Sea Level Rise Strategic Plan Anne Arundel County

Phase 1 Report: Vulnerability Assessment

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ANNE ARUNDEL COUNTY
MARYLAND

Prepared for

Maryland Chesapeake & Coastal Program Coastal Communities Project

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Phase 1 Report, Part 1: Vulnerability Assessment

Section 1 – Study Objective

Located on the western shore of the Chesapeake Bay, Anne Arundel County is almost completely surrounded by tidal and non-tidal waterways and has over 530 miles of shoreline. The County is therefore susceptible to the effects of climate change and sea level rise and has a need to better understand the scientific findings to date and their implications for the County. The County's General Development Plan, adopted in 2009, includes recommendations to develop a strategic plan for a phased implementation response to avoid or reduce sea level rise impacts to property, infrastructure, and other resources, and to establish policies to guide the relocation, extension or expansion of public infrastructure in at-risk areas.

To this end, the County has partnered with the Maryland Department of Natural Resources (DNR) through the Coastal Communities Initiative Program to conduct a study of potential sea level rise impacts and develop adaptation strategies. The project consists of four major components and will be conducted over a two-year period. The four components include: 1) a vulnerability assessment to identify potential areas impacted by sea level rise and develop inventories of resources at risk; 2) development of a framework for interagency strategic planning; 3) development of a strategic plan that establishes policies and specific steps to protect resources and minimize impacts; and 4) public outreach and education to promote public awareness of sea level rise issues.

This Phase I Report presents the results of the first major project component, the Vulnerability Assessment. The report includes an overview of relevant studies, a description of the methods used for this assessment, an inventory and assessment of vulnerable resources identified, a discussion of shoreline erosion and its potential impacts, and the conclusions that will help guide the strategic planning process to follow.

Section 2 – Maryland Climate Action Plan and Related Studies

The Maryland Climate Action Plan provides a framework for understanding the anticipated global and regional impact of climate changes. The Climate Action Plan was published by the Maryland Commission on Climate Change (MCCC), a group designated by Governor O'Malley in 2007. The MCCC was composed of representatives of all major stakeholder groups affected by the potential impacts of and responses to climate change. A brief overview of the Climate Action Plan provides an abbreviated background of its application at the local level as used in the Sea Level Rise Vulnerability Assessment.

Governor O'Malley and the General Assembly intended the Climate Action Plan to "…address the causes of climate change, prepare for the likely consequences and impacts of climate change to Maryland, and establish firm benchmarks and timetables for implementing the Commission's

recommendations." The Scientific and Technical Working Group (STWG) of the MCCC was tasked with completing an assessment of historical and projected climate changes across Maryland, and identifying the likely impacts to water resources and aquatic environments, farms and forests, coastal vulnerability, the Chesapeake Bay and coastal ecosystems, and human health. Additionally, the STWG developed a mitigation and adaptation strategy to climate change as a resource for stakeholders planning for such occurrences in their communities[1].

The Climate Action Plan is based on models used by the Intergovernmental Panel on Climate Change (IPCC) in its 2007 Fourth Assessment Report and incorporates an extensive literature review. The STWG selected seventeen specific models from the IPCC Assessment based on how each one replicated both global conditions and observation in Maryland. The model results were averaged in order to provide the most likely projections for sea level rise. Projections were presented using both 'lower' and 'higher' greenhouse gas emissions scenarios. The lower scenario reflects a peak in emissions at mid-century, then a trailing level of emissions through the end of the century while the higher scenario projects impacts given the current rate of emissions of greenhouse gases through the end of the century. In terms of sea level rise, the projections indicate a low emissions scenario of up to 2.7 feet of sea level rise and a high emissions scenario of up to 3.4 feet through 2100 for Maryland. This takes land subsidence rates into consideration which are projected to remain steady from the previous century at about 6 inches over the course of 100 years. An important caveat exists for the projections; the estimates "… should not be considered as model forecasts, but as reasonable bases for assessment and planning that take into account the admitted high-end uncertainties in estimating future sea levels."

The MCCC Climate Action Plan has served as an outline for further refinement by local jurisdictions. Three Maryland counties (Worcester, Somerset, and Dorchester counties) have used the Climate Action Plan to help complete their own sea level rise planning strategies. While all three counties used a simple bathtub model to assess sea level rise impacts, each of these localized sea level rise plans differ in terms of modeling approach, planning horizon, and responses in accordance with their specific planning needs. Each county found different degrees of impact but all acknowledge the need to address changing climatic conditions in their planning efforts now in order to mitigate anticipated changes in their local environment.

Maryland in particular experiences great variations in climate across the state and therefore changes from sea level rise and other climatic factors will have varying impacts depending on location. Projections at the state level for climate change, impacts, and response options provide general guidance for local jurisdictions. Thus the Sea Level Rise Strategic Plan Vulnerability Assessment incorporates the state's guidance but uses localized data analysis and evaluation of local conditions to assess the potential impact of climate changes and mitigation strategies for Anne Arundel County.

Section 3 – Study Methodology

3-1. Sea Level Rise Projections

The sea level rise projections used for this assessment are based in part upon research compiled by the Scientific and Technical Working Group (STWG) and Adaptation and Response Working Group (ARWG) of the MCCC. The MCCC, through these working groups, have stated that coastal lands

1 Maryland Commission on Climate Change, 2008. Comprehensive Assessment of Climate Change Impacts in Maryland, Scientific and Technical Working Group

situated along the Chesapeake Bay experience a greater degree of annual sea level rise relative to other areas around the globe due to its coastal geomorphology. Specifically, areas such as Anne Arundel County which lay along the eastern continental shelf continue to subside as a result of post glacial readjustment. In turn, the land slowly sinks (subsidence) relative to sea level. Once land readjustment is accounted for, the STWG factored climate change predictions from the Intergovernmental Panel on Climate Change (IPCC) and estimated between 2.7 and 3.4 feet of relative sea level rise by the end of 2100[2]. The IPCC projections utilized by the STWG and reported by the ARWG assume external variables including greenhouse gas emissions (lower v. higher) as well as accelerated melting of polar ice.

In light of the projections used in their report, and given the inherent uncertainty regarding how the external variables impact the IPCC sea level rise projections, the STWG recommended that adaptation measures intent on reducing coastal vulnerability should plan for at least a 1 foot rise in sea level by the end of 2050, and a 2 foot rise in sea level by the end of 2100. Further, the STWG also qualifies that planning for up to 4 feet in sea level rise may be warranted depending upon how reliable the IPCC projections are throughout the planning horizon. Planning for a rise in sea level up to 1 foot makes practical sense since historical records show relative sea level rise occurring at a rate of 1 foot per 100 years[3]. Thus, sea level has been shown to rise independently of direct external influences. However, given the extensive background research previously cited, it is reasonable to assume that externalities such as greenhouse gas emissions and melting polar ice will influence the IPCC projections. Therefore, incorporating up to 2 feet in sea level rise is justified in the vulnerability assessment. Furthermore, incorporating the upper end of the STWG sea level rise projections (i.e. 3.4 feet) was prudent given the planning level nature of the vulnerability assessment.

Taking into account the ranges in sea level rise mentioned previously, the methodology for the vulnerability assessment utilized a rise in sea level broken into two scenarios. The first scenario assumed a rise in sea level between 0 and 2 feet, with the second scenario assuming a rise in sea level between 2 and 5 feet. It is important to note that planning for up to 5 feet in sea level rise was based upon the available topographic / elevation data acquired from the Maryland Department of Natural Resources (DNR). It is also important to note that, for reporting purposes, the methodology used a cumulative approach to a 5 foot rise in sea level. This was done by incorporating a presumption that all resources impacted under the 0-2' scenario would also be impacted in the 2-5' scenario. Thus, for reporting purposes, the second planning scenario was treated as a rise between 0 and 5 feet.

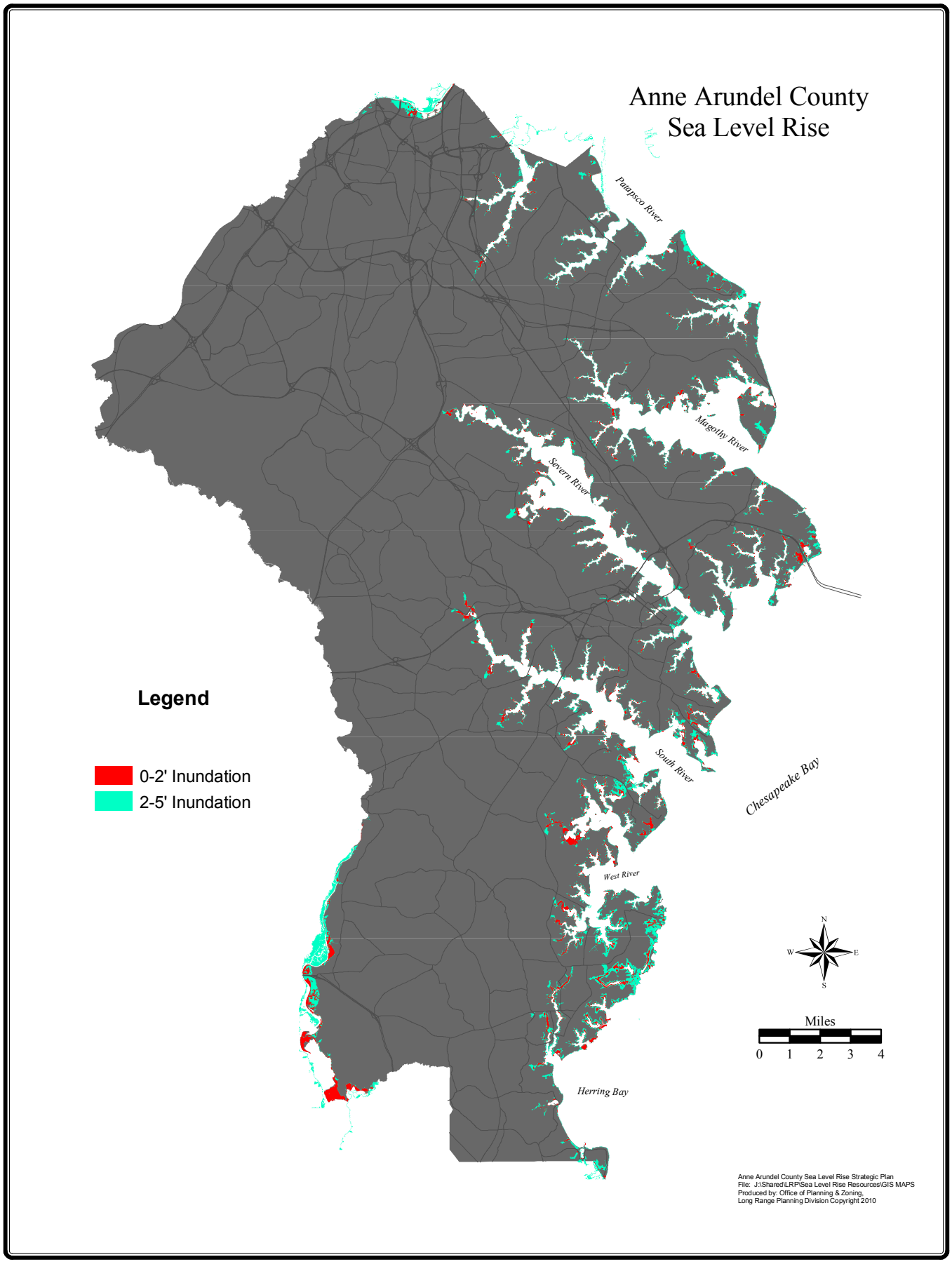
3-2. Data Acquisition

A Countywide model of sea level rise was provided by the Maryland Department of Natural Resources (DNR). The model was derived from high-resolution topographic data generated using a Light Detection And Ranging (LiDAR) remote sensing technology. LiDAR based topographic data was acquired by the State of Maryland in cooperation with local and federal agencies to identify areas vulnerable to sea level rise inundation. Digital representations of the earth's surface are also referred to as Digital Elevation Models (DEM). The data was provided to the County in a Geographic Information Systems

2 Maryland Commission on Climate Change; 2008. Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Adaptation and Response Working Group

3 Leatherman, S.P., and C.R. Volonte. 1992. Future Sea Level Rise Impacts: Maryland's Atlantic Coastal Bays. Maryland Department of Natural Resources, Annapolis, Maryland.

Figure 1. Anne Arundel County Sea Level Rise



(GIS) format. The dataset represents inundation areas in the event of a two foot and a five foot rise in sea level.

The sea level rise model incorporates both the LiDAR based DEM as well as the State of Maryland's official 'recent shorelines' data. The recent shoreline is used as the base elevation upon which the LiDAR elevation data is then derived. Processing the sea level rise model was done by the Towson University Center for Geographic Information Systems (CGIS). CGIS, at the direction of DNR, decided upon how the model would be classified in terms of the elevation breaks. Data classification breaks (i.e. 0-2' and 2-5') determined by DNR provide generally accepted sea level rise inundation levels that correspond well to the background research and detailed assessments by the MCCC. Noteworthy here is that CGIS completed a third sea level rise dataset, a five foot to ten foot rise in sea level model (5-10'). However, based upon previous discussion, planning for a rise in sea level beyond 5 feet will be determined by evaluation of how the IPCC sea level rise projections behave over the course of the planning time horizon.

The inundation data layers as well as the data sets of County resources to be assessed for vulnerability were brought into a Geographic Information System (GIS) for analysis. The project team identified the types of resources to be included in the assessment. These include land area, principal structures, transportation infrastructure such as roads and bridges, wells, septic systems, utility infrastructure such as water and sewer lines and storm drains, critical facilities, marinas, parks, archaeological sites, historic properties, and cemeteries. Data for the resources identified are readily available in a GIS format, as they are each used by various County agencies in their daily planning activities. While efforts are made to ensure that each resource is as current as possible, there are temporal differences between the data sets.

3-3. Data Idiosyncrasies & Caveats

There are some idiosyncrasies associated with the data used for the assessment. First, the inundation layers provided by DNR had instances of data overlap. Reasons for this overlap deal with the technical nature of how the LIDAR based DEM were generated. Even though only a few resources were discrete enough to be impacted by this data nuance (i.e. principal structures), it was imperative that the selection methodology eliminate duplication in order to tabulate results using the 0-2' and 0-5' planning scenarios.

In order to eliminate duplication, resources that were completely within the 0-2' inundation layer, but that also crossed the outline of both the 0-2' and 2-5' inundation layers, were counted as part of the 0-2' planning scenario. Resources that were totally within the 2-5' inundation layer were added to the 0-2' planning scenario count to generate the results of the 0-5' planning scenario. This allowed for cumulative reporting since the vulnerability assessment assumes that resources impacted by a 0-2' sea level rise would also be impacted by a 2-5' sea level rise.

Notable also is the fact that the inundation layers utilize a base shoreline that is not coincident with the official County shoreline, so the degree of horizontal inundation may vary if the inundation layers were recreated using the County base shoreline.

Selection of resources based upon their intersection with the sea level rise inundation layers is a simplified method to depict potential impacts. This selection method, however, does not qualify the degree or intensity of impact. Further, this method does not account for the effect shoreline protection measures may have on inundation levels.

One of the largest caveats is that the sea level rise models used to create the inundation layers assume uniform rates of sea level rise and land subsidence. This type of sea level rise modeling is often referred to as a 'bathtub' model since it simply fills a desired body of water up similar to a bathtub. The Chesapeake Bay (the 'bathtub') and the shoreline it shares with Anne Arundel County are treated as a theoretical surface. These types of sea level rise models do not factor in the ability for wetlands and marshes to absorb the rising waters, nor do they consider the ability for soils to resist erosion relative to others along and within the hazard impact zone.

3-4. Storm Surge & Sea Level Rise

The 2009 General Development Plan (GDP) acknowledges that rising sea level will exacerbate the impacts of coastal storm surge. The GDP references storm surge mapping data provided by the Army Corp of Engineers (COE) to the County Office of Emergency Management (OEM) to aid in emergency preparedness planning. However, the vulnerability assessment does not attempt to incorporate the sea level rise inundation data with the available COE / OEM storm surge data for a variety of reasons. The first reason is that the topographic data used to create the sea level rise inundation data was produced at a higher resolution than what was used to create the storm surge inundation data. Secondly, there was a lack of bathometric data associated with the storm surge data. Bathometric data is needed to project reliable wave heights from storm surge given that wave height is dictated in part by underwater topography. Finally, the 100 year planning horizon has a high degree of uncertainty associated with it already. Since it is virtually impossible to predict when tropical storms might affect a given area shown to be impacted by the sea level rise planning scenarios, the vulnerability assessment chose not to introduce additional uncertainty. The decision not to directly incorporate storm surge data into the assessment is not to suggest the data cannot be used to reinforce findings brought to light in the vulnerability assessment.Section 1.4 – Results of Sea Level Rise Vulnerability Assessment.

Section 4. Results of Sea Level Rise Vulnerability Assessment

4-1. Impacts on Land and Property Value

The County's current land cover data, as of 2007, was used to assess the amount of land area and the types of land uses that might be vulnerable to sea level rise, as well as the land value based on current tax assessment data. The results are shown in Tables 1 and 2 respectively.

Nearly 2,200 acres of land are vulnerable under a 0-2' sea level rise. Almost two-thirds of this area (62%) consists of woodlands (743 acres) and open wetlands (622 acres). Most of the remaining vulnerable land area contains residential uses or is open land. A relatively small amount of land area is used for commercial, industrial or agricultural uses.

When the sea level rise inundation area is expanded under the 0-5' scenario, over 6,900 acres of land are potentially impacted. Forty-two percent of the vulnerable area is woodlands, 24 percent is residential land, 14 percent is open wetland and nine percent is open land, with the remaining land uses comprising smaller percentages.

