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The opinions expressed herein are solely those of the authors and do not necessarily represent the official opinion of the Environmental Protection Agency.

The primary referring page for this report is

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CHAPTER 6

MARYLAND

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SUMMARY

Sea level is rising 3-4 millimeters per year (12 to 16 inches per century) along the Maryland coast. Beaches are eroding along the Atlantic Ocean and Chesapeake Bay. Especially in the lower Eastern Shore, marshes are converting to open water, and low-lying farms, forests, and residential yards are gradually converting to marsh. Water levels in roadside ditches rise and fall with the tides in Dorchester and Somerset counties. All of these effects would become more commonplace if rising global temperatures cause the rate of sea level rise to accelerate. The Intergovernmental Panel on Climate Change, for example, estimates that by the end of the next century, sea level is likely to be rising 0 to 8 mm/yr (3 inches per decade) more rapidly than today (excluding the possible impacts of increased ice discharges from the Greenland and Antarctic ice sheets).

Rising sea level erodes beaches, drowns wetlands, submerges low-lying lands, exacerbates coastal flooding, and increases the salinity of estuaries and aquifers. Coastal communities must ultimately choose between one of three general responses:

- *Armor the shore* with seawalls, dikes, revetments, bulkheads, and other structures. This approach preserves existing land uses, but wetlands and beaches are squeezed between the development and the rising sea.
- *Elevate the land* and perhaps the wetlands and beaches as well. This approach can preserve both the natural shores and existing land uses, but often costs more than shoreline armoring.
- *Retreat* by allowing the wetlands and beaches to take over land that is dry today. This approach can preserve natural shores, but existing land uses are lost.

Each of these approaches are being pursued somewhere in Maryland. Stone revetments are common along developed shores of Chesapeake Bay and the Potomac River. The federal and state governments have placed sand onto the eroding recreational beaches at Ocean City, Maryland. In the aftermath of Hurricane Isabel, homes have been elevated in many communities. Although few homes have been lost to erosion recently, some rural homes have been abandoned as rising water tables impair septic systems and convert yards to marsh; and substantial farm land is converting to marsh in Dorchester and Somerset counties.

Nevertheless, there is no explicit plan for the fate of most low-lying coastal lands as sea level rises. Environmental planners do not know whether to assume that the coastal wetlands will be lost or simply migrate inland. Those who plan coastal infrastructure do not know whether to assume that a given area will be submerged by rising waters or protected from the sea. And even in developed low lands that will presumably be protected, public works departments do not know whether to assume that the land surfaces will gradually be elevated or that the area will be protected with a dike.

This report develops maps that distinguish shores that are likely to be protected from the sea from those areas that are likely to be submerged, assuming current coastal policies, development trends, and shore protection practices. Our purpose is primarily to promote the dialogue by which society decides where to hold back the sea and where to yield the right of way to the inland migration of wetlands and beaches. A key step in evaluating whether new policies are needed is to evaluate what

would happen under current policies. The maps in this report represent neither a recommendation nor an unconditional forecast of what will happen, but simply the likelihood that shores would be protected if current trends continue.

We obtained statewide land use, planning, and conservation data, and comprehensive plans for the 9 coastal counties who thought that we needed it. We consulted with all 16 coastal counties and the City of Baltimore about how to best interpret the data given existing statutes, regulations, and policies. In some cases, hand renderings were necessary because of the unavailability of digital data. The result is a regionwide series of maps that uses existing data, filtered through the local governments who plan and govern how land is used.

By "shore protection" we mean activities that prevent dry land from converting to either wetland or water. Activities that protect coastal wetlands from eroding or being submerged were outside the scope of this study. This study does not analyze the timing of possible shore protection; it simply examines whether land would be protected once it became threatened. Nor do we analyze whether shore protection is likely to be a transitional response or sustained indefinitely.

The maps divide the dry land close to sea level into four categories of shore protection:

- Shore protection almost certain (brown);
- Shore protection likely (red);
- Shore protection unlikely (blue); and
- No shore protection, i.e., protection is prohibited by existing policies (light green).

For reasons related to data quality, our study area includes lands within about 17–18 feet (about 5 meters) above the tides. (We did not project the fates of military lands in rural areas but depicted them in red so that they stand out.)

One can also view these maps as representing three shore protection scenarios. For example, in an "enhanced wetland migration" scenario, only the areas depicted in brown would be protected; but in an "enhanced shore protection" scenario, only the areas depicted in light green would be submerged. Thus the prospects for shore protection are best understood in the areas shown in brown and light green, while those shown in red and blue are most amenable to coastal planning. "Expected shore protection" is an intermediate scenario in which the areas depicted in brown and red are protected, while those shown in blue and light green are submerged.

Results

Map 6-1 shows our assessment of the likelihood of shore protection for the coastal zone of Maryland and adjacent areas in Delaware, Virginia, and the District of Columbia. Table 6-1 quantifies the area of land within approximately 3 feet (1 meter) above the tides for each of the shore protection categories by county. Table 6-2 quantifies the length of shoreline along the Atlantic Ocean, Chesapeake Bay, and Potomac River by likelihood of shore protection.

All of Maryland's 31-mile (51-km) ocean coast is part of either Ocean City (9 miles) or Assateague Island National Seashore (22 miles). City and state officials are committed to defending the current shoreline of Ocean City. National Park Service officials are generally committed to allowing natural shoreline retreat. (Our maps omit recent plans to nourish the northern portion of Assateague Island as part of an effort to protect developed areas.) The mainland behind the barrier islands includes developed and undeveloped lands. The areas opposite Ocean City and the northern third of

Assateague Island are being developed. The mainland shore opposite the southern third of Assateague Island is subject to conservation easements that allow shore protection but preclude the development that would make shore protection likely. Aside from a few small settlements, the mainland opposite the middle third of Assateague Island is undeveloped. Although development is expected, efforts are under way to acquire conservation easements in some of these areas, and a countywide setback precludes the land immediately next to the shore from being protected.

Along Chesapeake Bay and its tributaries, the shore has been densely developed in and around Annapolis, Baltimore, and Washington—and moderate density development is along most of the Western Shore. In the 1980s, the state legislature recognized that continuation of current trends would eventually lead to the development of most privately owned lands along the shore, to the detriment of Chesapeake Bay. It enacted the Critical Areas Act, which limits development to one home in 20 acres in resource conservation areas, i.e., about 90 percent of the land within 1,000 feet of the shore that had not been developed or subdivided by 1985. Shore protection is uncommon along agricultural shores in Maryland, though it does occur elsewhere. As a result, shore protection is unlikely in resource conservation areas. In an “enhanced shore protection scenario,” however, these lands could be protected.

Maryland’s Critical Areas Act has the greatest impact on the Eastern Shore, where most of the shore had not been developed before 1985 because of the greater distance from major population centers. Development and expected future shore protection are most concentrated in the northern areas near Interstate-95, Kent Island, and the various necks near Easton and St. Michaels. County planners view development—and hence shore protection--as unlikely or precluded along half of the Chesapeake Bay shoreline between the Susquehanna and Choptank rivers. Among the major tributaries, shore protection is unlikely along most of the Sassafras, Chester, and Choptank rivers, but almost certain along most of the Wye, Elk, and North East rivers. Given current policies, only 40 percent of the land area within 1 meter above spring high water is likely or certain to be protected.

Along the western shore of Chesapeake Bay, by contrast, approximately 55 percent of the shoreline is almost certain to be protected, and shore protection is likely along another 20 percent. Compared with the Eastern Shore, Maryland’s Critical Areas Act is unlikely to preserve a major portion of the Western Shore, which was largely developed before the act was passed. Along the Western Shore, parks—not state regulation--account for most of the shoreline where protection is unlikely.

The land along the Western Shore of Chesapeake Bay is generally higher than along the Eastern Shore. With the exceptions of the Deal/Shady side area in Anne Arundel and military lands near Aberdeen, the 10-ft contour is generally within a few hundred feet of the shore—and often only tens of feet inland. Although very little land is being submerged by the rising sea, many shores are eroding. Stone revetments are common along the mostly developed shores of Anne Arundel and Baltimore counties.

Yet the Western Shore also has one of the only shore protection policies in the nation that prohibits shore protection along an estuary, even when the prohibition means that homes will be lost. Calvert County’s cliff erosion policy is designed to preserve the unique cliff areas that border Chesapeake Bay. These cliffs provide habitat to plants and wildlife, including endangered species, and also contain one of the largest exposures of fossils from the Miocene Age. Along approximately 7 miles of cliff, the County requires homes to be set back 300 feet and bans shore protection. Along another 5 miles, shore protection is allowed to protect only homes built before 1997.

The land along the Potomac River is generally steep, with only a few small communities below the 10-ft contour. With the state's first capital at St. Mary's City, several small longstanding resorts, and boating equivalent to that of Chesapeake Bay, the Potomac shore below the U.S. 301 bridge was largely developed or subdivided before passage of the Critical Areas Act. Above the bridge, however, almost all of Charles County is within a resource conservation area or owned by the military. Thus, the amount of Potomac River shoreline where shore protection is unlikely in Charles County alone (30 miles) is greater than the amount of shoreline along the entire Western Shore of Chesapeake Bay (16 miles) where shore protection is unlikely. Given its proximity to the nation's capital, about half of the Potomac shore in Prince George's County is developed; but 36 miles of shoreline along the Potomac and its tributaries are owned by the National Park Service and other conservation entities that preclude shore protection.

Findings

1. *The prospects for shore protection appear to be largely established along all of the 31-mile Atlantic Ocean coast.*

- High property values and dense development make shore protection almost certain along 9 miles in Ocean City.
- Conservation policies preclude shore protection along the other 71 percent of the ocean coast, which is part of Assateague Island National Seashore.

2. *Along the 768 miles of estuarine shoreline, the prospects for shore protection are much less certain than along the ocean. These lands include approximately 173.3 square miles of dry land within about 3 feet (1 meter) above the tides.*

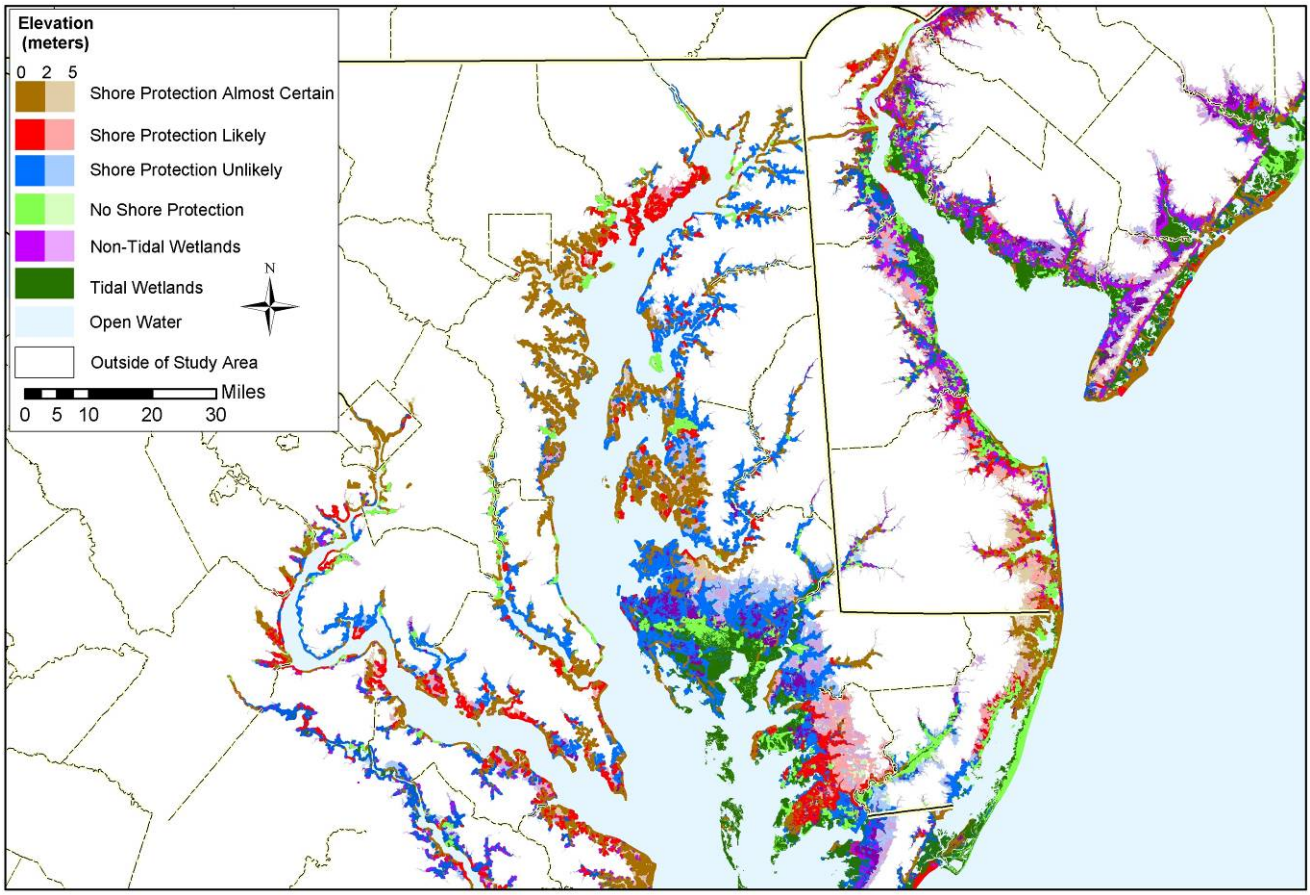
- Only 36 percent of the estuarine shore is developed enough for planners to view shore protection as almost certain.
- Approximately 1 percent of the estuarine shores are within conservation areas.

3. Despite the momentum toward coastal development, all of our options still appear to be open for more than 72 percent of the low dry land in Maryland.

- Development and shore protection are likely on about 27 square miles within about 3 feet (1 meter) above the tides; but it is not too late to design land use plans that could accommodate both development and wetland migration.
- In the other 97 square miles, development and shore protection seem unlikely today. Most of these lands are agricultural areas with conservation easements, or resource conservation areas in which state law limits development to no more than one home in 20 acres. Although shore protection is unlikely given today's practices, regulations and conservation easements generally allow shore protection.

4. The areas where shore protection is unlikely are concentrated along the Eastern Shore of Chesapeake Bay, the southern portion of Worcester County, and Charles County along the Potomac River.

- Shore protection is likely or almost certain along 76 percent of the 117 mile Western Shore, but only 40 percent of the 133-mile eastern shore.
- Shore protection is likely or almost certain along 58 percent of the Potomac River's 97 mile shoreline, but only 41 percent of Charles County's 56-mile shore.
- Shore protection is likely or almost certain along 99 percent of northern Worcester County's 28-mile shoreline, but only 25 percent along Worcester's southern, 112-mile coastline.



Map 6-1. Maryland: Likelihood of Shore Protection. For each shore protection category, the darker shades represent lands that are either less than 7 feet (2 meters) above spring high water or within 1,000 feet of the shore. The lighter shades show the rest of the study area. This map is based on data published between 1987 and 2003, and site-specific changes suggested by planners in 2002 and 2003.

Table 6-1.
Area of Land within 3.3 feet (1 meter) above Spring High Water by Likelihood of Shore Protection [1]
(square miles)

County	Likelihood of Shore Protection				Nontidal Wetlands	Total[1]	Elevation Error[2] (inches)	Tidal Wetlands
	Almost Certain	Likely	Unlikely	No Protection				
Chesapeake Bay Western Shore								
Harford	0.2	5.8	0.8	0.1	1.1	8.0	29	11.3
Baltimore	1.7	1.3	0.2	0.7	0.2	4.2	8	4.0
Baltimore City	0.7	0.0	0.0	0.0	0.0	0.8	30	0.1
Anne Arundel	2.6	0.1	1.3	0.1	0.4	4.5	16	4.7
Calvert	0.8	0.0	0.6	0.0	0.3	1.8	30	5.6
Chesapeake Bay Upper and Central Eastern Shore								
Cecil	0.4	0.0	0.5	0.0	0.1	1.1	30	4.8
Kent	1.1	0.1	2.4	0.2	0.7	4.5	19	7.1
Queen Anne's	1.5	0.1	1.5	0.1	0.9	4.1	8	8.3
Caroline	0.4	0.0	1.4	0.0	0.8	2.7	25	5.6
Talbot	3.4	0.5	2.2	0.0	0.3	6.6	7	10.1
Chesapeake Bay Eastern Shore								
Dorchester	5.8	0.7	60.7	4.9	24.2	96.3	7	164.2
Wicomico	0.8	0.1	7.3	0.7	4.6	13.5	7	25.7
Somerset	4.6	13.9	10.8	3.9	7.4	40.7	7	101.1
Worcester	0.5	0.0	0.8	0.4	0.5	2.2	8	9.1
Anacostia River								
Prince George's	0.0	0.0	0.0	0.1	0.0	0.2	30	0.0
Potomac River								
Charles	0.4	1.5	2.1	0.2	1.4	5.6	30	8.6
Prince George's	0.1	0.0	0.0	0.2	0.1	0.4	30	0.6
St. Mary's	1.8	1.1	1.7	0.0	0.7	5.3	30	4.1
Patuxent River								
Prince George's	0.2	0.0	0.0	0.2	0.2	0.6	30	4.8
Charles	0.0	0.0	0.1	0.2	0.1	0.3	30	0.5
St. Mary's	0.6	0.4	0.7	0.0	0.5	2.2	19	2.7
Atlantic Coast								
Worcester	5.0	1.4	1.9	3.7	2.7	14.7	8	45.2
Maryland	**32.8**	**27.2**	**96.9**	**15.7**	**47.0**	**220.3**		**428.2**

1. The estimates reported here are based on elevation data available at the time of the study. Since this study was conducted, the State of Maryland has developed more detailed elevation data from LIDAR. The data are available from the Maryland Department of Natural Resources.
2. Total Land includes the five categories listed plus land for which no data were available.
3. This table is based on the area of map polygons within 3.3 feet (1 meter) above the tides. Although the area of the polygons can be tabulated very precisely, the 3.3-ft (1-m) elevation estimate is subject to the accuracy limits of the underlying elevation data. The elevation error column displays the accuracy limits (root mean square error) of the data used to identify the 1-m elevation contour.

Source: See Table B-2 in Appendix B for details.

Table 6-2. Shoreline Length by Major Water Body and Likelihood of Shore Protection (miles)

County	Likelihood of Shore Protection				Nontidal Wetlands	Totals
	Almost Certain	Likely	Unlikely	No Protection		
Chesapeake Bay	106	38	76	17	14	250
Anne Arundel	32	0.7	6	0	<0.1	39
Baltimore	1	3	0.6	1	<0.1	6
Calvert	17	0.8	3	8	1	30
Cecil	5	2	3	3	0.4	13
Dorchester	6	2	19	0	2	29
Harford	2	16	2	0	1	21
Kent	4	3	18	0	0.8	26
Queen Anne's	9	0	4	0.2	1	14
Somerset	7	5	12	4	7	35
St. Mary's	13	5	3	0	0.4	21
Talbot	8	0.8	4	0.6	<0.1	13
Wicomico	2	0	1	0	0	3
Chester River	12	1	23	<0.1	4	40
Kent	0.8	0.1	11	0	1	13
Queen Anne's	11	1	12	0	3	27
Choptank River	21	6	44	0.3	1	72
Caroline	0.9	<0.1	8	0	1	10
Dorchester	14	6	12	0	<0.1	32
Talbot	6	0	24	0.3	0.2	31
Nanticoke River	9	0.3	29	3	6	47
Dorchester	3	0.3	17	0.3	2	23
Wicomico	6	0	13	3	4	26
Patapsco River	19	0.5	2	<0.1	0.2	22
Anne Arundel	3	0	1	0	0	4
Baltimore	5	0.5	0.2	0	0	6
Baltimore City	11	0	0	0	0.2	11
Patuxent River	25	8	31	4	0.4	68
Calvert	5	4	25	0	<0.1	34
Charles	1	0	0.8	1	0	3
Prince George's	5	0	0	1	0.2	6
St. Mary's	15	4	5	1	0.1	25
Potomac River	32	24	34	5	2	97
Charles	13	10	30	2	1	56
Prince George's	6	0.4	0	3	0	9
St. Mary's	14	13	4	0	1	32
Susquehanna River	6	<0.1	8	3	2	19
Cecil	5	0	4	0	1	10
Harford	1	0	4	3	1	9
Wicomico River	5	6	19	2	9	41
Somerset	4	6	8	1	3	22
Wicomico	0.4	0	10	0.5	6	17
Atlantic Ocean						
Worcester	9	0	0	22	0	31
Back Barrier Bays						
Worcester	40	6	10	47	4	107
State Total [1]	**2336**	**917**	**3430**	**655**	**365**	**7703**

[1] Includes tributaries to the major water bodies.
Source: See Appendix A for details

INTRODUCTION

Sea level rise creates unique problems for coastal communities, from loss of wetlands and beaches to loss of property and homes. Although geologists and climatologists disagree on the rate of sea level rise, they do not dispute that the seas will continue to rise. Tide gauge stations suggest that sea level has been rising by 1.4 inches per decade (3.5 mm/year) at Annapolis and Solomons Island, and 1.3 inches per decade (3.2–3.4 mm/yr) at Baltimore, Washington, D.C., Lewes, Delaware, and at Kiptopeke Beach, Virginia. Continuation of these historical rates would imply sea level rise of approximately 8 inches (21 cm) between 1990 and 2050, but the potential impact of climate change increases the "best-guess" sea level rise scenario for that period to approximately 1 foot (31 cm).[1,2]

A continued rise in sea level of the historical rate alone (1 foot per century) will have significant impacts along the low-lying areas of Maryland. According to Titus and Richman, 910 square miles (2,353 square kilometers) of land are below the approximately 11-ft (3.5-m) elevation contour, and of that, more than 600 square miles (1,547 square kilometers) are below the 5-ft (1.5-m) elevation contour.[3] With 70 percent of Maryland's residents currently living within the coastal zone area, rising water could prove to be extremely costly and devastating to many coastal communities and private landowners.[4]

Low-lying and higher elevation lands along the coast may also be threatened by other coastal hazards such as erosion and storms. Approximately 31 percent of Maryland's 4,360-mile coastline is currently experiencing some degree of erosion. Each year, Maryland loses approximately 260 acres of land along Chesapeake Bay to erosion, resulting in a loss of public and private property, historic and cultural sites, recreational beaches, productive farmland, and forested areas. The problem affects all 16 of Maryland's counties along Chesapeake Bay and the Atlantic coastline.[5]

Table 6-3 shows preliminary estimates by county of the land that could potentially be inundated from a 2-ft rise in sea level. Figure 6-1 shows lands vulnerable to that sea level rise.[6] Since these estimates were produced, the State has prepared more detailed analyses of the land vulnerable to inundation. As a result, future studies can more precisely estimate the area of land at specific elevations than we provide in this report.

Purpose of this Study

This study develops maps that distinguish the areas likely to be protected[7] as the sea rises from

[1]Titus, J.G. and V.K. Narayanan, 1995, *The Probability of Sea Level Rise*, EPA 230-R-95-008, EPA Office of Policy, Planning, and Evaluation.
[2]The term "sea level rise" is used as a shorthand for "relative sea level rise."

[3]Titus, J.G. and C. Richman, 2001, "Maps of lands vulnerable to sea level rise: Modeled elevations along the U.S. Atlantic and Gulf coasts," *Climate Research* 18:205–228.

[4]Bernd-Cohen, T. and M. Gordon, 1999, "State coastal program effectiveness in protecting natural beaches, dunes, bluffs, and rocky shores," *Coastal Management* 27:187–217.
[5]State of Maryland Shore Erosion Task Force, Final Report, 2000.
[6]See box on "Reference Elevations and Sea Level Rise" for an explanation of spring high water and sea level rise.

[7]For purposes of this study, "protect" generally means some form of human intervention that prevents dry land from being

the areas where shores are expected to retreat naturally, either because the cost of holding back the sea is greater than the value of the land or because there is a current policy of allowing the shoreline to retreat. This report is part of a national effort by the U.S. Environmental Protection Agency (EPA) to encourage the long-term thinking required to deal with the impacts of sea level rise issues.

Maps that illustrate the areas that might ultimately be submerged convey a sense of what is at stake, but they also leave people with the impression that submergence is beyond their control. Maps that illustrate alternative visions of the future may promote a more constructive dialogue.

For each state, EPA is evaluating potential state and local responses to sea level rise, with a focus on maps showing the likelihood that lands will be protected from erosion and inundation as the sea rises. These maps are intended for two very different audiences:

State and local planners and others concerned about long-term consequences. Whether one is trying to ensure that a town survives, that wetlands and beaches are able to migrate inland,[8] or some mix of both, the most cost-effective means of preparing for sea level rise often requires implementation several decades before developed areas are threatened.[9] For the last 25 years, EPA has attempted to accelerate the process by which coastal governments and private organizations plan for sea level rise, and evaluate whether the nation's wetland protection program will achieve its goals as sea level rises.[10] Preparing for sea level rise requires society to decide which areas will be elevated or protected with dikes and which areas will be abandoned to the sea. A key step toward such a decision is the baseline analysis of what will happen given current policies and trends. This report provides that baseline analysis.

National and international policy makers. National and international policies regarding the possible need to reduce greenhouse gas emissions require assessments of the possible impacts of sea level rise. Such assessments depend to a large degree on the extent to which local coastal area governments will permit or undertake shore protection efforts.[11] Moreover, the United Nations Framework Convention on Climate Change, signed by President Bush in 1992, commits the United States to taking appropriate measures to adapt to the consequences of global warming.

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inundated or eroded. The most common measures include beach nourishment and elevating land with fill, rock revetments, bulkheads, and dikes.

[8] In some areas, wetlands may accrete sufficient sediment to vertically increase elevation and thus avoid inundation. For further information on the potential for wetland accretion, see Reed, D.J., D.A. Bishara, D.R. Cahoon, J. Donnelly, M. Kearney, A.S. Kolker, L.L. Leonard, R.A. Orson, and J.C. Stevenson, 2007, Site-Specific Scenarios for Wetlands Accretion as Sea Level Rises in the Mid-Atlantic Region. In J.G. Titus and L. Strange (eds). *Background Documents Supporting Climate Change Science Program Synthesis and Assessment Product 4.1: Coastal Elevations and Sensitivity to Sea Level Rise*, EPA 430R07004, Washington, DC: U.S. EPA.

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[9] Titus, J.G., 1998, "Rising seas, coastal erosion and the takings clause: How to save wetlands and beaches without hurting property owners," *Maryland Law Review* 57:1279–1399.

[10] EPA began helping coastal communities prepare for an acceleration of sea level rise in 1982, long before the agency developed a policy for reducing greenhouse gases. See, e.g., EPA, 1983, *Projecting Future Sea Level Rise*,. See also the report of EPA's 1983 Sea Level Rise Conference: *Greenhouse Effect and Sea Level Rise: A Challenge for this Generation,* M.C. Barth and J.G. Titus, editors, Van Nostrand Reinhold, New York.

[11] Titus, J.G., et al., 1991, "Greenhouse effect and sea level rise: The cost of holding back the sea," *Coastal Management,* 19:171-204; and Yohe, G., "The cost of not holding back the sea: Toward a national sample of economic vulnerability," *Coastal Management* 18:403–431.

Table 6-3. Area of land vulnerable to sea level rise in Maryland (square miles)[a]

Jurisdiction[b]	Vulnerable Land[c]	Tidal Wetlands	0–2 feet elevation[d]		0–4 feet elevation[d]		0–8 feet elevation[d]	
			Dry land	Nontidal Wetland	Dry land	Nontidal Wetland	Dry land	Nontidal Wetland
Dorchester	220.2	164.2	39.9	16.1	85.2	27.6	127.9	42.0
Somerset	126.8	101.1	20.0	5.7	40.0	8.4	78.0	16.0
Worcester	62.2	54.3	6.3	1.6	18.7	4.0	52.1	9.6
Talbot	12.5	10.1	2.3	0.1	9.7	0.4	46.7	2.0
Caroline	[e]	5.6	[e]	[e]	2.3	1.0	5.1	2.0
Wicomico	34.3	25.7	5.0	3.6	11.5	5.3	25.4	12.2
Queen Anne's	9.7	8.3	1.1	0.3	4.7	1.2	15.7	2.7
Harford	[e]	11.3	[e]	[e]	8.0	1.2	13.9	2.1
St. Mary's	[e]	6.8	[e]	[e]	8.1	1.6	18.6	3.5
Charles	[e]	9.1	[e]	[e]	5.7	1.8	12.8	3.9
Kent	[e]	7.1	[e]	[e]	5.0	0.9	11.2	2.0
Anne Arundel	7.4	4.7	2.5	0.2	5.0	0.5	15.3	3.3
Baltimore County	6.3	4.0	2.2	0.1	5.1	0.3	12.2	0.5
Calvert	[e]	5.6	[e]	[e]	1.8	0.4	3.2	0.7
Prince George's	[e]	5.4	[e]	[e]	1.1	0.4	2.3	0.8
Cecil	[e]	4.8	[e]	[e]	1.4	0.1	3.4	0.5
Baltimore City	0.6	0.1	0.5	0.01	1.0	0.01	2.4	0.02
Howard	0.0	0.0	0.003	0.01	0.01	0.01	0.02	0.02
Statewide totals	**555**	**428**	**96**	**31**	**214**	**55**	**446**	**104**

[a] J.G. Titus and J. Wang. 2008. Maps of Lands Close to Sea Level along the Middle Atlantic Coast of the United States: An Elevation Data Set to Use While Waiting for LIDAR. Chapter 1 in *Background Documents Supporting Climate Change Science Program Synthesis and Assessment Product 4.1: Coastal Elevations and Sensitivity to Sea Level Rise*, EPA 430R07004, Washington, DC: U.S. EPA.

