media, press releases, or automated phone calls.
- Disseminate flood preparedness information to enable a safer and more aware public in the face of flooding.
- Integrate nuisance flooding-related public messaging in Anne Arundel County's existing public information plan and materials.

Planning

- Ensure Anne Arundel County's NFP is kept up to date and referenced in the Hazard Mitigation Plan and other pertinent locations.
- Schedule meetings of the nuisance flooding planning committee on an as-needed basis to address flood-related issues and review plans. The planning committee consists of subject matter experts who collectively designed the NFP. Reference Appendix IV – Nuisance Flooding Committee Members .
- Improve stormwater management planning and strengthen policies to reduce runoff.

Implementation

- Educate and train County staff on responsibilities under the NFP.
- Preserve floodplains as open spaces through the use of legal protection status.
- Protect and restore natural coastal features (forests, marshes, dunes, underwater grasses, and oysters) that can reduce the impacts of flooding.

Emergency Operations Plan

Coastal impacts will often result from a combination of more extreme weather events and storm surge with sea-level rise, but additional factors like erosion, subsidence, and wave action also come into play to threaten critical infrastructure. Emergency managers are faced with increased vulnerabilities due to climate risks to roads, airports, water treatment

plants, energy facilities, and hospitals related to sea-level rise and associated erosion and flooding. These vulnerabilities are detailed in greater length in many other county plans, and whereas the emergency Operation Plan examines the impacts as they relate to its mission of protecting the county's people, economy, and environment in the event of emergencies. Climate change is characterized as a condition that will change and potentially exacerbate the impact of other hazards, rather than a distinct hazard with unique impacts. These impacts will all affect the County's emergency management efforts. Increasing hazards resulting from climate change will necessitate a more robust emergency management and response community. An increase in emergency events, and an increase in magnitude of those events, is expected to overwhelm local, county, and regional resources more quickly, and necessitate the use of more resources. Continued coordination and collaboration between all levels of government, and private sector are imperative to ensure continued success and risk sharing among the emergency management community and the public.

The purpose of the EOP is to implement a comprehensive emergency management program for the County that seeks to prevent acts of terrorism, mitigate the effects of a hazard, to respond during emergencies, to take action to protect life and minimize damage and to establish a recovery system to return to pre disaster state. The EOP establishes a framework and guidance for the management coordination of actions to be taken to prepare for and respond to emergencies and disasters.

The EOP describes how the County will respond to emergencies within the County. Mitigation strategies are essential in easing the burden and recovering from the effects of a disaster. Developed strategies to include in plan.

Move Anne Arundel! County Transportation Plan

The County Transportation Plan describes the existing transportation system in the County, describes future challenges and demands on the transportation system including financial constraints on improving the system, and identifies the recommended policies and priority projects that make up Move Anne Arundel.

Goal: A transportation system that is resilient and protects the environment

Building resiliency into transportation planning and asset management is an iterative process that requires several steps, including identifying options, risks, and costs, and involving stakeholders and civic groups in the transportation planning process. Success depends on identifying determinate benefits, measuring effectiveness of outcomes, and modifying approaches when less-than-optimal results warrant. It will also require attention to factors beyond the control of Anne Arundel County, such as resiliency planning for state infrastructure and cost and budgeting constraints in implementing new plans and policies.

As a first step in resiliency planning, the County should identify at-risk roads, bridges and other infrastructure that are or will be vulnerable to flooding in the future and ensure that there are plans for appropriate maintenance and post-event recovery. Emergency evacuation plans and other contingency plans should also be developed for natural disasters such as

hurricanes and locusts. The County should review its design standards to ensure that adequate measures for bridge and pavement protection are in place as new infrastructure is constructed or existing infrastructure is rehabilitated.

Objectives:

- ✓ Improve air quality
- ✓ Improve water quality
- ✓ Identify assets vulnerable to the effects of climate change

The adoption of Move Anne Arundel! will set the framework to advance the vision and goals but it is the investments made in the transportation system that will drive achievement of performance measures.