Table 1 - Land Cover (in Acres)

Type of Land Cover	0-2 ft Inundation	0-5 ft Inundation
Commercial	13	182
Forested Wetland	5	29
Industrial	4	27
Open Land	262	650
Open Wetland	622	964

Type of Land Cover	0-2 ft Inundation	0-5 ft Inundation
Pasture/Hay	1	17
Residential 1-acre	24	116
Residential 1/2-acre	44	249
Residential 1/4-acre	66	332
Residential 1/8-acre	68	499
Residential 2-acre	78	381
Residential Woods	20	59
Row Crops	1	37
Transportation	7	70
Utility	1	7
Water	234	383
Woods	743	2,903
Total Acres	***2,193***	***6,905***

The average, median, and total assessment values of the properties at risk are shown in Table 2. In this analysis, properties include land parcels and subdivided lots. Properties at risk include those that fall fully or partially within the inundation area, as well as both improved and unimproved properties. As seen, the average property value in the vulnerable areas falls within the $200,000-$225,000 range. Although the total land area that is vulnerable to sea level rise is a small percentage of the total land in the County (265,770 acres), and a significant portion of it is unimproved woodlands or wetlands, the total value of properties at risk is not insignificant at nearly $3 billion under the 0-2' scenario and over $4.1 billion in the 0-5' scenario.

Table 2 - Properties at Risk and Assessment Values

Property	0-2 ft Inundation	0-5 ft Inundation
# of Properties at Risk	11,607	18,850
Average Assessment Value	$223,854	$202,018
Median Assessment Value	$143,027	$133,700
Total Assessment Value	***$2,904,959,889***	***$4,135,714,067***

4-2. Impacts on Principal Structures

Principal structures are those considered principal to the use of land upon which the structure resides. This analysis did not include secondary structures such as sheds or other accessory structures. Principal structures were considered at risk if they fell entirely or partially within the area of inundation.

Results in Table 3 indicate that only 140 principal structures are impacted in the 0-2' scenario; a relatively small number. The majority of these are residential (125 structures), primarily single family detached dwellings. Of the 15 non-residential structures impacted in the 0-2 foot scenario, 13 are commercial marinas and 2 are associated with community associations or civic groups.

A significantly higher number of 2,398 principal structures are impacted in the 0-5' scenario. Of these, approximately 96% are residential structures, again primarily single family detached homes in the R5, R2 and R1 zoning districts (low to medium density residential zoning).

There are 74 non-residential structures impacted in the 0-5 foot scenario, 59 more than are impacted in the lower sea level rise scenario. Among these 59 structures, 49 are commercial uses, two are places of worship, two are private educational uses, and six are other institutional uses including a private club, four civic group uses, and a structure on the Smithsonian Environmental Research Center site.

It is noted that critical public safety facilities such as police and fire stations and evacuation centers were included in the analysis but are not seen in the results since no such facilities are located in the inundation areas.

Table 3 - Principal Structures at Risk (# of structures)

Building Use Type	0-2 ft Inundation	0-5 ft Inundation
Commercial	13	62
Educational	0	2
Other Institutional	2	8
Place of Worship	0	2
Residential	125	2,324
Total	***140***	***2,398***

Table 4 indicates that the principal structures at risk are located all along the shoreline from Pasadena in the north down to South County. Under the 0-5' scenario, the Deale peninsula which includes the communities of Deale, Shady Side, Churchton, and Galesville, is particularly vulnerable with over 1,000 structures located in at-risk areas. The Edgewater/Mayo, Annapolis Neck, and Lake Shore peninsulas also have fairly large numbers of structures at risk.

Table 4 - Location of Principal Structures at Risk (# of structures)

Location (Planning Area)	0-2 ft Inundation	0-5 ft Inundation
Annapolis Neck	9	319
Broadneck	6	82
Crownsville	14	50
Deale/Shady Side	35	1,007
Edgewater/Mayo	30	431
Glen Burnie	0	36
Lake Shore	11	289
Pasadena/Marley Neck	4	34
Severna Park	18	108
South County	13	42
Total	***140***	***2,398***

4-3. Impacts on Transportation Infrastructure

Inundation of road facilities, even periodically, can lead to costly maintenance issues as well as dangerous driving conditions. As underlying soils become saturated, road pavement will crack more easily and potholes will occur.

As seen in Table 5, major transportation infrastructure in the County such as freeways and arterial highways does not appear to be significantly vulnerable to sea level rise impacts, and even local and collector roads are shown to be minimally impacted (in terms of total road miles) under a sea level rise of 0-2 feet. Under the 0-5' scenario, there are approximately 35 miles of local and collector roads that are potentially at risk. The local roads at risk are found primarily on the Lake Shore peninsula (communities of Bayside Beach, Venice on the Bay, Gibson Island); the Annapolis Neck peninsula (communities of Arundel on the Bay, Oyster Harbor, Bay Ridge); 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).

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. However, individual streets in several areas could eventually require elevation or abandonment, leaving isolated properties with no access. MD 214 is of some concern since its partial inundation 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. This will be examined in more detail during the strategic planning phase of this project.

Table 5 - Road Miles at Risk

Road Classification	0-2 ft Inundation	0-5 ft Inundation
Freeway	0.02	0.09
Principal Arterial	0.05	0.11
Minor Arterial	0.07	1.03
Collector	0.34	5.56
Local Road	1.49	29.54
Total Road Miles	***1.97***	***36.33***

4-4. Impacts on Utility Infrastructure

Many of the areas vulnerable to sea level rise inundation are served by public water and sewer systems owned and maintained by the County. As the areas become inundated, soils become saturated and water tables rise. This can cause infiltration and inflow into water and sewer pipes as well as storm drain pipes, reducing their capacity and resulting in malfunctions of the systems.

Public utility infrastructure that falls within or intersects the areas of inundation is summarized in Table 6. Water lines located in vulnerable areas are not concentrated in any specific communities but are scattered along various coastal areas. Most water lines in these areas are 6" to 12" in diameter, with some of the vulnerable segments as large as 24 inches.

The public sewer lines that are located in vulnerable areas are mostly 8" diameter pipes but range in size from 4" to 48" diameter. They are also located all along the coastal areas, but there are small concentrations of sewer lines at risk in Glen Burnie along Marley Creek, in Severna Park, along the coastal areas on the Annapolis Neck, Mayo, and Deale peninsulas, and in Rose Haven.

The sewer pump stations in at-risk areas are located in the Broadneck (6 stations), Annapolis (10 stations), Mayo-Glebe Heights (5 stations), and Broadwater (3 stations) sewer service areas. No public water or sewer treatment facilities are located in the inundation areas, although the Broadwater Water Reclamation Facility which serves the Deale/Shady Side area just borders the five foot inundation area.

Storm drain pipes are found in almost all of the inundation areas along the coastline. The data in Table 6 includes storm drain lines that are maintained by the County as well as privately maintained, but the vast majority (65,897 feet in length) is maintained by the County. However, the County's data on storm drains does not include facilities owned and maintained by the State, the City of Annapolis, or the Federal military complexes in the County such as the Naval Academy.

Table 6 - Public Utility Infrastructure at Risk

Facility	0-2 ft Inundation	0-5 ft Inundation
Water Lines (pipe length in feet)	26,684	53,729
Water Hydrants	2	9
Sewer Gravity Lines (pipe length in feet)	12,169	169,202

Facility	0-2 ft Inundation	0-5 ft Inundation
Sewer Force Mains (pipe length in feet)	21,602	137,663
Sewer Manholes	36	591
Sewer Pumping Stations	1	24
Storm Drain Pipes (pipe length in feet)	22,880	66,212
Stormwater Management Facilities	1	9

Private water and sewer facilities were also evaluated. There are approximately 40,700 private individual septic systems in the County, and roughly 35,000 private wells serving individual homes or properties. In addition, there are over 500 community wells in the County. These facilities are also susceptible to impacts of sea level rise, 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 saltwater intrusion in water supply wells, contaminating the drinking water supply.

Table 7 indicates the number of properties with private well and septic facilities that are located in the 0-2' and 0-5' inundation areas. Septic systems on properties susceptible to sea level rise are concentrated primarily along the coastal portions of the Lake Shore peninsula, the Broadneck peninsula, areas of Crownsville along the Severn River, portions of the Annapolis Neck along the South River, and the coastal areas in South County excepting the Deale/Shady Side peninsula which is served by public sewer.

Private wells at risk are found in general in the same locations with septic systems at risk, with the addition of the Mayo and Deale/Shady Side peninsulas which do not have public water service and are therefore at risk of private well contamination in inundation areas. The majority of residential properties served by community wells that may be vulnerable are in the Sherwood Forest and Epping Forest communities along the Severn River.

Table 7 - Private Wells and Septic Systems at Risk (# of properties)

Facility	0-2 ft Inundation	0-5 ft Inundation
Septic systems	5,206	7,238
Private wells	4,718	7,633
Community wells	69	123

4-5. Impacts on Marinas

The marine industry is an important segment of the local economy in Anne Arundel County given its many miles of shoreline. Based on a recent inventory, there are 221 marinas currently operating in the County including community marinas, commercial marinas, and yacht clubs. The principal services that are provided at marinas are facilities for storing, launching, and hauling boats. Other services often include fresh water supply for the docked boats, electric power, repair, fuel, grocery sales, marine supplies, hardware, restaurants, restrooms, tennis, swimming pools, ice, boat sales, boating schools, and sometimes motels.

The results in Table 8 indicate that the majority of marinas are vulnerable to sea level rise under the 0-2' scenario, and all are vulnerable under the 0-5' scenario.

Table 8 - Marina Properties at Risk (# of marinas)

Marina Type	0-2 ft Inundation	0-5 ft Inundation
Commercial	73	79
Community	123	130
Yacht Club	12	12
Total	***208***	***221***

4-6. Impacts on Park Lands

Analysis of public park properties vulnerable to sea level rise indicates there are 49 properties at risk under the 0-2' scenario and 59 properties at risk under the 0-5' scenario. Most of these are County parks. Many are open natural areas, but the vulnerable properties also include active recreation parks with sports fields, public school recreation areas, and public piers. Of the 59 park properties, 12 are located in South County, 11 in Deale/Shady Side, 8 in Edgewater/Mayo, 6 in the Lake Shore area, 5 on the Broadneck peninsula, and the remainder in other communities.

Five State parks were identified as being potentially vulnerable to sea level rise. These are Franklin Point Park, Patapsco Valley State Park, Patuxent River Natural Resource Management Area, Sandy Point State Park, and Severn Run Natural Environment Area. In addition, the federally-owned Smithsonian Environmental Research Center may be affected by inundation.

Table 9 - Park Properties at Risk (# of properties)

Parks	0-2 ft Inundation	0-5 ft Inundation
County Parks	39	46
Board of Education properties	2	5
State Parks	5	5
Federal Parks	1	1
Other Preserved or Land Trust properties	2	2
Total	***49***	***59***

4-7. Impacts on Archaeological and Historic Resources

Anne Arundel County has a rich cultural heritage, and settlement here has long focused on the shorelines. While more recent (modern) development relies upon a network of roadways and there has been increased privatization of large waterfront parcels, historically, the waterfront, and the areas most vulnerable to impacts from sea level rise, have been intensively used by humans for thousands of years. Historic sites, and archaeological resources in particular, are non-renewable resources. Once they are destroyed—whether by man-made or natural forces—the information these sites can tell us of our past is also lost forever. This fragile nature of archaeological resources makes the threats to them even more challenging.

The County is a leader in the State with its proactive policies to preserve historic resources. With nearly 1,500 recorded archaeological sites and over 2,000 Maryland Inventory of Historic Places (MIHP) properties, the County has a rich and tangible heritage. These lists includes Native American camp sites, colonial homesteads, remnants of 19th and early 20th century farms, along with cemeteries, still-standing historic buildings, historic districts, and objects such as bridges or transportation structures. While this summary is condensed for inclusion in this report, a more detailed report on the County's cultural resources, and the threats they are under from climate change and sea level rise, has been prepared as a seperate document.

It is hoped that this opportunity to focus on this very real threat to historic sites in Anne Arundel County can also benefit the State and other local governments. This study is of great interest to the State's Historic Preservation Office which has been considering these same challenges at the State level in recent years.

Methodology for Assessment of Archaeological and Historic Resources

The sea level rise threat levels for the initial vulnerability assessment were determined based on visual assessment of each individual site. The team overlaid the 0-2' and 0-5' inundation layers with three

historic resources data layers (the State's archaeological sites data, standing historic properties listed on the Maryland Inventory of Historic Properties, and the County's inventory of historic cemeteries). The team then determined how much of the resource would be impacted by sea level rise.

If the inundation layer merely touched or covered less than 25% of the representative historic resource polygon, it was designated as "Not impacted or minimally impacted." If the inundation layer(s) covered between 25% and 50% of the resource, it was designated "Partially Impacted." The site was determined to be "Fully Impacted" if it was completely contained by the inundation layer(s). In several cases, the sites have already been impacted and are designated as "Completely or Partially Submerged" at this time. It is compelling as the County looks forward to developing policies and solutions to this threat in that this assessment identified 24 formerly terrestrial (land-based) archaeological sites that have already been impacted since they were recorded with the State of Maryland.

Archaeological and Historic Resources Results

A total of 371 archaeological sites are threatened by 0-2' of sea level rise. That number rises to 422 with a 0-5' sea level rise. The 422 threatened sites account for nearly 30% of the total sites recorded in the entire County. Ninety-one of these sites date from the historic period (from the mid-seventeenth- ca. 1650, through the early twentieth century- ca. 1940), and 215 are from the prehistoric period (or, Native American sites that pre-date the arrival of Europeans to Anne Arundel County ca. 1650AD to ca. 8,000 BC). The remaining sites either contain both historic and prehistoric components (n=52) or date to an unknown time period (n=64).

Table 10 - Archaeological Sites at Risk

Recorded Archaeological Sites	0-2 ft Inundation	0-5 ft Inundation
Not impacted or minimally impacted	36	50
Partially impacted	239	269
Fully impacted	70	77
Completely or partially submerged*	26	26
Total	***371***	***422***

*Includes two underwater shipwrecks

Table 11 - Archaeological Sites by Type

Cultural Affliation	0-2 ft Inundation	0-5 ft Inundation
Prehistoric	192	215
Historic	80	91
Prehistoric & Historic	43	52
Unknown	56	64
Total	***371***	***422***

Records indicate that 47 recorded structures listed on the Maryland Inventory of Historic Properties (MIHP) will be affected by 0-2' of sea level rise, while 74 will be affected by up to 5' of rise (Table 12). However, the majority of them will not be significantly affected. Only 11 sites will be moderately, significantly, or fully impacted by 0-2 ft. of projected rise, while an additional nine sites will be similarly affected by 0-5' of rise. These sites include historic buildings, bridges, lighthouses, and historic roads and districts, along with several Federal historic resources outside of the County's jurisdiction.

Clearly, when compared to the quantity of archaeological sites potentially impacted by sea level rise, the historic building stock is less at risk. Perhaps most significant to assessing the vulnerabilities of historic building stock is a careful consideration of the 12 impacted historic districts. Historic districts often contain multiple resources within a confined geographic area, thus while the table below indicates 12 historic districts may be impacted, the number of individual buildings and landscape features that are within those districts could number in the hundreds and may comprise a much larger threat.

Table 12 - Historic Properties at Risk

Recorded Historic Sites*	0-2 ft Inundation	0-5 ft Inundation
Not impacted or minimally impacted	36	54
Partially impacted	7	10
Fully impacted	3	6
Completely or partially submerged	1	4
Total	*47*	*74*

* Properties are listed on the Maryland Inventory of Historic Properties.

Table 13 - Historic Properties by Type

Recorded Historic Sites*	0-2 ft Inundation	0-5 ft Inundation
Structures/Dwellings	12	26
Bridges	8	11
Lighthouses	4	4
Historic Roads	1	2
Historic Districts	12	12
Federal - US Coast Guard & US Navy resources	10	19
Total	***47***	***74***

* Properties are listed on the Maryland Inventory of Historic Properties.

Ten cemeteries in Anne Arundel County will be impacted by 0-2' of sea level rise, while an additional eight will be affected by up to 0-5' of sea level rise. However, only one of these will be fully impacted. Cemeteries in the County are traditionally located on higher ground, away from shorelines, where they are not threatened by fluctuations in sea level. However, sites near bluffs are very susceptible to destruction by erosion.

Table 14 - Cemetaries at Risk

Recorded Cemetaries Threatened	0-2 ft Inundation	0-5 ft Inundation
Not impacted or minimally impacted	3	8
Partially impacted	4	5
Fully impacted	2	4
Completely or partially submerged	1	1
Total	***10***	***18***

This analysis quantitatively assesses the vulnerabilities of the County's cultural resources to the sea level rise threat. From a more qualitative perspective, archaeological sites are highly vulnerable due to their irreplaceable nature and will require a proactive response to ensure our collective cultural

heritage is not lost to rising waters. These resources are significant and tell of history not found in history books or archives, and thus warrant careful consideration and planning in the coming years as the impacts of climate change are realized in Anne Arundel County.

Section 5 – Shoreline Erosion Vulnerability Assessment

Sea level rise will certainly have an impact on low-lying coastal plains, especially as it relates to shoreSea level rise will certainly have an impact on low-lying coastal plains, especially as it relates to shoreline erosion. Coastal storm events and their associated storm surge and winds tend to amplify areas currently vulnerable to shoreline erosion. In turn, shoreline erosion that occurs as a result of these storm events will only be amplified by a future rise in sea level. In order to understand the geographic context of shoreline erosion as it relates to sea level rise, shoreline erosion data at the State and regional level was examined.