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[b] Jurisdictions ranked by amount of dry land within 2 feet above the ebb and flow of the tides.

[c] The area of tidal wetlands plus the area of land within 2 feet above spring high water.

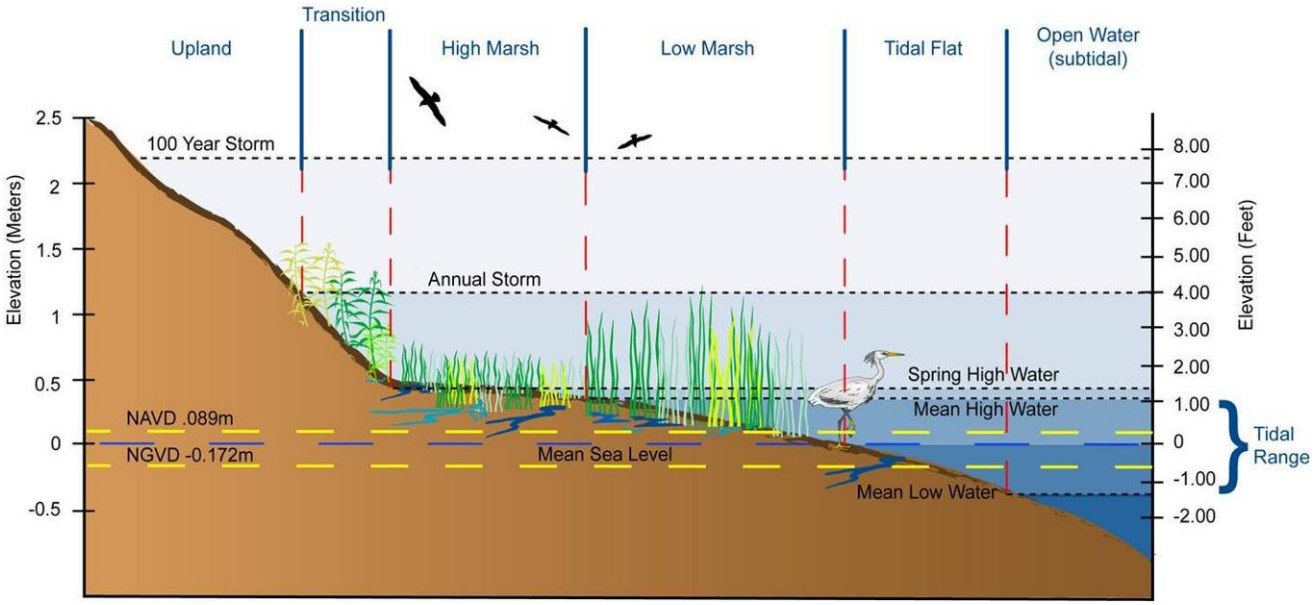
[d] Elevations relative to spring high water, that is, the average highest tide during full moons and new moons. Therefore, the land within 2 feet of spring high water is the area that would be tidally flooded if the sea rises 2 feet.

[e] Value omitted because the topographic information Titus and Wang used for this jurisdiction had poor vertical resolution.

BOX 1: TIDES, SEA LEVEL, AND REFERENCE ELEVATIONS

Tides are caused by the gravitational attraction of the moon and sun on the ocean water. Most places have two high and low tides every day, corresponding to the rotation of the earth. The daily tide range varies over the course of the lunar month. *Mean high water* and *mean low water* are the average elevations of the daily high and low tides. During full and new moons, the gravitational pull of the moon and the sun are in alignment, which causes the tide range to be 15–25 percent more than average. The averages of the full and new moon high and low tides are known as *spring high water* and *spring low water*. In addition to the astronomic tides, water levels fluctuate owing to winds, atmospheric pressure, ocean current, and—in inland areas—river flow, rainfall, and evaporation. Daily tide ranges in the mid-Atlantic are as great as 8 feet in parts of the Delaware River and less than an inch in some of the sounds of North Carolina.

In coastal areas with tidal marshes, the high marsh is generally found between mean high water and spring high water; low marsh is found from slightly below mean sea level up to spring high water. In bays with small (e.g. 6 inch) tide ranges, however, winds and seasonal runoff can cause water level fluctuations more important than the tides. These areas are known as "*irregularly flooded*". In some locations, such as upper Albemarle Sound in North Carolina, the astronomic tide range is essentially zero, and all wetlands are irregularly flooded. Freshwater wetlands in such areas are often classified as "nontidal wetlands" because there is no tide; but unlike most nontidal areas, the flooding—and risk of wetland loss—is still controlled by sea level. Wetlands whose hydrology is essentially that of nontidal wetlands, but lie at sea level along an estuary with a very small tide range, are called *nanotidal wetlands*.



e term *sea level* refers to the average level of tidal waters, generally measured over a 19-year period. The 19-year cycle is necessary to smooth out variations in water levels caused by seasonal weather fluctuations and the 18.6-year cycle in the moon's orbit. The sea level measured at a particular tide gauge is often referred to as local mean sea level (LMSL).

Tide gauges measure the water level relative to the land, and thus include changes in the elevation of the ocean surface and movements of the land. For clarity, scientists often use two different terms:

- *Global sea level rise* is the worldwide increase in the volume of the world's oceans that occurs as a result of thermal expansion and melting ice caps and glaciers.
- *Relative sea level rise* refers to the change in sea level relative to the elevation of the land, which includes both global sea level rise and land subsidence.

In this report, the term "sea level rise" means "relative sea level rise."

Land elevations are measured relative to either water levels or a fixed benchmark. Most topographic maps use one of two fixed reference elevations. United States Geological Survey (USGS) topographic maps measure elevations relative to the National Geodetic Vertical Datum of 1929 (NGVD29), which was approximate sea level in 1929 at the major coastal cities. New maps and high-resolution data measure elevations relative to the North American Vertical Datum of 1988 (NAVD88). This report measures elevations relative to spring high water (for 2000), which indicates how much the sea must rise before the land is inundated by the tides. NAVD88 and NGVD29 should not be used as equivalent to present-day LMSL.

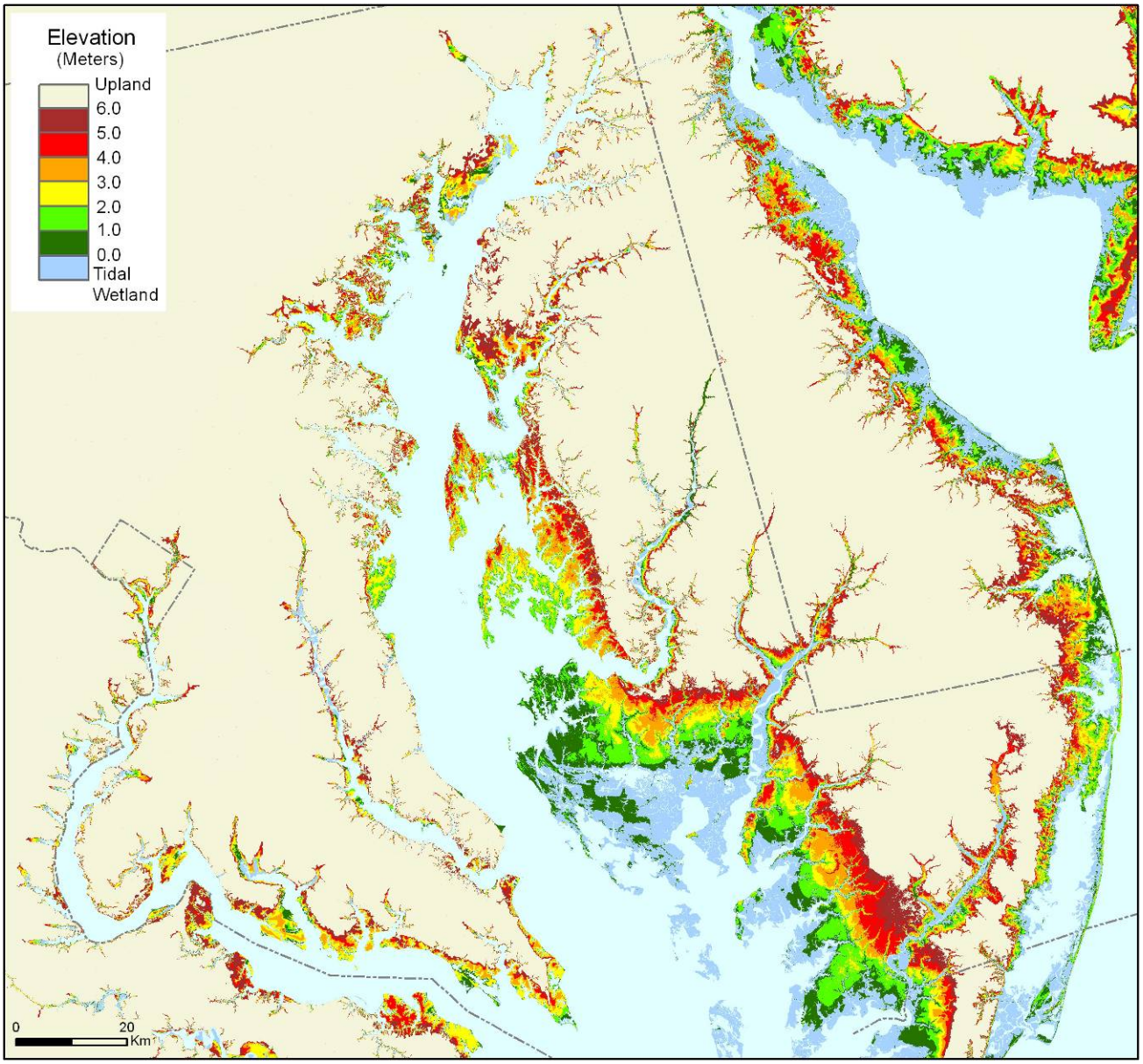


Figure 6-1. Lands Vulnerable to Sea Level Rise. Source: Titus and Wang (see Table 6-3). Elevations are relative to spring high water. Because the map has a contour interval of 1 meter (3.28 feet), we did not convert the legend from metric to the English units used in the text of this report.

Caveats

This report has two fundamental limitations. First, it is literally a "first approximation" of the likelihood of shore protection. Like most first-of-a-kind studies, our effort includes methodological judgments that may later prove ill-advised. We examine the implications of current trends in coastal development and coastal management policies. We have attempted to account for uncertainty by dividing our study area into lands where shore protection is almost certain, likely, unlikely, and precluded by current policies. But many important factors can not be foreseen—and in many cases the only available data are several years old. Therefore, we often relied on planners to fill in the gaps by telling us about recent and expected development. But what is expected now may be different from what was expected when we visited the planners. As new information emerges, assessments of the likelihood of shore protection will change.

Second, this study is not even intended to address all of the issues that some people think about when they hear the term "shore protection." Our intention is to distinguish those lands where a natural retreat would occur from those areas where people will at least attempt to hold back the sea. Our maps are *not* intended to identify:

- the vulnerability of particular lands (we simply evaluate whether lands would be protected *if and when* they are threatened);
- options for protecting existing wetlands (we analyze protection only of dry land);
- which areas will receive government funded shore protection;
- whether people will hold back the sea forever, which would depend on cost factors and scientific uncertainties outside the scope of this analysis; and[12]
- whether hard structures, soft engineering, or some hybrid of the two approaches is likely in areas that will be protected, or the environmental impacts of shoreline armoring.

How to Read this Report

This chapter is one of eight state-specific chapters in Volume 1. Each of the eight chapters was written and reviewed as a stand-alone document, because the authors assumed that many readers are only interested in the analysis of a single state. To assist readers interested more than one state, each chapter (except the short chapter on the District of Columbia) is organized in a similar fashion, including a summary of likely responses, introduction, methods, relevant state policies, city and county-specific policies and responses, results appendices, and other appendices as needed.

Some subsections appear verbatim in each chapter, including the subsections on purpose, caveats, and the text box on tides and reference elevations. Subsections on map scale and use of experts have text that is nearly verbatim, except for changes that reflect state-to-state differences. The methods sections reflect differences in available data for each state, but the study area subsection is nearly the same from state to state.

This chapter has separate sections in which we describe:

- *methods* by which we assess the likely sea level rise responses;
- *state policies* that affect the management of the coastal lands; and
- *county-specific* policies and the likely extent of future shore protection.

At the end of this chapter, we provide detailed quantitative results in three appendices:

(A) best estimates of the length of shoreline by likelihood of shore protection;

(B) best estimates of the area of land at various elevations by likelihood of shore protection; and

(C) uncertainty ranges of the amount of land at various elevations by likelihood of shore protection.

Because the quantitative results were developed after this study was complete, those results are not integrated into the text of this report, other than the summary.

The final appendix (D) provides a complete list of data sources.

[12]For example, the sea could rise 10–20 feet over several centuries if one of the world's ice sheets were to melt. See, e.g., IPCC, 2001, *Climate Change Science 2001*, Cambridge University Press, New York and London.

METHODS

This section provides detailed information on the approaches employed over the course of this study. The following subsections discuss:

- scope of the study area;
- methods used to develop the initial maps;
- our approach for gathering updated information and to confirm the content of the maps and report; and
- the appropriate scale for viewing the resulting maps.

Study Area

The study area consists of dry lands that are either below the 20-ft (NGVD) elevation contour or within 1,000 feet of the shore.[13] We use the 20-ft contour as an inland boundary to be consistent with studies of neighboring states, and to ensure that the study area includes all portions of the state that might be affected by rising sea level during the foreseeable future.[14] This large study area is not meant to suggest that sea level rise would inundate all of these lands. We merely are attempting to avoid the possibility that subsequent improvements in elevation data reveal areas we omitted to be vulnerable. *Although our study area extends to the 20-ft contour, those using our results need not include the higher elevations*. For example, if one wanted to analyze the area protected from inundation with a 3.3-ft (1-m) rise in sea level, one need consider only the land within approximately 3 feet above the ebb and flow of the tides, which would generally be between 5 and 6 feet NGVD in Maryland.[15]

Within the study area, our maps use the following colors for the four categories depicting likelihood of shore protection:

Brown—areas that will **almost certain**ly be protected if and when the sea rises enough to threaten them, assuming a continuation of existing policies and trends.

Red—areas where shore protection is **likely**, but where it is still reasonably possible that shores might retreat naturally if development patterns change or scientists were to demonstrate an ecological imperative to allow wetlands and beaches to migrate inland.

Blue—areas where shore protection is **unlikely** generally because property values are unlikely to justify protection of private lands, but in some cases because managers of publicly owned lands are likely to choose not to hold back the sea.

Light Green—areas where there would be **no shore protection** under existing policies, which already appear to preclude holding back the sea. These areas include both publicly and privately owned lands held for conservation purposes.

Although our maps are based on a continuation of current policies, we were also mindful of the possible implications of changing priorities. If

[13]Until recently, most topographic maps provided contours that measured elevation above the National Geodetic Vertical Datum of 1929. That datum represented mean sea level for the tidal epoch that included 1929, at approximately 20 stations around the United States. The mean water level varied at other locations relative to NGVD, and inland tidal waters are often 3–6 inches above mean sea level from water draining toward the ocean through these rivers and bays. Because sea level has been rising, mean sea level is above NGVD29 almost everywhere along the U.S. Atlantic Coast.

[14]In Delaware, USGS maps generally have a 5-ft contour interval. Available maps for parts of Maryland have 20-ft contour intervals, however, and maps have 10-ft contour intervals for much of Pennsylvania, New Jersey, and Maryland. Numerous assessments have suggested that sea level could rise more than 2 meters over the next few centuries, which would bring the 100-year floodplain up to what is now the 15-ft (NGVD) contour interval.

[15]If the spring tide range is 35 inches (90 cm), the tides extend 18 inches (45 cm) above mean tide level. In Maryland, mean tide level is generally about 8 inches (20 cm) above NGVD29.

the costs or environmental consequences of shore protection led society to deliberately reduce shore protection compared with what one might expect given current policies, then (ignoring site-specific environmental and shore protection cost issues) the light green, blue, and red identify those areas where retreat would be feasible as a matter of land-use planning. If development and/or land values increase beyond what is currently expected, the brown, red, and blue areas might all be protected.[16]

Outside the study area, we generally show nontidal wetlands as purple and tidal wetlands as dark green. We differentiate tidal and nontidal wetlands because the effects of sea level rise are potentially very different. We differentiate nontidal wetlands from dry land because this report evaluated only whether dry land would be protected.[17]

We also include all land within 1,000 feet of tidal wetlands or open water, regardless of elevation, to be consistent with the existing Critical Areas Act boundaries. Extending the boundary inland also accounts for possible cliff erosion, and ensures that the study area is large enough to be seen on maps depicting a county on a single sheet of paper.

Draft Maps

We started the study by researching state and county laws and plans for development to determine the policies that affect coastal management decisions. Next, we conducted meetings with state regulators and county planners to investigate existing and anticipated coastal policies and land uses.[18] Their knowledge about local priorities and wishes allows us to glean broad policy directions based on land use.

State and local officials had not previously assessed the areas that might ultimately be protected, aside from a few areas with well-known erosion problems, such as Ocean City, the cliffs of Calvert County, and the heavily armored shores of Anne Arundel County and the City of Baltimore. Nevertheless, the primary question for this study involves many of the same issues that planners routinely consider most important: Which areas will become densely developed and which areas will be placed off limits to development? Because the results of such considerations are increasingly published as a GIS data layer, we assumed at the outset that, wherever possible, we would rely on available land use data, especially data on land use plans, existing land use and land cover, and boundaries of conservation areas.[19] Table 6-4 lists the data we obtained and used in this study; Appendix D lists the complete documentation.

During the meetings, state and county staff indicated which policies and regulations relate to or could be used to address the threat of sea level rise. County and state planning staff were then asked to consider the anticipated planning responses given rising seas of 1–3 feet in the

[16]During the pilot testing of this multistate study, the initial approach was to obtain planner input on three scenarios of shoreline protection. Those scenarios included 1) Enhanced Protection—protection of all areas that can be protected under existing state and local policies); 2) Expected Protection—an assessment of current as well as anticipated behavior; and 3) Enhanced Wetland Migration—an assessment of alternative policies that would provide greater protection to natural resources (e.g., wetlands) or culturally significant resources.
This report uses the four map colors to—in effect—display all three scenarios on a single map. For additional information on the three scenarios and the relationship to the likelihood of shore protection, see the discussion of the project evolution in the Overview or New Jersey chapter (Chapter 3).

[17]Shore protection designed to protect dry land does not necessarily have the same impact on nontidal wetlands. Erosion control structures designed to prevent homes from eroding into the sea may also protect adjacent nontidal wetlands. Efforts to elevate land with fill to keep it dry would not necessarily be applied to nontidal wetlands. Some nontidal wetlands in developed areas may be filled for development.

[18]Because this assessment is intended to reflect the general consensus of officials within the area depicted, we rely heavily on the informed opinions of local planners. Although available land use and land planning data guide the results and often defined the boundaries in these maps, the expert judgment of local officials generally was the most important source of information.

[19]For example, we use 1997 land use data provided by Maryland Department of Planning to delineate currently developed lands (i.e., residential, commercial, industrial lands). In the state-wide decision rule and county response sections of this report, we identify key GIS layers used in preparation of the maps.

TABLE 6-4. SUMMARY OF GIS DATA APPLIED IN STUDY

Data Name	Application in Study	Source/Scale/ Year Published
Land use/land cover in Maryland	Developed (i.e., residential, commercial, industrial) and undeveloped lands within study area.	Maryland Department of Planning (MDP)/ 1:63,360/ 1997
Maryland Property View	County-specific identifying the location of private property, land use types, and priority funding areas (PFAs).	MDP/ 1:24,000/ Cecil-2000; Caroline-2001; Wicomico-2000; Worcester-1999
Critical Area lands	Used in Anne Arundel and Charles county studies to identify intensely developed areas (IDAs), limited development areas (LDAs), and resource conservation areas (RCAs).	
Federally owned lands	Federal lands, including U.S. Fish and Wildlife Service and military lands.	
State-owned land	Land owned by Maryland's Department of Natural Resources, including state parks, state forests, wildlife management areas, and Natural Heritage Conservation lands.	Maryland's Environmental Resources & Land Information Network (MERLIN) produced by Maryland Department of Natural Resources (DNR) / between 1:24,000 and 1:63,360/ 2000
Agricultural easements/districts	Maryland Agricultural Land Preservation Program identified lands within Agricultural Preservation Districts and lands from which development rights have been purchased.	
Maryland Environmental Trust lands	Land held in conservation easements by the Maryland Environmental Trust.	
Rural legacy lands	Used in Calvert County study to identify rural areas for which the state has purchased land or conservation easements.	
Forest legacy lands	Used in Calvert County study to identify forest lands for which the state has purchased development rights.	
County-owned lands	Park and recreational land owned by the counties.	
Private conservation land	Privately owned natural areas managed for open space and natural resource preservation.	
Maryland Department of Natural Resources wetlands	Used to identify tidal and nontidal wetlands in for the entire study area of Cecil and Caroline counties and portions of Baltimore, Harford, Kent, Talbot, and Dorchester counties.	Maryland DNR// 1:24,000/ 1988 to 1995
National Wetlands Inventory	Used to identify tidal and nontidal wetlands for the entire study area of Prince George, Charles, St. Mary's, Calvert, Anne Arundel, Queen Anne's, Wicomico, Somerset, and Worcester counties and portions of Baltimore, Harford, Kent, Talbot, and Dorchester counties.	U.S. Fish and Wildlife (provided via DNR MERLIN 2000)/ from 1:20,000 to 1:132,000/ 1981 to 2000
Maryland grid maps	Used for eastern shore counties to identify the boundaries of municipalities.	Maryland Department of Transportation/ 1:24,000/ 1998
Baltimore County land use	For Baltimore County, identifies developed and undeveloped lands within the study area.	Baltimore County/ 1:24,000 or better/ 1998
Baltimore County parks	For Baltimore County, used to identify the location of county-owned parks.	Baltimore County/1:24,000 or better/ 2004
Calvert County cliff categories	For Calvert County study, used to identify areas where erosion-prevention structures are not allowed.	Calvert County Planning Department/1:100,000 or better/ 2001
Dorchester digital orthophotoquads	For Dorchester County, used to identify the location of existing development located west of Cambridge and north of Rte. 16.	Maryland DNR/ 1:12,000/ 1991 to present
Worcester County conservation Lands	Private conservation lands and public lands that would not receive shoreline armoring.	Worcester regional GIS/1:24,000 or better/ 2003
Roads	Used to map lands to be protected along a roadway corridor.	Environmental Systems Research Institute Data CD// 1:50,000/ 2001
Study area	Defines landward boundary of study area by identifying lands that are higher than 20 feet in elevation or within 1,000 feet of mean high water based on tidal wetlands data.	ICF Contract to EPA/ 1:24,000 / 2003

Note: Appendix D gives additional detail on each data source.

next 100 years and as much as 10 feet over the next few hundred years. We also discussed public access to the water, economic conditions, areas of cultural or historical importance, and flood-prone areas.

We also asked the planners to identify general categories of lands that would be protected or lost under different circumstances. If possible, those general categories correspond to a designation in a GIS dataset, which enabled us to create a generalized sea level response map by applying a "decision rule" to the data. *We use the term "decision rule" in this report because our processing of land use data treats the county-specified general categories as GIS decision rules; we do not mean to suggest that those categories represent policy decision rules.*[20] Those general categories consider existing policies that influence both future development and shoreline armoring and nourishment and the likelihood of future shoreline protection. For example, a decision rule might be that all development outside designated growth areas will probably be protected (red).

We then identified area-specific exceptions to these general rules. For example, a county might be quite certain that specific towns will be protected (brown), even though they are not within the designated growth areas. These site-specific exceptions sometimes required hand editing of the map.[21] Based on this information, we then developed the maps depicting the relative likelihood of shoreline protection within each county.

The county-specific sections each have a table that describes the data used and the order in which we integrated the data when we created the planning maps. One can visualize the final maps as layers of brown, red, blue, and light green polygons placed on top of one another. Data-specific decision rules classify a particular type of land as brown, red, blue, or light green. If more than one data set has something to say about a particular parcel of land, then our data-integration decision rules determine which dataset takes precedence; i.e., whichever polygon ends up on the "top" of the pile is the polygon that shows up on the final map. Data representing a subset of the land in a particular area (e.g., conservation lands) are placed on top of layers whose polygons cover all the land in the same area (e.g., land use data showing developed versus undeveloped lands). A county-wide default decision rule yields to site-specific or special purpose information. This approach is reasonable because we did not have cases where two different datasets provided alternative estimates of the same boundary; if we had, then we probably would have put larger-scale data on top of smaller-scale data.

County planners tended to suggest similar decision rules. Therefore, we also devised a set of generalized decision rules for the sole purpose of providing the reader with an overview of how counties tended to view the issue. The county-specific sections of this report fully explain the specific assumptions used in creating the maps, including both the county-wide decision rules and any site-specific designations.

County Stakeholder Review

To ensure that our maps correctly conveyed the expectations of county officials, we sent the draft

[20]Some of those "decision rules" are based on current policies; others are based on current expectations. Because current policies were not designed to address accelerated sea level rise, one possible use of this study is as a baseline analysis to help determine whether—and if so where—additional shore protection policies are needed..

[21]These manual edits were made based on the most precise information for effectuating the edits sought by the counties. Planners would typically delineate the boundary of the site-specific change on the draft planning maps (printed at the resolution where the county would fit on a 11×17 page) or on other ancillary maps such as a county map that identifies roadways, and then they would verbally describe the area where a change was desired. We made manual edits using the edit feature in ArcGIS, using the marked map as a guide. Landmarks (e.g., roads) were usually sufficient to guide the transfer from the marked map to the planning data. Where there this was not possible, we applied the closest boundary that could be identified using land use data which, in effect, interpreted planner changes as referring to areas that are designated by existing data. Therefore, the hand changes are unlikely to have changed the scale at which our maps would be valid under national mapping standards.

report and maps to each county and to Baltimore City. In 2002 and 2003, we held follow-up meetings at which we obtained suggested changes to both the maps and the report. Those changes were then incorporated into the report and into the accompanying maps. The county-specific sections of this report explain these stakeholder modifications from the stakeholder review.

Map Scale

Our maps are based on decision rules and previously published data. Therefore, the horizontal resolution at which one should reasonably display our maps is limited by the precision of the input data. Because the different protection designations are identified based on different data sources, the precision varies. For example, areas shown as "shore protection almost certain" are predominately identified by developed lands (residential, industrial, and commercial land) delineated in 1997 Maryland Department of Planning's Land Use data, which are accurate at a scale of 1:63,360. The conservation lands designated as "no shore protection" were mostly identified by the state's MERLIN datasets, which generally range from 1:24,000 to 1:63,360, although a few are worse than that. The areas identified as "shore protection 'likely" were typically created through site-specific changes, often with manual ("heads-up") digitizing at a screen scale between 1:25,000 and 1:50,000. That process can introduce errors, although often the errors are minimal because existing boundaries are used.

Thus, the boundaries between shore protection likely and shore protection unlikely categories are likely to have the least precision. Therefore, it is reasonable to conclude that the site-specific changes caused some deterioration in scale. Stakeholder review generally involved county-scale maps on 11 × 17 paper, i.e., a scale of roughly 1:150,000. This approach tended to further deteriorate precision.

Considering quality of input data and the subsequence deterioration from hand edits, these maps should not be displayed at scales less than 1:100,000.