Green Infrastructure Master Plan

The Green Infrastructure Master Plan is a guide to conserving an interconnected network of the most significant remaining natural lands in Anne Arundel County through voluntary actions. The lands identified in the Green Infrastructure Network (Network) help protect water quality and air quality, provide habitat for plants and wildlife, create opportunities for recreation, and support mitigation of, and adaptation to, climate change. The Green Infrastructure Network supports the land use policies of the County's General Development Plan (GDP) by prioritizing areas for natural resource conservation, providing open space, and maintaining rural character.

This Plan establishes a **goal t**o conserve an additional 5,000 acres of land in the Network by 2030 (using 2020 as a baseline), representing 30% of the County land area. In comparison, approximately 5,075 acres of land in the Network were conserved through public acquisition and voluntary conservation easements from 2010-2020.

Climate Change Considerations

The impacts of climate change are becoming more apparent in Anne Arundel County. In particular, we experience:

- Tidal flooding caused by sea level rise
- Coastal flooding exacerbated by sea level rise and subsidence
- Increased extreme precipitation events

- Increased flooding as a result of more frequent and intense storms
- Longer heat waves, including more days above 90 degrees throughout the year

The Green Infrastructure Master Plan takes these issues into consideration by including forests, floodplains, and coastal areas that meet criteria for inclusion in the Network.

Green Infrastructure plays an important role in mitigating and adapting to the effects of climate change. Forests and wetlands capture and store carbon, acting as a sink for greenhouse gases. Shading from tree canopy reduces heat at a local

scale. This is especially important in more developed areas of the County where high amounts of concrete and asphalt reflect heat from the sun. Floodplains, wetlands, and low-lying natural areas also provide storage of stormwater runoff and floodwater, reducing impacts to developed areas. Protection of natural shorelines also can reduce risk of inundation from sea level rise.

A broader set of policies to address climate change are included in Plan2040 to reduce greenhouse gas emissions, promote green building design, transition to electric vehicles, and invest in resilient infrastructure.

Chesapeake Bay TMDL Phase II Watershed Implementation Plan

Anne Arundel County's Phase II Watershed Implementation Plan (WIP) identifies programs, policies and practices and establishes a commitment to implementation that ensures achievement of the nitrogen, phosphorus, and sediment load reductions assigned to the County by the Maryland Department of the Environment (MDE) in compliance with the Chesapeake Bay TMDL. The County's Phase II WIP sets forth a strategy for implementation that identifies statutory authority, capital projects, funding mechanisms and timelines for achieving its allocated loads using Total Nitrogen as the keystone nutrient.

In 2010, the Environmental Protection Agency (EPA) established the Chesapeake Bay Total Maximum Daily Load (Bay TMDL) to advance the restoration of the Chesapeake Bay. The Bay TMDL sets limits on the amount of nitrogen, phosphorus and sediment that can enter the Bay, while still meeting water quality standards for committing the State of Maryland to have all pollutant control practices in place by 2025 to meet reduction goals. To determine how they will meet their pollutant reduction goals, jurisdictions develop Watershed Implementation Plans (WIPs). The first and second phases of the WIPs were developed in 2010 and 2012, respectively. In April 2019, the State completed their draft Phase III WIPs, which provide information on the actions and commitments they plan to implement between 2019 and 2025 to meet their local and Bay restoration goals. For the first time, states were expected to include a written strategy in their Phase III WIPs, detailing how they currently, and will account for a changing climate while putting plans in place to reduce pollutant loads.

Under the *Chesapeake Bay Watershed Agreement*, Bay Program partners committed to continually monitor and assessing trends and likely impacts of changing climatic and sea-level conditions changes will play a role in how the state can estimate what the climate will look like in 2025 and build these considerations into their Phase III WIPs. Any additional pollutant loads that would arise from climate change are added to the loads the jurisdictions have already committed to reducing.