Comprehensive shoreline erosion assessments have been conducted with support from Federal and State resources. Shoreline erosion rates were originally collected in 2000 by the Maryland Geologic Survey (MGS) through the Maryland Department of Natural Resources (DNR) Coastal Zone Management (CZM) program[4]. Shoreline change maps were compiled using historical aerial imagery (1841–1977), digital ortho-quarter quadrangles (DOQQ) from 1988 to 1995, and National Wetland Inventory (NWI) maps from the US Fish and Wildlife Service. These were then used to create a single, statewide coverage of shoreline erosion. Finally, DNR and MGS worked with the Towson University Center for Geographic Information Science (CGIS) to compile and attribute the erosion rates for each stretch of shoreline across the State. The finished product was then broken up by each County and the City of Baltimore.

Based upon the shoreline data provided, CGIS analysts utilized a shoreline erosion rate model from the US Geologic Survey (USGS) to assign attributes to each stretch of shoreline[5]. Instances of shoreline advance ('Accretion') or retreat (Erosion – 'Slight', 'Low', 'Moderate', 'High') were attributed based upon predefined thresholds contained within the erosion rate model. Shorelines classified as 'Protected' were where stretches of shoreline accretion or erosion were not observed due to a protection structure in place. Erosion levels with 'No Change' were where stretches of shoreline did not show a discernable level of erosion or accretion yet did not have a protection structure in place. Shorelines classified with 'No Data' were instances where historical shoreline data was not available to compare rates of erosion over time.

In order to enhance the utility of the shoreline erosion dataset compiled by MGS, the Center for Coastal Resources Management (CCRM) at the Virginia Institute of Marine Science (VIMS) recently performed updates to the previously collected shoreline erosion dataset. Starting in September of 2002 and ending in May of 2005, CCRM analysts conducted field work along the shoreline. Data was recorded on natural features including land use, bank height, bank cover, presence of marsh or beach, and shoreline stability. The presence of shoreline protection structures was also recorded including bulkhead, riprap, breakwater, debris (tires, bricks, etc. tossed haphazardly along the shoreline),

4 From Metadata documentation downloaded with Erosion Vulnerability Assessment Tool (EVA) GIS data available from the Center for Coastal Resources Management (CCRM).

5 Danforth, W.W., and Thieler, E.R., 1992, Digital Shoreline Analysis System (DSAS) User's Guide, Version 1.0: U.S. Geological Survey Open-File Report 92-355, 18 p. as found in DNR-MGS Metadata for Recent Maryland Shorelines with Erosion Rate Attributes.

Figure 2. CCRM-VIMS Shoreline Erosion Rates

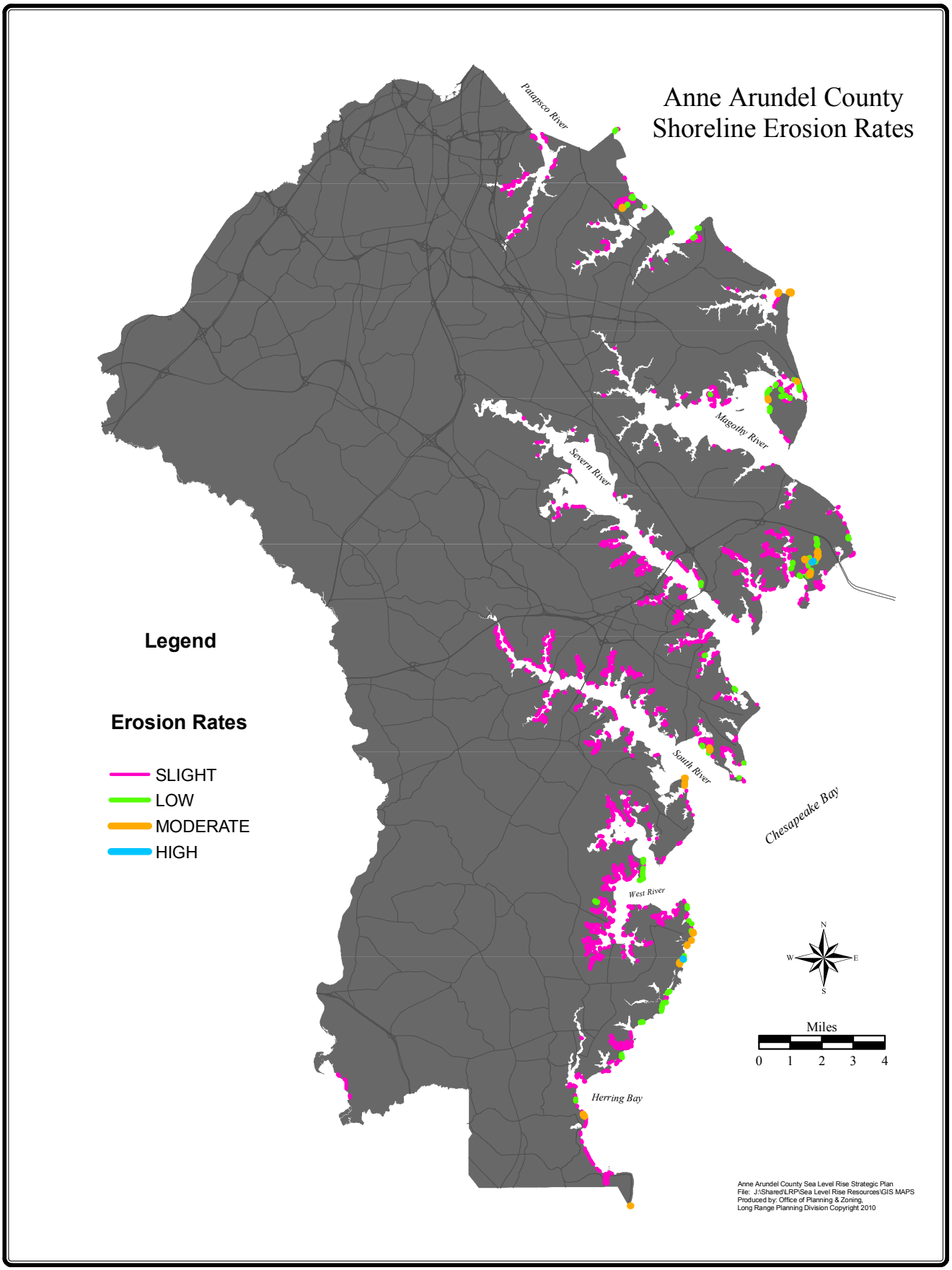
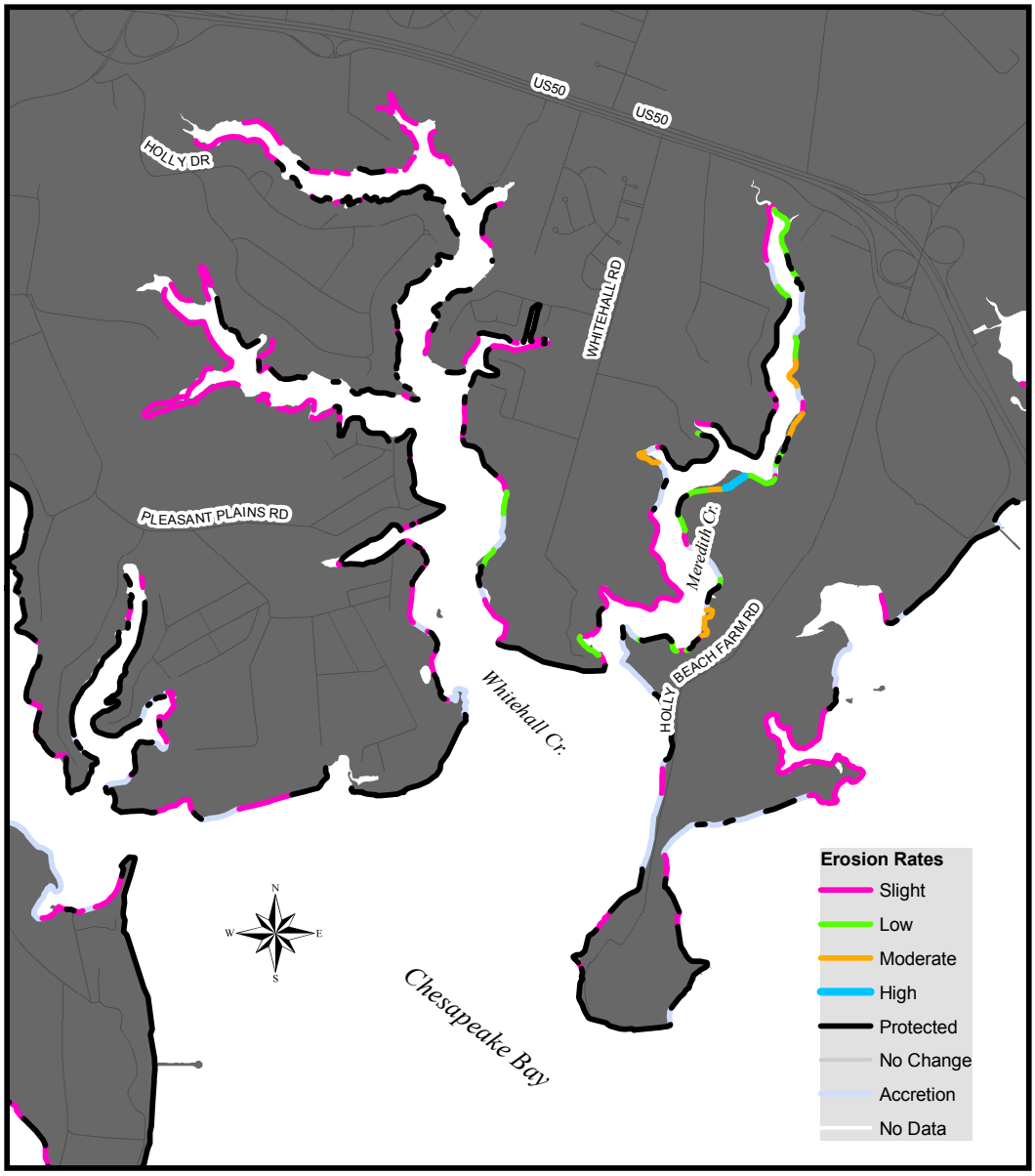


Figure 3. CCRM-VIMS Erosion Rates - Meredith Cr. / Whitehall Cr.



unconventional (concrete blocks or other miscellaneous material placed along the shoreline for stabilization), groin field, jetty, wharf, dilapidated bulkhead, and marinas (<50 slips, or >50 slips).

The results are shown in Table 15 below. Of the 533 miles of Anne Arundel County shoreline, approximately 328 (62%) were surveyed as part of the CCRM shoreline erosion update project. This is based upon a comparison of the linear distance calculated across each shoreline classified by CCRM and downloaded for analysis by County staff. The results, shown in Figure 2, serve to identify which geographic areas may be more susceptible to shoreline erosion relative to others.

Table 15 - County Shoreline Erosion Surveyed by CCRM Update

Erosion Category	Erosion Rate (ft/yr)	Lineal Shoreline Distance	Percentage of Shoreline
Accretion	>0.01	25 mi.	4.7 %
Slight	-0.01 to –2.00	77 mi.	14.4 %
Low	-2.00 to –4.00	5 mi.	0.9 %

Erosion Category	Erosion Rate (ft/yr)	Lineal Shoreline Distance	Percentage of Shoreline
Moderate	-4.00 to –8.00	1 mi.	0.2 %
High	< -8.00	411 ft.	< 0.01 %
Protected	n/a	203 mi.	38.1 %
No change	-0.01 to 0.01	6 mi.	1.1 %
No Data	n/a	11 mi.	2.1 %
Not Surveyed	n/a	205 mi.	38.5 %
Total	***n/a***	***533 mi.***	***100.00%***

Slight erosion was found to occur most frequently throughout the County, impacting approximately 14% of shoreline miles surveyed. All watersheds that empty into the Chesapeake Bay, and their associated tributaries, were impacted to a certain extent by these slight erosion rates. This holds true for the lower portions of the tidal Patuxent River as well.

Low to moderate rates of erosion were found to impact approximately one percent of the County shorelines surveyed. Areas where low to moderate erosion rates were found include portions of the following geographic areas: Cox Creek (Pasadena), Stony Creek, Rock Creek, Bodkin Creek, Gibson Island (northwestern shore), Meredith Creek, Whitehall Creek, Turkey Point, Rhode River (eastern edge of Smithsonian Environmental Research Center), Cox Creek (Galesville), Felicity Cove, Snug Harbor, Columbia Beach, Franklin Point Park, Cape Anne/Swans, Deale Beach, Fairview / Herring Bay, Fairhaven on the Bay, and North Beach Park (southern portion).

High erosion rates were found in specific portions of Meredith Creek (Whitehall Manor), and some sections of shoreline north of Columbia Beach.

It is important to note that approximately 38% of the shorelines observed during the CCRM-VIMS update were treated with some degree of protection measure. As was stated briefly during the methodology section of this report, shoreline protection measures should be used to further qualify results from the sea level rise inundation models.

The CCRM-VIMS data show that virtually each and every watershed throughout the County experiences some degree of shoreline erosion. Moreover, erosion classified as 'slight' by the CCRM-VIMS update does not imply that losing shorelines at a rate of less than a foot per year is insignificant. To this end, the shoreline erosion data offers some validation that sea level rise will likely exacerbate erosion of unprotected County shorelines. In addition, the CCRM-VIMS data includes projections of the future shoreline position over a 50-year planning horizon, assuming current rates of erosion. This data may prove useful during Phase II of the project when developing strategic planning recommendations or in determining where opportunities for shoreline stabilization or restoration may be most beneficial.

Section 6 – Conclusions

The vulnerability assessment has proved very valuable in enabling the County to better understand the level of threat posed by a future rise in sea level. Compared to other nearby jurisdictions such as Dorchester County, which has significantly large land areas that may become inundated, Anne Arundel County is fortunate in that its areas of potential vulnerability to sea level rise are not expansive, and the number of public and private facilities and structures that could be at risk is relatively small.

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 will pursue the next stages of the project to determine what preventive planning measures and actions should be undertaken to minimize any damages or loss of important resources.

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.

Phase II of the Sea Level Rise project will involve more detailed consideration of these findings in order to develop policies, recommend actions, conduct outreach, and identify additional resources needed to fully address and plan for sea level rise.

The shoal marker that delineates the once prominent High Island in the Rhode River looks upon the eroded

Adena Burial Ground

Part 2:

Vulnerability Assessment for Cultural Resources

Assessing and Protecting the County's Heritage from Climate Change

Impacts- Archeological Sites, Historic Buildings, Cemeteries, and Scenic & Historic Roads.

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Abstract

Cultural resources planners and archaeologists with Anne Arundel County's Department of Planning and Zoning, Cultural Resources Division, in cooperation with the Chesapeake and Coastal Program at the Department of Natural Resources, conducted a study of archaeological sites, historic structures, and cemeteries threatened by sea level rise and subsequent coastal erosion. The project goals included reviewing how various domestic and international governmental agencies relate climate change policy to cultural resources, a desk audit and initial vulnerability assessment of every threatened site in Anne Arundel County, and physically visiting over 20% of the archaeological sites. An initial assessment of significance, integrity, current conditions, and threat level was determined by the team of professional archaeologists following the site visit. No excavation took place but important data was gathered on the status and threats to the County's range of cultural resources. Information obtained during the site visits was combined with Department of Natural Resources and Maryland Historical Trust data to get an initial sense of the types and status of threatened cultural resources. This information will be utilized during Year II of this study when solutions, actions and policy responses are developed.

Phase 1 Report, Part 2: Vulnerability Assessment for Cultural Resources

Section 1 – Introduction

With over 530 miles of shoreline, Anne Arundel County is particularly susceptible to impacts associated with a changing climate and sea level rise. Though these changes will be slow to materialize, hints of the possible devastation were seen in the property and environmental damages from Hurricane Isabel in 2003. As wave action, storm surge, and flood waters inundated the shoreline, archaeological sites were lost to the receding waters and several historic buildings sustained irreparable damage.

Anne Arundel County's Planning and Zoning department, in cooperation with the Chesapeake and Coastal Program at the Department of Natural Resources, has embarked upon an effort to identify vulnerable resources and develop a strategic plan that will address these long term impacts in a planning context. Following the example of recently prepared plans in Dorchester, Somerset and Worcester Counties, Anne Arundel County staff identified obvious resources that will be impacted, including transportation and public utilities infrastructure, critical government services and facilities, public facilities, and private structures, wells and septic. However, only the Worcester County plan addressed historic buildings and none of the three mentioned archaeological resources. These represent a significant and highly vulnerable element of Maryland's cultural heritage that will be impacted by sea level rise.

Anne Arundel County has long been a leader in innovative, proactive cultural resources management at the local level. In this study, which specifically addresses cultural resources, the research team sees an opportunity to bring to the fore one of the most threatened resource types that will be impacted by long-term coastal climate change and sea level rise. Archaeological resources in particular are non-renewable resources. Once they (and the data they contain) are lost, they can not be rebuilt, resurrected, or studied. The loss of an archaeological site without data recovery or study is akin to ripping up the pages from an ancient book. The delicate nature of archaeological resources makes this study both compelling and timely.

Anne Arundel County has a rich heritage, reflected in more than 3,500 unique and non-renewable recorded cultural resources. Archaeological sites, historic buildings, cemeteries, and scenic and historic roads tell the story of the County's history. Once lost, these authentic places cannot be recreated.

As Anne Arundel County's history is integrally tied to its waterways, many of the County's significant cultural resources are located near or on the shoreline. As part of the broader sea level rise study, the County's Cultural Resources Division (CRD) has focused specifically on the impacts rising tides will have on cultural and historic resources.