The quality of our input data is not the primary uncertainty associated with our map boundaries. Future development and shore protection are very uncertain. Thus, the scales we suggest are simply our advice regarding the maximum scale at which one ought to display the maps for a given location, rather than our assessment of the accuracy of what would transpire in the decades ahead assuming current policies and trends.

Use of Experts

This study is a hybrid between a pure data-driven assessment and an expert panel assessment. Like most assessments of shore protection, we start with the premise that (under current policies) lands will be protected if the cost of protection is less than the value of the resources being protected, except for where specific policies dictate otherwise. But estimating the costs and benefits of shore protection at every location would have been infeasible—and possibly involve wasted efforts for areas where the question is not close.

Instead, we adopted a simpler model: First, we identify those areas where conservation lands preclude shore protection, areas that governments have decided to revert to nature for flood mitigation or environmental reasons, and those areas that are so densely developed that no one seriously doubts the likelihood of shore protection (given current policies). Second, along estuaries, we assume that residential, commercial, and other developed lands will be protected and that undeveloped lands will not be protected.[22] We rely on local

[22]The cost of shore protection along estuaries is small compared to property values in developed areas—and homes are rarely given up to retreating estuarine shores except for where policies prohibit shore protection.

planners to help us correctly use land use, planning, and zoning data—and to apply current land use policies—to identify current and project future development. Third, along ocean coasts, our premise is that current shore-protection policies generally have defined the areas where beach nourishment is almost certain, and that shore protection is likely in other areas that reach high densities. All of these aspects of the study are essentially data-driven, using a very simple model of the areas where shores are protected.

Nevertheless, we had to rely on local planners to provide facts or opinions in those cases in which the necessary data are unavailable, are out of date, or provide an ambiguous result requiring a human tie-breaker. Most of the map changes provided by local planners involved cases where our data showed no development, but planners were aware of recent or imminent development. But in a small number of cases, planners reviewed our initial results, made a policy-based conjecture, and requested a map change. Judgment-based map designations constitute a very small percentage of the land depicted in the maps in this study.[23]

We hope that the way we document our results does not leave researchers with the impression that our estimates of the likelihood of shore protection are simply the opinions of planners on a subject over which they lack expertise. We rely on planners to help us identify current and future land use and identify policies related to development and shore protection—matters that fall within their responsibility. Given expected development, the favorable or unfavorable economics of shore protection—not planner opinions—generally determine our results.

For most readers, these distinctions may be of little interest. For brevity, the report often says "planners expect shore protection" at a specific location, when a more precise exposition of our analysis might say "planners provided us with data on existing land use data and/or master plans. These data, along with site-specific planner knowledge, imply a level of development that would more than justify shore protection if current policies and economic trends continue. Therefore, planners expect shore protection."

[23]The key examples of judgment-based designations are agricultural lands in Somerset County (designated as shore protection likely) and Baltimore County's expectations regarding shore protection of its many parks.

MARYLAND COASTAL POLICIES AND REGULATIONS

Many state regulations, programs, and policies seek to manage land use within the coastal area and in some cases to address a response to continued sea level rise. Notable efforts to examine the sea level rise issue are being conducted by the Maryland Department of the Environment and the Department of Natural Resources. Based on meetings conducted between 2001 and 2002, we summarize the efforts of these and other groups below.[24]

Maryland Critical Areas Commission

Based on communication with:

Mary Owens, Maryland Critical Areas Commission

The Maryland General Assembly enacted the Chesapeake Bay Critical Area Protection Act in 1984 to reverse the deterioration of Chesapeake Bay.[25] The law seeks to control development in the coastal zone and preserve and protect a healthy Chesapeake Bay ecosystem. The jurisdictional boundary of the Critical Area includes all waters of Chesapeake Bay and all state and private wetlands designated under Natural Resources Article, Title 9 (now Title 16 of the Environment Article). The boundary also extends to areas 1,000 feet beyond the landward boundaries of state or private wetlands.

The Critical Area Commission approves management programs developed by the coastal counties. The commission also reviews proposed activities within the Critical Area to ensure conformity with local management programs. One of the key management measures of the program is establishing a 100-ft natural buffer adjacent to tidal waters. No new development activities, with the exception of those supporting water-dependent facilities, are allowed within the buffer. The 100-ft buffer provides properties along Chesapeake Bay a first line of defense against coastal erosion and flooding induced by sea level rise. Furthermore, by limiting development in the buffer to uses classified as water dependent, the amount of infrastructure located in areas vulnerable to sea level rise will be minimized in the near term.

Although the act limits development within the buffer, its current provisions allow the installation of shoreline protection structures (which are deemed to be a water-dependent use).[26] Such protective structures, however, may block the landward migration of coastal wetlands. Thus, as sea levels rise, these wetlands may become inundated.

Local Critical Area programs and implementing provisions also restrict land use activities within 1,000 feet of tidal waters. Local Critical Area programs identify three land use management subdistricts within the Critical Area: intensely developed areas (IDAs), limited development areas (LDAs), and resource conservation areas (RCAs). The land use management classifications were delineated from an analysis of the land uses in 1985. Policies for each subdistrict are implemented through local ordinances (e.g., zoning codes and subdivision regulations) and direct new intense development to areas outside the Critical Area. The programs limit future intense development activities to lands within the IDAs, permit some additional

[24]Since these meetings, Maryland has undertaken extensive efforts to understand the vulnerability of the state to sea level rise and plan for sea level rise. We recommend that readers refer to Maryland's Coastal Program for the latest information from the state (http://www.dnr.state.md.us/bay/czm/ accessed on December 1, 2007).

[25]Chesapeake Bay Critical Area Protection Act, Natural Resources Article, §8-1807.

[26]http://www.dnr.state.md.us/criticalarea/.

low-intensity development in the LDAs, and strictly limit development in the RCAs. The RCAs protect open space, forestry, fisheries activities, and other resource utilization activities. Within the RCAs, development is limited to one home per 20 acres.

Maryland Department of the Environment (MDE)

Based on communication with:

Bob Tabisz, section chief, MDE Tidal Wetlands Division; Julie Labranch, MDE Non-Tidal Wetlands Division.

Wetlands and Riparian Rights Act (§16-101 to §16-503)

The Wetlands and Riparian Rights Act gives the owner of land bounding on navigable water the right to protect their property from the effects of shore erosion. The most important section of the act, section 16-201, is summarized below.

A person who is the owner of land bounding on navigable water is entitled to any natural accretion to the person's land, to reclaim fast land lost by erosion or avulsion during the person's ownership of the land to the extent of provable existing boundaries. The person may make improvements into the water in front of the land to preserve the person's access to the navigable water or protect the shore of that person against erosion. After an improvement has been constructed, the improvement is the property of the owner of the land to which the improvement is attached. A right covered in this subtitle does not preclude the owner from developing any other use approved by the Board. The right to reclaim lost fast land relates only to fast land lost after January 1, 1972, and the burden of proof that the loss occurred after this date is on the owner of the land.[27]

Strict interpretation of this provision by MDE results in the approval of hard erosion control structures, including in areas suitable for nonstructural shore erosion techniques. This practice conflicts with the Critical Area Act, which gives preference to nonstructural shore erosion protection by mandating that structural control measures be used only in areas where nonstructural control measures would be impractical or ineffective. The Wetlands and Riparian Rights Act, as currently interpreted, however, supersedes the Maryland Critical Areas Act. This practice may also conflict with the Clean Water Act's requirement for a permit to fill wetlands. The U.S. Army Corps of Engineers, however, has issued Maryland a Programmatic General Permit for wetlands, which generally allows for shoreline armoring. But it does not include reclamation of lands lost to erosion since 1972 and, hence, such activities would still require a permit from the Corps.

Nontidal Wetlands Act

The goal of the Nontidal Wetlands and Waterways program[28] is to manage nontidal wetlands and provide essential resource protection by authorizing only necessary and unavoidable impacts. To accomplish this goal, property owners must obtain a permit to conduct the following activities within a nontidal wetland or within 25 feet of a wetland:

- grading or filling;
- excavating or dredging;
- changing existing drainage patterns;
- disturbing the water level or water table; and
- destroying or removing vegetation.

This 25-ft buffer is expanded to 100 feet for wetlands of special state concern. Applicants are required to demonstrate that proposed impacts to nontidal wetlands are necessary and unavoidable. For example, an "alternatives analysis" may be required to ensure that nonstructural alternatives are considered.

[27]Environment Article Title 16: Wetlands and Riparian Rights, § 16-201. Accretion to and improvement in front of land on navigable water; reclamation of lost fast land; continuation of existing rights.

[28]Environment Article Title 5, Subtitle 5-901 through 5-911; Annotated Code of Maryland, COMAR 26.23.

Maryland Department of Natural Resources (DNR)

Coastal Zone Management Program

Based on communication with:

Zoë Pfahl Johnson, and Rachel Smyk-Newton, NOAA Coastal Management Fellows; Cornelia Pasche Wikar, Coastal Hazards planner.

Under the guidance of the Coastal Zone Management Act (CZMA) of 1972 (16 USCA. §§ 1451-1464), Maryland's Coastal Zone Management (CZM) Program is designed to achieve a balance between economic development and resource protection in the coastal zone. Maryland's CZM Program, administered by DNR, uses a networked approach to achieve its goals and objectives. The program relies on the planning and regulatory programs of several state agencies and local governments. State agency participation is ensured through an Executive Order and Memoranda of Understanding between DNR and the departments of agriculture, environment, housing and community development, transportation, and planning. Under the CZMA, sea level rise is an element of Maryland's coastal hazards enhancement area.[29] It is considered a "high risk" element, along with flooding, storm surge, and erosion. The impacts of Tropical Storm Isabel in September 2003 highlighted the importance and consequences of coastal hazards to Maryland.

In the past few years the Worcester County Sea Level Rise Inundation Model was completed as a cooperative project with DNR, USGS, and Worcester County.[30] The study used projected rates of sea level change and high-resolution LIDAR to model future conditions. Results are being used to call for greater building freeboard in floodprone areas and to direct growth to safer locations.

Numerous recommendations for sea level planning were in *A Sea Level Rise Response Strategy for the State of Maryland*.[31] They are focused on four areas, which address outreach, data needs, incorporating sea level planning into environmental practices, and removing institutional barriers. Shoreline inventories, erosion analyses, LIDAR acquisition, and "living shoreline" alternatives to hard stabilization have been recent program initiatives.[32]

Shore Erosion Control Program

Based on communication with:

Len Cassanova, Maryland DNR, Shore Erosion Control Program; and Rachel Smyk-Newton, NOAA Coastal Management Fellow.

In 1968, the state General Assembly established the Shore Erosion Control Program as a program within DNR. The program provides both financial and technical assistance to Maryland property owners to resolve erosion problems through both structural and nonstructural shore erosion control projects.

The state program has focused on nonstructural projects using bioengineering methods for shoreline restoration. The Shore Erosion Control Program is authorized to provide 25-year, interest-free loans for the establishment of structural erosion control projects. Because of budgetary constraints, however, the structural erosion control program currently provides only technical assistance for private and public property owners.[33]

Maryland Shore Erosion Task Force

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[29] Maryland Department of Natural Resources, Coastal Zone Management Program, *CZMA, Section 309 Assessment & Strategy*, July 1, 2006, p. 17

[30] Maryland Department of Natural Resources & USGS, November 2006, *Worcester County Sea Level Rise Inundation Model Technical Report.*

[31] Zoë Pfahl Johnson, October 2000, *A Sea Level Rise Response Strategy for the State of Maryland*. Maryland Department of Natural Resources, Coastal Zone Management Division

[32] Maryland Department of Natural Resources, Coastal Zone Management Program, *CZMA, Section 309 Assessment & Strategy*, July 1, 2006, pp. 5–7.

[33] One county reviewer stated that this situation varies from year to year and that funding might be available in a future year.

Based on communication with:

Len Cassanova, Maryland DNR, Shore Erosion Control Program; and Rachel Smyk-Newton, NOAA Coastal Management Fellow.

Recognizing the magnitude of the shore erosion problem, Governor Parris N. Glendening appointed a Shore Erosion Task Force in August 1999. Task force members include representatives from the Maryland legislature; departments of natural resources, agriculture, and the environment; leaders of special interest groups; and other concerned and knowledgeable individuals in the field of erosion control. The task force was charged with identifying shore erosion control needs; reviewing contributing factors to shore erosion; clarifying local, state, and federal roles regarding shore erosion; and establishing 5- and 10-year erosion-control plans. The primary findings of the task force include the need to:[34]

- develop a comprehensive and regional approach for shore erosion control;
- improve coordination of shore protection activities among various entities;
- establish project review and selection criteria;
- encourage the use of dredge materials in regional projects;
- review engineering standards and conduct technical evaluations;
- develop a financial strategy to address funding needs;
- conduct public education; and
- determine and fulfill data needs.

Actions in support of those recommendations include the development of the Maryland Shorelines Online internet site on coastal hazards, production of shoreline position maps and determination of 20th century historical erosion rates, a comprehensive inventory of shoreline structures, promotion of "living shoreline" erosion control measures, and development of an erosion protocol and priority rating system.[35]

The task force's findings indicate that each year erosion carries approximately 5.7 million pounds of nitrogen and 4.2 million pounds of phosphorus into Chesapeake Bay, significantly degrading water quality. Additionally, each year erosion contributes approximately 11 million cubic yards of sediment into Chesapeake Bay, intensifying the need for navigational dredging and diminishing water quality because of increased turbidity.

Although not itself an examination of sea level rise, the task force report examined one of the effects of sea level rise, increased erosion. Accelerating rates of sea level rise were noted in the report as a factor in prolonging and exacerbating Maryland's shore erosion problems.

Maryland Port Administration

The Maryland Port Administration, a part of the Maryland Department of Transportation, is currently conducting a beneficial use project on Chesapeake Bay to restore an island destroyed by sea level rise and the forces of erosion. The Poplar Island Restoration Project is using dredge materials from the Port of Baltimore to restore the island to its approximate footprint in the mid-1800s. The Port and the Corps of Engineers are currently working at Smith Island to combat erosion through a program to place dredged material on portions of the island. Preliminary examinations are under way to see if dredged materials can be used to restore other Chesapeake Bay islands such as James Island, Barren Island, and Hollen Island or to protect valuable environmental resources such as the eroding lands of the USFWS Eastern Neck National Wildlife Refuge.

[34]State of Maryland, Shore Erosion Task Force, Final Report 2000.

[35]Maryland Department of Natural Resources, Coastal Zone Management Program, *CZMA, Section 309 Assessment & Strategy*, July 1, 2006, pp. 5–7.

Maryland Smart Growth Program

Based on communication with:

Jessica Cogan, Governor's Office of Smart Growth[36]

The 1992 Planning Act (which amended Article 66B of the Annotated Code of Maryland and is referred to as the Planning and Zoning Enabling Act) and the subsequent adoption of the 1998 Smart Growth Act are the legislative basis for Maryland's "Smart Growth" initiatives. As a result of these acts, counties are required to identify priority funding areas in which they will focus future county growth. The state then directs its capital improvement efforts to these areas to support concentrated growth patterns. The program also allocates state funds to purchase conservation easements for large contiguous natural areas.

Maryland Agricultural Land Preservation Program

The Maryland Agricultural Land Preservation Program (MALPF) was created by the Maryland General Assembly to preserve productive agricultural and forest lands. The program comprises two basic steps: (1) establishing agricultural preservation districts and (2) purchasing perpetual development rights easements. Entering an agriculture preservation district is a preliminary step to sale of development easements and indicates the desire of the landowner to retain the land in agriculture use. Sale of development easements effectively eliminates landowner development expectations and fixes land values at a level associated with the natural resource capabilities (e.g., agricultural use) of the land. Local land preservation programs augment the state program. For instance, Calvert County's program has set aside more land than the state in that county.[37]

[36]This meeting was conducted in November 2001. One reviewer, Zoë Johnson indicates that there may have been a change in state priorities since the meeting.

[37]Stakeholder review comments from Dr. David Brownlee, planner, Calvert County on February 6, 2003, at a meeting held at the Calvert County Office Complex.

OVERVIEW OF GENERALIZED STATE-WIDE RESPONSE TO SEA LEVEL RISE

Note to the Reader: This section is intended to summarize the basis for delineating the likelihood of shoreline protection within Maryland's coastal counties. This summary should provide the reader with a basic understanding of the typical decision rules applied in the county studies. To understand the anticipated response specific to a particular county, however, the reader must refer to that specific county's write-up.

Existing Policies

As described above, the Wetlands and Riparian Rights Act states that "a person may make improvements into the water in front of the land to preserve the person's access to navigable water or to protect the shore of that person against erosion." Thus, Maryland state law effectively gives property owners the right to armor or elevate their land. Landowners can armor their shoreline to protect their property from rising seas and increased erosion. Although bulkheads are prohibited in many areas, sloping revetments are allowed essentially anywhere. Although local governments might be able to impose regulations to limit shoreline armoring, most have no local policies to restrict such protections. Therefore, the counties generally base the likelihood of shore protection on the density of development and—to a lesser extent—the cost of holding back the sea in a particular area. Only Calvert County has passed policies to limit armoring along the ecologically sensitive portions of their shoreline. See the Calvert County section of this report for more information on its policies. Current state policies do not specifically address the management of publicly owned lands.

Anticipated Responses

Table 6-5 summarizes the typical assumptions applied in developing county maps to identify the likelihood that specific areas will be protected. This section reviews the general shore protection assumptions that are implied by state policies. The planning maps depart from this general approach in many cases for site-specific reasons, and in some cases for county-wide reasons. Those departures are documented in the county-specific sections of this report.

The meetings for this study were conducted by different individuals. Peter Johnston worked with all the Eastern Shore counties except Dorchester and Somerset; Will Nuckols worked with the other counties. The EPA project manager (Jim Titus, also a lifelong Maryland resident) met several times with Worcester and Somerset counties, and visited the shores of all counties. Each individual followed the same approach of conducting initial meetings, developing the draft shoreline protection maps, and conducting follow-up stakeholder review meetings to obtain revisions. During the discussions with planners, however, these three individuals had different styles. Johnston followed a systematic approach attempting, as much as possible, to start with a consistent set of GIS decision rules for all the counties, and identifying site-specific changes as requested. Will Nuckols took an individualistic approach in which he discussed sea level rise at length with counties and prepared decision rules for each based on specific—and in some cases unique— situations. Jim Titus tended to re-examine issues again and again, and was the most inclined of the three to go back and look at a particular shoreline when our decision rules seemed to yield a surprising result for a

particular location.[38] Continued interactions with Worcester and Somerset counties made generic decision rules the least applicable for those counties.

Counties had at least one (and often two to four) opportunities to revise the maps. Therefore, the ultimate result should reflect what they actually believe, rather than our individual approaches for determining what they expect—especially for those lands that matter most. Nevertheless, for areas where county officials had little or no basis to predict the future, or small areas where their concern was the least, the maps may reflect a residual from the respective approaches and perspectives of the three Maryland residents involved in the production of this study, try as we did to prevent our own subjective expectations from influencing the results.

Lands where protection is almost certain to occur are the areas with substantial existing development or where extensive development is planned, such as in "locally designated (and state-approved) growth areas."[39] Those areas often encompass intensely developed areas and limited development areas within the Chesapeake Bay Critical Area and lands identified by the counties as priority funding areas (PFAs, priority locations for state-funded infrastructure improvements under the state's Smart Growth Initiatives). Local officials believe it is reasonable to assume that protection is virtually certain in these areas, because private and public sector investment in capital facilities and structures will continue. Because investment in these areas is many times greater than the cost of holding back the sea, it would be economically irrational to abandon the land to the rising sea unless one could demonstrate that retreat was necessary to preserve irreplaceable ecosystems. Areas where protection is almost certain also include government lands used for schools, offices, and residential and industrial uses.

Planners in some counties suggested that we should assume that protection is likely—but not certain—in currently developed areas with relatively low density, especially if they are not in an area designated for future growth.[40] Because shoreline armoring is relatively inexpensive compared with home construction costs and property values, most lightly developed areas will be protected. Nevertheless, lightly developed areas are less likely to have sewer and other major infrastructure investments, and thus the value of structures potentially lost to the sea will be less. Therefore, if environmental concerns preclude as much shore protection, as currently seems likely, growth areas and densely populated areas would usually have a higher priority for shore protection than nongrowth areas.[41] This reasoning led four counties to assume that most lightly developed areas outside of growth areas are likely (but not certain) to be protected.[42] Most counties assume that currently developed areas are all certain to be protected.

Undeveloped areas where development is expected are also less likely to be protected than similarly situated lands that are already developed. Until land is actually developed, it is possible that events will occur to prevent the development from taking place. Therefore, these

[38]For example, when decision rules predicted that property might not be protected, when he had taken a photograph showing that it is already protected, Titus tended to suggest that we should assume that it is certain the be protected unless the County had articulated a reason for expecting the armoring to be removed and the property abandoned.

[39]For counties on the Eastern Shore of Maryland, we define these areas based on locally designated "growth areas" shown in the comprehensive plan for each county. Growth areas shown in county comprehensive plans may have different descriptive titles; e.g., in Wicomico County the primary growth area is called "Metro Core." Regardless of their title, the designated growth areas encompass existing areas of the most intense development, areas where the highest investment in infrastructure has been made and include priority funding areas.

[40]We identify currently developed lands in Cecil, Caroline, Worcester, and Wicomico counties using Maryland Property View data (available from Wicomico 2000, Cecil 1998, Caroline 2001, Worcester 1999) and 1997 land use data for the remaining counties (available from Maryland Department of Planning).

[41]As indicated in the county-specific sections, however, most counties assume that most existing development will be protected regardless of the growth areas.

[42]Baltimore, Kent, Caroline, Talbot, Wicomico, and Worcester counties agreed with a decision rule in which lightly developed areas outside of growth areas are likely to be protected. This "decision rule" ultimately had no effect on the maps of Caroline and Wicomico counties, however, either because site-specific edits changed those areas to "certain to be protected" or because there were no such areas in the study area anyway.

types of lands are less likely to be protected than areas that are already developed. Most counties assume that protection is almost certain in official growth areas even if they are not developed, but five counties treat at least some undeveloped areas as likely but not certain to be protected.[43]

Secured installations (e.g., military bases) are a special case: most county planners felt that it would be beyond the scope of their expertise to speculate on the Department of Defense's intentions. Available data sets generally fail to distinguish open lands from developed lands within military bases, and federal lands in general are outside of the planning process.[44] In response to this finding and similar findings in other states, EPA decided the most appropriate approach would be to classify all military lands in the intermediate category (red), except for those lands that are within urban areas where protection would be certain even if the land was held by the private sector. Thus, the Naval Academy is assumed certain to be protected because Annapolis is certain to be protected; but most other military lands are colored red. *In this one case, red is meant to convey uncertainty and the desirability of better information*.

In contrast to the areas where protection is likely, we identify a small number of areas where protection is extremely unlikely: lands that are managed for conservation. Most of these lands (depicted in light green) are publicly owned; but, we also include some privately owned lands managed for conservation.[45] We map parks and other lands that are important recreational areas as likely to be protected (red). For parks where there is both a conservation and a recreational purpose, we attempt to discern whether a gradual retreat would impair the recreational purpose enough for protection to be required. For example, at Fort Washington, part of National Capital Parks East, the fort itself would almost certainly be protected; but much of the park is undeveloped forest, and the Park Service's general pro-retreat policy would imply that protection is extremely unlikely.

Conservation easements in Maryland seek to control development but do not necessarily preclude measures for holding back the sea. Consequently, these lands are shown as unlikely to be protected (blue). The state's model conservation easement includes specific language allowing the landowner to armor the shore, even while other structures near the water are prohibited.[46] Moreover, erecting a dike[47] and drainage system[48] to prevent wetlands from migrating inland is explicitly allowed. Therefore, it would be incorrect to map lands with these conservation easements as if shore protection is precluded. Instead, one must view shore protection in these areas as having about the same likelihood as areas where land will remain as farm or forest for other reasons. The one exception is the rare case where a conservation easement is obtained on land where shore protection costs are so low or land values so high that even farmland would certainly be protected. In such cases one should still assume that shore protection might occur.[49] Staff at the Maryland

[43]Baltimore, Charles, Dorchester, Somerset, and Worcester. Only Baltimore and Somerset counties suggested a specific decision rule to treat future development as likely to be protected; Charles, Dorchester, and Worcester suggested specific areas as likely to be protected that have not yet been developed.

[44]Rather than ask local planners to speculate on what a federal agency is likely to do, EPA intends to approach DoD directly.

[45]We map both private and public conservation lands based on Protected Lands data available from DNR's Maryland's Environmental Resource & Land Information Network (MERLIN) data.

[46]"…Grantor may…(2) place soil, rock, other earth materials, vegetative matter, and compost reasonably necessary for the purpose of combating erosion or flooding…" Maryland Environmental Trust/Rural Legacy Model Easement (2001) (II)(E)(2). Cited on March 26, 2004 at http://www.dnr.state.md.us/rurallegacy/easement.pdf.

[47]See ibid., which clearly allows an earthen dike.

[48]See ibid. at (II)(F). "Excavation of Materials". "No excavation of materials is permitted…Notwithstanding the previous sentence, Grantor may excavate materials (1) for Agricultural use…(2) reasonably necessary for the purpose of combating erosion or flooding.

[49]This exception was applied only in Worcester County, where it was first brought to our attention. Elsewhere, that is, we probably have classified some areas as blue that actually probably will be protected. Likely examples would include farms with historic structures near the water, farms where the easement allows children of the owner to each build a home, all of which would probably be along the water, farms in areas that are sufficiently desirable for well-to-do individuals to purchase the property and either lease the farmland to others or graze their horses, and farms with high ground along well-sheltered shores where a rock revetment provides cost-effective protection.

Environmental Trust believe that removing these provisions would reduce the amount of conservation easement; i.e., farmers place significant value on retaining the option to protect their property from erosion and flooding. The easements generally allow one or two homes, which might require shore protection. Moreover, any conservation easements on coastal lands within areas that are otherwise certain to be protected are likely to be enclaves that would be protected as adjacent lands are protected.

The remaining lands are mapped in blue, which represents land where shore protection seems unlikely. The rationale for this category is that shore protection currently seems unlikely in areas where development is unlikely for the foreseeable future. The areas that we map as blue can broadly be classified into two categories: areas where we have data and reasons to expect the land to remain undeveloped, and areas where we have no data or specific reason to expect the land to be developed or protected. Maryland has two unusual land use conventions that make shore protection unlikely (but possible) in some areas:

- conservation easements that explicitly allow shore protection; and
- resource conservation areas in the Critical Areas Act, which mandate 20-acre zoning within 1,000 feet of the wetlands.

Unfortunately, when we created the maps, the resource conservation areas had been delineated electronically only for two counties. Once data become available, it will be possible to refine our maps to distinguish lands where shore protection seems unlikely from those areas where state law makes it unlikely.[50]

In the mean time, we would caution the reader that portions of the areas depicted in blue in some counties probably will be protected, for two reasons. First, many of the blue areas may eventually be developed because they are not part of an RCA. Second, private property owners in Maryland have a statutory right to hold back the sea to protect vacant land; some property owners may opt to protect undeveloped lands to preserve their investment in the land.[51] Nevertheless, shore protection is clearly more likely in those areas where development has occurred or is expected.

[50]Most of the RCA lands are depicted as unlikely to be protected in our maps. The counties analyzed by Peter Johnston had included RCA lands within a broader category of lands where residential development is not planned. Most of the other counties consciously included RCA lands to the best of their ability in defining area where shore protection is unlikely. If the coastal zone of Maryland continues to be developed, many counties will probably modify plans to allows development in some of the shorefront lands where development is not planned; i.e., many of the areas depicted in blue would eventually require shore protection if trends in coastal development continue. The RCA lands, however, are an exception.

[51]The fact that farmers place value on retaining the right to hold back the sea suggests that at least some must be able to conceive of circumstances that would lead them to erect shore protection structures. Such circumstances might include (a) a very valuable waterfront home as part of the farm, (b) inexpensive shore protection, and (c) farming being profitable enough to justify protecting the land from rising sea level.