Under the Bay TMDL, the stat submits milestones to the EPA every two years so that they may check on their progress to reduce pollutants. While the Phase III WIPs include a written strategy for addressing climate impacts, each the must begin accounting for climate impacts in their 2022-23 milestones.

Stormwater Management Practices and Procedures Manual

The Environment Article, Title 4, Subtitle 2 requires the Maryland Department of the Environment (MDE) to implement a statewide stormwater management program to control new development runoff. MDE is obligated to perform many duties to meet this mandate. The most significant of these is adopting regulations that establish criteria and procedures for stormwater management throughout Maryland

The purpose of this manual is to provide developers, consultants and County staff with guidance regarding the procedures, processes, policies, and regulations that apply to stormwater management for proposed developments within Anne Arundel County. The manual addresses criteria specific to Anne Arundel County that are not addressed within the Maryland Stormwater Design Manual

- 100 Year Flood Delineation
- FEMA Base Flood Elevation and previous platted Base Flood Elevation
- Floodplain Study – Simplified / Detailed Studies
- For both Stormwater Management Regulations

To ensure that stormwater facilities continue to function, a stormwater design will need to include a determination of a future wet-season water table. The future wet-season water table will be assumed to be increased by the difference in sea level in the year that the wet-season water table determination was made and the projected sea level 30 to 50 years after permitting. The estimated sea level rise projections adopted by the County would be used for this determination. A newer approach to stormwater management is called Low Impact Development or Design (LID). This approach seeks to replicate a more natural hydrologic function on the landscape and uses a combination of stormwater management practices to meet stormwater management objective. Some of these practices include pervious pavement, vegetated swales, vegetated filter strips, bioretention systems, cisterns, and green roofs.

Stormwater Management Ordinance

The purpose of stormwater management in Anne Arundel County is to protect and promote the public health, safety, and general welfare through the management of stormwater, to protect public and private property from damage, to reduce the effects of land use changes on stream channel erosion, to assist in the maintenance and attainment of water quality improvement, to preserve and enhance the environmental quality of streams and stream valleys, to minimize adverse impacts on water quality and conserve plant, fish, and wildlife habitat, to reduce flooding, to maintain as near as possible predevelopment runoff characteristics, and to establish the minimum requirements and procedures to control the adverse impacts associated with increased stormwater runoff.

The primary goal of the Anne Arundel County Stormwater Management Program is to maintain after development, as nearly as possible, the pre-development runoff characteristics and to reduce stream channel erosion, pollution, siltation

and sedimentation, and local flooding which would otherwise have adverse impacts on the water and land resources of this County and State.

Floodplain, Erosion, Sediment Control, and Stormwater Ordinance

Manufactured homes and the placement of fill are prohibited in coastal high hazard areas. New construction of or a substantial improvement to a structure in a coastal high hazard area is prohibited unless the construction or improvement is in accordance with the Federal Emergency Management Agency's Coastal Construction Manual (FEMA 55), Manufactured Home Installation in Flood Hazard Areas (FEMA 85), Flood Resistant Design and Construction (ASCE 24-05) and NFIP Technical Bulletin 5 and 9.

A modification to the provisions contained in § 16-2-202(f) and (g) relating to development in coastal high hazard areas and floodways is prohibited. A modification to the requirement that the lowest floor of a new or substantially improved residential structure be elevated to the flood protection elevation is prohibited.