The following report summarizes the teams' efforts in year one of the study, which focused on a vulnerability assessment and sought to develop a framework for interagency strategic planning. The first year of study also attempted to characterize natural forces that are affecting resources. The study has also allowed the CRD team to document how these resources have faired in the past half century, as the County inventory includes geographic data and conditions information on historic sites identified as early as the 1940s and 1950s. By capturing this information and comparing the sites current condition through field-truthing and site visits, we have gained significant insights into the real "on the ground" impacts of sea level rise.

The County currently protects its cultural resources through the Site Development Review process. Under Article 17 of the County Code (www.aacounty.org/PlanZone/CulturalResources/Resources/Article_17.pdf), when development is proposed, the property owner must comply with protective measures that ensures that resources are either retained in place (as for most historic structures), or mitigated prior to their destruction. Mitigation ensures the data these sites contain is recovered for future generations. This local regulation, along with provisions at the State and Federal level, comprise the tools used to protect historic resources. However, these regulations only address human-initiated threats. Threats from natural forces can not be legislated or regulated, thus planning efforts such as this will ensure the County remains on the forefront of developing sensitive and proactive policies for the protection of its cultural resources. Identifying the resources is only a first step, and each resource type will require a varied set of responses to effectively adapt to the potential impacts of coastal climate change.

The Heritage of Anne Arundel County

Anne Arundel County has a rich cultural heritage represented by nearly 1,500 recorded archaeological sites, more than any other County in the State of Maryland. These sites include Native American temporary camps and villages, European colonial hamlets from the seventeenth and early eighteenth centuries, early American houses, mills, and wharves built after the Revolutionary War, plantations that included grand mansions, outbuildings, and slave quarters used through and after the Civil War, and the remains of the countless people who lived, worked, and played in the County in the nineteenth and early twentieth centuries (Table 1). A tremendous amount of our collective heritage is buried beneath the ground surface, and the archaeological record is often the only way of glimpsing the culture of those that came before us.

Native Americans were the first residents of what later became Anne Arundel County, and they relied heavily upon the bounty of Chesapeake Bay and its tributaries to survive. Camps were established along the shore to catch fish and shellfish and harvest the plant species that grow in the marshes and rives. These food procurement camps were temporary, but artifacts were left behind that can tell the Native American story. Fish was dried and oyster was smoked for long-term preservation, houses were constructed out of local trees, and pottery and stone or bone tools were made by hand. These sites provide the only surviving insights into a Native American culture that once thrived in the region.

Ample evidence is available in the State records that indicate that large Archaic and Early Woodland sites identified in the early to mid twentieth century have since been lost to sea level rise and shoreline erosion. Some of the State's earliest sites, (ca 10,000-3,000 years BP) were actually discovered by watermen dredging in shallow waters. Studies have shown that the earliest Native American populations occupied these now submerged lands, which were once habitable on the edges of the ancestral Susquehanna. The most recent paleochannel of the Bay dates to 18 ka and its subsequent inundation was integral to the environment upon which the regions earliest inhabitants lived.

More recent Native populations and their settlement pattern and cultural traditions were further shaped by the Medieval Warm Period (ca A.D. 800-1250) when the regions Native populations were increasingly sedentary and camps became more permanent and populations increased. The Little

Ice Age (ca A.D. 1300-1880) created more challenges for Native populations' subsistence strategies. Stresses on food supplies created the culture encountered by Europeans in the seventeenth century.

The earliest European settlers arrived in the Chesapeake in pursuit of riches through tobacco and the exploitation of the region's natural resources. As such, these newcomers to the land were inextricably bound to the Bay and its tributaries for their own subsistence, agricultural pursuits, and as transportation routes. Many sites from the colonial period were established along the shorelines, including the wharves, mills, and trade shops that provided the backbone to the burgeoning economy.

This dependence on local waterways continued through nineteenth century as some portions of Anne Arundel County made the transition from agriculture to industry. However, harvesting of local seafood became an increasingly important source of commerce, and a bourgeoning population of watermen began developing communities in the area. To support the seafood industry, marine tradesmen also joined these communities by building and repairing boats, developing oyster and fish processing sites, and assisting in transportation of goods via local wharves.

In the late nineteenth and early twentieth centuries, increased leisure time resulted in the opening of several summer resorts along the rivers and Chesapeake Bay. These resorts signaled the beginning of the increasing focus of recreation along Anne Arundel County's coastlines. Privatization of waterfront properties has become the norm as the area experienced intensive development through the late twentieth century. As the population is expected to continue to grow at a similar pace over the next several decades, cultural resources in the region will feel this pressure and will surely be impacted.

Table 2 - Anne Arundel County Timeline

Name	Time Period	Description
Paleoindian	10,000-7,500BC	Radical climatic change at the transition from the Pleistocene to the Holocene. A mobile society of small bands with settlement oriented towards large rivers. Chesapeake Bay did not exist.
Early Archaic	7500-6000BC	Human populations utilized the ancestral Susquehanna for food and transportation. These sites have been lost to the rising waters that formed Chesapeake Bay.
Middle Archaic	6000-3500BC	Period marked by rising temperatures, decreasing precipitation, and the development of a more seasonally variable climate.
Late Archaic	3500-1000BC	Stable shellfish beds were first harvested by increasingly sedentary populations. Groups along major river drainages began to show signs of territoriality.
Early Woodland	1000BC-AD 200	Ceramic technology introduced; sand and quartz are used as clay temper
Middle Woodland	AD 200-900	Medieval Warm Period begins ca. AD 800. Ceramic is first produced with crushed oyster temper.
Late Woodland	AD 900-1600	Local populations pursue agriculture; Little Ice Age begins ca. AD 1300
Early Colonial	AD 1650-1700	First European settlement in Anne Arundel County
Late Colonial	AD 1700-1776	Establishment of Annapolis as Maryland State capitol. Expansion of plantation economy and exploitation of Bay resources
Federal	AD 1776-1850	Plantation economy flourishes, expanded role of Bay resource exploitation for commercial use. End of Little Ice Age.

Name	Time Period	Description
Victorian	AD 1850-1910	Little Ice Age comes to an end ca 1880. Increased urbanization and rise in population.
Modern	AD 1910-present	Increasingly rapid warming trend

Section 2 – Methodology

Literature Search

The first step in this project was to conduct a literature review of sources addressing the effects of sea level rise, coastal erosion, and climate change on cultural resources. Domestic and international governmental policy and scholarly research were included in this study. This review culminated in the following background narrative and all of the collected sources are listed at the end of this report.

Archaeologists have a unique perspective on the relationship between climate change and heritage. Practitioners are required to consider how people dealt with the impacts and implications of a naturally changing climate throughout history.

> "This long-term perspective, together with the detailed geographical and temporal resolution provided by archaeological investigation, offers considerable potential to refine climate-change models in the future," (English Heritage 2008:9).

The Europeans, and the British in particular, have taken the lead on addressing this issue from a governmental standpoint. Beginning in 1998, English Heritage, a quasi non-governmental organization largely responsible for managing the historical buildings, cultural landscapes, and archaeological sites of the country, commissioned a series of coastal archaeological surveys to mitigate the effects of government coastal defense to prevent further erosion (English Heritage 2008:11). Since then, they have produced several publications that outline their evolving position on the implications of climate change for the historic environment. Most recently, they identified "the management of change" as their theme of future research. This involves addressing several topics, including:

- climate change related processes that are immediate (such as the impacts caused by current mitigation and adaptation measures) or with the highest probability of occurrence (such as responses to sea-level rise, flooding and water shortages);
- topic areas which ensure that the historic environment can make a significant contribution to Government targets for climate-change mitigation and adaption (such as research on understanding and improving the energy efficiency of historic buildings; the efficiency and cost-effectiveness of differing options for mitigation and adaptation; and the impact of fiscal incentives and investment in reducing the carbon footprint of the built environment) ;
- learning relevant lessons from the past (including better understanding of climate change mechanisms drawn from the record of long-term environmental change and sustainable approaches to living drawn from past low-carbon societies);
- initiatives to improve our ability to monitor the impacts of climate change on the historic environment;
- initiatives to improve our ability to predict changes to the historic environment arising from climate change… (English Heritage 2008:14).

Earlier English Heritage documents confront the complex issue of the value and significance of cultural resources versus the actual cost of preservation. They state, "The 'save all' approach to the historic environment needs to be re-evaluated. It is not realistic to conserve anything forever or everything for any time at all," and admit that they "…are already facing up to difficult decisions on how to manage the coastal heritage in the face of sea level rise induced by climate change" (Cassar 2005:2).

However, they believe that effects to the historical environment can be quantified by creating risk maps in GIS by overlaying predicted climate change models with current cultural resources data. These maps can constantly be refined and updated by utilizing new information on each heritage resource and the latest climate change research and statistics (Cassar 2005:44-61).

The British government leaves coastal erosion management planning largely up to local jurisdictions that employ varying degrees of preventative measures. However, the responsibility for recording coastal archaeological sites that are imminently threatened by erosion often falls to non-profit organizations like Scottish Coastal Archaeology and the Problem of Erosion, or SCAPE. SCAPE works with Historic Scotland (an organization comparable to English Heritage) to monitor, research, and record eroding coastal sites and historic coastal landscapes. They also encourage landowners and community members to become active stewards of these sites through the Shorewatch project (http://www.shorewatch.co.uk/). Engaging the public in such a way is certainly cost-effective, as people work strictly on a volunteer basis. But, perhaps more important, a sense of local pride is developed when people embrace the value of their local heritage.

In this country, University of Northern Colorado anthropologist Michael Kimball has considered the fleeting nature of local heritage and archaeological sites. He stated, "It may be intangible, but when a community loses its connection to history it loses something pretty important" (Curry 2009). Kimball organized a panel discussion on the effects of climate change on archaeological sites at the World Archaeology Congress in 2008 and is currently organizing an international Workshop on Climate Change, Local Communities, and Coastal/Island Heritage. This workshop will include U.S. and international heritage professionals and geographers who are attempting to mitigate and minimize the effects of climate change on coastal sites. Kimball has three main goals for the workshop. First, he wants to highlight several high-profile endangered sites in order to communicate the implications of losing coastal heritage to an international audience. Second, he wants to address the local-level repercussions of lost heritage sites and the possible effects on economic well-being. Finally, a research agenda will be developed for the future studies of threatened coastal heritage resources.

There are few local or state jurisdictions in this country that have confronted the potential impacts of climate change on archaeological sites. At the federal level, the National Park Service initiated a "Climate Friendly Parks" program in 2003, but it does not directly address heritage resources. Rather, this program works through individual parks to attempt to lessen their own environmental footprints.

Three counties on Maryland's Eastern Shore have conducted sea level rise vulnerability assessments funded by Maryland Department of Natural Resources grants. Large portions of Somerset, Worcester, and Dorchester counties are low-lying and will be severely impacted by rising seas. However, little to no mention of the potential effects on historic buildings exists in these documents and archaeological sites are not addressed at all.

This is not to say there is an absence of heritage resources in those areas. Indeed, Maryland Historical Trust data indicates that there are hundreds of archaeological sites and historic buildings on the Maryland Inventory of Historic Places (MIHP) that will be inundated by 0-2 ft or 2-5 ft of sea level rise (Table 2). In addition, dozens of properties listed on the National Register of Historic Places (NRHP) are threatened.

Table 2: NRHP, MIHP, and Archaeological Sites in Dorchester, Somerset, and Worchester Counties Threatened by Sea Level Rise

	NRHP		MIHP		Archaeological	
County	0-2 ft	2-5 ft	0-2 ft	2-5 ft	0-2 ft	2-5 ft
Dorchester	8	3	98	154	283	50
Somerset	45	10	75	181	198	34
Worcester	8	4	15	41	47	14

Many of these threatened archaeological sites are ephemeral Native American sites, for which there is no supplementary written record. Several are exceedingly rare contact period or seventeenth century sites. Anne Arundel appears to be the first county in the state to take such a proactive approach to preserving or recording all of their heritage resources in the face of rising tides.

The State of Maryland has begun to more intently consider these challenges in recent years. The Maryland Historic Trust (the State Historic Preservation Office operating within the Department of Planning) recently completed an assessment of the "Potential Impacts of Sea Level Rise to Historic and Cultural Resources" in response to the Maryland Climate Action Plan. Headed by Jennifer Chadwick-Moore and Maureen Kavanagh, the MHT conducted a desk audit of the resources potentially affected across the State, considering archaeological sites, MIHP-listed properties, easements held by the State and Sites that are listed on the National Register or are listed as a National Historic Landmarks. In their study they determined that:

1. Rising sea levels, erosion and major storms all pose a significant threat to historic and archeological sites, districts, and landscapes;

2. A preliminary analysis of archeological sites indicates that over 30% of coastal county sites would be affected, and scarce Paleoindian, contact period and 17th century sites are proportionately most endangered;

3. Other historic resources will need to be examined in much greater detail to determine which classes of properties are most vulnerable.

After several internal briefing with colleagues in the SHPO, all are in agreement that this is a real threat to our State's heritage resources, and one that should be placed in the forefront of preservation planning State-wide. The confluence of the Anne Arundel County detailed vulnerability assessment and the State's efforts should raise this issue to a new level, and encourage continued dialogue and a response to this threat.

While the State has now begun to seriously address the issue, perhaps the relative delay of U.S. governmental climate change initiatives when compared to other countries is due to the ongoing and vociferous debate in the United States as to whether or not global warming is actually occurring. However, heritage professionals are noting the increased intensity of coastal erosion and the loss of previously recorded sites. In California's Channel Islands, archaeologist Jon Erlandson has excavated several large coastal shell middens that are rapidly eroding. He has stated,

> "If we've lost a meter in 10 years, how much will we lose in 50 or 100? If this keeps up, we're going to lose an incredible amount of archaeological sites" (Curry 2009).

The shore is a dynamic environment and has always been one of the most attractive settlement locations. Today, rising sea level and increased coastal erosion threaten to destroy an untouched wealth of information about past civilizations. Several colonial sites in the Chesapeake Bay have been partially inundated since their initial discovery, including Jamestown and Flowerdew Plantation on the James River in Virginia and Londontown on the South River in Maryland (Ruppé 1998), not to mention the untold thousands of Native American sites already destroyed. As Erlandson (2008:168) stated, "This loss of our communal island and coastal heritage represents a crisis for human history."

Cultural heritage is a non-renewable resource that must be recorded for future generations. Any disruption in climate will have an effect on both archaeological sites and the historic built environment. As English Heritage points out, "Changes in rainfall patterns and temperatures…are likely to have dramatic effects on buried or exposed archaeological sites…For old buildings and their preserved contents the problems are also likely to prove acute; it has long been understood that fluctuations in the local microclimate present the main danger to continued survival. Historic building materials are extremely permeable to the environment of air and soil; changes in moisture content can occur rapidly, and these can activate damaging cycles of salt crystallisation…" (Cassar 2005:5-6). The effects on fragile cultural resources must be considered in any climate change management plan.

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Desk Audit Survey

In order to grasp the full range of cultural resources in danger of inundation, a comprehensive review was undertaken of every site threatened by sea level rise. Since time and resources precluded the physical visitation to all 422 archaeological sites, 18 cemeteries, and 74 historic structures and other resources, a desk audit was conducted. Cultural resource data for this survey was obtained from the Maryland Historical Trust and was supplemented by files in the Anne Arundel County Cultural Resources division of the Department of Planning and Zoning.

Archaeological sites received the most in-depth analysis for several reasons. There are 422 archaeological sites that will be affected by sea level rise in Anne Arundel County, far more than any other cultural resource. Some have been studied intensively, while others were merely noted decades ago. These sites are typically ephemeral, yet are representative of human habitation spanning thousands of years. During this study, pertinent information was collected about each site, including location, type, level of previous excavation, and identified below-ground features (including shell middens, foundations, or burials). During the course of this project, it was discovered that some information was outdated or inaccurate. Corrections were made when possible, but the Maryland Historical Trust site file data was generally taken at face value.

The sites were organized according to whether they were threatened by 0-2 ft or 2-5 ft of potential inundation. When sites were threatened by both 0-2 ft and 2-5 ft of inundation, they were included in the 0-2 ft category.

The geography and surroundings of each site were observed using 2010 aerial photography and Pictometry data which enabled the team to identify current threats, such as shoreline stabilization, natural bank erosion, or development. Information such as Small Area Plan (SAP) boundaries, shoreline boundaries, and property ownership was garnered from County GIS data. The most critical data source was the bathymetric inundation layers received from the Maryland Department of Natural Resources. The various source data was overlaid in ArcGIS and queried to learn about the potential impact of sea level rise on Anne Arundel County's cultural resources.

Threat levels were determined based on visual assessment using GIS to determine how much of the resource would be impacted by sea level rise. If the inundation layer merely touched or covered less than 25% of the representative historic resource polygon, it was designated as "Not Impacted or Minimally Impacted." If the inundation layer(s) covered between 25% and 50% of the resource, it was designated "Partially Impacted." The site was determined to be "Fully Impacted" if it was completely contained by the inundation layer(s). Sites that have already been impacted were designated as "Completely or Partial Submerged."

This desk audit not only resulted in an initial vulnerability assessment, but also formulated site visit recommendations. This was conducted by staff archaeologists and post-graduate intern Kathleen Clendaniel, who made significant contributions to this aspect of the project.

In preparation for site visits, the information from the various sources was organized into a database that contained all of the relevant data related to location, ownership, previous investigations, site type, etc. Figure 1 shows the first page of the site visit packet for site 18AN482, Quiet Waters Farm IV, a County-owned prehistoric shell midden site that has undergone minimal archaeological testing.