TABLE 6-5. STATE-WIDE GENERAL APPROACH FOR IDENFITYING LIKELIHOOD OF SHORELINE PROTECTION[a]

Likelihood of Protection	Land Use Category	Source Used to Identify Land Area
Protection almost certain (brown)	Existing developed land (commercial/ industrial/residential/ governmental) within extensively developed areas or designated growth areas.	Developed lands identified from MD Property View data (various years) and land use/land cover in Maryland (MDP 1997); Growth areas identified from planner input, local comprehensive plans, and Critical Area lands data (DNR MERLIN 2000).
	Future development within extensively developed areas or designated growth areas.	Planner input, local comprehensive plans, and Critical Area lands data (DNR MERLIN 2000).[b]
	Publicly owned developed (e.g., historical landmarks) and military lands.	County-owned, state-owned, and federally owned lands (DNR MERLIN 2000)
	Extensively used state parks operated for purposes other than conservation.	State-owned lands (DNR MERLIN 2000)
Protection likely (red)	Existing development within less densely developed areas or outside growth areas (in the majority of counties).	Developed lands identified from MD Property View data (various years) and land use/land cover in Maryland (MDP 1997); growth areas identified from planner input, local comprehensive plans, and Critical Area lands data (DNR MERLIN 2000).
	Existing development within less densely developed areas or outside growth areas (in a minority of counties).	Planner input.
	Projected future development outside growth areas.	Planner input.
	Military lands in areas where protection is not certain.	Federally owned lands (DNR MERLIN 2000).
Protection unlikely (blue)	Conservation easements in some areas where shore protection would be certain even if land remained as farmland.	Maryland Environmental Trust and agricultural easements/districts (DNR MERLIN 2000) plus site-specific knowledge indicating willingness to protect shores of farmland.
	Undeveloped privately owned land in areas expected to remain sparsely developed (i.e., not in a designated growth area and not expected to be developed).	Undeveloped lands identified from MD Property View data (various years) and land use/land cover in Maryland (MDP 1997); nongrowth areas identified from planner input, local comprehensive plans, and Critical Area lands data (DNR MERLIN 2000).
	RCA (Critical Areas Act).	Critical Area lands (DNR MERLIN 2000) (Anne Arundel and Charles counties only).
	County-owned lands.	County-owned lands (DNR MERLIN 2000).
No protection or protection extremely unlikely (light green)	Conservation easements in most locations.	Maryland Environmental Trust and agricultural easements/districts (DNR MERLIN 2000).
	Private lands owned by conservation groups (when data available).	Private conservation lands (DNR MERLIN 2000).
	Publicly owned natural lands.	State-owned and federally owned lands (DNR MERLIN 2000).

[a] These generalized categories describe the typical decision rules applied in the county studies. County-specific differences in decision rules and site-specific departures from this approach are discussed in the county-specific sections of this report.

[b] Areas where future development is anticipated consist of (a) all undeveloped areas in designated growth areas and (b) lands outside designated growth areas identified by county planners.

COUNTY POLICIES AND ANTICIPATED RESPONSE TO SEA LEVEL RISE

In this section, we provide background information on each county's relative risk to the impacts of sea level rise and then describe the anticipated future shoreline protection responses. This information is separated into two sections—western and eastern Chesapeake Bay counties—with the county-specific write-ups organized geographically from north to south. Figure 6-2 identifies the location of each county.

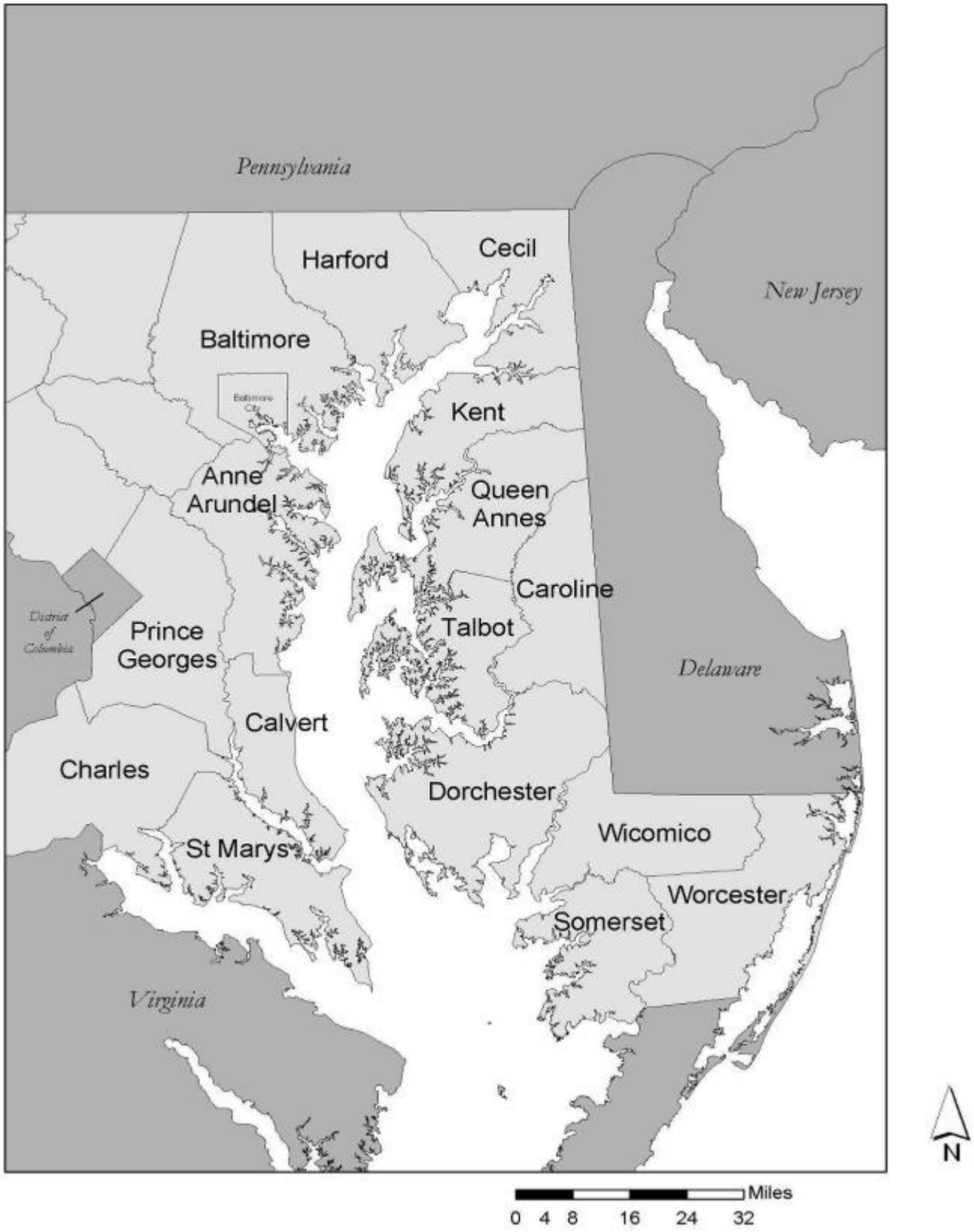


Figure 6-2. Locations of Counties in Maryland

WESTERN SHORE COUNTIES

Harford County

Background

Harford County has more than 200 miles of shoreline and covers approximately 281,600 acres. More than 70 percent of its 225,000 residents live in the "Development Envelope," an area of the county along the Rte. 24/924 and Interstate 95 corridor served by public water and sewer and targeted for development. The county's three incorporated towns (Aberdeen, Bel Air, and Havre de Grace) lie within the Development Envelope and contain approximately 16 percent of the county's population. The county's population has been growing in recent years and is expected to increase to nearly 250,000 by 2020.[52]

Sixty-two percent of the land is zoned for agricultural land use. Agricultural land is scattered throughout the central and upper portions of the county and is interrupted only by small pockets of developed land.[53] Along Chesapeake Bay, Aberdeen Proving Ground, the Army's oldest active proving ground, occupies more than 72,500 acres of land.[54] This Army base contains the largest concentration of land within 10 feet of sea level along the entire Western Shore of Maryland.

Harford County owns more than 3,800 acres of park land. The County also has an aggressive program to purchase development rights on agricultural lands. In addition, the Maryland Agricultural Land Preservation Program and the Maryland Environmental Trust purchase development rights through easement programs. Collectively, these programs have preserved more than 32,800 acres in the county. State-owned land within the county includes the Susquehanna State Park, which is approximately 3 miles north of Havre de Grace; Rocks and Palmer State Parks along Deer Creek; and, the Gunpowder State Park along the Little Gunpowder Falls, which forms the border between Baltimore and Harford counties.

The Harford County Division of Water and Sewer provides potable water and public sewerage service for county residents within the Development Envelope. Havre de Grace also owns its own wastewater plant, which is capable of processing 1.9 million gallons per day to a secondary treatment level. In December 2000, the city approved a $6.7 million upgrade to the system.[55]

Anticipated Response to Sea Level Rise

Based on communication with:

Pat Pudelkewicz, administrator, Environmental Protection, Harford County Department of Planning and Zoning; Joe Paff, director of Harford Parks and Recreation; Jerry Wheeler, Harford County Department of Public Works; Bruce Johnson, Harford County IS/GIS; and Jim Bailey, U.S. Army, Aberdeen Proving Ground

Table 6-6 summarizes the general response to sea level rise in Harford County by land classification suggested by county staff during our initial meeting.[56] Because development within the county is concentrated in the Development Envelope, including incorporated towns, county planners indicate that these

[52]http://www.dnr.state.md.us/greenways/counties/harford.html.
[53]http://www.dnr.state.md.us/greenways/counties/harford.html.
[54]http://www.apg.army.mil/aberdeen_proving_ground.htm.
[55]http://www.havredegracemd.com/MainPage/HavredeGraceMainPage.html.
[56]Except for the "additional rural lands" resulting from the stakeholder review.

developed areas are almost certain to be protected. For instance, Jappatown is already heavily developed and has largely been bulkheaded. Meanwhile, rural lands (predominately agricultural lands) are unlikely to be protected.

Much of Harford County's threatened lands are located within Aberdeen Proving Grounds (APG). Although no federal policies specifically address whether the shore would be protected from sea level rise, some portions of APG are already protected. Citing security concerns, the U.S. Army declined to identify the areas of the APG that would be armored. For the purpose of this assessment, however, our original maps assumed that all dry land on the base will probably be protected. Originally, this assumption was meant to be a compromise to roughly reflect the fact that some parts of the base must be protected, although a large part of the base consists of wetlands and low undeveloped dry land onto which wetlands could migrate without impairing the military function of this land.[57]

The stakeholder reviewers agreed that the maps based on (the original version of) Table 6-6 generally reflected the anticipated response in the county. The only changes that they suggested concerned the lands (1) north of APG along Swan Creek, (2) north of Gum Point along the Bush River, and (3) along Rte. 40 east of Otter Point Creek.[58] Although our data showed those areas as developed, they are in reality undeveloped rural areas that will remain undeveloped. Therefore, the County asked us to show those areas as unlikely to be protected (see Map 6-2).

During the final review of the maps, the authors realized that county parks had been erroneously listed as conservation lands that will not be protected. Because the County has no specific policy to promote a natural shoreline retreat, we corrected the maps to show county parks as unlikely to be protected.

[57]As discussed in the general methods section, secured installations are red unless they are within heavily urbanized areas where protection of surrounding lands is certain.

[58]Stakeholder review comments provided to William Nuckols by Pat Pudelkewicz, Harford County Planning Department, and Jim Bailey, U.S. Army, Aberdeen Proving Grounds wetlands biologist, during meetings at the county offices on January 2 and February 5, 2003. Additionally, email and telephone follow-up was conducted between William Nuckols and Pat Pudelkewicz on February 10, 2003. Changes were requested by marking the boundary of areas to be changed on the draft planning map.

TABLE 6-6. HARFORD COUNTY'S ANTICIPATED RESPONSE TO SEA LEVEL RISE [a]

Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Area
		No protection	Unlikely	Likely	Certain	
Public	County-owned parks[b]		✓			County-owned lands (DNR MERLIN 2000)
Public	State-owned open space	✓				State-owned lands (DNR MERLIN 2000)
Public	Federal lands–Aberdeen Proving Grounds			[c]		Federal lands (DNR MERLIN 2000)
Mostly private	Additional rural Lands		✓			Manual GIS edit per stakeholder review comments
Mostly private	Lands subject to conservation easements		✓			Agricultural easements/districts and Maryland Environmental Trust lands (DNR MERLIN 2000)
Mostly private	Private conservation lands	✓				Private conservation lands (DNR MERLIN 2000)
Mostly private	Havre de Grace and other developed private lands				✓	Land use/land cover in Maryland (MDP 1997)[d]
Mostly private	Undeveloped privately owned lands		✓			Land use/land cover in Maryland (MDP 1997)[e]

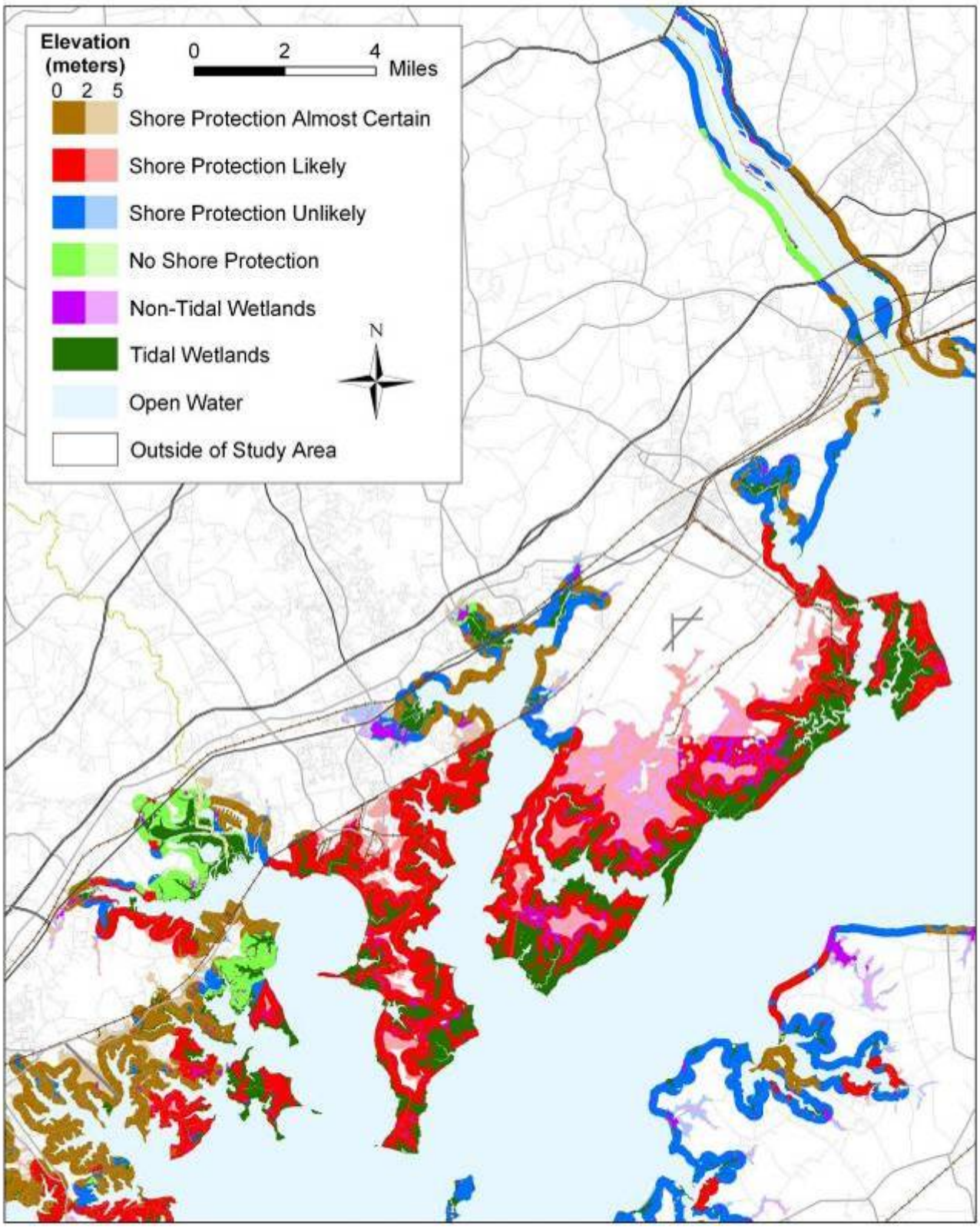
[a] Where land areas overlap, classifications higher in the table take precedence.

[b] Author-initiated change from conservation lands to protection unlikely, after stakeholder review. This change corrected a map error in the stakeholder review draft: the County originally excluded parks from areas likely to be protected; the stakeholder review draft had erroneously included county parks within conservation lands even though the County has no policy precluding shore protection.

[c] Based on the nationwide approach of this study for secured installations, the maps depict these areas as red. The data we distribute assign the code "military" rather than "protection likely."

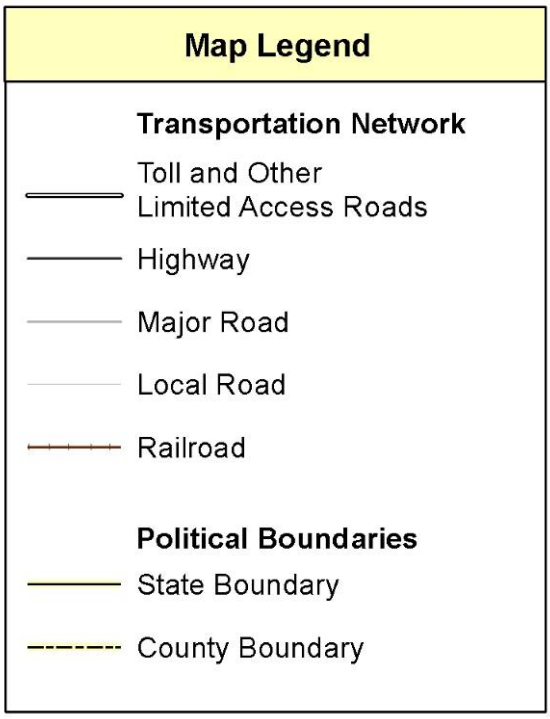
[d] We identify developed lands based on residential, commercial, industrial, and infrastructure land uses identified in 1997 land use data provided by the Maryland Department of Planning. Includes public and private lands.

[e] We identify rural privately owned lands based on agricultural, range, forest, and wetlands land use classifications identified in 1997 land use data provided by the Maryland Department of Planning.



Map 6-2. Harford County: Likelihood of Shore Protection. The caption and detailed legend for this and the other locality-specific maps is located on the following page.

Map 6-2. Harford County: Likelihood of Shore Protection. For each shore protection category, the darker shades represent lands that are either less than 20 feet above spring high water. This map is based on data published between 1987 and 2003. Although the map also reflects site-specific changes suggested by planners in 2002 and 2003, the intended use of this map is to convey city and county-wide prospects for shore protection, not to predict the fate of specific neighborhoods. Changes in the policies and trends we considered—or factors that we did not consider—may lead actual shore protection to deviate from the likelihoods depicted in this map.



Baltimore County

Background

Baltimore County, which surrounds the city of Baltimore, is the third most populous county in the state. In 2001, more than 762,000 people resided in the county.[59] Although its population has grown steadily over the last 70 years, the rate of growth is expected to decline in the future because of Smart Growth efforts.[60]

Agriculture is a key industry in the county, contributing more than $400 million annually to the economy and comprising 156 square miles of land. Residential areas cover approximately 160 square miles, which accounts for 25 percent of the Baltimore County's 640 square miles of land. Approximately 90 percent of the population lives within the developed and industrialized area.[61]

There are 132,500 acres of forest and tree cover in Baltimore County. Along with the fertile soils, streams, wetlands, and Chesapeake Bay tidal rivers, these forests provide habitat for terrestrial and

[59]U.S. Census Bureau, http://quickfacts.census.gov/qfd/states/24/24005.html.
[60]http://www.dnr.state.md.us/greenways/counties/baltimore.html.
[61]http://www.dnr.state.md.us/greenways/counties/baltimore.html.

aquatic wildlife and support many human uses. Large agricultural and resource preservation areas have been established to limit growth and development in these valuable rural areas. In 1967, the County created the Urban-Rural Demarcation Line to promote a separation between the developed and rural areas to prevent continued urban sprawl.[62,63]

Water quality protection remains one of the County's highest priorities. The county comprehensive water quality program promotes improving stormwater management systems, dredging streams, restoring waterways, and stabilizing the shoreline. The County also constructs, maintains, and manages area public water and sewer utility systems in conjunction with Baltimore City. To avoid further urban expansion, however, the County has shifted from installing new systems to maintaining and upgrading existing systems.[64]

Anticipated Response to Sea Level Rise

Based on communication with:

Don Outen, chief, Planning, Research and Development; Jeff Mayhew; and Karin Brown, planner, Office of Planning

Table 6-7 summarizes the anticipated response to sea level rise in Baltimore County by land classification. County planners expect that likely protection responses in the future will be based on existing policies. All privately owned lands are at least likely to be protected. Because of the economic cost of shoreline protection, county planners identify less densely developed areas along the Patapsco River as likely to be protected but not definite. Property owners in densely developed areas can share the cost of protection strategies and thus protection is almost certain in these areas.[65]

A small portion of Aberdeen Proving Grounds is located within Baltimore County along the Gunpowder River. As with other secured installations, we follow the general procedure of coloring the land red to indicate uncertainty.[66] Currently, no policies address whether parks and other recreation areas should be protected from sea level rise. Hart-Miller Island, however, is a hardened, elevated, dredged material placement site and is currently protected. Thus, planners anticipate that Hart-Miller Island will continue to be protected, while other state- and county-owned lands are likely to be abandoned. Stakeholder reviewers noted general agreement with the planning maps.[67] The

[62]http://www.dnr.state.md.us/greenways/counties/baltimore.html.

[63]The "urban" areas currently have or are expected to receive public water and sewer infrastructure, and therefore can accommodate further development, including employment, retail, and residential uses. In the rural areas, reliance on private well and septic systems limits the amount of development that could be accommodated, and thereby helps ensure the area's continued use for agricultural production, natural resource protection, and low-density rural development. For more information, see Baltimore County's Master Plan2010 available at http://resources.co.ba.md.us/Documents/Imported_Documents/m/masterplan2010.pdf.

[64]http://www.co.ba.md.us/p.cfm/agencies/planning/mpwater.cfm.

[65]Lands along the Patapsco River are largely not threatened because of their high elevation. For those lands that could be impacted, sea level rise is not seen as a significant threat because much of the land is either publicly owned or unsuitable for development owing to limited access to sewer facilities. Private landowners in low-lying areas would be responsible for providing their own connection to the public sewer. Historically, such systems, even when divided among several owners, proved to be too costly. If this area is more densely developed, however, the cost of shoreline protection per homeowner will decrease and may increase in likelihood.

[66]During the initial and stakeholder review meetings, Jim Bailey of the U.S. Army told Will Nuckols that security concerns precluded him from the identifying where armoring is expected without higher level clearance. The difficulty of obtaining base-specific clearance for this study has led the authors of this study to conclude that the most efficient way to address military lands in this sea level rise planning map study is to omit secured installations from the analysis, and then undertake a cooperative assessment with the Department of Defense that examines all coastal bases within a multistate area.

[67]Stakeholder review comments provided to William Nuckols via 1) telephone on February 24 by Dave Thomas and Steve Walsh of Baltimore County Department of Public Works and Alex George, JMT-Engineering; 2) emails from Don Outen, natural resource manager of Baltimore County on February, 26 and May 20, 2003; and 3) email from Patrick McDougall, planner II, Baltimore County Recreation and Parks on May 9, 2003. The county Department of Public Works provided a

county requested, however, that select county-owned parks be shown as unlikely to be protected, likely to be protected, and almost certain to be protected. The County wrote the following:

> "[The] eventual decision of whether or not to protect existing parklands and recreational facilities in the case of sea level rise is not simple and straightforward, and will be dependent on a wide variety of factors including future Baltimore County policy and the availability of funding for protective measures. At this stage in time, in which we have no real concept of the extent of potential problems and when they will occur, it is only feasible to identify parks that may be affected and rate the likelihood that significant fiscal expenditures would be invested to preserve them. The following matrix [see Table 6-8] places study area-situated parks within one of four classifications that have been identified to rate the likelihood of protection: conservation lands that would almost certainly be lost if eroded (displayed in light green within the study map), lands for which protection is allowed but unlikely (dark blue on study map), lands for which protection would almost be certain (brown on study map), and lands for which protection is reasonably likely (red on study map). These ratings do not take into account adjacent land uses."[68]

Table 6-8 lists the county-owned land and the likelihood of protection indicated by the county. Map 6-3 shows the final product depicting likelihood of protection.

GIS file indicating the approximate location of each park (via a point file). To transfer these data to the maps, we identified the boundaries of the parks using DNR MERLIN data on county-owned lands. At the time of preparing the maps, the County did not possess a GIS file that identified the boundaries of the parks (in a polygon format). Consequently, for parks not included in the DNR MERLIN data, we note the parks in Table 6-8 but do not include them in the map.

[68]Email correspondence from Patrick McDougall, Planner II, Baltimore County Recreation and Parks to William Nuckols on May 9, 2003.

TABLE 6-7. BALTIMORE COUNTY ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Area
		No protection	Unlikely	Likely	Certain	
Public	Hart-Miller Island State Park[b]				✓	Baltimore County land use (1998)
Public	State-owned open space	✓				State-owned lands (DNR MERLIN 2000)
Public	County-owned lands	Varies (see Table 3)				County-owned lands (DNR MERLIN 2000) and Baltimore County Parks (2004)
Public	Park and recreation lands not included in county-owned land data		✓			Baltimore County land use (1998)
Public	Federally owned lands (Aberdeen Proving Ground)[c]			[d]		Federal lands (DNR MERLIN 2000)
Mostly private	Land held in conservation easements		✓			Agricultural easements/districts and Maryland Environmental Trust lands (DNR MERLIN 2000)
Mostly private	Densely developed lands				✓	Baltimore County land use (1998)[e]
Mostly private	Undeveloped and less-developed private lands			✓		Baltimore County land use (1998)[f]

[a] Where land areas overlap, classifications higher in the table take precedence.

[b] Hart-Miller Island is already elevated with dredge material and may not be vulnerable to sea level rise.

[c] Other than those in urban areas, secured installations are treated as uncertain and colored red in the maps as a general rule applied nationwide until better information becomes available.

[d] Based on the nationwide approach of this study for secured installations, the maps depict these areas as red. The data we distribute assign the code “military” rather than “protection likely.”

[e] Based on residential, commercial, industrial, and institutional land categories.

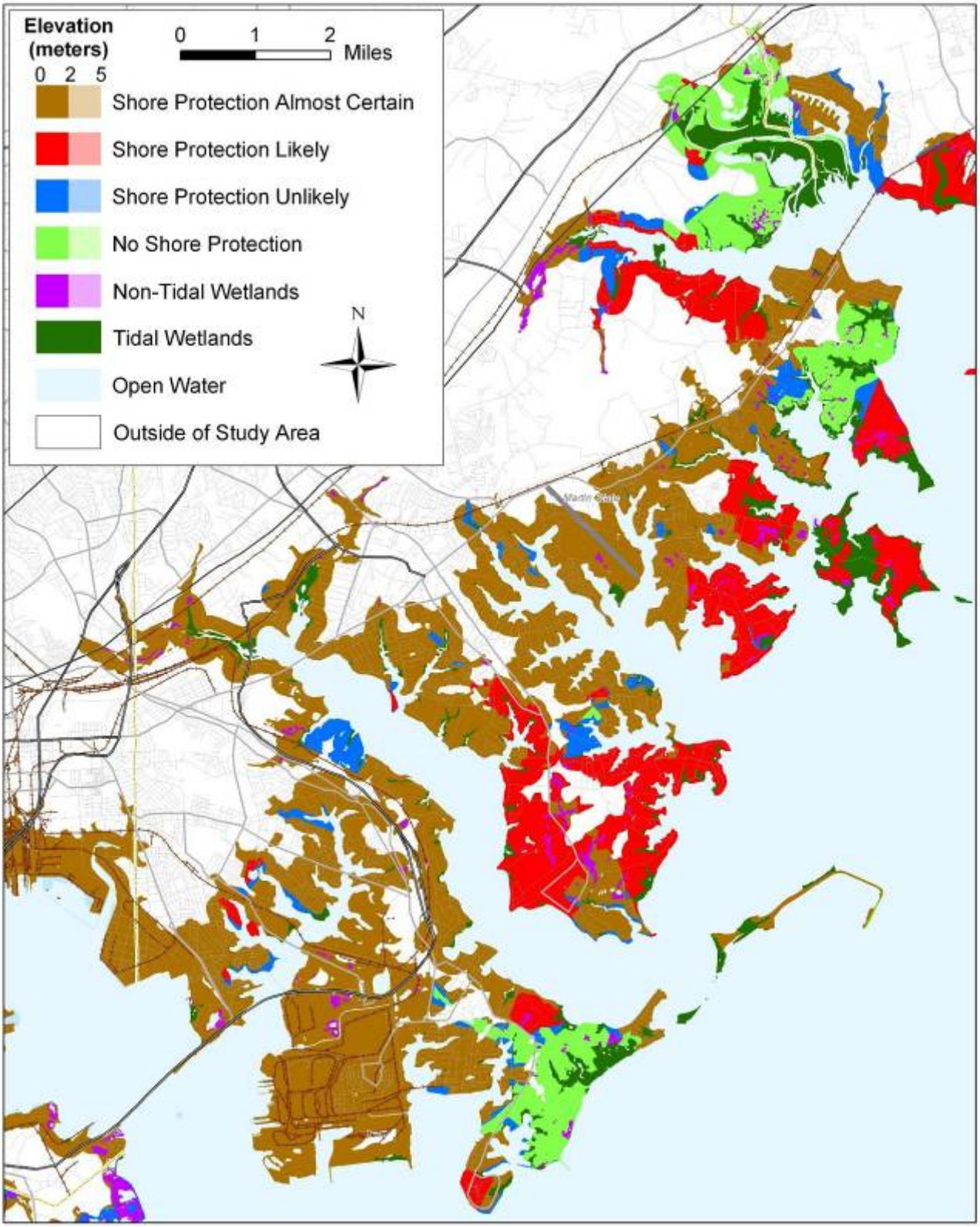
[f] Based on single family detached rural, agriculture/open space, and forest land categories.