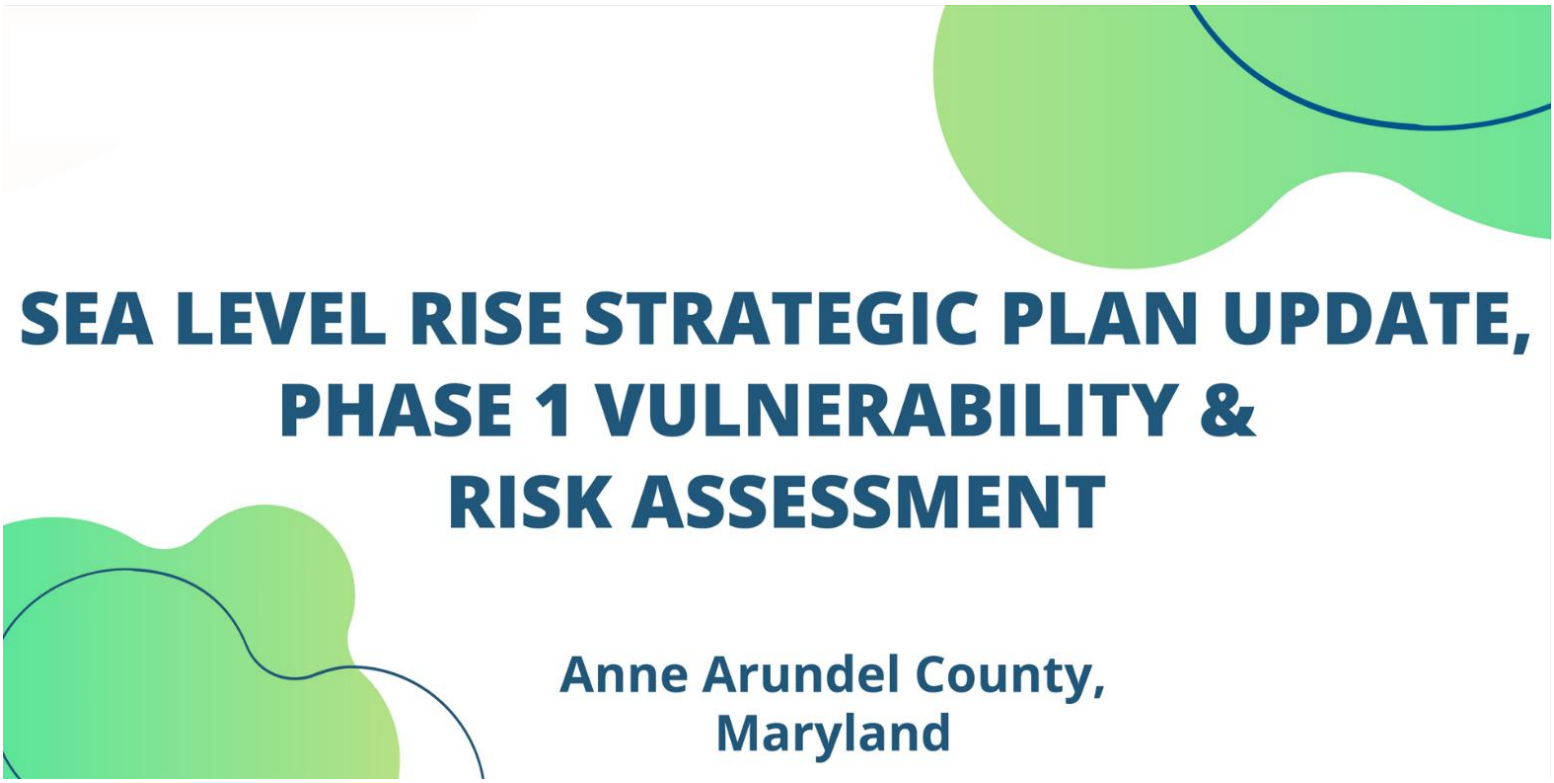
Even with wide-spread public dissemination of predictions of a more-than-likely significant rise in the rate of relative sea level, and potentially more intense and perhaps increased frequency of major coastal storms, coastal floodplains continue to attract extensive development. By 2015, the population of coastal counties is predicted to increase by an additional 12 million people. FEMA's Assistant Administrator for Mitigation and Insurance stated, in part, 'communities must proactively take steps to reduce risks based on their own knowledge of local risks. It is the local implementation of risk reduction programs that make the difference'. 'Through the implementation of local floodplain ordinances alone, it is estimated that $1.1 billion in flood damages are prevented annually'.