Site Visits

A total of 88 archaeological sites, two cemeteries, and two historic houses were physically visited by professional archaeologists during this study. A goal was set to visit at least 10% of the threatened archaeological sites, broken down by Anne Arundel County Small Area Plans (SAP). In the end, over 20% of the sites were physically visited, many of these in partnership with the Smithsonian Environmental Research Center (SERC) in the Rhode and West River drainages.

Figure 1. Sample Site Visit Packet from 18AN482

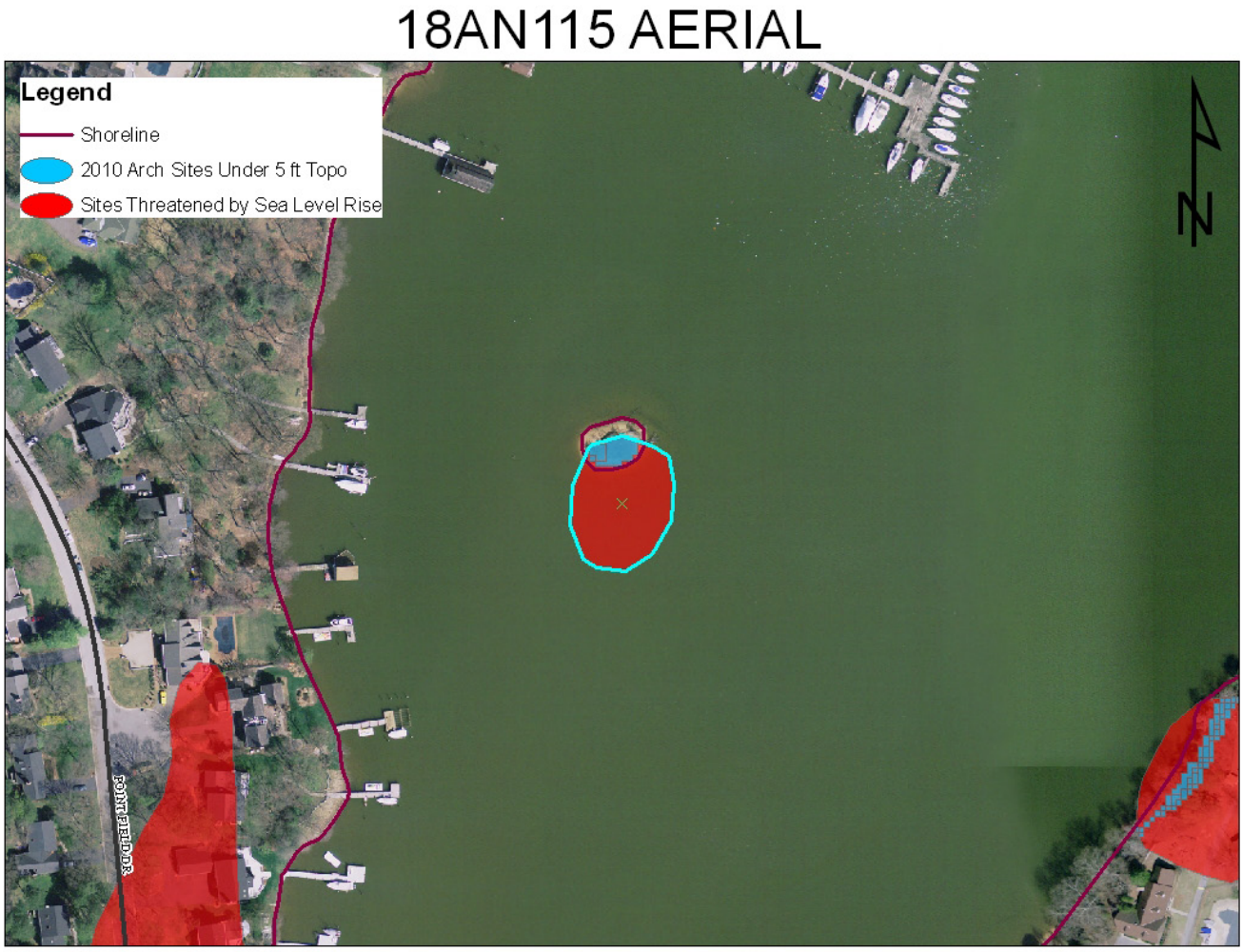
Coastal Climate Change Site Visit Data

Site #	18AN482
Site Name	Quiet Waters Farm III
Site Type	Prehistoric
Distance	Partially Submerged
Elevation	Majority of site less than 5 ft.
Quad	South River
Small Area Plan	Annapolis Neck
Property Address	Quiet Waters Park, 600 Quiet Waters Park Rd., Annapolis MD 21403
Ownership Status	County
Current Owner Info	AA County, C/O AA Cty O B&F, PO BOX 2700 MS 1309, Annapolis, MD 21404
Easement Status	Unknown
Phase of Excavation	Phase I
Features?	Yes
Shell Midden	Yes
Hearth	
Subsurface Pit	
Burial	
Foundations	
Reported Condition	Disturbed
Previous Disturbance	Natural Impacts
Site Form Filing Date	1977
Current Threats	Natural Degradation
Part of MW survey	Yes - visited
Initial Vulner. Ass'mt?	Impacted, % unknown
Recommendations	Site Visit - High Priority
Comments	Middle Woodland shell midden and short-term resource procurement. · Site actually encompasses entire peninsula - MAAR dug STPs all along SW side and found portions of an intact midden·We dug two STPs and didn't see any shell subsurface· Few shells even seen in banks, just some here and there· The peninsula becomes very marshy at the tip, but we didn't dig out there· Only diagnostic found was Mockley, single component??? · Looks unplowed, but narrow spit of land might not be conducive to living areasMW Survey Notes:

An effort was made to visit a variety of historic and prehistoric sites. While prehistoric shell midden sites make up a majority of the visited sites, several historic period wharves, house and farm sites, slave quarters, brick and lime kilns, and cemeteries were also visited.

Recommendations from the desk audit were strongly considered in developing the list of visited sites, as this could reveal current conditions. For example, several previously recorded terrestrial sites were currently underwater, as was the case with the Indian Landing III site (18AN115; Figure 2). This Woodland period shell midden was recorded in 1959 on a small island near the head of the Severn River. Aerial photographs suggest significant submersion of the island and the site is likely severely eroded. This site was given low priority for physical site visitation.

Figure 2: Indian Landing III (18AN115) Showing Original Site Boundaries and Current Condition of Island



If a site was originally identified with a low concentration of artifacts, it was also given a low priority. Several low-density shell middens or light artifact scatters fell into this category. However, sites with potential for extant, undisturbed cultural resources were given a high priority. The Worthington site (18AN299), located on the Rhode River, consists of a large Woodland period shell midden and a historic wharf constructed around 1760 that was used through the early twentieth century. It also appears that some of the oyster shell collected by the Native Americans was used hundreds of years later by the builders of nearby Ivy Neck plantation to make shell mortar around 1785. All of these aspects of the site are apparently intact, but are threatened by a high degree of erosion (Figure 3).

Figure 3: The Worthington Site (18AN299) is rapidly eroding into the Rhode River.

Four main aspects of the site were evaluated upon visitation: significance and integrity, conditions and level of preservation, level of previous investigations, and threat level (Table 3). This provided a thorough sense of the status of each site and enabled the team to quantify visited sites for comparative purposes.

Table 3: Four Aspects of Cultural Resources Evaluated during Site Visits

Evaluation Aspect	Determination Considerations
Significance and Integrity	Significance: Consider the site within its respective historic context and function. Can the site yield new information that will enhance our understanding of Anne Arundel County's past?
Integrity: Are features and other deposits temporally diagnostic, spatially discrete, and functionally defined? Is there spatial patterning to subsurface artifacts or features, and is the site relatively undisturbed by later activities?	

Evaluation Aspect	Determination Considerations
Condition and Level of Preservation	Does the site appear to have been impacted by natural or human actions? The following scale can be used to estimate the level of disturbance across the documented site boundaries: disturbance of 0-10% would offer excellent preservation; minimal is 10-25%; moderate is 25-50%; extensive is 50-75%; and destroyed is 75-100% of the site.
Level of Previous Investigation	Surface Collection/Reported; Phase I; Phase II/III
Threat Level	Will the site be inundated by SLR? Is it quickly eroding away? Is construction or destruction imminent?

A Site Evaluation Worksheet was prepared to organize the newly accumulated data and was filled out after completion of the site visit. Each also contained a USGS quad map with the site location and an aerial photograph overlaid with the portion of the site threatened by sea level rise. Figure 4 and 5 provide an example from site 18AN1323, Kirkpatrick-Howatt 7. This prehistoric shell midden, located near the head of Sellman Creek in the Rhode River watershed, was first identified in 2006 and it seems that significant erosion has occurred in the intervening four years. Today, large oyster shells are eroding at least 15ft into the creek from what remains of an intact, 2-3ft thick midden still visible in the bank (Figure 6). Only about 5ft of level ground is present behind the bank before a steep uphill rise, suggesting that there is little left of this ancient shell processing site. Erosion and sea level rise will surely act to destroy the remainder of the site in the next few years.

Figure 4. Sample Worksheet Utilized during Site Visits

CCI Grant: Archaeology Site Visits
SITE EVALUATION WORKSHEET

SITE NUMBER: 18AN1323

SITE NAME: Kirkpatrick Howat 7

Significance to Anne Arundel County History and Integrity:

Top 15%		*Middle*		*Bottom 15%*	
1	2	3	4	5	3

Conditions/Level of Preservation:

Excellent	*Minimal*	*Moderate*	*Extensive*	*Destroyed*	
1	2	3	4	5	4

Level of Previous Investigation:

Surface Collection/Reported	*Phase I*	*Phase II/III*	
1	2	3	1

Threat Level

Destroyed	*High*	*Moderate*	*Minimal*	*None*	
1	2	3	4	5	2

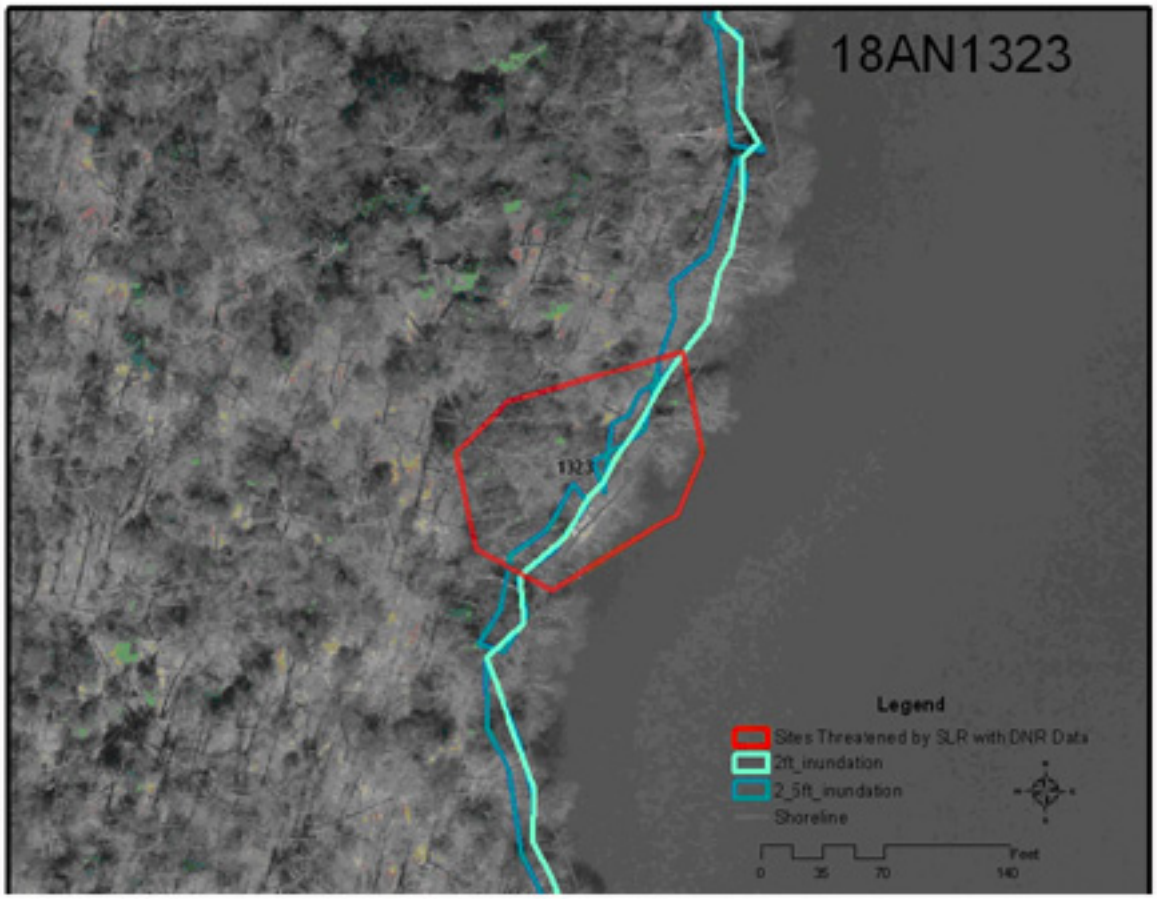
Due to…

SLR Erosion Other:

Field Notes:

-Identified and given site designation by Lost Towns Project archaeologists in 2006, who noted "moderate erosion" at the time
-There are hundreds of shells eroding out of the bank and countless more extend at least 15ft into the river
-Midden appears stratified; measures about 30ft in length by 2-3ft thick
-Intact portion of midden is likely all that remains of this site – very steep uphill slope is not far from the back edge of the midden; it's only about 5ft wide at this point (must have originally been at least twice this size before significant erosion)
-Would be good to test ASAP before it is totally gone – we have noted a very high degree of erosion in the Rhode watershed

Figure 5: Location Maps from Sample Worksheet Utilized During Site Visits



18AN1323 USGS South River QUAD

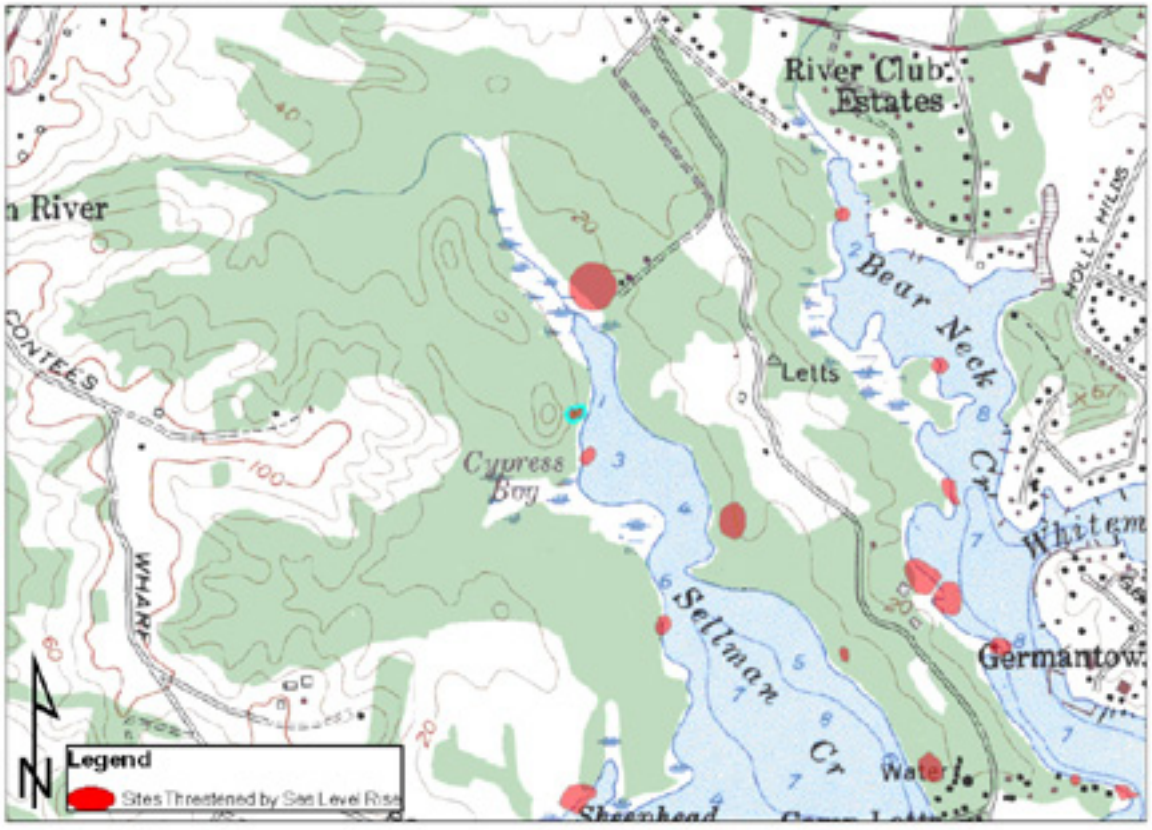


Figure 6: Remains of the Prehistoric Shell Midden at 18AN1323, the Kirkpatrick-Howatt 7 Site, Erode into Sellman Creek

Upon visitation, each site was digitally photographed, and little to no excavation took place. A determination of site integrity was based on surface conditions and observation. Several of the sites were located on private property, and the homeowners were engaged to obtain permission to visit the site and inform them of the nature of this project. In many cases, they were unaware that an archaeological site was located on their property. Sites can be recorded with the Maryland Historical Trust without landowner permission, and many were identified decades ago, long before construction of current houses or development. Large surveys like this provide an excellent opportunity to inform the public about the sometimes hidden nature of subsurface cultural resources and to develop stewardship of these sites. It also gives archaeologists an opportunity to inquire if more artifacts or site components have been discovered by the landowners since the site was recorded.