TABLE 6-8. ANTICIPATED RESPONSE FOR BALTIMORE COUNTY PARKS

Land Area with Almost Certain Protection Likelihood	Land Area with Likely Protection Likelihood	Land Area with Unlikely Protection Likelihood	Land Area with Assumed Lost Protection Likelihood
Fleming Community Center *	Oliver Beach ESRC	Watersedge Park*	Lyons Homes Park
Southeastern Tech HSRC	Southwest Area Park*	Concrete Homes Park	Peach Orchard Park
Merritt Pt. Activity Center	Turner Station Park*	Lynch Cove Park*	Charlesmont Park
Grange ESRC	Chesterwood Park*	Del Rio Park	Edgepoint Open Space
Inverness Center	Merritt Point Park*	Bear Creek Park*	Battle Park Open Space
Sandy Plains ESRC	Stansbury Park*	Battle Acre Monument	Lincoln Estates LOS
Bear Creek ESRC	Inverness Park	Acquilla Randall Monument	Elstann Village LOS
Stricker MSRC	Fort Howard Center	Battle Grove Park	Millers Island Road Endings
Charlesmont ESRC	Millers Is. Park (leased from state)	Oak Road Park Site	Swan Point- Interior Lots
Battle Monument ESRC	Cox's Point Park*	Martindale Park*	Swan Point- Millers Island Blvd.
Battle Grove ESRC	Miami Beach Park*	Deep Creek Village Park	Baylight Beach Shore Access
Edgemere Sr. Center & Park	Tidewater Village Park	Fox Ridge Park*	Maryland Manor Open Space
Edgemere ESRC		Walnut Grove Park	Montrose Farms Open Space
Sparrows Point HSRC		Hyde Park ESRC Site	Macelee Open Space
Chesapeake Terrace ESRC		Pottery Farm Park	Stemmers Run Grnwy- Golden Ring
Fort Howard Park*		Bauernschmidt Manor Park	Sunnyside Lane Open Space
Sussex ESRC		Turkey Point Park*	Race Road Open Space
Deep Creek ESRC		Hopkins Creek ESRC Site	Riverside LOS- Essex Wood Circle
Sandalwood ESRC		Hawthorne/Midthorne Park	Riverside LOS- Seneca Rd.
Deep Creek MSRC		Darkhead Creek Park	Marlyn Ave. Bridge Open Space
Rocky Point Park*		Kingston Park*	Sue Creek Park*
Middleborough ESRC			New Haven Woods LOS- Flaxleaf
Hawthorne ESRC			New Haven Woods LOS- Bauerns.
Chesapeake Village Park Site			New Haven Woods LOS- Leyland
Wilson Pt. Park (leased from state)			Middleborough LOS- Antietam Rd.
Seneca ESRC			Seneca Harbor LOS- Cutter Cove
Bengies Community Center			Seneca Harbor LOS- Bowleys Qtrs.
Chase ESRC			Seneca Harbor LOS- Clarks Pt. Rd.
Eastern Reg'l. Park (incl. Chase MSRC site)			Seneca Harbor LOS- Seneca Garden
Dundee and Saltpeter Creeks Park*			Carrollwood Manor LOS- Nollmeyer
Oliver Beach ESRC			Carrollwood Manor LOS- Holly Hunt Rd.
			Carrollwood Manor LOS- Kittendale
			Heritage LOS- Congressional Ct.
			Heritage LOS- Freedom Ct.
			Cunninghill Cove LOS- Graces Qtrs.
			Cunninghill Cove LOS- Cunninghill Cove Rd.
			Twin River Beach LOS
			Ebenezer Road Open Space
			Bird River Beach Shore Access

Key:
ESRC, Elementary School Recreation Center;
MSRC, Middle School Recreation Center;
HSRC, High School Recreation Center;
LOS, Local Open Space.

*Parks that were identified in county-owned land dataset and incorporated into the planning map. The remaining lands are not included in the county-owned lands polygon and therefore not mapped.



Map 6-3. Baltimore County: Likelihood of Shore Protection. For the western portion of Baltimore County, see the map of the City of Baltimore**.** For additional details, see the legend and caption accompanying Map 6-2.

Baltimore City

Background

The City of Baltimore is located on the western shore of the Chesapeake Bay and is surrounded by Baltimore County. The city is a center for both tourism and commerce; however, over the last 30 years, it has experienced a steady population loss. According to the U.S. Census Bureau, the city's population dropped from more than 900,000 in 1970 to approximately 635,000 in 2001.[69] Its population is projected to drop another 5 percent by 2010.[70]

The city is highly urbanized throughout its approximately 55,000 acres. Zoning laws set aside 8,655 acres for business use, 15,134 acres for industrial use, and 25,394 acres for residential use. The city's major industry, Port of Baltimore shipping, generates almost $1.8 billion in annual revenues and supports 127,000 jobs.[71]

Baltimore City shares its public water and sewer utility systems with Baltimore County. Plans are under way to restore the 390 square miles of pipes and pumping stations that constitute the city's aging sewer system. The city is channeling $135 million into a 6-year capital program to make these repairs and upgrades.

The city has nearly 400 parks totaling approximately 5,700 acres. This parks and greenways system includes large city parks, golf courses, community parks, neighborhood playlots, and open spaces. Baltimore's green spaces were once considered among the nation's finest, but in the last 30 years have suffered from decreased maintenance.[72]

Anticipated Response to Sea Level Rise

Based on communication with: Peter Conrad, environmental planner; Duncan Street, city planner/Critical Area coordinator; and Susan Williams, manager of current planning

As shown in Table 6-9, city planners anticipate that all land within the city will certainly be protected from sea level rise. The city's highly urbanized waterfront is almost completely hardened at this point. For this reason, planners envision that all privately owned lands will be protected. Additionally, all publicly owned lands, including Fort McHenry National Monument, will be protected. Portions of the city are currently prone to flooding, and as more impervious surface is added to the city's landscape, the problem will worsen. These periodic flooding events may provide the impetus for longer-term planning to mitigate sea level rise impacts.

Thus, the key issue for the City of Baltimore is not whether to hold back the sea, but how. In many cases, dikes would cause an unacceptable interference with waterfront uses; and there is often little or no land between buildings and the water. A gradual elevation of land surfaces thus may be more appropriate in areas such as Fell Point and the Inner Harbor. But many policies must be reviewed before the city could begin to embark on even this course of action. For example, planners stated that some adaptation options such as elevating old structures pose additional difficulties in an urban environment. For example, elevated waterfront properties could obstruct the views of property owners on interior blocks. To address the viewshed issue, Baltimore has adopted height restrictions for structures. Consequently, elevated houses might violate the height restriction.

Stakeholder reviewers noted no changes needed for the planning maps.[73] At a presentation to the Coastal Zone 2003 sea level rise session, the city's representative reaffirmed that retreat is unlikely and that a gradual elevation is most likely.[74] Map 6-4 shows the final product depicting the likelihood of shore protection.

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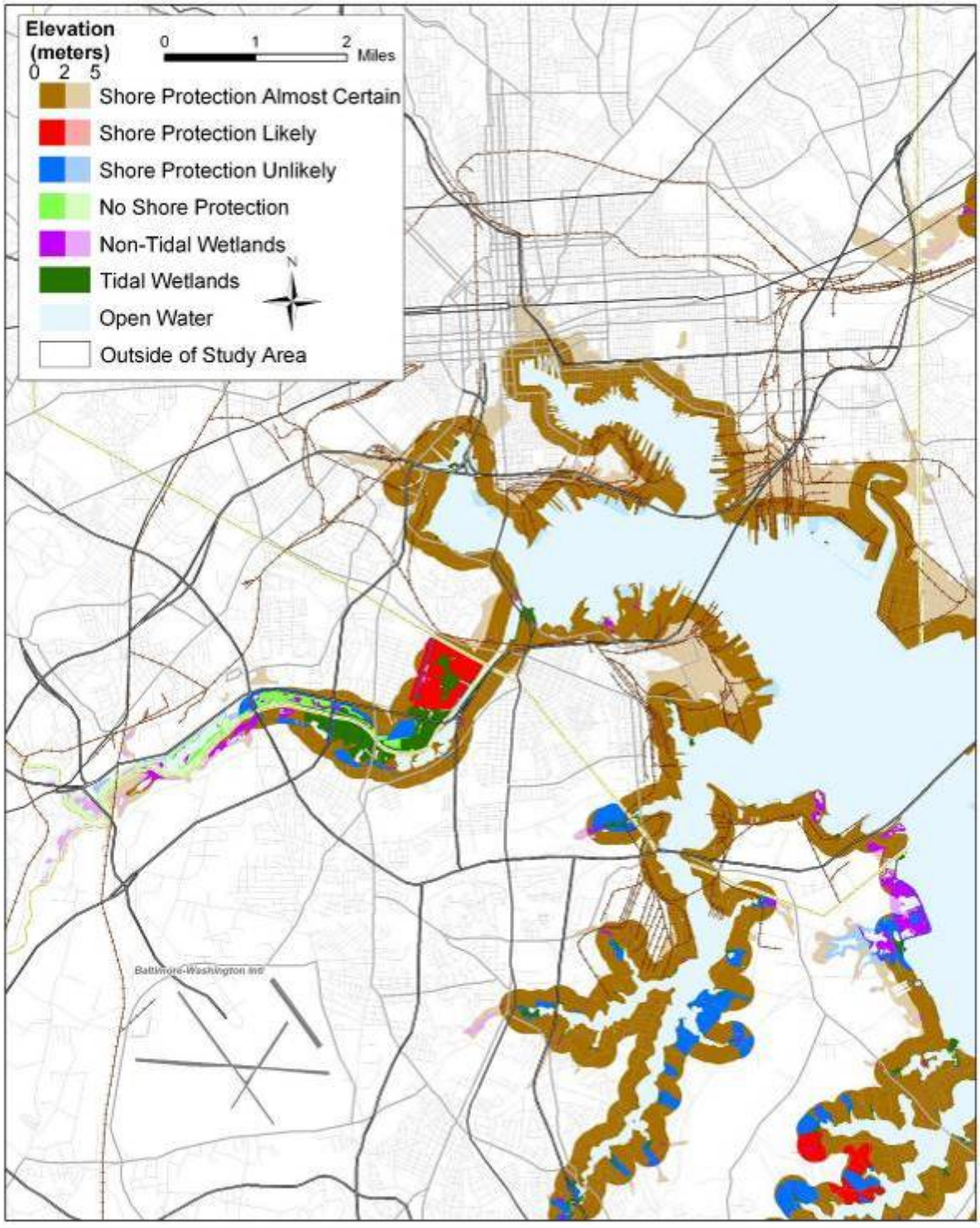
[69]U.S. Census Bureau, USA Counties, http://tier2.census.gov/cgi-win/usac/table.exe and Census 2000.
[70]http://www.dnr.state.md.us/greenways/counties/baltimorecity.html
[71]http://www.mdarchives.state.md.us/msa/mdmanual/01glance/html/port.html
[72]http://www.dnr.state.md.us/greenways/counties/baltimorecity.html

[73]Stakeholder review comments provided to William Nuckols by Peter Conrad via telephone on March 14 and March 19, 2003.
[74]Presentation by Peggy Drake, floodplain coordinator and principal planner, at "What Can America Learn from How Maryland Is Responding to Coastal Erosion and Rising Sea Level?", Coastal Zone 2003, held July 15, 2003.

TABLE 6-9. BALTIMORE CITY ANTICIPATED RESPONSE TO SEA LEVEL RISE

Land Area	Protection Likelihood	Data Used to Identify Land Area
All private and publicly owned lands	Certain	Land use/land cover in Maryland (MDP 1997)



Map 6-4. Baltimore City: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2.

Anne Arundel County

Background

Anne Arundel County, which is approximately 12 miles east of Washington D.C. and directly south of Baltimore, includes Annapolis, the state capital, as well as the Chesapeake Bay bridge, the gateway to Maryland's eastern shore. Between 1970 and 1995, the county's population grew from 298,042 to 459,700. The County anticipates much slower growth over the next several decades, with its population reaching only 531,500 by 2020. Nearly two-thirds of the county's residents live within 2 miles of tidal waters.[75]

Land-use studies conducted in 1995 indicate that 50 percent of the county's land is developed. Low- and medium-density residential use accounts for 29 percent of this developed land. Urban concentrations are found in northern Anne Arundel County and in Annapolis. Development within the eastern portion of the county is primarily suburban, while the southern portion of the county is mostly undeveloped. Agricultural land accounts for 13.6 percent of the county.[76]

As a result of the county's rapid population growth, water and sewer extensions have been important land management issues. Since the Master Plan for Water Supply and Sewerage Systems was proposed in 1966, the frequency of new water and sewer extensions has declined. These reductions are in part due to the Chesapeake Bay Critical Area Program's resource conservation area regulations, which restrict waterfront development. Current water and sewer upgrades will extend service only to remedy failing septic systems, saltwater intrusion, and other health-related problems. Extension of service to broad, new areas is restricted in an attempt to manage growth and development problems in the county.

Most coastal areas in the county have enough elevation to avoid direct inundation. The key exception is the peninsula in the Deal-Shady side area, where substantial lands are within about 3 feet (1 meter) or so of high water. A few blocks of downtown Annapolis are below the 5-ft (NGVD) contour. Both of these areas were flooded by the storm surge of Hurricane Isabel, in September 2003. (See Photos 1 through 8.)

Floodplains in the county are protected by subdivision regulations, the zoning code, and a floodplain ordinance. In areas where floods are caused by excessive rainfall, subdivision regulations require that these "riverine" floodplains remain in their natural condition. Zoning codes classify most of these floodplains as open space, and floodplain ordinances state that new subdivisions are not permitted within these 100-year floodplains.[77] Lots that have previously been platted, however, can still be developed. No structures are allowed to be constructed in the riverine floodplain. Along the coastal 100-year floodplain, subdivisions are allowed but all structures must be constructed with the first floor at least 1 foot above the base flood elevation.[78]

The City of Annapolis took the lead in banning the construction of new bulkheads (repairs of existing structures are allowed) before the state began to discourage their use (albeit after a large part of the City was bulkheaded). Although the County still permits other shoreline protection measures, local citizens and county managers recognized the environmental and recreational benefits of banning vertical structures.

Anticipated Response to Sea Level Rise

Based on communication with:

Rich Josephson, chief of Comprehensive Planning; Vivian Marsh, long range planner; Ginger Ellis, administrator of Environmental Services, Planning Division; and Elinor Gawel, planner

Table 6-10 summarizes the response to sea level rise by land classification that county planners expect. Highly urbanized areas will almost certainly be protected. For purposes of this

[75]Anne Arundel County 1997 General Development Plan.
[76]Anne Arundel County 1997 General Development Plan.

[77]Floodplain maps are generally developed by FEMA; when developing a new subdivision, however, the County does require the preparation of a new, local floodplain model.
[78]These two sentences were added by the county stakeholder review.

Photos 1–4. Anne Arundel County the Morning after Isabel. Photos 1 and 2 show the view walking along Main Street from the Capitol to the harbor at 10:30 a.m. The debris at the lower right of Photo 1 shows that the water had been higher earlier in the morning. (3) Along Randall Street, the water is up to the tops of newspaper boxes in the foreground, the harbor to the left, and businesses along Compromise Street in the background. (4) A motorized raft makes a turn from Prince George to Craig Street.

study, the County defined these areas as the city of Annapolis, town centers, and areas designated as intensely developed areas (IDAs) under the county's Critical Area Program. County planners have indicated that all medium-density lands and areas currently serviced by sewer systems (or planned for service within the next few years) will also certainly be protected.[79]

In general, rural, low-density development is unlikely to be protected. One exception is the privately owned Gibson Island, a community where property values are high. Critical Area lands designated as resource conservation areas (RCAs) are unlikely to be developed extensively and are therefore unlikely to be protected. Threatened agricultural lands outside of the RCAs, however, are expected to be developed and therefore are certain to be protected.

The County anticipates protecting all county-owned lands such as roads, sewer systems, buildings, and parks. In addition, although the state lacks policies to dictate future responses on state-owned lands, the County anticipates that these lands will be protected. In particular, Sandy Point State Park is assumed to continue its current policy of beach nourishment. The County assumes that federal land managers will continue their present courses of action. Lands associated with the U.S. Naval Academy are already heavily armored and will continue to be protected.

[79]The Deal/Shady Side area located within the southern portion of Anne Arundel was designated as a priority funding area under former Governor Glendening's Smart Growth program. That program directed growth into existing developed areas, but did not consider the impacts of coastal hazards. This is the only community in the county with a substantial amount of land within about 3 feet (1 meter) above the ebb and flow of the tides.

Photos 5–8. Anne Arundel County the Morning after Isabel. Photos (5) and (6) Views from Dock Street of Compromise and Randall streets, respectively. Photos 7 and 8 show Deal in the vicinity of Tracy's Creek, shortly after noon.

Stakeholder reviewers noted no changes needed for the planning maps.[80] At a presentation to the Coastal Zone 2003 sea level rise session, a county official presented the County's anticipated response to sea level rise.[81] Map 6-5 shows the final product depicting the likelihood of shore protection.

[80]Stakeholder review comments provided to William Nuckols by Ginger Ellis, administrator of Environmental Services, Planning Division, and Elinor Gawel, planner, at a meeting held at the county offices on January 24, 2003.

[81]Presentation by Ginger Ellis, administrator of Environmental Services, Planning Division, at "What Can America Learn from How Maryland Is Responding to Coastal Erosion and Rising Sea Level?", Coastal Zone 2003, held July 15, 2003.

TABLE 6-10. ANNE ARUNDEL COUNTY'S ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Area
		No protection	Unlikely	Likely	Certain	
Public	County-owned lands[b]				✓	County-owned lands (DNR MERLIN 2000)
Public	Sandy Point State Park and other park lands				✓	State-owned lands (DNR MERLIN 2000)
Public	U.S. Navy lands[c]				✓	Federal lands (DNR MERLIN 2000)
Mostly private	Lands subject to conservation easements		✓			Maryland Environmental Trust and agricultural easements/districts (DNR MERLIN 2000)
Mostly private	Private conservation lands	✓				Private conservation (DNR MERLIN 2000)
Mostly private	Gibson Island[d]				✓	Manual GIS edit
Mostly private	RCA lands		✓			Critical Area lands (DNR MERLIN 2000)
Mostly private	City of Annapolis and town centers				✓	Critical Area lands (DNR MERLIN 2000)
Mostly private	Other land outside of RCA lands				✓	Land use/land cover In Maryland (MDP 1997)[e]

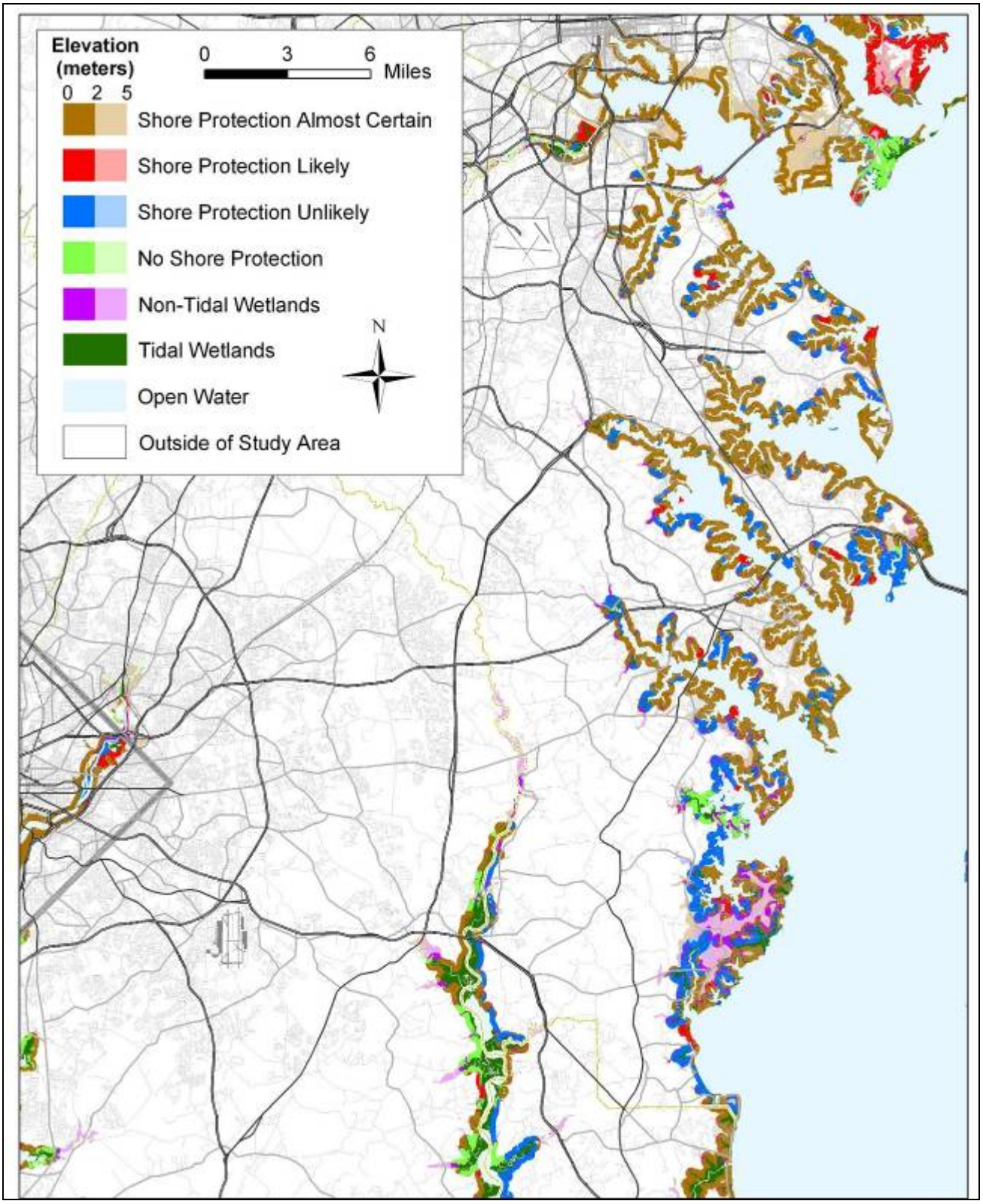
[a] Where land areas overlap, classifications higher in the table take precedence.

[b] County-owned lands include roads, sewer systems, county buildings, and parks.

[c] Other than those in urban areas, secured installations are treated as uncertain and colored red in the maps as a general rule applied nationwide until better information becomes available. Because the Naval Academy in Annapolis occupies land that would be protected even if the Navy sold the land to another institution, it is treated as certain to be protected.

[d] Although Gibson Island includes RCA lands, the County indicated an expectation that the entire island would be protected.

[e] Based on all land use classifications identified in land use/land cover data with the exception of open water and wetlands.



Map 6-5. Anne Arundel County: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2.

Calvert County

Background

Calvert County is located on a peninsula approximately 30 miles southeast of Washington, D.C. It is bounded on the east by Chesapeake Bay and on the west by the Patuxent River. The county is approximately 220 square miles in area and has 120 miles of shoreline. Calvert County is the smallest county in southern Maryland, but is also one of the fastest growing. Despite this growth, the County is committed to maintaining its rural character and agrarian roots through efforts such as farmland preservation programs.

The county has two incorporated towns, North Beach and Chesapeake Beach, which are located on Chesapeake Bay at the northeast corner of the county. (See Photos 9 through 15.) In addition, the county's Comprehensive Plan identifies seven "town centers": from north to south, Dunkirk, Owings, Huntingtown, Prince Frederick, St. Leonard, Lusby, and Solomons.

Calvert County's economy has changed significantly in recent decades. For 300 years, the residents relied on fishing and tobacco farming. In the twentieth century, tourism and recreation became an important part of the county's economy when the towns of North Beach and Chesapeake Beach were developed. Solomons also emerged as a location for fishing, marinas, and restaurants. When the Calvert Cliffs Nuclear Power Plant was built in the mid-1970s, the dependency of the county's economy on agriculture was further reduced.

Cliff Zoning

Calvert County is seen by many to be visionary in their planning efforts and policies on shore erosion control. Its unique erosion policy focuses on the presence of unique cliff areas that border Chesapeake Bay. The cliffs are viewed as a valuable natural resource, known as the best exposure of Miocene Age sediments in North America. They are a unique visual landmark and provide habitat to plants and wildlife, including endangered species.

As detailed by its 1998 Critical Area Program, the County will allow erosion control structures in certain developed areas to protect property interests, but will also ban structures in other areas to protect endangered species and the unique landscape.[82] Cliffs in Calvert County are separated into three categories according to the priority for preservation of the land:

- Category 1 provides the greatest environmental protection. Within Category 1 areas, no erosion control is allowed and new development must be set back from the cliff edge by 300 feet.
- Category 2 allows limited shoreline armoring. Within Category 2 areas, shore erosion control is allowed solely for the protection of structures built before 1997. A 200-ft setback for new development is also required.[83]
- Category 3 comprises all remaining cliff areas on the Chesapeake Bay. In this area and in noncliff areas, shore erosion control measures are allowed.

Calvert County has broad acceptance that its regulation takes precedence over the right to control erosion stipulated in the state Wetlands and Riparian Rights Act. This may be in part due to the open, public process under which the Calvert cliff policy was developed. To date, no legal challenges to the cliff policy have been made.[84]

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[82]Personal communication from Dr. David Brownlee to William Nuckols and Daniel Hudgens during an initial planning meeting at the county offices, December 14, 2000.

[83]Setbacks within each category are based on a specified distance from the top edge of the cliff or at the position the shoreline is estimated to be in 50 years, whichever is greater.

[84]Editor's Note: State law generally preempts county law, so the Calvert County policy might be challenged as inconsistent with state law. If challenged, the County would have several arguments, including (a) no statutory intent to override preexisting Calvert County policy if the legislature was acting in its role of trustee for the public trust waters; the states law might be pre-empted by the federal Clean Water Act, which bars general permits to fill waters unless there is no cumulative impact from doing so; or (c) the state law is pre-empted by the federal Endangered Species Act with which the County is attempting comply by protecting the tiger beetle.

Photos 9–15. Chesapeake Beach and North Beach the Day after Isabel. The beach at Chesapeake Beach has almost all been replaced by stone revetment, which protects against erosion but not high water (9). The new condominiums have first floors elevated to the base flood elevation, but owners suffered substantial uninsured losses because most had improved the floor below the first floor. As late as 2:00 p.m., the Bay was still over the road between Chesapeake Beach and North Beach (10), and several feet deep throughout low-lying areas of North Beach (11–12). The most severe damage occurred along the boardwalk section of Atlantic Avenue (13), although flooding was also severe along the avenue's paved portion (14–15).

Anticipated Response to Sea Level Rise

Based on communication with:

Dr. David C. Brownlee, Department of Planning and Zoning

Table 6-11 summarizes anticipated response to sea level rise in Calvert County by land classification. As discussed in the section on state policies, the Wetlands and Riparian Rights Act provides the statutory right to control shore erosion. However, the Calvert cliffs regulation and efforts to preserve endangered species limit erosion control efforts. As a result, shore protection is prohibited within sensitive species areas, Category 1, and undeveloped Category 2 cliff areas.[85]

Cliff Areas and Sensitive Species Areas

Within the Category 1 cliff area, the undeveloped Category 2 cliff area, and the sensitive species areas, property owners would be denied shore protection based on the existing policies. Consequently, lands within these areas cannot be protected and are therefore shown as light green.