Watershed Protection and Restoration Program (WPRP)

In 2002, the Anne Arundel County Watershed Protection and Restoration Program (WPRP) conducted systematic and comprehensive assessments of the County's watersheds. These assessments are conducted to assess current water quality conditions and prioritize the County's streams and sub watersheds for restoration and preservation to improve the conditions of the County's watersheds. The studies partially fulfill the watershed assessment and restoration requirements of the County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer (MS4) permit. Conditions of this permit, administered by the Maryland Department of the Environment, are required to be met by the County.

Assessment of County watersheds were initiated in 2016 to complete the comprehensive assessments of the County's twelve major watersheds. The assessment included field investigations and characterization of the stream and watershed conditions. This full-scale assessment was designed to catalog infrastructure, assess stream habitat for fish and aquatic insects, characterize stream channel stability and stream bank erosion, and assess water quality conditions of watershed streams.

Data were used to prioritize the watershed's individual stream reaches and sub watersheds for restoration and preservation measures to ultimately improve the conditions of the watershed. In addition to the stream assessments, indicators of watershed condition related to land use, stormwater best management practices (BMPs), and pollutant loading models were compiled in prioritization models that rank and prioritize the watersheds at the stream reach and sub watershed scales for restoration and preservation priorities.



ATTACHMENT B. GIS Data Catalogue

SLR_BathtubModel

Folders contain both shapefiles and rasters of countywide inundation depths and extents for the 2050, 2065 and 2100 SLR scenarios.

AnneArundelCounty_Vulnerability_Analysis.gbd

Geodatabase containing shapefiles resulting from the vulnerability assessment for the 2050, 2065 and 2100 SLR scenarios across all of Anne Arundel County.

Layers included for each SLR scenario are as follows:

- Buildings_inundated
- CountyMaintainedRoads
- Flooded_bridges
- Flooded_HistoricRoads
- HistoricResourceInventory
- Inundated_Septic
- Inundated_Wells
- Landcover_inundated
- MajorRoads
- Sewer_Main
- StormPipe
- WaterMain

HazusDatabase.gbd

Geodatabase containing shapefiles resulting from Hazus analysis conducted within Region 9.

Layers included are as follows:

- OceanBayOverlay
- Reg9_AtRiskStructures
- Reg9_AtRiskStructures_LossEstimates
- Reg9_DebrisGeneration
- Reg9_ShelterNeeds
- Reg9_UDF_BuildingFootprints
- Region9_Boundary

Region9_ShorelineErosion_Analysis.gdb

Geodatabase containing shapefiles resulting from shoreline erosion analysis conducted within Region 9.

Layers included are as follows:

- Erosion_Rates
- Suitable_for_Living_Shoreline

Region9_Vulnerability_Analysis.gdb

Geodatabase containing shapefiles resulting from the vulnerability assessment for the 2050, 2065 and 2100 SLR scenarios within Region 9. Vulnerability to each SLR scenario is distinguished with the layer attributes by a field provided for each scenario and "Vulnerable" included when impacted by the corresponding scenario.

Layers included for each SLR scenario are as follows:

- Bridges_Region9
- Critical Areas_Region9
- FEMA_2015FloodPlain_Reg9
- HistoricResource_Region9
- LandCover_Reg9
- Parks_Reg9 -
- Properties_with_Wells
- Region9_CriticalFacilities
- Region9_SepticSystems
- Region9_SewerMain
- Region9_SewerManhole
- Region9_SewerPumpStations
- Region9_SewerTreatmentPlant
- Region9_StormInlet
- Region9_StormManhole
- Region9_StormOutfall
- Region9_StormPipe
- Region9_WaterMains
- Region9_WaterTreatmentPlant
- Roads_Streets_Region9
- Region9_Scenic_and_Historic_Roads