Once arriving back in the office, an Excel spreadsheet was developed to organize and sort the data. All photographs and data are stored in the shared computer files at the Office of Planning and Zoning.

Data Analysis

The cultural resources were analyzed based on several factors, including SAP, location in either the 0-2 ft or 2-5 ft inundation area, and if they were cross-listed in multiple resource categories. For example, archaeology sites cross-listed in the Maryland Inventory of Historic Properties were removed from the secondary source to ensure they were not tabulated multiple times. Resources that were outside of the jurisdiction of Anne Arundel County, such as those in the City of Annapolis, were also removed from the datasets.

Archaeological sites in particular required further analysis. This included tabulating and synthesizing feature data for each site, level of previous archaeological investigation, cultural affiliation, etc. Terrestrial sites that have already been submerged due to sea level rise were accounted for in the threat category, "Completely or Partial Submerged." Two shipwrecks were also included in this category, considering they will be further affected by sea level rise. This type of information will aid in future planning for these resources in the face of sea level rise.

Section 3 – Findings

Anne Arundel County has a rich and varied coastal history that is vanishing under rising tides and eroding from the shores. The following narrative will attempt to quantify the types of historic districts and structures, scenic and historic roads, cemeteries, and archaeological sites previously recorded in the county and the degree to which each is threatened. Almost 20% of the threatened archaeological sites were visited by County professionals, and this section will conclude with the findings of that portion of the project.

Historic Buildings and Districts

Anne Arundel County uses the Maryland Inventory of Historic Properties (MIHP) as a planning tool to preserve and protect its heritage resources. This list has been developed over several decades and includes a variety of resources such as historic buildings, districts, roads, and structures (include bridges, boats, and lighthouses). While over 2,000 resources in the County have been assigned MIHP numbers, there are only 728 remaining standing buildings, 27 designated historic districts, 31 roads, and 52 other transportation-oriented resources.

Eleven threatened Historic Districts also warrant special consideration as we assess the vulnerabilities of historic building stock. Historic districts generally contain multiple resources within a confined geographic area, and therefore, the number of individual buildings and landscape features that are within those districts could number in the hundreds and may comprise a much larger threat. Based on a preliminary review of our files, we estimate that more than 700 buildings alone are within potentially impacted districts. Table 4 lists the 11 districts that will have some portion impacted by either the 0-2 or 0-5 ft inundation models.

Table 4: Historic Districts Threatened by Sea Level Rise

Historic District	Estimate of contributing buildings within the District	MIHP Inventory Number
Gibson Island Historic District	190	AA0936
Sherwood Forest Historic District	300	AA0941
Annapolis Roads	20	AA0949
Bay Ridge Historic District	121	AA0950
Town of Galesville Historic District and West Benning Road District	25	AA2242/ AA2317
Patapsco State Park	2	AA2290
Sandy Point State Park	5	AA2305
Belle Grove Linear District	17	AA2360
Fort Smallwood Park	12	AA0898
Cumberstone Rd. Historic Area	22	AA0068
** The Cumberstone district also has extensive archaeological resources within its boundaries, many of which will be impacted by 0-5 ft. SLR		

This study identified 74 unique MIHP properties that are threatened by sea level rise in Anne Arundel County and nearly 73% of them (n=54) will be minimally impacted (Figure 7; Figure 8). Only four properties will be fully inundated by 5ft of sea level rise; three are located on the US Coast Guard facility Curtis Bay (AA0786- Boat Building Section #5, AA0787- Public Works Section #12 USCG, and AA0789- Machine Shop #11. The most threatened structure on private lands or under County jurisdiction is AA0899 - the Carr Log House, which is on an island in Round Bay, Crownsville, MD. Other structures are within the inundation zone, but with adequate planning, any potential damages could be mitigated in a manner that is sensitive to the buildings historic character and fabric and compliant with applicable Federal Preservation standards (specifically the Secretary of Interior Guidelines) and best practices in the field.

Figure 7: MIHP Properties Threatened by Sea Level Rise

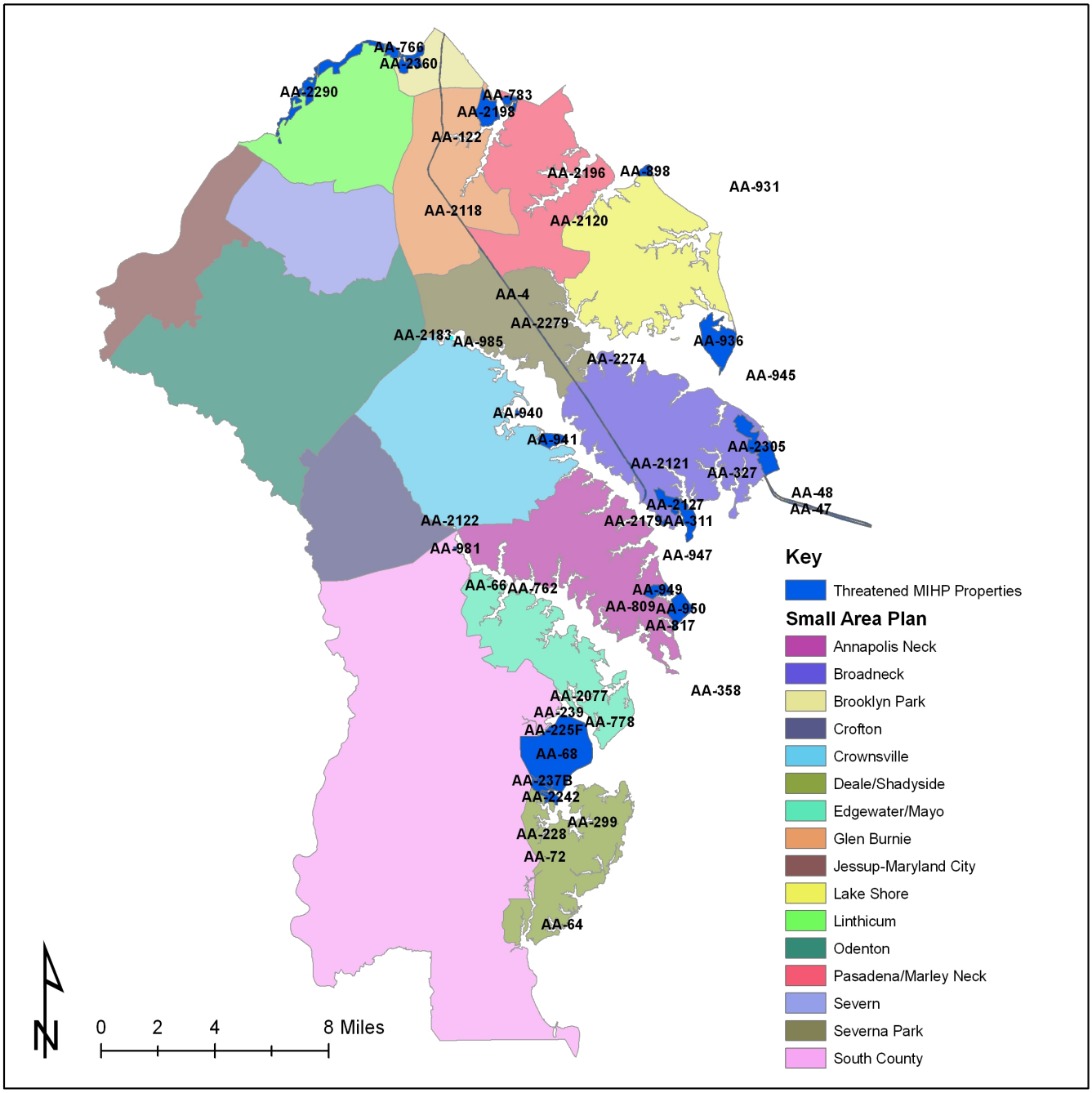
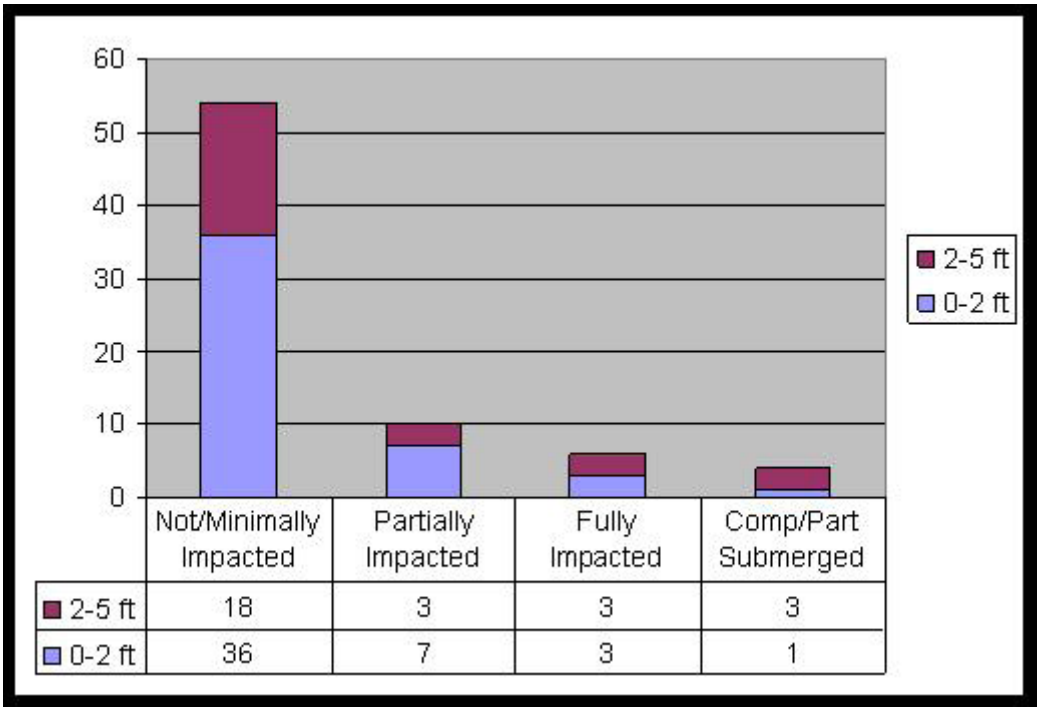


Figure 8: Threatened MIHP Properties by Degree of Potential Impact



The highest percentage of threatened resources is located in Pasadena (20%), Annapolis Neck (16%), Deale/Shadyside (13%), and Broadneck (10%) (Table 5; Table 6). The high percentage of threatened resources in Pasadena's SAP is likely a result of the numerous resources that have been listed on the MIHP from the Curtis Bay Coast Guard Facility. The majority of Pasadena's threatened historic resources (88%) are owned by the United States Coast Guard. A water-reliant historic resource like that naturally will have many resources built near, on or over the water, thus many resources in this highly documented area will be in the inundations zones. Fourteen of the structures on their base are listed on the MIHP. Many of these structures are located on low ground in close proximity to the water.

Annapolis Neck, Deale/Shady Side and Broadneck constitute the next three SAP's that have a high percentage of threatened historic buildings. Annapolis Neck's threatened historic resources include nine historic structures, two historic districts, a road, and a bridge. This SAP is one of the longest-settled areas in the county, and its historic resources have also been intensively surveyed. The nine threatened structures are all located in a small community named Highland Beach. It is an historic, late-nineteenth century African American summer community located between Black Walnut and Oyster Creeks, at the confluence with the Chesapeake Bay. There has been no shoreline stabilization in the community. One of the threatened structures is Frederick Douglass' summer home, Twin Oaks, which is listed on the National Register of Historic Places.

All three of the SAP's noted above were well-developed in the 18th and 18th century, when reliance upon and proximity to the water defined settlement patterns, thus historic buildings that survive from these periods often had uses closely related to the water. Waterman's' homes, ferry landings, and commercial buildings used to ship goods by boat are just a few examples of typical MIHP listed resources in these SAP's that are near the shoreline and within the inundation zones.

Table 5: Threatened MIHP Properties, Grouped by Small Area Plan

Small Area Plan	0-2 ft	0-5 ft	TOTAL %
Pasadena	9	16	20%
Annapolis Neck	7	13	16%

Small Area Plan	0-2 ft	0-5 ft	TOTAL %
Deale/Shadyside	3	10	13%
Broadneck	7	8	10%
South County	5	6	8%
Crownsville	4	5	6%
Edgewater	3	4	5%
Glen Burnie	2	4	5%
Brooklyn Park	4	4	5%
None	4	4	5%
Lake Shore	3	3	4%
Severna Park	0	2	3%
Linthicum	1	1	1%
Odenton	0	0	0%
Total	***52***	***80****	***100%***

Table 6: Threatened MIHP Properties by Type

Threatened MIHP Properties	0-2 ft	0-5 ft
Structures	12	26
Bridges	8	11
Lighthouses	4	4
Historic Roads	1	2
Historic Districts	12	12
USCG and USN resources	10	19
TOTAL	***47***	***74***

Scenic and Historic Roads

Anne Arundel County protects a class of roads designated as "Scenic and Historic" under Article 17 of its development code. These designated roads represent historic road systems, some established as early as the eighteenth century, and possess characteristics that make their preservation a public benefit. Many also possess high integrity for their scenic characteristics, view-sheds, and landscaping, and evoke an earlier, more rural time. When development is proposed, each road is reviewed under a 14 point checklist which focuses on retaining the roads meander, elevation, slope, width, vegetation, and other character-defining elements.

As part of this project, the team ran a data inquiry to determine how many roads currently listed on the County's inventory of Scenic and Historic roads would be impacted by the 0-5 ft inundation level. While a broader review of road systems was conducted in the main body of this report, Scenic and Historic Roads have special evaluation criteria that should be considered as the project moves toward policy development phases.

There are 169 road segments that make up the official Scenic and Historic Roads list and represent 50 actual roads. (Some segments represent the same road name.) Of these, 33 road segments (representing 14 roads) will see some level of inundation under the 0-5 ft. model (Table 7). Most of these are found within the Broadneck and South County SAP boundaries and traverse low-lying areas or represent roads that end at the water's edge. These roads often were established to support the traditionally heavy reliance on the waterways of the region and once accessed wharves or docks used for commercial purposes.

Table 7: Scenic and Historic Roads Threatened by Sea Level Rise

Road Name	Number of Impacted Segments
Defense Highway	5
River Road	4
Whitehall Road	4
St. Margaret's Road	3
Friendship Road	3
Swamp Circle Road	3
Wrighton Road	2
Hammonds Ferry Road North	2
Riverview Road	2
Contee's Wharf Road	1
Ridout Road	1
Round Bay Road	1
Harness Creek Road	1
Town Point Road	1
14 ROADS	33 SEGMENTS

Cemeteries

Only 18, or about 4%, of the 441 recorded cemeteries in Anne Arundel County are threatened by sea level rise. This is likely due to the typical placement of cemeteries on the landscape. In this region, cemeteries are generally not placed adjacent to waterways, but rather are located on high ground, such as a hilltop. The proximity of cemeteries to water was a documented health concern in the historic period and continues in the present. Almost all of the recorded cemeteries in Anne Arundel County are historic, and the locations of these are typically known due to the presence of gravestones or markers. However, undiscovered or forgotten cemeteries surely exist, and some of these may be exposed and threatened by sea level rise (Figure 9).

The area of the County with the highest number of threatened cemeteries is in the Deale/Shadyside SAP (Table 8). Ten cemeteries there are threatened by sea level rise, which is not surprising, given its low terrain and its long history of settlement beginning in the 1600s.

Table 8: Threatened Cemeteries, Grouped by Small Area Plan

Small Area Plan	0-2 ft	0-5 ft	% of TOTAL
Deale/Shadyside	5	10	56%
Broadneck	1	3	17%
Severna Park	2	2	11%
South County	0	1	6%
Lake Shore	1	1	6%
None (Previously Submerged)	1	1	6%
Annapolis Neck	0	0	0%
Pasadena	0	0	0%
Edgewater	0	0	0%
Linthicum	0	0	0%
Glen Burnie	0	0	0%

Small Area Plan	0-2 ft	0-5 ft	% of TOTAL
Odenton	0	0	0%
Brooklyn Park	0	0	0%
Crownsville	0	0	0%
Crofton	0	0	0%
TOTAL COUNT	*10*	*18*	*100%*

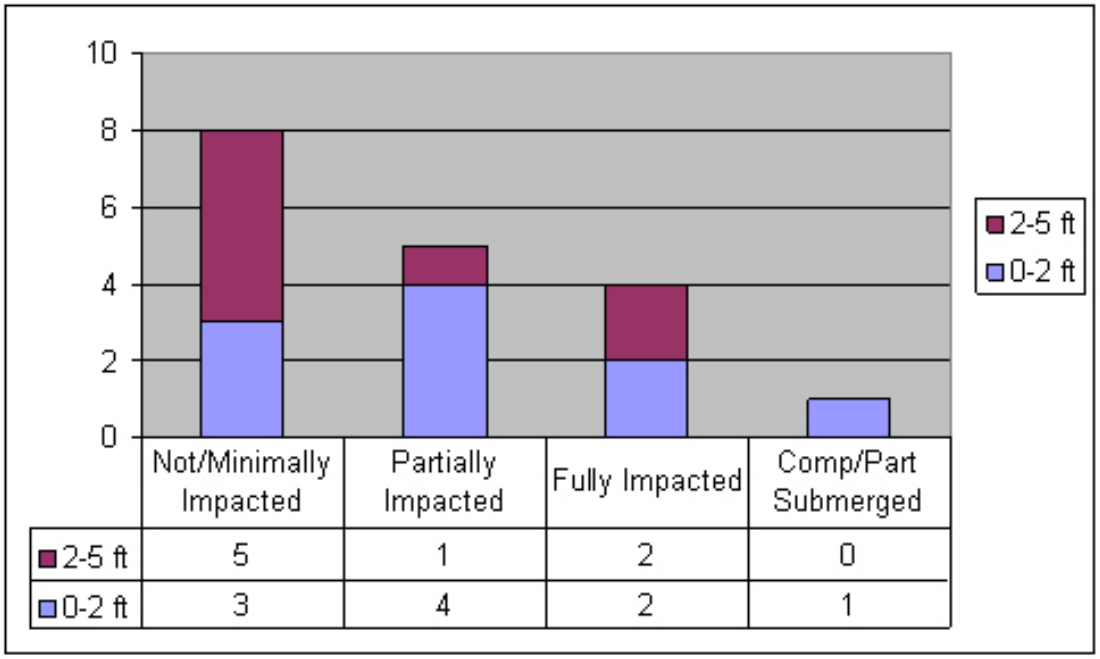
Figure 9: Cemeteries Threatened by Sea Level Rise

The St. Matthews Cemetery in Shady Side was visited as part of this study, and it appears that it will be significantly impacted by sea level rise (Figure 10). Located near the West River headwaters, many of the graves are partially above-ground crypts due to the existing high water table. The cemetery is surrounded on two sides by marsh and is vulnerable to inundation.