The County anticipates that lands within the developed Category 2 and Category 3 cliff areas, which can be armored, will almost certainly be protected.

Lands Outside of Cliff Areas and Sensitive Species Areas

The County anticipates that significantly developed areas outside of the cliff and sensitive species areas will almost certainly be protected. The County also expects that lands outside the rural planning areas (we assume that this area is defined by the Critical Area RCA designation and the county's resource preservation and farm community districts) will be developed and therefore practical to protect. Within the rural areas, development will remain limited and shoreline protection is unlikely.[86] The communities of Buena Vista and Pots Point, however, are likely to be protected.[87]

The state and county lack policies and programs to address sea level rise on publicly owned lands. State-owned lands (such as Calvert Cliffs State Park) will be left to natural processes and thus not protected. Federal military lands (such as the Naval Air Test Center) and county recreational lands (such as Flag Ponds County Park and Patterson Park, which are currently armored), however, will almost certainly be protected.

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[85]During the stakeholder review meeting on February 6, 2003, Dr. David Brownlee noted that the sensitive species areas would also be preserved and shoreline protection would not be allowed. The sensitive species areas are identified by the Maryland DNR based on the authority of the Nongame and Endangered Species Conservation Act (Annotated Code of Maryland 10-2A-01). This act is supported by regulations (Code of Maryland Regulations 08.03.08) that contain the official state threatened and endangered species list.

[86]To prevent the increased density that accompanies sewer service replacing septic systems, the County will not extend water and sewer services to these rural lands.

[87]During the stakeholder review meeting held on February 6, 2003, Dr. David Brownlee noted that these communities, which were previously shown as unlikely to be protected, would most likely be protected in the future.

Based on stakeholder review comments, we revised the draft planning maps by incorporating the sensitive species area data as conservation lands that will not be protected from sea level rise.[88] In addition, the County asked us to change the communities of Buena Vista and Pots Point, which are located in the rural designated areas, from unlikely to likely to be protected because of the existing level of development in those communities.[89] The resulting maps were presented at the Coastal Zone 2003 conference.[90] Map 6-6 shows the final product depicting the likelihood of shore protection.

[88]These modifications produced a few narrow slivers, which would ordinarily indicate cases of data mapping problems (e.g., adjacent parcels share a boundary in reality, but two different sources for the adjacent polygons have slightly different estimates of the location of the boundary). In a few places where the sensitive species land extends almost 1,000 feet inland, our maps depict narrow areas or blue, red, or brown immediately behind the sensitive species land. These designations reflect the anticipated response of the land barely within the 1,000-foot buffer area but outside the sensitive species lands.

[89]Based on stakeholder review meeting held between William Nuckols and Dr. David Brownlee on February 6, 2003 at the county offices.

[90]Presented by William Nuckols. "What Can America Learn from How Maryland is Responding to Coastal Erosion and Rising Sea Level?", Coastal Zone 2003, held July 15, 2003. Dr. Brownlee was in the audience for a portion of the meeting, and indicated a general awareness of the EPA study during the question period at his own presentation on the cliff policy the following day.

TABLE 6-11. CALVERT COUNTY ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Area
		No protection	Unlikely	Likely	Certain	
Public	Federal lands – Navy			[b]		Federally owned lands (MERLIN 2000)
Public	Sensitive species areas	✓				Sensitive Species Project Review Area (DNR MERLIN 2000)
Public	County-owned lands				✓	County-owned lands (DNR MERLIN 2000)
Public	State-owned open space	✓				State-owned lands (DNR MERLIN 2000)
Mostly private	Sensitive Species Areas	✓				Sensitive Species Project Review Area (DNR MERLIN 2000)
Mostly private	Lands subject to conservation easements		✓			Agricultural easements/districts, Maryland Environmental Trust, rural legacy, and forest legacy lands (DNR MERLIN 2003)
Mostly private	Buena Vista and Pots Point			✓		Manual GIS edit per stakeholder review comment
Mostly private	Undeveloped lands in Category 2 cliff areas	(not legal[c])				Calvert County cliff categories /2001
Mostly private	Developed lands in Category 2 cliff areas and all lands in Category 3 cliff areas				✓	Calvert County cliff categories /2001
Mostly private	Category 1 Cliff areas[d]	(not legal)				Calvert County cliff categories /2001
Mostly private	Private conservation lands	✓				Private conservation lands (MERLIN 2000)
Mostly private	Industrial lands				✓	Land use/land cover in Maryland (MDP 1997)
Mostly private	Rural areas such as RCA Critical Areas and county resources preservation districts outside above cliff areas		✓			Manual GIS edit[e]
Mostly private	Remaining privately owned lands[f]				✓	Land use/land cover in Maryland (MDP 1997)

[a] Where land areas overlap, classifications higher in the table take precedence.

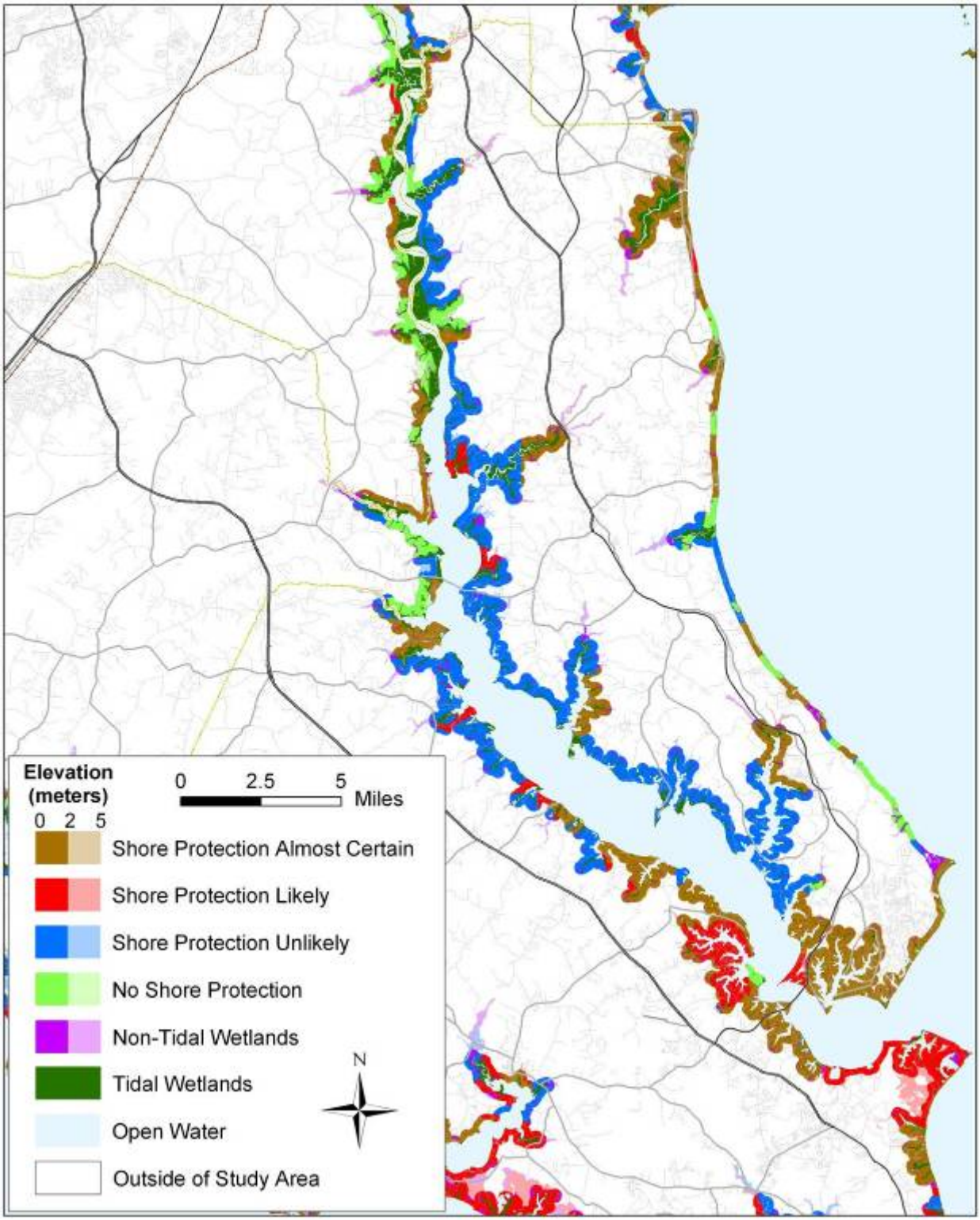
[b] Based on the nationwide approach of this study for secured installations, the maps depict these areas as red. The data we distribute assign the code “military” rather than “protection likely.”

[c] Calvert County is one of the very few locations in the nation where regulations prevent all shore protection (including soft engineering) along some private lands. We emphasize this situation by referring to protection as “not legal.” Otherwise, this classification is identical to “no protection.”

[d] Cliff areas identified from GIS data provided by the County.

[e] GIS data delineating these categories were unavailable when the response map was made. We delineated these areas in the response maps by manually adding the areas in GIS based on the location of the areas (and nearby landmarks) as identified in the Calvert County comprehensive plan maps available at http://www.co.cal.md.us/planning/complan/compmain.htm, which identify the resource preservation districts. The resulting areas represent the general boundaries and should not be considered to represent the actual regulatory boundaries.

[f] Based on all land use classifications identified in land use/land cover data with the exception of open water and wetlands.



Map 6-6. Calvert County: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2.

St. Mary's County

Background

St. Mary's County is located on the southern portion of Maryland's western shore. More than 600 miles of shoreline stretch along Chesapeake Bay, the Patuxent River, and the Potomac River. The county has more than 87,000 residents and is experiencing significant growth. By 2010, the county population is expected to reach 106,000.[91]

The county is predominately rural, with more than 83 percent of the land (nearly 192,000 of 231,000 acres) in agriculture production. To protect the natural areas of the shoreline, the County adopted a cliff ordinance that increases the development setback for lands with cliffs with a height of 20 feet or more to require either a 100-ft setback with an additional setback of 4 feet for every foot of cliff elevation above 20 feet or approved shore erosion protection designed for the 45-year storm event before construction of any principal structure on the site. An additional 2 percent (or 4,500 acres) of the county is local, state, or federally owned. These lands include Point Lookout, St. Clements Island, and St. Mary's River State Park. The U.S. Navy also owns the Patuxent River Naval Air Warfare Center and Webster Field.

The county has several growth areas, including the Lexington Park Development District and numerous town centers. The community on St. George's Island is particularly vulnerable to the impacts of sea level rise. Although the island is already hardened on the seaward side, the other side of the island lacks protection.

Anticipated Response to Sea Level Rise

Based on communication with:

Theresa Dent, environmental planner, and Sue Veith, county planner

Table 6-12 summarizes the anticipated response to sea level rise in St. Mary's County by land classification. In general, current and potentially future developed areas will be protected from sea level rise. County planners, however, identified protected areas through a neighborhood-by-neighborhood review where they marked the location of each neighborhood on a map. The St. Mary's County response map (Map 6-7) identifies these protected communities. Planners assume that lands within these identified communities are certain to be protected.

We relied on planner input via a detailed neighborhood by neighborhood designation of protection levels to determine the protection levels for areas within and outside potential cliff areas. The County's Comprehensive Zoning Ordinance has site development standards that mandate setbacks on lands with steep slopes, but a proposed special cliffed-coast measure that would have prevented shore protection on those shorelines was never implemented.[92] However, other regulatory guidance about stabilization is still in effect for shorelines with steep slopes.

The County anticipates that state and county-owned parks will be protected.[93] Thus, St. Clements Island and Greenwell state parks are shown as certain to be protected on the response map.

Through the stakeholder review process, additional changes were identified. Because the cliff policy had not been enacted, one of our first questions was whether the maps correctly reflect

[91] See U.S. Census Bureau, Quickfacts, http://quickfacts.census.gov/qfd/states/ 24/24037.html, and the Maryland Atlas of Greenways, Water Trails, and Green Infrastructure, http://www.dnr.state.md.us/greenways/counties/stmarys.html.

[92] See Calvert County, above, for a discussion of that county's policy.

[93] Based on stakeholder review comments received by William Nuckols during 1) a telephone conversation with Teresa Dent, environmental planner, on January 21, 2003, and 2) a meeting held at the county offices with Sue Veith, county planner, and Theresa Dent, environmental planner, on February 6, 2003.

the anticipated level of protection in the cliff areas. Based on their review of these areas and the remaining portion of the county, the following changes were made:

- St. Catherine and Clement islands were missing on the original maps. These islands are certain to be protected.
- St. Margaret Island is likely to be protected.
- Land between Mill Point Shores and Longview Beach is certain to be protected.
- The portion of land between White's Neck and Coltons Point is likely to be protected.
- Medleys Neck is likely to be protected.
- Land along Breton Bay in Leonardtown is likely to be protected.
- Land around Cornfield Harbor is likely to be protected.
- Point Lookout State Park is certain to be protected.[94]
- East of Rte. 235, land near St. James is likely to be protected.
- Lands bordering the inland creeks near Clarks Landing are likely to be protected.

[94]During the initial meetings, the planners identified the state and county-owned lands as unlikely to be protected, except for Point Lookout State Park, which is a recreational park that has already been armored. At that time, we forgot to ask the county planners whether the park should be considered likely or certain to be protected (red or brown). Given that the other parks were not likely to be protected at all, and that this peninsula is vulnerable to erosion from both sides and has, in fact, been gradually submerged over the last 100 years, the stakeholder review draft assumed that there was a reasonable chance that Point Lookout would ultimately be abandoned. Hence, the stakeholder review maps identified the land as only likely to be protected (red) instead of certain to be protected (brown). Stakeholder review comments, however, indicate that the County feels that this park will almost certainly be protected.

TABLE 6-12. ST. MARY'S COUNTY ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Area
		No protection	Unlikely	Likely	Certain	
Public	County sewage treatment plants				✓	Manual GIS edit based per planner input
Public	St. Clement Island				✓	Land use/land cover (MDP 1997)
Public	Point Lookout State Park				✓	Land use/land cover (MDP 1997)
Public	Other county-owned lands				✓	County-owned lands (MERLIN 2000)
Public	Other state-owned open space				✓	State-owned lands (MERLIN 2000)
Public	Federal lands—Patuxent River Naval Station and Webster Field U.S. Navy			[b]		Federally owned lands (MERLIN 2000)
Mostly private	Lands subject to conservation easements		✓			Maryland Environmental Trust and agricultural easements/districts (MERLIN 2000)
Mostly private	Private conservation lands	✓				Private conservation lands (MERLIN 2000)
Mostly private	St. Catherine Island				✓	Land use/land cover (MDP 1997)
Mostly private	St. Margaret Island			✓		Land use/land cover (MDP 1997)
Mostly private	Additional stakeholder review changes			✓	✓	Manual edits per stakeholder review comments (see description in text)
Mostly private	Areas around creeks			✓		Manual GIS edits per stakeholder review comments[c]
Mostly private	Future/currently developed areas				✓	Manual GIS edits per stakeholder review comments[d]
Mostly private	Other privately owned lands[e]		✓			Land use/land cover (MDP 1997)

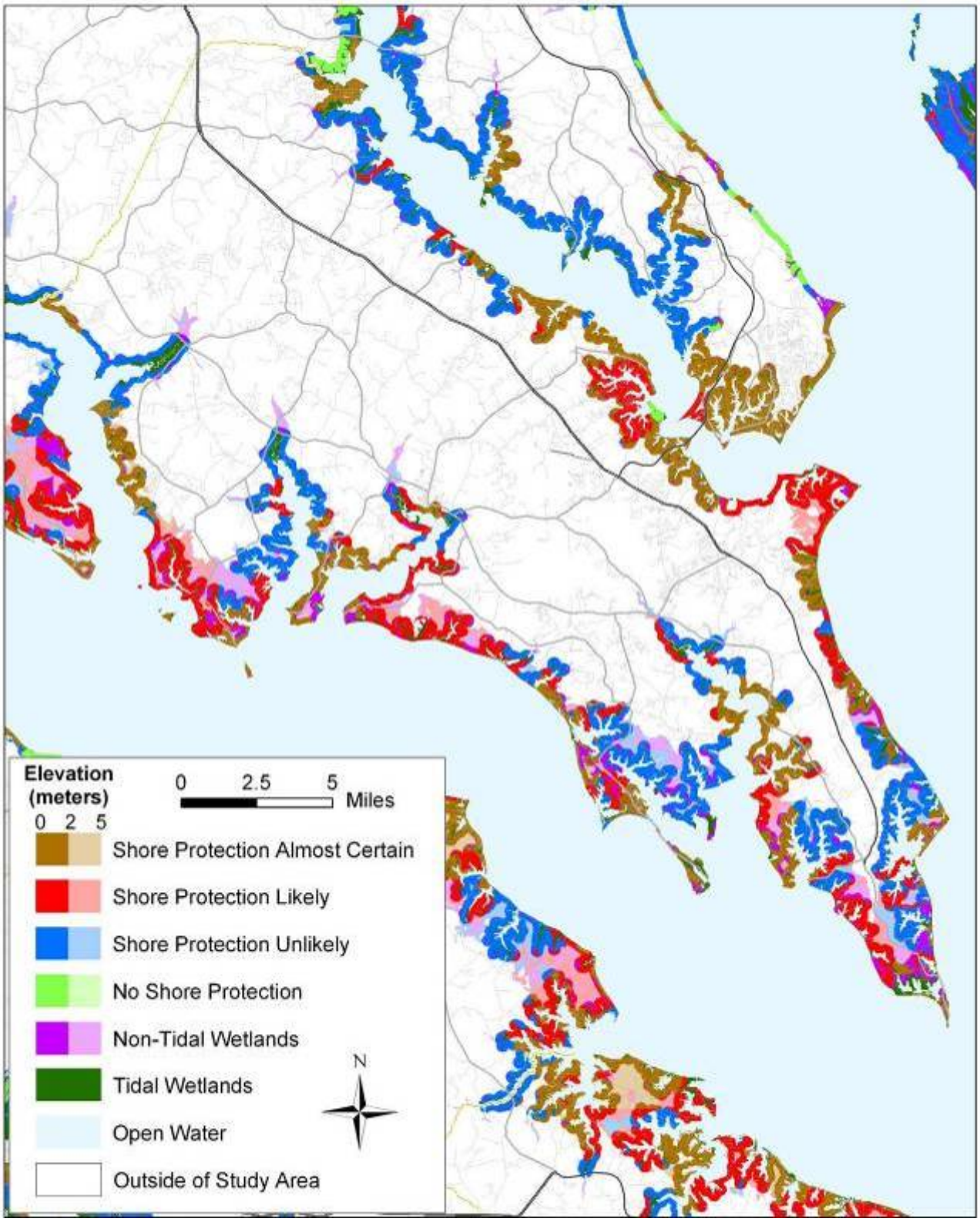
[a] Where land areas overlap, classifications higher in the table take precedence.

[b] Based on the nationwide approach of this study for secured installations, the maps depict these areas as red. The data we distribute assign the code "military" rather than "protection likely."

[c] Area identified by creating a buffer of 1,000 feet around existing creeks.

[d] During the initial meeting with St. Mary's County, the planners identified the communities along the shoreline that would be protected from sea level rise on a map. We used this information to manually delineate the protected neighborhoods in GIS.

[e] Based on all land use classifications identified in land use/land cover data with the exception of open water and wetlands.



Map 6-7. St. Mary's County: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2.

Charles County

Background

Charles County is located along the Potomac River and is predominately rural. Approximately 64 percent of the county can be characterized as forestland; the county's proximity to Washington, D.C., however, has led to increasing suburban development.[95] In 2000, Charles County had more than 120,000 residents, or 19.2 percent more than in 1990. The bulk of the population increase stems from development in the La Plata/Waldorf area, which is located well inland and not threatened by sea level rise.[96] Nevertheless, the demand for waterfront homes within a reasonable commuting distance to Washington is also creating pressure to develop along the shore. The most widely debated land use decision in the county in the last decade concerned the proposed development at Chapman's Landing, along the Potomac River just above Indian Head.

Cobb Island, which lies at the junction of the Potomac and Wicomico rivers, is shaped like a bowl and faces potentially significant impacts from sea level rise. The island is almost entirely armored along the Potomac and Wicomico sides. (See Photos 16 through 19.) Although the island itself is above the 10-ft contour, floodwaters often cover the area on the mainland side of the bridge that connects it to the rest of the county. Cobb Island is almost completely developed and served by a new sewer system, which allows for higher development densities than otherwise permitted.

Anticipated Response to Sea Level Rise

Based on communication with:

Steve Magoon, planning director; Chuck Beall, director of development; Glen Rauner, IT/GIS department; Don McGuire, director of emergency services; Cathy Currey, historic sites planner; and Karen Wiggen, environmental planner

Table 6-13 summarizes the anticipated response to sea level rise in Charles County by land classification. County staff indicate that the Critical Areas designations are useful in mapping future responses to sea level rise in Charles County. Land classified as intensely developed areas (IDAs) or limited development areas (LDAs) will be protected. Resource conservation areas (RCAs), where land is primarily undeveloped or developed at low densities, will not be protected. For areas outside the Critical Area lands, the planners told us to assume that existing development lands will certainly be protected and undeveloped lands will be abandoned.

Exceptions to the above, however, are as follows:

- Zakiah Swamp and Gilbert Swamp are both on the list of wetlands of special state concern. As a result they receive a 100-ft buffer rather than the 25-ft buffer typical of other nontidal wetlands.[97] The County purchased easements to protect the Zakiah Swamp from development. Consequently, it is unlikely that this land would be armored or nourished.
- The Morgantown power plant and the county sewer treatment plants are almost certain to be protected.
- Cobb Island has already been armored to protect the island's significant development. Steve Magoon stated that because of the island's shape and geology, erosion and inundation problems may result in protection being less economically feasible in the future. Therefore, the maps initially showed this island as blue.
- The historic town of Port Tobacco would be protected because of its cultural value. Three small islands in Port Tobacco, however, which currently house parking spaces and restaurants, are not likely to be protected.

[95]Charles County Master Plan.
[96]Charles County Demographic Trends, Volume 5, No. 2, April 2001.
[97]Charles County Comprehensive Plan Summary, 1997.

Photos 16–19. Cobb Island and Vicinity. Views of Cobb Island from (16) the mouth of Neal Sound into the Wicomico and from the Potomac (17). On the other side, some of the shores are armored (18) while some low areas still have marsh shores (19) (October 29, 2004).

- Over the next several decades, the Naval Surface Warfare Center at Indian Head would probably not need to armor the shore to protect its facilities, which are on high ground and hundreds of feet inland with only a few exceptions such as the small marina on the base. Eventually, armoring would be necessary as the shore erodes. In keeping with the study-wide practice of showing military lands in the intermediate category of protection likelihood, we show the Naval Surface Warfare Center and Blossom Point Proving Grounds as likely to be protected (red).

Currently, no state or county policies address whether publicly owned lands should be protected from sea level rise. The Maryland Historical Trust's inventory of historic sites lists nearly 400 sites in the county.[98] Prehistoric resources are located along the shorelines and swamps of the county and would be affected by rising seas. The County values its historic and cultural resources and protection is desired; no program or resources, however, are currently allocated for this purpose.

During stakeholder review of the report and maps, Steve Magoon, planning director, indicated that the GIS layers should be distributed as part of the state's Property View data. In addition, he noted that:

- Property value of land in the area of Cobb Neck is increasing in value (we changed the designation for this areas from protection unlikely to protection likely); and
- The historic town of Port Tobacco should be shown as certain to be protected.[99]

During a final review of this study, the EPA project manager sought to verify the reasons for assuming that Cobb Island is less likely to be protected than other developed areas. The result for Cobb seemed anomalous, given the relatively high ground and modest wave climate. The authors were unable to provide reasoning beyond the text of this report, which did not compare shore protection costs with property values.

Steve Magoon no longer worked for the county, and so the EPA project manager spoke with Karen Wiggen, an environmental planner generally familiar with shoreline issues. She confirmed that the homes on Cobb Island are older and smaller than those in the nearby areas we depict with brown. The island experienced substantial flooding with piers and other coastal structures damaged or destroyed by Hurricane Isabel. It also has a more serious erosion problem in places. Her observation is that people are putting up shore protection structures where necessary, and that the waterfront property is quite valuable. Older owners appear to be tolerating the loss of backyards, while new owners are tending to invest in shore protection structures. She indicated that as far as she can tell, planners within the county would not view Cobb Island as more likely to be abandoned as sea level rises than the other areas depicted in brown. She further indicated that saw no reason for such an assumption, and hence the final version of this study shows Cobb Island as brown.

During the final review of the maps, the authors realized that county parks had been erroneously listed as conservation lands that will not be protected. Because the County has no specific policy to promote a natural shoreline retreat, we corrected the maps to show county parks as unlikely to be protected.

Map 6-8 shows the final product depicting the likelihood of shore protection.

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[98]Charles County Comprehensive Plan Summary, 1997.
[99]Stakeholder review comments provided to William Nuckols by Steve Magoon, planning director, during a meeting at the planning office on January 30, 2003.

TABLE 6-13. CHARLES COUNTY ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

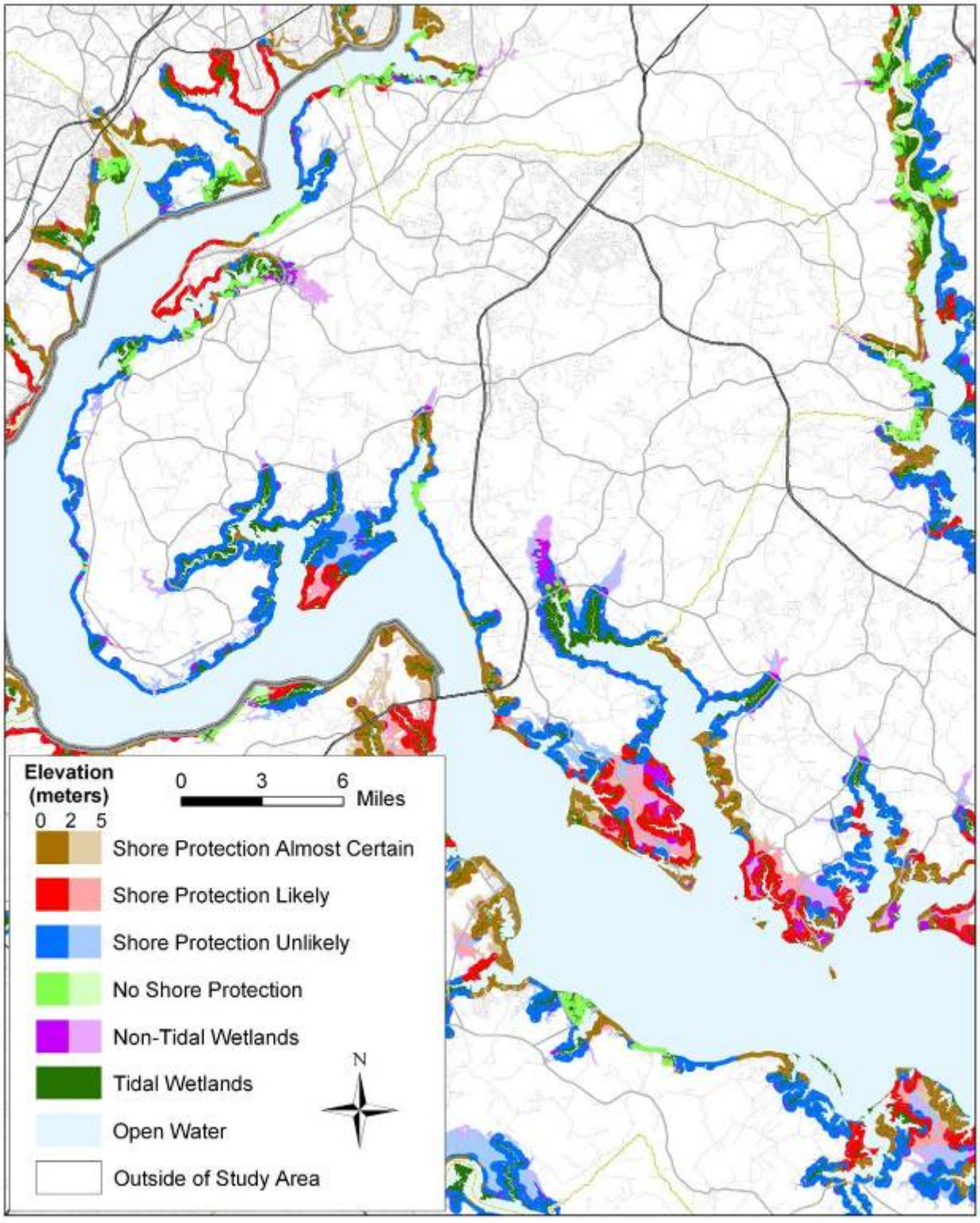
Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Area
		No protection	Unlikely	Likely	Certain	
Public	County-owned parks		✓			County-owned lands (MERLIN 2000)
Public	State-owned open space	✓				State-owned lands (MERLIN 2000)
Public	Federal lands—Naval Surface Warfare Center at Indian Head and Blossom Point Proving Grounds and Cedar Point Neck			[b]		Federally owned lands (MERLIN 2000)
Mostly private	Lands subject to conservation easements		✓			Maryland Environmental Trust and agricultural easements/districts (MERLIN 2000)
Mostly private	Private conservation lands	✓				Private conservation lands (MERLIN 2000)
Mostly private	Town of Indian Head				✓	Land use/land cover (MDP 1997)
Mostly private	Cobb Island				✓	Conversation with County during final review
Mostly private	Cobb Neck			✓		Land use/land cover (MDP 1997)
Mostly private	Port Tobacco Historic District				✓	Manual GIS edit per stakeholder review comment
Mostly private	IDA and LDA Critical Areas and developed lands outside Critical Area				✓	Critical Area lands (MERLIN 2000) and land use/land cover (MDP 1997)[c]
Mostly private	Rural lands (e.g., RCA areas)		✓			Critical Area lands (MERLIN 2000) and land use/land cover (MDP 1997)[d]

[a] Where land areas overlap, classifications higher in the table take precedence.

[b] Based on the nationwide approach of this study for secured installations, the maps depict these areas as red. The data we distribute assign the code “military” rather than “protection likely.”

[c] Identified by the intersection of land use codes representing developed lands including residential, commercial, industrial, and institutional with IDA or LDA designation in MERLIN Critical Area lands data. Includes private and governmental lands.

[d] Critical Area lands identified as rural Critical Area and lands identified as agricultural, range, or forestland in MDP land use data are identified as unlikely to be protected.



Map 6-8. Charles County: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2. For the eastern portion of Charles County along the Patuxent River, see the map of Calvert or St. Mary's County.

Prince George's County

Background

Prince George's County provided most of the land for the nation's capital, and hence the county borders Washington, D.C., on the northern, eastern, and southern sides. During the 1960s it was the fastest growing county in the nation, and today it is the wealthiest majority-black jurisdiction in the nation. Although a large part of the county is urbanized, tobacco barns are still found along the southeastern portion.

The county has three separate tidal areas. The southwestern portion along the Potomac River is largely suburban homes, but it also includes units of National Capital Park East and the still-vacant land just south of the Woodrow Wilson Bridge, which will eventually become Washington Harbor. The eastern border is the Patuxent River, which is tidal up to approximately Upper Marlboro, the county seat. The lands along the Patuxent River are mostly park lands that are off limits to development on the Prince George's County side of the river, but developing along Calvert County side. Finally, although most of the tidal Anacostia River is within the borders of Washington, D.C., the upper portion of the river is in Prince George's County, including the historic port of Bladensburg.

Even with sea level rise of 3 to 6 feet (1 to 2 meters), economic impacts would be minimal. Very little of the county's industry is located near the rivers. Along the Potomac River, the 20-ft contour tends to be within a few hundred feet of the water's edge, and significant waves are rare. Therefore, it would generally be cost-effective to protect most residential areas. Some of the land along the Anacostia River is fairly low, having formed from sedimentation near the river's head-of-tide. These areas are floodprone because high water levels accompany severe rainstorms. To some extent, this land is protected against a rise in sea level through a system of hardened shorelines and levees constructed to protect against river flooding. Pumping stations have been constructed along these levees to provide artificial drainage when river water levels are higher than the surrounding streets. Although there is some debate whether these levees are sufficiently high to protect against an extreme surge in the river, these levees could be elevated if necessary as the sea rises. Most of the land adjacent to the Anacostia River is publicly owned park land that provides a buffer along the river.

Along the Patuxent River, Program Open Space, a state program, has been acquiring land as a riparian buffer. In addition, the state's Rural Legacy Program owns lands along the Patuxent, further controlling development and lessening the impact of sea level rise.

The county is almost fully developed and the remaining open lands are not vulnerable to sea level rise. The county's policies regarding new building elevations for new construction should be noted for their progressive approach. In the 1940s, Prince George's County established a stormwater tax district to maintain a professional staff that conducts detailed county floodplain studies, works with ultimate conditions hydrology, and produces maps that extend the understanding of flooding beyond the FEMA Flood Insurance Rate Map (FIRM) coverages. County regulations establish FEMA/FIRM as the minimum elevation that needs to be addressed by a builder, but defines the floodplain for a particular development as the ultimate conditions hydrology, also known as ultimate build-out.

Anticipated Response to Sea Level Rise

Based on communication with:

Larry S. Coffman, associate director, Brian R. Willsey, senior planner, Christopher Akinbobola, Programs Administration Section head, all in the Department of Environmental Resources; and Cecelia A. Lambers, The Maryland-National Capital Park and Planning Commission

Table 6-14 summarizes the anticipated response to sea level rise in Prince George's County by land classification. County planners indicate that the existing policies provide an accurate assessment of the likely responses in the future. Given the current flood protection controls along the Anacostia River, adjacent lands are considered almost certain to be protected. All

remaining private lands are also almost certain to be protected.[100]

A number of policies have been implemented to protect the natural scenic beauty of the portion of the Prince George's County shoreline that can be seen from Mount Vernon, so that visitors looking across the Potomac at Maryland will be able to see what George Washington saw. Scenic easements have long been held by the U.S. government and others to ensure low-density development and prevent tree cutting in Moyonne Reserve in Accokeek and other areas directly across the river from Mount Vernon. More recently, the Piscataway Park Unit of National Capital Park East purchased land and scenic easements to protect the larger panorama. Although those easements do not directly address shoreline armoring, the clear intent to maintain the view as it was during the time of George Washington would probably imply that these shores will probably not be armored, even if preventing armoring were to require additional easements. Given the relatively mild wave climate, however, other forms of shore protection may be possible. Nevertheless, most of the viewshed within Prince George's County is now part of Piscataway Park, which the maps treat as not protected. The maps show some developed and undeveloped lands just inland of the park as likely and unlikely to be protected, respectively.

No programs or policies address the protection of public lands within the county. Residential areas around Bladensburg along the Anacostia River, however, are already protected to some extent by river levees and pumping systems as a result of efforts by the Army Corps of Engineers to reduce river flooding from extreme rainfall. Publicly owned lands along the Potomac and Patuxent rivers, however, would probably not be protected as the sea rises, except for Fort Foote and parts of Fort Washington, both units of National Capital Park East. Within Fort Washington Park, the fort itself and the Fort Washington Marina are almost certain to be protected. Other parts of the park, however, along both Piscataway and Swan creeks, are less likely to be protected, in keeping with the Park Service's general approach of allowing shores to migrate. Nevertheless, the area between the marina and the fort might be protected, because such protection could prove to be the most effective way to protect the fort and the marina.

Stakeholder reviewers noted no changes needed for the planning maps.[101] Map 6-9 shows the final product depicting the likelihood of shore protection.

[101]Stakeholder review conducted by William Nuckols via 1) a telephone discussion with Brian Willsey on February 25, 2003, and 2) an in-person meeting at Prince George's Department of Environmental Resources offices on May 5, 2003.

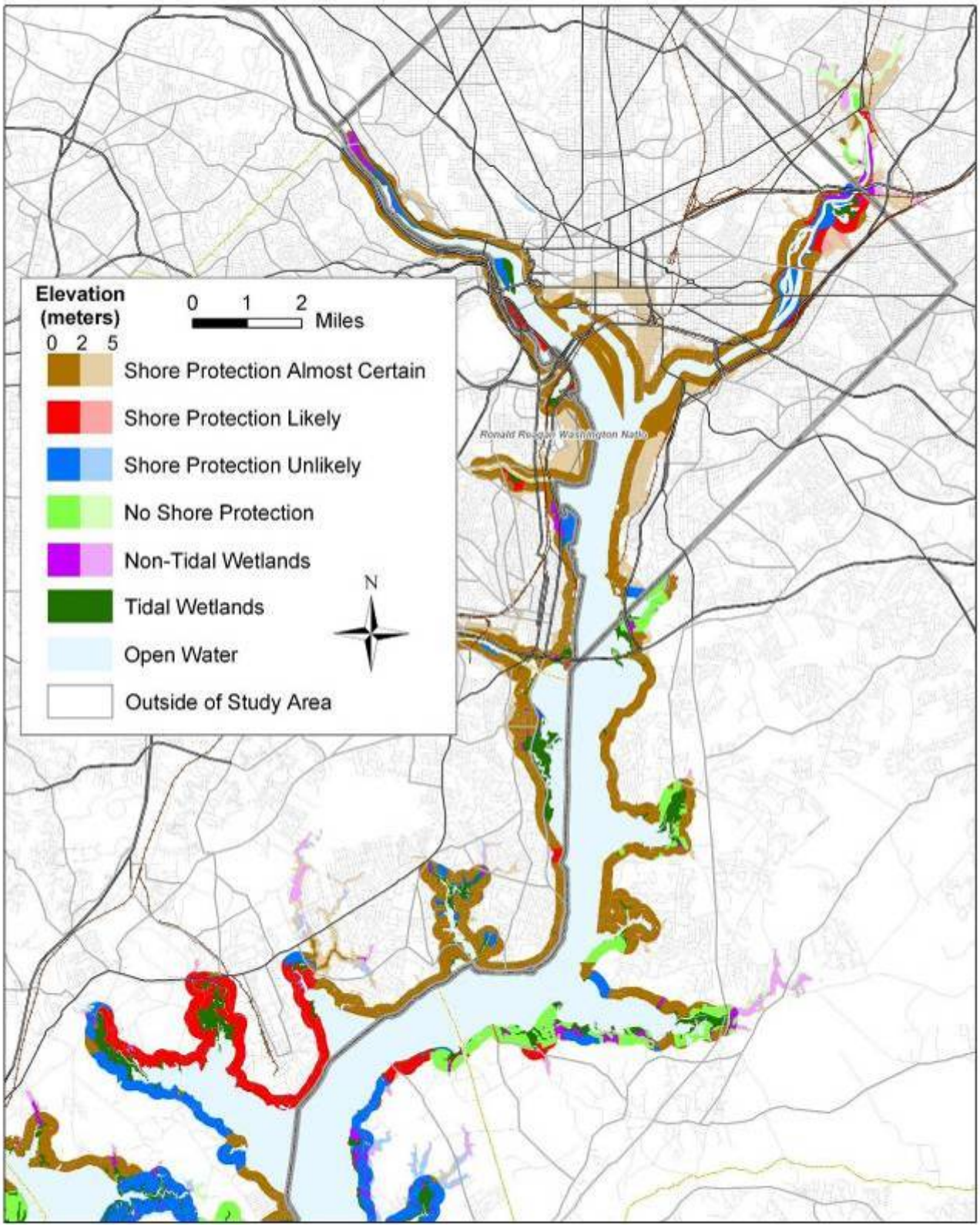
TABLE 6-14. PRINCE GEORGE'S COUNTY ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Area
		No protection	Unlikely	Likely	Certain	
Public	Fort Foote Park				✓	Federally owned lands (MERLIN 2000)
Public	Fort Washington and Fort Washington Marina[b]				✓	Federally owned lands (MERLIN 2000)
Public	Lands along Swan Creek within Fort Washington Park	✓				Federally owned lands (MERLIN 2000)
Public	Public lands on the Potomac and Patuxent rivers	✓				State-owned lands and county-owned lands (MERLIN 2000)
Public	Lands between Fort Washington and Washington Marina		✓			Manual GIS edit
Public	Remaining federal lands	✓				Federally owned lands (MERLIN 2000)
Mostly private	Lands subject to conservation easements		✓			Maryland Environmental Trust and agricultural easements/districts (MERLIN 2000)
Mostly private	Undeveloped areas within Mount Vernon viewshed		✓			Based on location of Accokeek Foundation as delineated in private conservation lands (MERLIN 2000)
Mostly private	Developed areas within Mount Vernon viewshed			✓		Based on location of Accokeek Foundation as delineated in private conservation lands (MERLIN 2000)
Mostly private	Private conservation lands	✓				Private conservation lands (MERLIN 2000)
Mostly private	All private lands[c]				✓	Land use/land cover in Maryland (MDP 1997)

[a] Where land areas overlap, classifications higher in the table take precedence.

[b] Fort Washington and Fort Washington Marina are almost certain to be protected. The cliffs along Piscataway Creek between the marina and the fort and lighthouse might be protected as an indirect results of efforts to protect the facilities.

[c] Identified by all land use classifications in land use/land cover data with the exception of open water and wetlands.



Map 6-9. Prince George's County: Likelihood of Shore Protection For additional details, see the legend and caption accompanying Map 6-2. For the eastern portion of Prince Georges County along the Patuxent River, see the maps of Anne Arundel and Calvert counties.

EASTERN SHORE COUNTIES

Cecil County

Background

Cecil County, the northernmost county along Chesapeake Bay, is located between the Susquehanna and Sassafras rivers. Although most of the water flowing into the Bay comes from the Susquehanna River, most of the ship traffic comes through the Chesapeake & Delaware Canal, which connects to the Elk River at Chesapeake City. More than 85,000 people reside in the county.

Cecil County has experienced substantial growth as a result of spillover development pressure from the east (New Castle County, Delaware). Most of this development has occurred in the I-95 and U.S. 40 corridors, which run east–west through the county. Population centers are located in and around the incorporated towns of Elkton, Charlestown, North East, and Perryville and in small coastal communities along the waterfront. Future growth is expected to occur in the vicinity of these existing communities.

Most of the county's land is above the 20-ft elevation contour, with coastal areas along the Susquehanna River (north of Perryville) characterized by high bluffs and minimal tidal wetlands. Several major towns, however, are located directly along the coast and are at risk:

- Port Deposit, located on the Susquehanna River, has experienced a number of floods in the past, often exacerbated by floodwater discharge from Susquehanna Dam.
- Perryville is located at the mouth of the Susquehanna River and has experienced floods in the past. Perryville's shoreline consists of a mix of marinas, commercial uses, and a medium-density residential condominium project.
- Charlestown and North East are located along the Northeast River and have experienced flooding in the past.
- Elkton is located at the head of the Elk River and has also experienced flooding.

Each of these towns is served by wastewater treatment plants and possesses unique historic buildings and structures, some of which are located below the 20-ft elevation contour. (See Photos 20 through 6-26.)

Cecil County reports that nonstructural shore erosion measures have been used with some regularity and success in the county. In one instance, Cecil County used a special taxing district to implement an area-wide shore erosion protection program.

Anticipated Response to Sea Level Rise

Based on communication with:

Eric Sennstrom, director of Planning, Zoning, Parks & Recreation

Table 6-15 summarizes the anticipated response to sea level rise in Cecil County by land classification, used in creating both the original draft and final maps. Cecil County anticipates that developed lands will be protected. To the extent necessary, the County will take steps to help landowners in densely developed areas protect their properties. We identify all existing developed lands under the 20-ft elevation contour as almost certain to be protected in the future. These areas are located within the incorporated towns of Port Deposit, Perryville, Charlestown, North East, and Chesapeake City. Chesapeake City, which is located on the C&D Canal (see Photos 27 and 28), will benefit from any protection measures instituted by the Corps of Engineers to protect the canal. Other

Photos 20–23. Crystal Beach. This community along the mouth of the Elk River sits atop a 30-foot bluff. (May 2005).

Photos 24–26. Shores of the Elk River. Stone revetments along the shore at Town Point (24) as well as the other side of the Elk River (25). A narrow sandy beach in front of a concrete bulkhead at Hollywood Beach (26) (May 2005).


Photos 27–28. Chesapeake City (May 2005).

developed portions of the shoreline along the C&D Canal, an important state economic feature, are typically located above 40- to 50-ft bluffs, some of which were created by excavation of the canal. These shores would be protected if necessary, either to protect development or to maintain the canal.

Cecil County reports that nonstructural shore erosion measures have been used with some regularity and success in the county. In one instance, Cecil County used a special taxing district to implement an area-wide shore erosion protection program. Existing developments along Grove Neck and Pond Neck will certainly be protected. Current and planned development patterns are likely to result in more development along the northern banks of the North East River between Perryville and North East. Some development has already taken place in this area, including an industrial development on the north side of Perryville and a townhouse project on the south side of North East. The area between North East and Perryville is also designated as part of the county's Development District. Based on the decision rules, the original draft projected that future development in this district will probably be protected.

Public facilities at risk will also almost certainly be protected. For example, the Seneca Point Sewer System, which is expected to serve future development in the county's designated development areas, will almost certainly be protected by the state.

Although property owners can protect their land, in less-developed areas the economic cost of installing and maintaining seawalls or other structures may be prohibitive. For example:

- The undeveloped portions of Elkton are unlikely to receive shoreline protection.
- Little development has taken place along the Sassafras River. The County does not expect significant future development in this area south of the C&D Canal, and therefore shoreline protection is also not likely.

County staff reviewed the original draft maps and suggested the following changes [102]:

- The planners had originally told us that the areas depicted in red should include those areas where they expect development. During the stakeholder review, the planners decided that these areas will almost certainly be protected, eventually.
- The County anticipates that the entire Knights Island area will almost certainly be protected.

During the final review of the maps, the authors realized that county parks had been erroneously listed as conservation lands that will not be protected. Because the County has no specific policy to promote a natural shoreline retreat, we corrected the maps to show county parks as unlikely to be protected.

Map 6-10 shows the final product depicting the likelihood of shore protection.

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[102]Based on a stakeholder review meeting between Peter Johnston and Eric Sennstrom at the county offices in September 2002.

TABLE 6-15. CECIL COUNTY ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

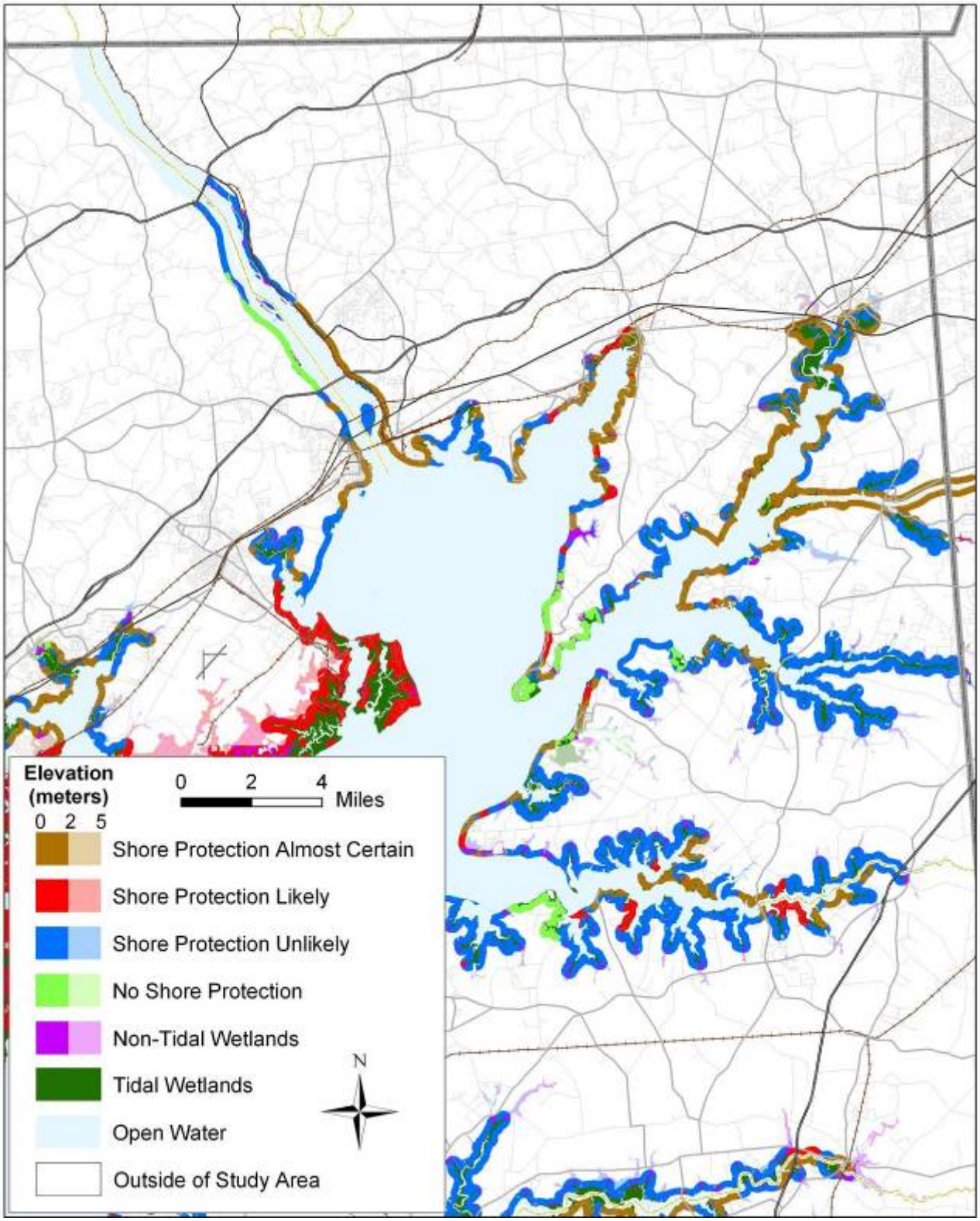
Ownership	Land Area	Protection–Draft	Protection–Final[b]	Data Used to Identify Land Area
Public	Federally owned lands	No protection	No protection	Federally owned lands (DNR MERLIN 2000)
Public	State-owned open space	No protection	No protection	State-owned lands (DNR MERLIN 2000)
Public	County-owned parks	No protection	Unlikely[c]	County-owned lands (DNR MERLIN 2000)
Public	County-owned utilities and transportation facilities	Certain	Certain	MD Property View data (1998)
Mostly private	Land held in conservation easements	Unlikely	Unlikely	Maryland Environmental Trust lands and agricultural easements/districts (DNR MERLIN 2000)
Mostly private	Municipalities (Port Deposit, Perryville, Elkton, Chesapeake City)[d]	Certain	Certain	MD Property View data (1998)
Mostly private	Areas of current and planned infrastructure investment priority funding areas (PFA)	Certain	Certain	Manual GIS edit per County Comprehensive Plan (1990)
Mostly private	Existing high- to medium-density residential areas, IDA lands, existing major employment and commercial areas, and planned growth areas	Certain	Certain	Manual GIS edit per County Comprehensive Plan (1990)
Mostly private	Knight's Island[b]	Likely	Certain	Manual GIS edit per stakeholder review comment
Mostly private	Low-density areas already developed, e.g., LDA lands, villages and enclaves at low densities	Certain	Certain	Manual GIS edit per County Comprehensive Plan (1990)
Mostly private	Areas where development is expected	Likely	Certain	Manual GIS edit per County Comprehensive Plan (1990)
Mostly private	Agricultural/RCA land (very low-density residential)	Unlikely	Unlikely	Manual GIS edit per County Comprehensive Plan (1990) and MD Property View data (1998)

[a] Where land areas overlap, classifications higher in the table take precedence.

[b] Changes based on stakeholder review meeting between Peter Johnston and Eric Sennstrom, Cecil County, September 2002.

[c] Author-initiated change to correct map error in stakeholder review draft: the County originally excluded parks from areas likely to be protected; the stakeholder review draft had erroneously included these parks within conservation lands even though the County has no policy precluding shore protection.

[d] This category includes privately owned lands and municipally owned lands contained within the municipalities.



Map 6-10. Cecil County: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2.

Kent County

Background

With fewer than 20,000 residents, Kent County is one of the least densely developed counties on Maryland's eastern shore. The County has succeeded in concentrating growth in the incorporated towns, which are its designated growth areas. Much of the development is concentrated in the municipalities of Rock Hall and Chestertown, which are at least partially located under the 20-ft elevation contour. Rock Hall Harbor is an important landing and off-loading area for local watermen, and Chestertown contains numerous important historic and cultural resources. (See Photos 29 and 30.)

Sea level rise will pose problems for sewer treatment facilities in many of the county's designated growth areas. Sewer treatment facilities in the towns of Rock Hall, Chestertown, Millington, and Betterton are located below the 20-ft elevation contour. (See Photos 31 and 32.) The Millington sewer treatment plant is also located within the 100-year floodplain.

Outside the incorporated towns, development is limited and is not likely to expand in the future. Between low population growth and limitations imposed by the county's Critical Area Program and rural/agriculture conservation zoning (one dwelling unit per 30 acres), only minimal new development can take place in the county's coastal areas.

Anticipated Response to Sea Level Rise

Based on communication with:

Gail Owings, planning director[103]

Table 6-16 summarizes the anticipated response to sea level rise in Kent County by land classification. The County anticipates that shoreline protection will almost certainly take place in existing settlements and in those areas planned for future growth, which include the area surrounding Rock Hall, Chestertown, Betterton, and Tolchester Estates (See Photo 33).

In less developed areas, however, protection may not be feasible. The economic cost of installing and maintaining seawalls or other structures will most likely limit their use. Consequently, the County anticipates that protection is unlikely in coastal areas outside the currently designated growth areas.

Additionally, the local Critical Area regulations will limit development in the first 1,000 feet shoreward of tidal limits in the coastal areas unless the County opts to use "growth allocation" to permit more intense coastal development than would be currently permitted. Growth allocation is a limited means of rezoning property in the near-shore zone for development that is more intensive than one dwelling unit per 20 acres. Because of the limited acres of growth allocation available in the county, however, the potential impact of growth allocation on the Critical Area is minimal.

During the final review of the maps, the authors realized that county parks had been erroneously listed as conservation lands that will not be protected. Because the County has no specific policy to promote a natural shoreline retreat, we corrected the maps to show county parks as unlikely to be protected.

Map 6-11 shows the final product depicting the likelihood of shore protection.

[103]Kent County's planning director also indicated the need for continued consideration of sea level rise impacts in many federal, state, and local planning efforts. For example:

- The county would benefit from more accurate flood elevation data.
- The Governor's Smart Growth initiatives should consider the impacts of sea level rise on the current and potential priority funding areas.
- Sea level rise may cause conflicts between current state policies and major shore erosion control projects, e.g., Poplar Island.
- Managing for sea level rise at the local government level will require the state and federal governments to dedicate more resources to education and to financial assistance and will require state or federal legislative mandates that require appropriate management practices.
- The location of existing structural and nonstructural erosion control measures should be mapped.

Photos 29–30. Rock Hall (September 2002).
Photos 31–32. Betterton Beach (September 2002).

Photo 33. Tolchester Beach (September 2002). "Tolchester Beach Amusement Park. Opened…in 1877 in an era when the steamboat was a primary mode of social and commercial transportation in the tidewater region…Steamers ran daily between Baltimore and the Park, which grew to over 150 acres and included a hotel, pavilion, and bathing beach, and a variety of rides and attractions. The park closed in 1962." From nearby historic marker.