Figure 10: St. Matthews Cemetery in Shady Side with Marsh Adjacent to the South Parcel Edge

In general, cemeteries in Anne Arundel County are almost equally threatened by 0-2 ft and 2-5 ft rise, and the majority of the sites will only be marginally impacted (Figure 11). The Adena Burial Ground, a prehistoric burial ground once located on a high bluff overlooking the Rhode River, is one cemetery that has already been destroyed. This highly significant site (dating to around A.D. 350-400) is the only one of its kind ever recorded on the western shore of Chesapeake Bay and yielded an amazing collection of artifacts unique to the County (Figure 12). It was recorded and portions were excavated in the 1950s. Recent archaeological testing (in the late 1990s) has confirmed that this ancient burial ground has completely eroded into the Rhode River (Figure 13). This serves as a reminder that erosion can be a significant threat to resources located on bluffs overlooking the water.

Figure 11: Threatened Cemeteries by Degree of Potential Impact



	Not/Minimally Impacted	Partially Impacted	Fully Impacted	Comp/Part Submerged
2-5 ft	5	1	2	0
0-2 ft	3	4	2	1

Figure 12: Stone Blades Recovered from 18AN18 in the 1950s

Figure 13: Severe Erosion has Already Destroyed the Highly Significant Adena Burial Ground

Archaeological Sites

There are over 1,500 recorded archaeological sites in Anne Arundel County, more than any other County in the State of Maryland. Of these, 113 are located in the City of Annapolis, leaving nearly 1,400 under the purview of the County government. The coast has always been an attractive settlement location, and accordingly, about 30% of the County sites are threatened by sea level rise (Table 9). These include both prehistoric (Native American) and historic (the period since European contact) sites, and account for a strikingly large percentage of our cultural heritage.

Table 9: Archaeological Sites Threatened by Sea Level Rise in Anne Arundel County

Archaeological Sites In Anne Arundel County	Count	% of Total
Threatened by Sea Level Rise	962	70%
Threatened by Sea Level Rise	422	30%

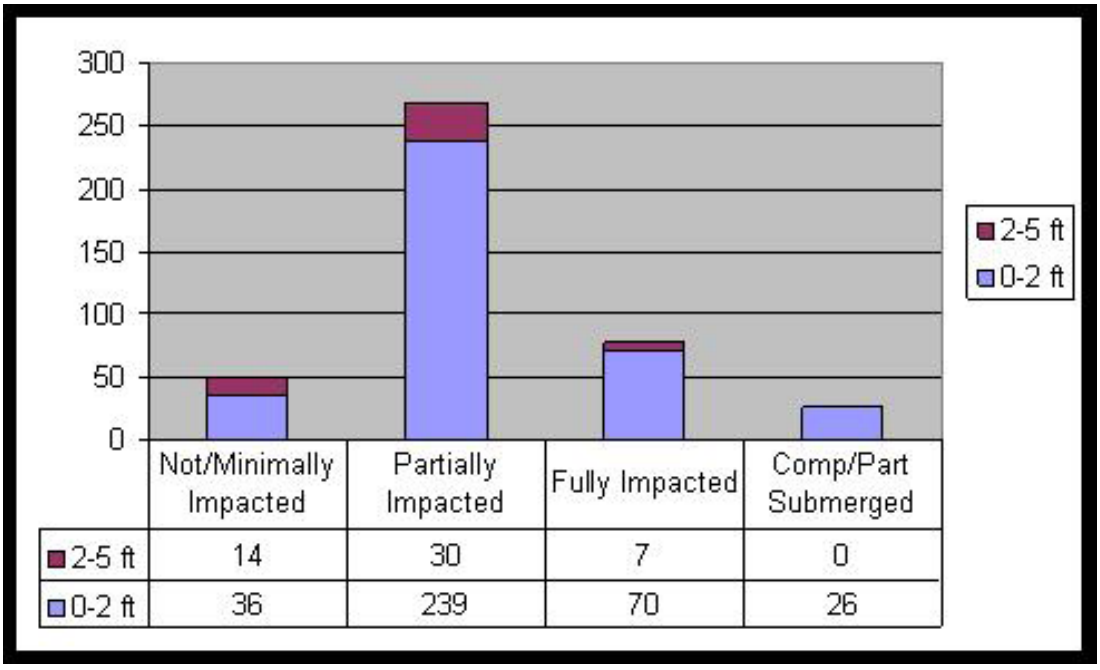
About 63% of the threatened sites are from the prehistoric time period, and represent the only record of the rich Native American cultures that lived here hundreds or thousands of years ago (Table 10). This includes sites with only prehistoric components and several with both prehistoric and historic components. Sites like 18AN225, Contee's Wharf, fall into this category. Located on the Rhode River, this site has both a shell midden that dates to the Middle to Late Woodland periods of prehistory (about 400 B.C. through A.D. 1600) and a late eighteenth century house site. This type of riverine site is representative of dozens in Anne Arundel County that were appealing to vastly different cultures separated by thousands of years.

Table 10: Threatened Archaeological Sites by Cultural Characteristic

Cultural Affiliation	0-2 ft	0-5 ft
Prehistoric	192	215
Historic	80	91
Prehistoric & Historic	43	52
Unknown	56	64
Total	***371***	***422***

About 88% of the threatened sites will experience at least minor inundation by 2 ft of sea level rise (n=371), while the remaining 51 sites will be inundated by up to 5 ft of rise (Figure 14). This is a significant statistic, as it demonstrates that only a conservative estimate of future sea level rise will severely damage the coastal archaeological record of Anne Arundel County. About 6% of the sites have already been submerged by rising seas since they were first recorded. Most of these were once terrestrial or represent the remains of wharfs or other shoreline structures. Two shipwrecks were also included in the dataset because they will also be affected by future sea level rise.

Figure 14: Threatened Archaeological Sites by Degree of Potential Impact



Hundreds of below-ground features have been recorded in these threatened archaeological sites. These include shell middens, hearths, pits, foundations, and burials. By far, shell middens are the most affected feature type. Of the 322 recorded middens in Anne Arundel County, 76% will be impacted by 0-2 ft of rise and 81% will be impacted by the 0-5 ft model (Table 11). This includes 100% of the historic period middens and nearly 60% of the prehistoric middens.

Table 11: Affect of Sea Level Rise on Shell Middens

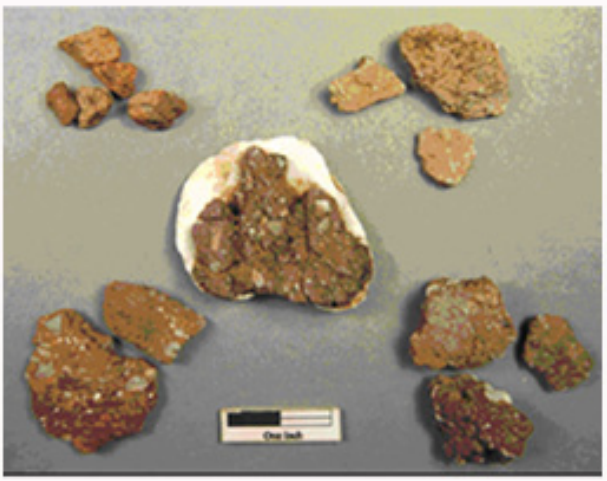
Small Area Plan	Total	Not Affected	Affected by Sea Level Rise	
			0-2 ft	0-5 ft
Unknown affiliation	66	10	50	56
Prehistoric	202	40	153	162
Historic	15	0	14	15

Small Area Plan	Total	Not Affected	Affected by Sea Level Rise	
Prehistoric and Historic	39	10	27	29
Total Number	*322*	*60*	*244*	*262*
Total Percentage		*19%*	*76%*	*81%*

These shell heaps have produced tremendous data about the lifeways of the Native Americans who once depended heavily on the rich oyster beds along the County's coastlines. These ancient people left behind artifacts, including pot sherds and stone or bone tools, as they camped along the local waterways and harvested shellfish for food, trade, and raw materials. Occasionally, the dead were buried in shell middens, as was reported at the Wilde site (18AN530) in Shady Side. This large shell midden was mined for lime in the 1920s, and a Native American skeleton was reportedly unearthed at that time. Its current whereabouts are unknown, and what remains of the midden will be fully inundated by 2 ft of sea level rise.

The Camp Letts 11 site (18AN1285), located along Bear Neck Creek in the Rhode River drainage, is another important shell midden that will be impacted by only 2 ft of rise (Figure 15). In 2007, archaeologists discovered the remains of pottery manufacture that took place on this peninsula during the Middle Woodland period (between about A.D. 200 and A.D. 900). Sherds of failed, soft pottery were found in the shell midden, still adhered to the oyster shells that provided temper. This is an incredibly rare find and represents irreplaceable knowledge that could be lost to sea level rise.

Figure 15: Camp Letts 11 Site is Low-Lying (l) and Susceptible to Sea Level Rise, but has Contributed Greatly to the Knowledge of Ancient Pottery Manufacture (r)

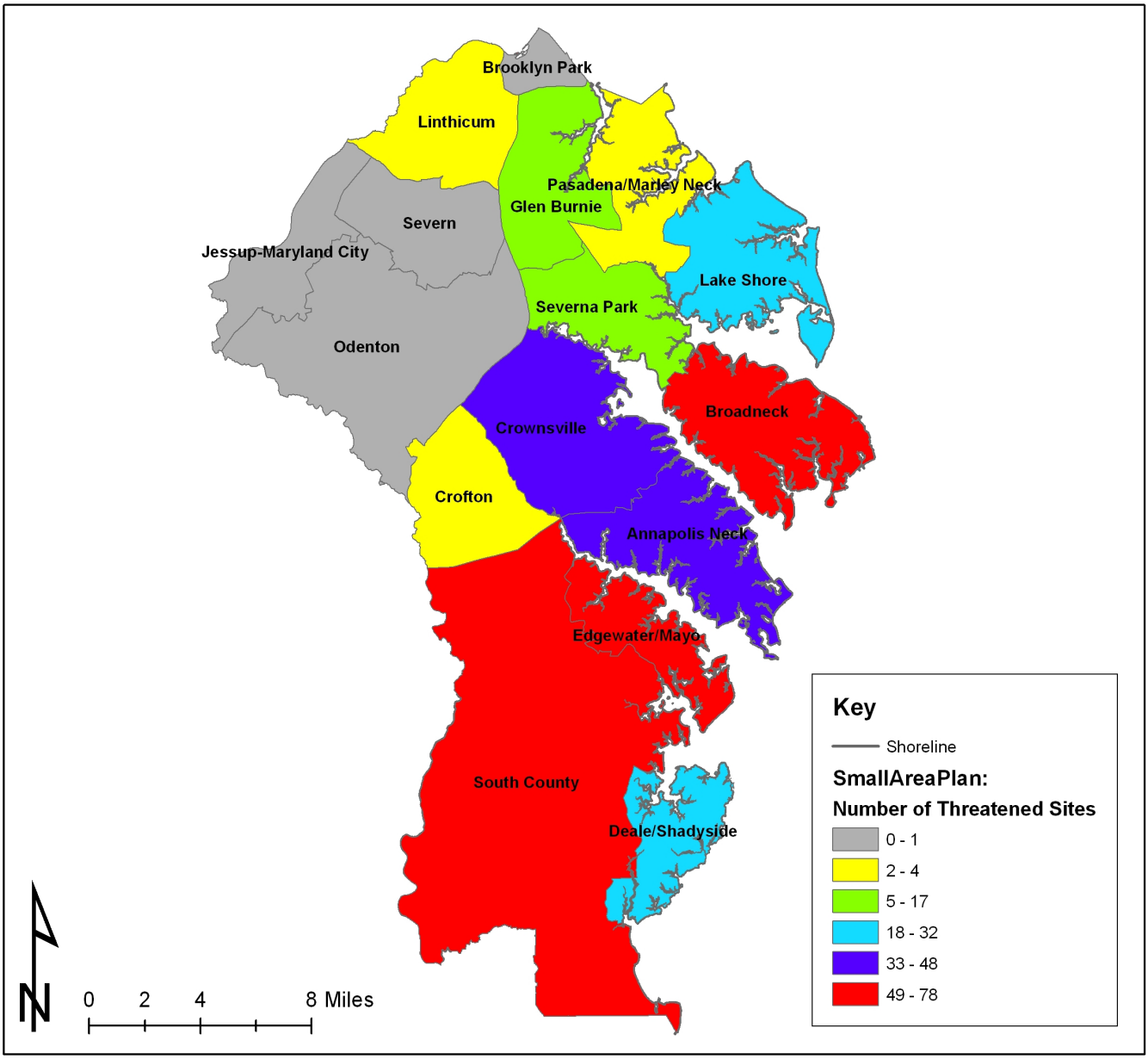


Proportionally more archaeological sites in South County (18%), Edgewater (16%), and Broadneck (16%) will be affected by sea level rise and account for half of the threatened archaeological sites in the county (Table 12; Figure 16). There are two main reasons for this. First, these areas of the County have large swaths of low-lying land that are vulnerable to sea level rise. But second, these areas have traditionally been more intensively explored by archaeologists and researchers over the past century, resulting in more sites registered with the MHT.

Table 12: Threatened Archaeological Sites, grouped by Small Area Plan

Small Area Plan	0–2 ft	0-5 ft	TOTAL %
South County	61	78	18%
Edgewater	62	69	16%
Broadneck	58	68	16%
Annapolis Neck	43	48	11%
Crownsville	38	38	9%
Lake Shore	29	32	8%
Deale/ Shadyside	22	26	6%
None (Already Submerged)	26	26	6%
Severna Park	15	17	4%
Glen Burnie	10	10	2%
Pasadena	3	4	1%
Linthicum	1	3	1%
Odenton	0	0	0%
Brooklyn Park	1	1	0%
Crofton	1	2	0%
TOTAL	***370***	***422***	***100%***

Figure 16: Archaeological Sites Threatened by Sea Level Rise by Small Area Plan



The team set a goal to visit at least 10% of the threatened archaeological sites, divided by Anne Arundel County SAPs. Realizing that visiting every site was beyond the time constraints of the projects time table, a sampling strategy of 10% was determined to be statistically useful for assessing the general state and condition of these sites. In the end, over 20% of the sites were physically visited (Table 13).

Table 13: Number of Sites Visited Per Small Area Plan

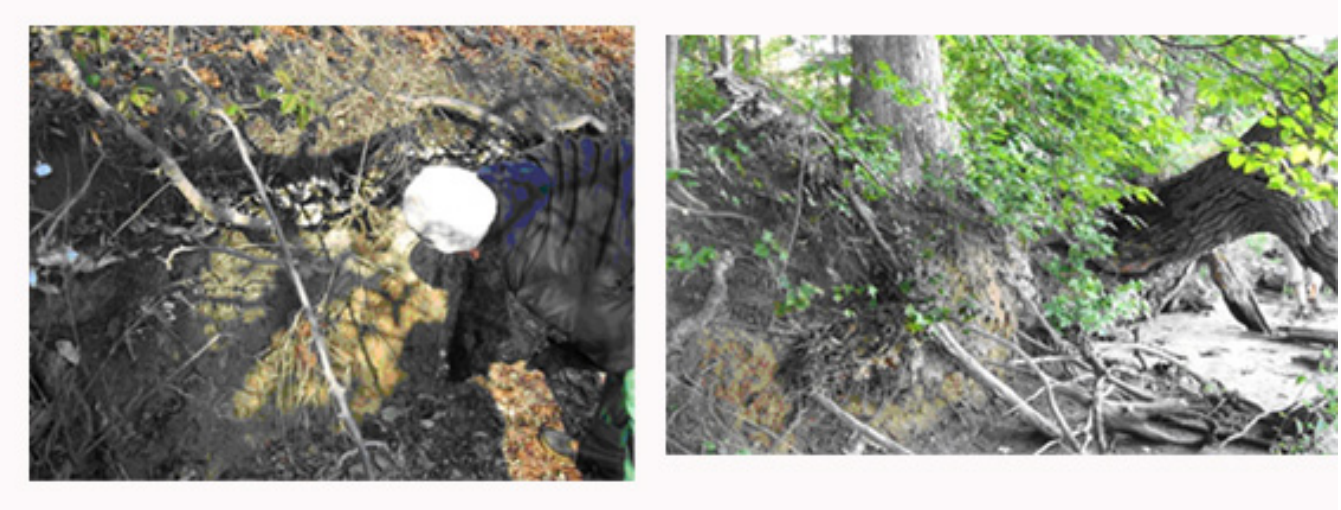
Small Area Plan	Number of Sites Visited
South County	40
Edgewater/Mayo	16
Broadneck	11
Annapolis Neck	6
Deale/Shadyside	5
None/Submerged	5

Small Area Plan	Number of Sites Visited
Crownsville	4
Total	*87*

Sites in Broadneck, Annapolis Neck, Deale/Shadyside, and Crownsville were selected and visited according to the 10% goal, but under a partnership with the Smithsonian Environmental Research Center (SERC), the team was able to visit nearly every threatened site in the Rhode River watershed (which straddles the South County-Edgewater/Mayo SAP line). SERC scientists escorted County archaeologists to 60 coastal sites in their small aluminum "Jonboat", which enabled a holistic and rapid examination of the entire watershed. It was determined that in general, sites in the Rhode drainage are more threatened by coastal erosion than by a bathtub-model inundation of rising sea levels.

This high degree of erosion was evident after a visit to the Fox Creek East II site (18AN287) in the Rhode drainage. This Middle Woodland period shell midden on Fox Creek was identified in 1939, revisited in 1968, and was visited by County archaeologists on January 9, 2009. On that day, a dense shell midden, approximately 60 ft in length, was noted eroding out of the bank. Shovel test pits excavated on the bluff above the midden did not show any additional shell below the ground surface, suggesting the midden had greatly eroded since 1968 (when it measured 90 ft long by 30 ft wide). This site was revisited on June 24, 2010 and the midden is completely eroded away - no evidence of it was visible in the bank, but several oyster shells were noted lying just below the tide line in the water (Figure 17).

Figure 17: Fox Creek III (18AN287) shell midden examined by an archaeologist in 2009 (left) and the severely eroded sterile bank present in 2010 (right)



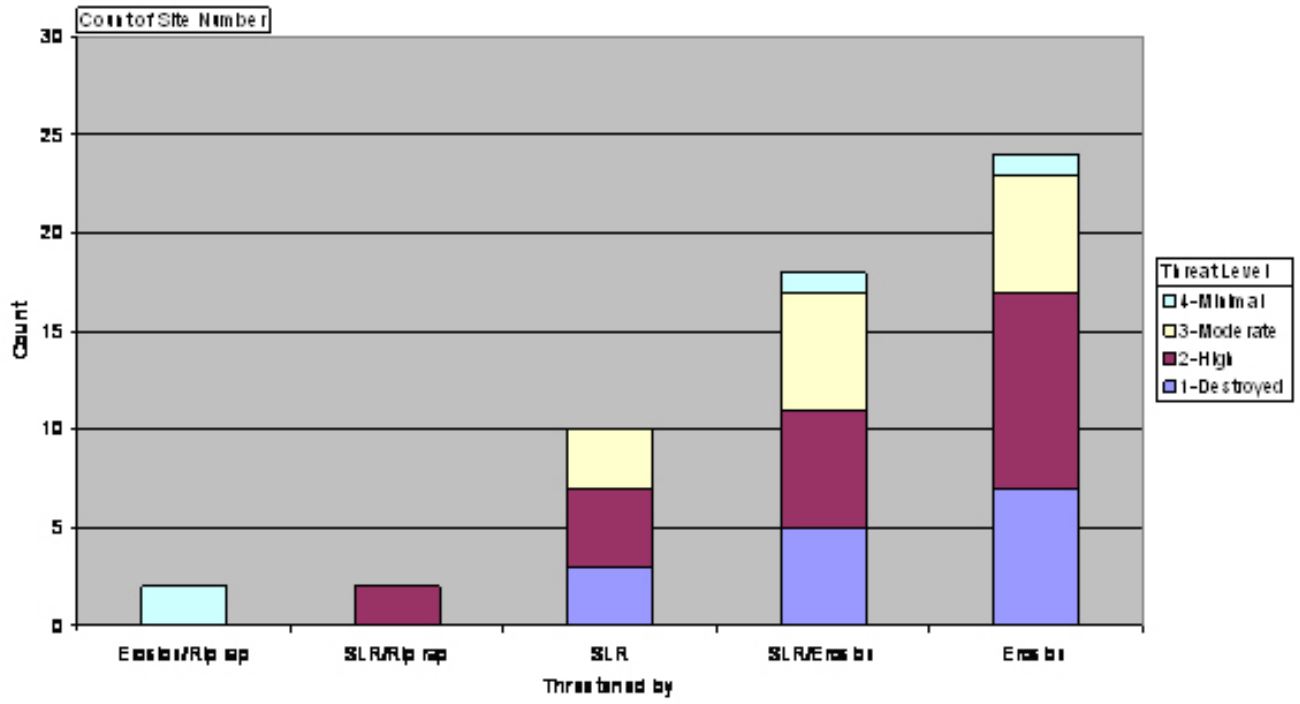
A new site was discovered while exploring the threatened sites of the Rhode River. The so-called "Fleeting Midden" shell midden site (18AN1456) was discovered eroding out of the bank near the southeastern tip of the Camp Letts peninsula. This midden was not discovered during a full-scale investigation of the cultural resources of the Rhode River area conducted by professional archaeologists in 2005 (Cox 2005). The likely reason for this is the severe erosion that has occurred in the five years since this survey took place: it simply was not visible in 2005 and every new storm surge rapidly erodes it further into the Rhode River (Figure 18).

Figure 18: Archaeologists Examine the Newly Discovered Fleeting Midden Site (18AN1456) during the Rhode River Site Visit

In fact, the team established that erosion threatens more archaeological sites in the Rhode River area

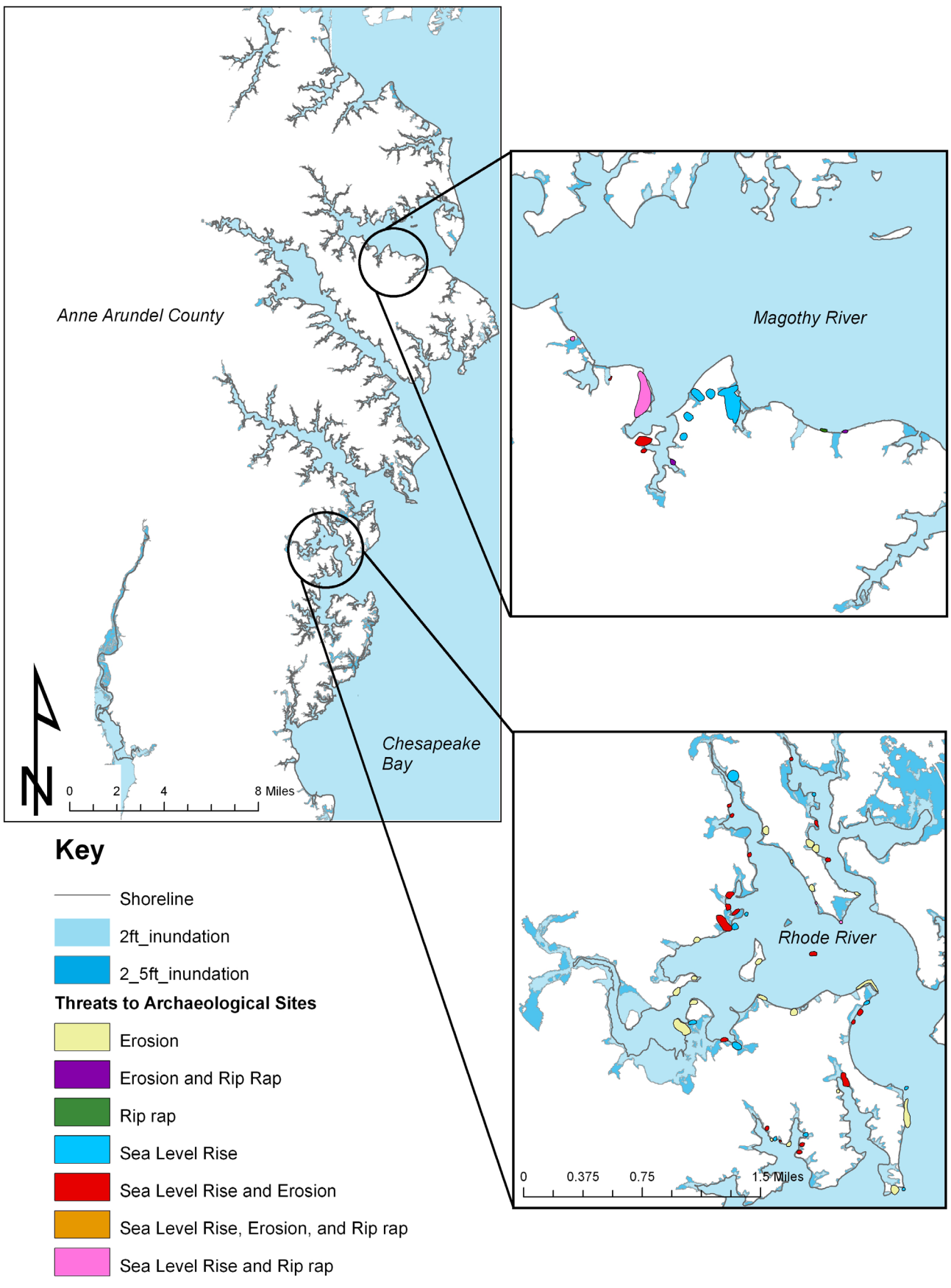
than a "bathtub" inundation model of sea level rise. As Figure 19 demonstrates, of the 56 visited sites in the watershed, about 79% (n=44) are most threatened by erosion alone or a combination of sea level rise and erosion. Only four visited sites are threatened by shoreline stabilization measures, such as rip rap. Figure 19 also suggests that a distressing number of sites are moderately (n=15) or highly (n=22) threatened. Several have already been destroyed by erosion (n=15).

Figure 19: Threats to Rhode River Area Sites



This same general trend was noted throughout parts of Anne Arundel County with lower population density and fewer hard shorelines. However, in areas like the Broadneck SAP, with the high population areas of Severna Park and Arnold, the "bathtub" model of sea level rise is the bigger threat (Figure 20). In this case, large swaths of the coast along the Magothy River are privately owned and have experienced some sort of shoreline stabilization to prevent further erosion. In these cases, the low-lying areas are threatened by rising seas but there is little further threat from erosion. However, this shoreline construction is highly detrimental to fragile coastal archaeological sites, and most of them have likely been destroyed.

Figure 20: SLR Threats to Rhode River and Magothy River Sites



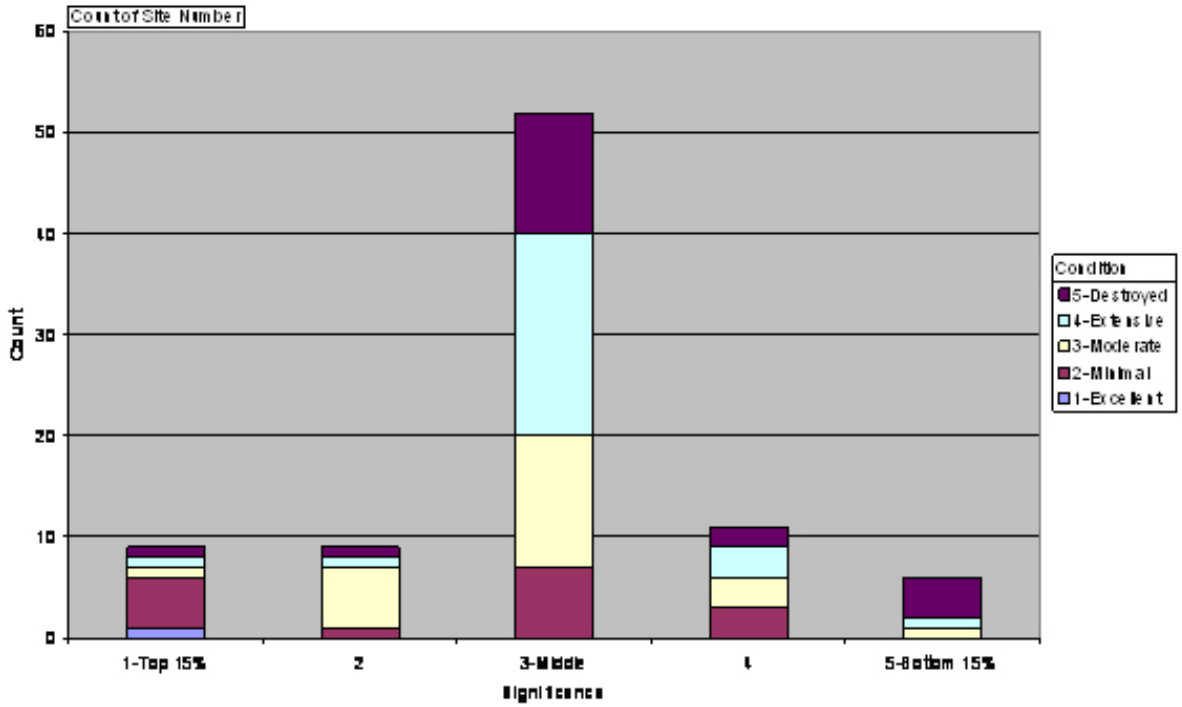
This was also demonstrated in the Annapolis Neck SAP. The owner of the Harness Creek II site (18AN437), a low-density shell midden site recorded in 1977, reported he had never seen an oyster shell or anything resembling a midden on his large waterfront property. When the site was recorded, this part of the South River drainage consisted of agricultural fields, and the existing multi-million dollar homes were later constructed in the 1980s and 1990s. Construction of this development and the subsequent shoreline stabilization likely destroyed the small Early and Late Woodland midden, and what is left is not under threat from erosion. However, the homeowner pointed out that a set of stairs in the lawn that once led to a sandy beach now leads directly into the water (Figure 21). The sea has inundated the beach since they purchased the home over a decade ago.

Figure 21: Stairs Constructed to Provide Access to a Sandy Beach Have Since Been Inundated by Rising Seas at the Harness Creek II Site (18AN437)

Quantifiably ranking the significance of the archaeological sites proved somewhat difficult. There are several nuanced factors that make one site more or less significant than another. The team decided to rank every visited shell midden as a "3", or mid-range significance, unless they were extraordinary in some way. Sites that had been recorded with intact features or were unique in some way were given higher rankings, while poorly defined sites were few artifacts were given lower rankings.

Current conditions were not considered when ranking the sites' significance, but rather had their own category, ranging from excellent (or, intact) to destroyed. Figure 22 compares the significance of a site with its current condition. As this shows, a majority of the more significant sites are better preserved, while a majority of the less significant sites have sustained more damage. The mid-range sites have about equal percentages of intact and destroyed sites. In general, it seems that the more significant and high profiles sites have either been preserved or have been intentionally left alone after recordation while the lower profile sites are often destroyed by construction or have eroded away.

Figure 22: Conditions of Visited Sites by Significance



Section 4 – Summary and Conclusions

An innovative and wide-ranging study of the potential threats of sea level rise to heritage resources was undertaken by the Cultural Resources Division of Anne Arundel County's Department Planning and Zoning. The overall goal was to produce a vulnerability study of archaeological sites, historic buildings and districts, scenic and historic roads, and cemeteries. In order to reach this goal, a comprehensive literature search was conducted, followed by a desk audit survey of all the 422 threatened archaeological sites, 74 historic buildings or structures, 11 historic districts, 14 scenic and historic roads, and 18 cemeteries.

A goal was set to physically visit 10% of the threatened archaeological sites by their geographic location in the County (based on Small Area Plan), but ultimately, over 20% of the sites were visited due to a partnership with the Smithsonian Environmental Research Center (SERC). SERC scientists escorted project archaeologists to every threatened site in the Rhode River watershed and several under their jurisdiction in the West River drainage. During the site visits, each resource was ranked according to its significance, condition, level of previous investigation, threat level, and individual threats. No excavation took place during this study.

About 30% of the recorded archaeological sites in Anne Arundel County will be impacted by rising seas, and 88% of these will be impacted by the more conservative estimate of 0-2 ft of rise. The impact will be felt by both prehistoric and historic sites located mainly in the eastern part of the County along the Magothy, Severn, South, Rhode, and West Rivers and on Herring Bay. A few sites along the Patuxent River and Jug Bay will also be impacted, but considering this river flows through only a small portion of the County after the head of tide (near Queen Anne's Bridge), these sites may avoid major damage.

Erosion is more of a threat to sites in parts of the County that have experienced minimal shoreline stabilization measures. The bluffs that typify this part of the Chesapeake Bay watershed are particularly susceptible to erosional forces intensified by a changing climate. In more populated, wealthy areas,

where large swaths of the coast have already been stabilized, sea level rise is the bigger threat. This assumes that anything is left of the site once the construction is completed – this is not often the case.

Shell middens, generally given a "moderately significant" ranking in this study, represent the single site type that will be most affected by sea level rise. About 76% of the recorded middens will be inundated by 2 ft or rise and over 81% will be inundated by 5 ft of rising seas. This represents a striking loss of a tremendous amount of information about the ancient prehistoric and more recent historic residents of the County.

As this project continues into Year II, the team will consider the public outreach efforts put forth by the British government and non-profit groups to engage the public to become stewards of their heritage resources. The team will also work closely with the State of Maryland's Historic Preservation Office on developing appropriate policies and responses from the Cultural Resources community to this natural threat. Working with archaeologists and planners with the State will ensure that the detailed research conducted by Anne Arundel County and the lessons learned from this intensive study will benefit the entire State. While not every site can, or should, be saved from destruction by natural forces, heightening awareness of the rich heritage resources that surround us is the first step towards mitigating the damage that we may see inflicted upon our cultural heritage in the coming decades.

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