TABLE 6-16. KENT COUNTY ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Area
		No protection	Unlikely	Likely	Certain	
Public	State-owned open space	✓				State-owned lands (DNR MERLIN 2000)
Public	County-owned park and recreation lands[b]		✓			County-owned lands (DNR MERLIN 2000)
Public	County-owned utilities and transportation facilities				✓	Manual GIS edit and land use/land cover in Maryland (1997)
Mostly private	Land held in conservation easements		✓			Maryland Environmental Trust lands and agricultural easements/districts (DNR MERLIN 2000)
Mostly private	Municipalities (Rock Hall, Chestertown, Millington,[c] Tolchester Estates,[c] and Betterton)[d]				✓	Statewide grid maps (1998)
Mostly private	Areas of current and planned infrastructure investment priority funding areas (PFA)				✓	Manual GIS edit per County Comprehensive Plan (1996) and planner input
Mostly private	Existing high- to medium-density residential areas, IDA lands, existing major employment and commercial areas, and planned growth areas				✓	Manual GIS edit per County Comprehensive Plan (1996) and planner input
Mostly private	Low density areas already developed, e.g., developed LDA lands, villages, and enclaves at low densities			✓		Land use/land cover in Maryland (1997)[e] and manual GIS edit per County Comprehensive Plan (1996)
Mostly private	Agricultural/RCA land (very low-density residential)		✓			Land use/land cover in Maryland (1997) and manual GIS edit per County Comprehensive Plan (1996)

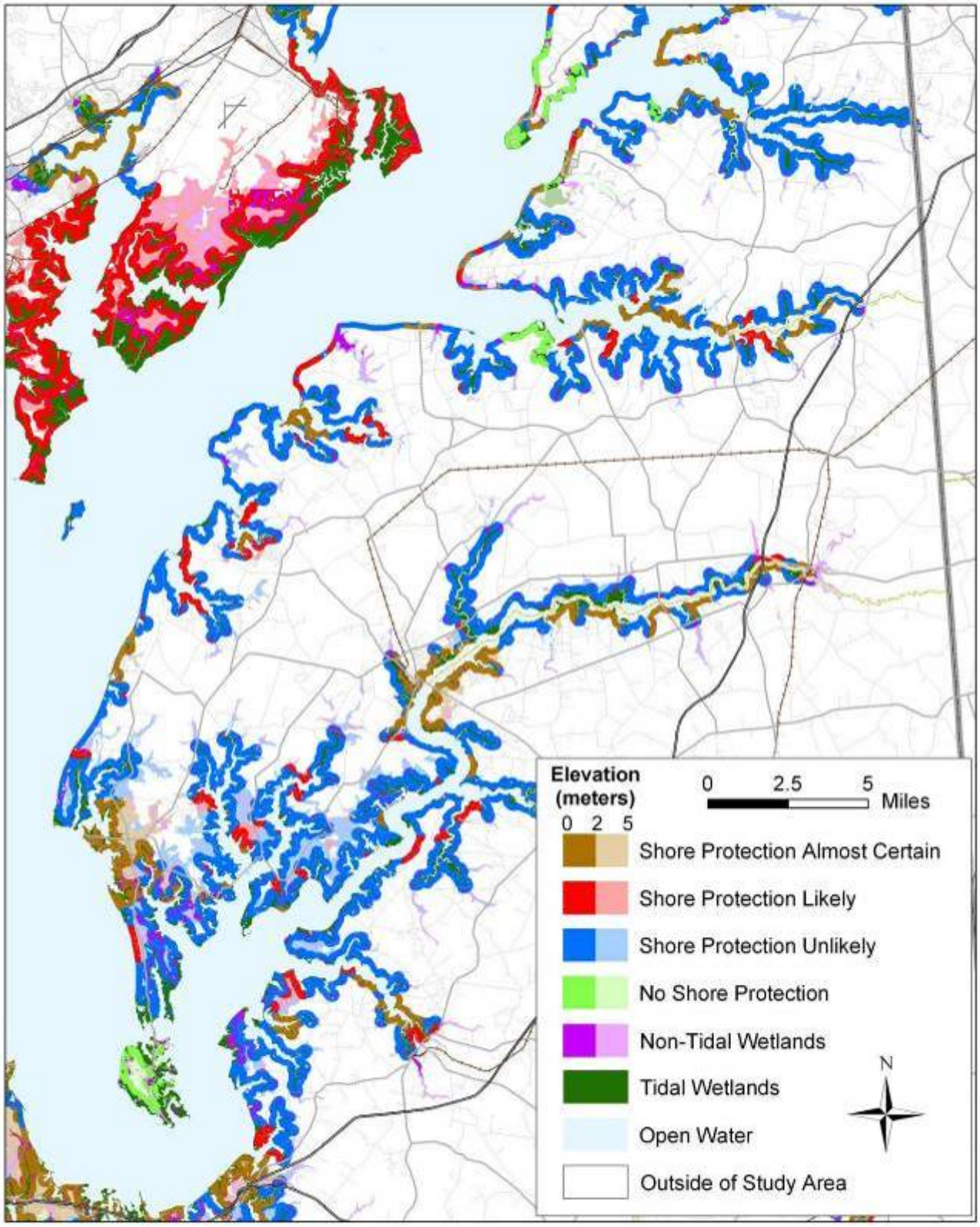
[a] Based on original maps, unless otherwise indicated. Where land areas overlap, classifications higher in the table take precedence.

[b] Author-initiated change from conservation lands to protection unlikely, after stakeholder review. This change corrected map error in the stakeholder review draft: the County originally excluded parks from areas likely to be protected; the stakeholder review draft had erroneously included these parks within conservation lands even though the County has no policy precluding shore protection.

[c] Added as a result of the stakeholder review; originally mapped as likely to be protected.

[d] This category includes privately owned lands and municipally owned lands contained within the municipalities.

[e] Residential, industrial, commercial, institutional. Includes private and publicly owned lands.



Map 6-11. Kent County: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2.

Queen Anne's County

Background

Queen Anne's County is located along Maryland's eastern shore, and is easily reached from the western shore because the Chesapeake Bay Bridge connects Kent Island to Anne Arundel County. As a result, the state has invested a great deal in transportation facilities in this area (the U.S. 50/301 corridor).

The county has more than 40,000 residents and several municipalities, including Centerville. Its growth management policies continue to encourage growth in areas located below the 20-ft elevation contour. Most of Queen Anne's County's development since the 1950s has been on or near Kent Island, because of proximity to the Bay Bridge. As a result, the County has committed to capital improvements in this area to support growth, including a regional sewer system.

Anticipated Response to Sea Level Rise

Based on communication with:

Steven Ziegler, planning director

Table 6-17 summarizes the anticipated response to sea level rise in Queen Anne's County by land classification. Existing developed areas and those areas where growth management policies focus future development will almost certainly be protected from sea level rise. The County anticipates continuing its policy of concentrating growth in its six designated growth areas, the Centerville, Chester, Kent Narrows, Grasonville, Stevensville, and Queenstown areas.[104] The County and state will continue making major capital investments that support growth in this area and consequently will open up coastal areas to more intense development than is currently permitted under the county's Critical Area protection requirements. As a consequence of these growth patterns, population concentrations, and public capital investment, the County will seek state and federal assistance to protect these areas.

Outside the developed areas, the county and municipal Critical Area programs limit growth in coastal areas. Queen Anne's County has implemented a Critical Area buffer that requires a 100-ft buffer from the shoreline for all new development.[105] Although property owners in these areas can protect their land, it is unlikely that low-density development will be protected. The economic cost of installing and maintaining revetments is high compared with property values in those areas. County planners, however, anticipate that on Kent Island some low-density development areas are certain to be protected to prevent the surrounding developed lands from becoming separate islands.[106]

Our original maps were based entirely on the general tendencies based on land use classifications. The County suggested nine site-specific changes during the stakeholder review, all of which would tend to increase the likelihood of shore protection.

Change the blue polygons that include the Cloverfields Subdivision (with 1,000 homes) from blue to brown.[107]

Change the pending Gibson's Grant (750 units) and the Chester Haven Beach development (188 lots of record) from blue to brown.[108]

Change the existing Bennett Point Estates development from blue to brown.[109]

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[104]Stakeholder review letter from Steven Kaii-Ziegler, director, Department of Planning and Zoning, Queen Anne's County, to Daniel Hudgens, IEc, October 18, 2002.

[105]Until 2002, Queen Anne's County required a 300-foot buffer from the shoreline for all new nonresidential and moderate/high-density residential development. Even then, the "shore buffer" could be reduced to 100 feet for low-density residential uses and for all other uses in hardship cases. This rules was repealed in 2002. Stakeholder review letter from Steven Kaii-Ziegler, director, Department of Planning and Zoning, Queen Anne's County, to Daniel Hudgens, IEc, October 18, 2002.

[106]Stakeholder review letter from Steven Kaii-Ziegler, director, Department of Planning and Zoning, Queen Anne's County, to Daniel Hudgens, IEc, October 18, 2002. In addition, Peter Johnston met with Steve Kai-Ziegle and Steve Cahoon, GIS specialist, Queen Anne's County, on September 4, 2002, at the offices of the Department of Planning and Zoning.

[107]This area was apparently omitted because the development took place after our dataset was created.

[108]Our data had not listed this area as a planned growth area. We are unsure why the initial meetings with the County did not identify this location as an area that is likely to be developed.

Change the peninsula with Coursey Point, across Little Queenstown Creek from old Queenstown, from blue to brown.[110] This area already has 200 units, and 2,000 units are proposed.

Change five large blue polygons on Kent Island from blue to brown because if those lands are not protected, nearby residential areas would eventually become islands as sea level rises.

We made most of the changes that the County sought.[111] The major exception was the five polygons requiring protection to prevent Kent Island from becoming several islands. Because the role of the County was not to provide civil engineering advice to this project, their view regarding the most effective way to protect Kent Island is not necessarily dispositive. If neighborhoods are protected with fill, it would be feasible to allow intervening lands to convert to marsh and even open water, while elevating the road to maintain road access. Therefore, as long as those lands remain undeveloped, protection is not certain. On the other hand, we do want to be responsive to the County's perspective, which may also implicitly reflect an expectation that the land will eventually be developed. Therefore, we show these lands as likely to be protected.

During the final review of the maps, the authors realized that county parks had been erroneously listed as conservation lands that will not be protected. Because the County has no specific policy to promote a natural shoreline retreat, we corrected the maps to show county parks as unlikely to be protected.

Map 6-12 shows the final product depicting the likelihood of shore protection.

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[109]This area has a number of very large homes. We originally assumed that areas with low density will not be protected. The County recognized that our assumption would tend to understate likely shore protection in areas where the number of units are low because the homes are large and the owners affluent.

[110]We are unsure why the initial meetings had not identified this area as likely to be developed.

[111]The County also asked us to change the light green polygon north of the Bay Bridge from light green to brown because it includes the county's wastewater treatment plant. That polygon was Terrapin Park, not the industrial park that includes the wastewater treatment plan. The park, however, had been erroneously depicted as green rather than blue, which we corrected.

TABLE 6-17. QUEEN ANNE'S COUNTY ANTICIPATED SEA LEVEL RISE RESPONSE[a]

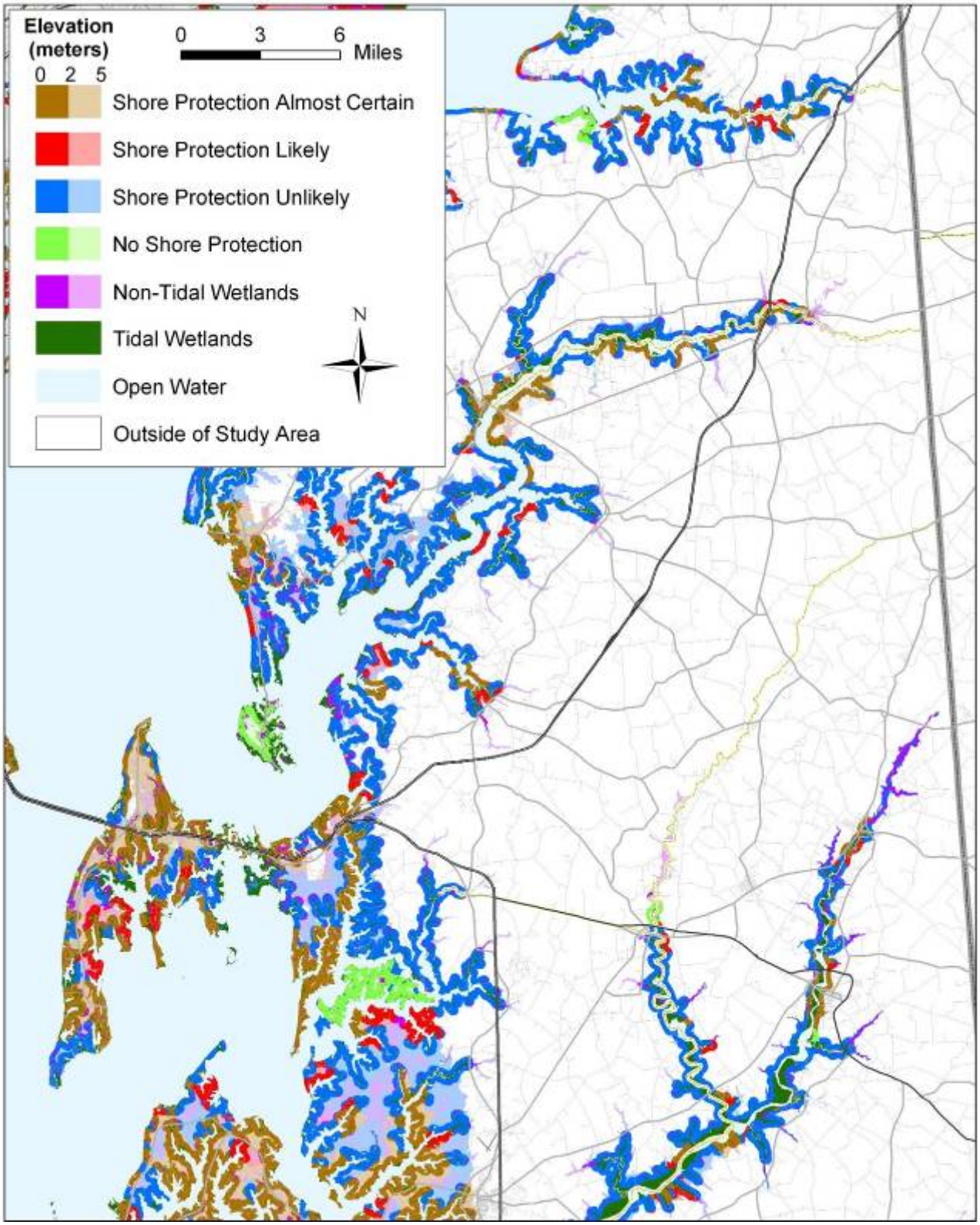
Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Area
		No protection	Unlikely	Likely	Certain	
Public	State-owned open space	✓				State-owned lands (DNR MERLIN 2000)
Public	County-owned parks[b]		✓			County-owned lands (DNR MERLIN 2000)
Public	County-owned utilities and transportation facilities				✓	Land use/land cover in Maryland (1997)
Mostly private	Land held in conservation easements		✓			Maryland Environmental Trust lands and agricultural easements/districts (DNR MERLIN 2000)
Mostly private	Municipalities and developed areas (Millington, Centreville, Queenstown, Cloverfields subdevelopment,[c] Bennett Point Estates,[c] Gibson's Grant residential development,[c] Cluster Haven Beach residential development[c])[d]				✓	Land use/land cover in Maryland (1997) and USGS topographic quadrangle maps (1987)
Mostly private	Areas of current and planned infrastructure investment, priority funding areas (PFA)				✓	Manual GIS edit per County Comprehensive Plan (1987)
Mostly private	Existing high- to medium-density residential areas, IDA lands, existing major employment and commercial areas, and planned growth areas				✓	Manual GIS edit per County Comprehensive Plan (1987)
Mostly private	Less-densely developed land on Kent Island needed to prevent developed areas from becoming separate islands[c]			✓		Manual GIS edits per stakeholder review comments
Mostly private	Low density areas already developed, e.g., LDA lands, villages, and enclaves at low densities				✓	Manual GIS edit per County Comprehensive Plan (1987)
Mostly private	Agricultural/RCA land (very low density residential)		✓			Land use/land cover in Maryland (1997) and Manual GIS edit per County Comprehensive Plan (1987)

[a] Where land areas overlap, classifications higher in the table take precedence.

[b] The stakeholder review draft erroneously included the county parks with conservation lands where shores will not be protected. In the original meeting, the County had excluded the parks from those areas where shores would be protected under current policy; but there is no policy specifically ensuring that shores are allowed to retreat in response to natural erosion processes.

[c] These changes resulted from stakeholder review and are annotated in the map that accompanied the stakeholder review letter from Steven Kaii-Ziegler, director, Department of Planning and Zoning, Queen Anne's County, to Daniel Hudgens, IEc, October 18, 2002.

[d] This category includes privately owned lands and municipally owned lands contained within the municipalities. Planners identified the boundaries of the land that would be protected by drawing on various maps. We used topographic and land cover maps to approximate the boundaries rather than directly digitizing the boundaries.



Map 6-12. Queen Anne's County: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2.

Talbot County

Background

Talbot County is almost entirely surrounded by the waters of Chesapeake Bay and its tributaries. Portions of Talbot County, because of its relationship to Chesapeake Bay, are already subject to severe erosion caused by wind and wave action. The Bay Hundred area, which is the westernmost part of the county, is subject to the direct wave action of the Bay, and some shoreline reaches sustain losses of up to 16 feet of land per year.

Talbot County has approximately 600 miles of shoreline and more than 30,000 residents. The incorporated towns of Oxford, St. Michaels, and Easton are major population centers in the county's coastal area. In addition, smaller population centers are Tilghman Island, Claiborne, McDaniel, Bozman, Wittman, Newcomb, Sherwood, Royal Oak, Neavitt, and Bellevue. These primarily rural waterfront villages have evolved from historic water commerce communities. The Talbot County Comprehensive Plan and zoning policies require new development to be located in and around these incorporated towns and existing village centers. These policies will help ensure that existing large, undeveloped waterfront tracts will remain largely undeveloped.

All of Tilghman Island is below the 20-ft contour. Roughly 48 percent of the dry land in Talbot County (approximately 85,700 acres) is below the 20-ft elevation contour.[112] More than 41 percent of Talbot County's population and approximately 42 percent of all residential housing units are in this area.[113]

Publicly owned lands and facilities are also at risk from sea level rise. Areas of potential concern include the following:

- Four public sewer collection and treatment systems in the western portion of the county are below the 20-ft elevation contour.[114]
- Three public school facilities are below the 20-ft elevation contour: St. Michaels High School, St. Michaels Elementary School, and Tilghman Elementary School. In addition, the Calhoun MEBA Engineering School, a recognized training facility in the field of maritime education, is located along the Miles River.
- Two state parks, Black Walnut Point State Park and the Choptank River Park and Fishing Pier, are waterfront sites below the 20-ft elevation contour.
- County parks in the area of concern include Causeway Park in Oxford, Perry Cabin Park in St. Michaels, and Back Creek Park on Tilghman Island. Talbot County also provides direct access to the water at 28 public landings that offer boat ramps, mooring facilities, fishing and crabbing piers, picnic areas, and parking facilities.

Several private and publicly owned conservation lands area also located below the 20-ft elevation contour. Important natural environmental sites and conservation areas include the following:

- **Pickering Creek Audubon Center.** This private nonprofit sanctuary contains more than 400 acres of forests, fields, and shoreline dedicated to community-based conservation of natural resources and environmental education and outreach.
- **Poplar Island.** This joint project involving the U.S. Fish and Wildlife Service and other federal, state, and local entities is creating a 1,110-acre island from dredged material,

[112]Based on an analysis of USGS DLG elevation data by Redman-Johnston Associates, Ltd.

[113]The approximately 9,700 properties below the 20-ft elevation contour represent a significant portion of the assessed valuation of the county. Based on the 2001 tax assessment records, the total value of land and improvements in this area is estimated to be more than $2.5 billion. Of this total, more than 82 percent of the assessed value ($2.0 billion) is improved residential properties. About 5.6 percent of this value, more than $141 million, is improved commercial properties. Assessed value and property information was derived from Maryland Property View, Talbot County 2001 dataset, a Maryland Department of Planning data product that includes the Department of Assessment and Taxation property assessment records for Talbot County.

[114]These systems serve the towns of Easton, Oxford, Tilghman Island, St. Michaels, Rio-Vista-Bently Hay, Newcomb, Royal Oak, Bellevue, Unionville, Tunis Mills, and Copperville.

approximating the island's historic configuration in 1847.

- **Black Walnut Point.** This site is a 57-acre combination wildlife management and environmental recreation area and site of a bed and breakfast facility.

Anticipated Response to Sea Level Rise

Based on communication with:

Dan Cowee, planning director

Table 6-18 summarizes the anticipated response to sea level rise in Talbot County by land classification. In developed areas and areas where the land has been subdivided for future dense development, county planners assume that private property owners will take steps to protect their shorelines. All areas inland of existing and anticipated structures (e.g., rip-rapped shoreline, sea wall, tidal dike) are considered certain to be protected regardless of whether it is privately or publicly owned land. Existing historic structures concentrated in existing settlements will also almost certainly be protected. The eastern and northwestern portions of the county, however, are unlikely to be protected. Future development will be limited in these areas and agriculture will be the dominant land use.

County land holdings along the shoreline are limited to public landings at the end of county roads and are likely to be abandoned. State policies, especially those relating to state highways, have a particular importance for Talbot County. Primary access to properties and communities located in the area of concern depends on state highways. Larger population centers like St. Michaels, Oxford, and Tilghman are directly accessed from state routes. The state and County will protect access to these properties, especially in those areas where it has significant investment in public sewer facilities.

Many smaller communities and individual properties can be reached only by county roads that branch off primary state roads. The County does not expect to take extraordinary steps to protect county roads in low-density development areas because of the expense involved.

The County anticipates that the federal and state governments will take steps necessary to protect Poplar Island. Other significant state land holdings (i.e., Black Walnut Point and Choptank River Park and Fishing Pier) will not necessarily be protected, however, if the state develops policies that emphasize permitting wetland migration. We also assume that privately owned conservation will not be protected, thus allowing natural processes to continue unabated. The County examined the stakeholder review draft, found the maps reasonable, and supported use of the maps and reports as planned.[115]

During the final review of the maps, the authors realized that county parks had been erroneously listed as conservation lands that will not be protected. Because the County has no specific policy to promote a natural shoreline retreat, we corrected the maps to show county parks as unlikely to be protected.

Map 6-13 shows the final product depicting the likelihood of shore protection.

[115]Frank Hall, assistant planning officer, Talbot County Office of Planning and Zoning. letter to Dan Hudgens, IEc, October 29, 2002. A stakeholder review meeting between Peter Johnston and Dan Cowee, planning director, Talbot County, was held at the Department of Planning Courthouse on September 27, 2002.

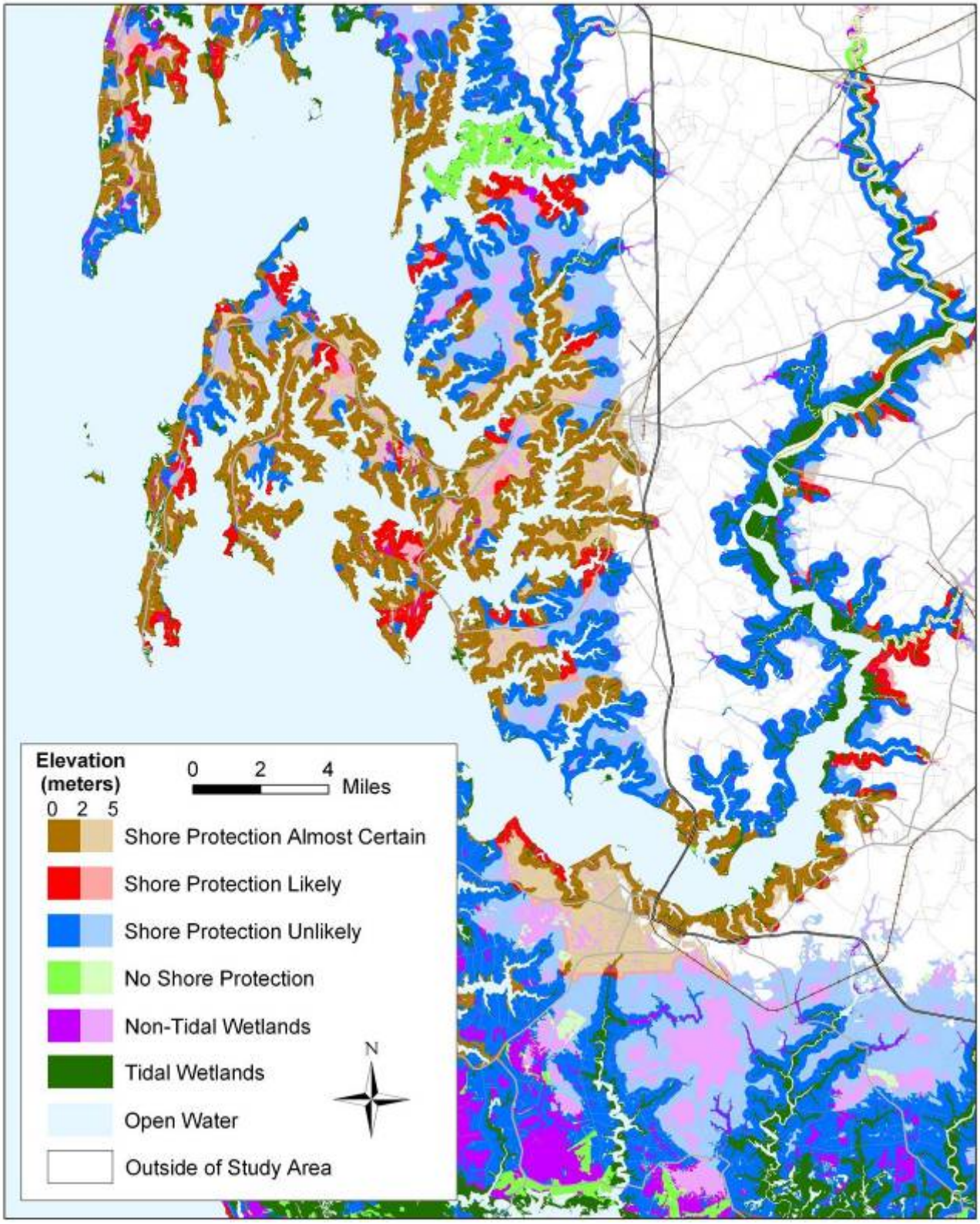
TABLE 6-18. TALBOT COUNTY ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Area
		No protection	Unlikely	Likely	Certain	
Public	State-owned open space	✓				State-owned lands (DNR MERLIN 2000)
Public	County-owned park and recreation land[b]		✓			County-owned lands (DNR MERLIN 2000)
Public	County-owned utilities and transportation facilities				✓	Land use/land cover in Maryland (1997)
Mostly private	Land subject to conservation easements		✓			Maryland Environmental Trust lands and agricultural easements/districts (DNR MERLIN 2000)
Mostly private	Municipalities (Oxford, St. Michaels, Easton)[c]				✓	Manual GIS edit per County Comprehensive Plan (1997) and land use/land cover in Maryland (1997)
Mostly private	Poplar Island				✓	Manual GIS edit per USGS topographic quadrangle maps (1983)
Mostly private	Areas of current and planned infrastructure investment, priority funding areas (PFA)				✓	Manual GIS edit per County Comprehensive Plan (1997)
Mostly private	Existing high- to medium-density residential areas, IDA lands, existing major employment and commercial areas, and planned growth areas				✓	Manual GIS edit per County Comprehensive Plan (1997)
Mostly private	Low-density areas already developed, e.g., LDA lands, villages, and enclaves at low densities			✓		Manual GIS edit per County Comprehensive Plan (1997)
Mostly private	Agricultural/RCA land (very low-density residential)		✓			Manual GIS edit per County Comprehensive Plan (1997) and land use/land cover in Maryland (1997)

[a] Where land areas overlap, classifications higher in the table take precedence.

[b] The County originally excluded parks from areas likely to be protected; the stakeholder review draft erroneously included these parks within conservation lands even though the County has no policy precluding shore protection.

[c] This category includes privately owned lands and municipally owned lands contained within the municipalities.



Map 6-13. Talbot County: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2.

Caroline County

Background

Caroline County is located along the Choptank River and has a population of more than 30,000. Compared to its neighboring counties along Maryland's eastern shore, Caroline County is not extensively vulnerable to sea level rise. Extensive reaches of its shoreline are in a bluff configuration, with narrow bands of fronting wetlands. The primary areas of concern are the incorporated towns of Greensboro, Federalsburg, and Denton and the village of Choptank. Municipal sewer treatment facilities in Greensboro and Federalsburg are also below the 20-ft elevation contour.

Most of the land located along the Choptank River is in agricultural production, with only minimal development. Several county and municipal-level policies suggest that the county will not experience significant future development along the coast:

- The County does not permit any new development in the 100-year floodplain unless the restriction would create a hardship for the property owner.
- Much of Caroline County is included in an agricultural zoning district that limits future development to one dwelling unit per 20 acres.
- The incorporated towns that have experienced flooding in the past (Federalsburg and Greensboro) have instituted programs to acquire land in the 100-year floodplain to eliminate hazards to existing structures.

Anticipated Response to Sea Level Rise

Based on communication with:

Betsy Krempasky, planning director, and Shane Johnston, environmental planner

Table 6-19 summarizes the anticipated responses to sea level rise in Caroline County by land classification. Although property owners can protect their land, it may not always be feasible to do so. The economic cost of installing and maintaining seawalls or other structures is likely to limit their use. The County anticipates that existing developed lands will almost certainly be protected while agricultural and state-owned natural areas (the most extensive land uses in the study area) are likely to be abandoned as rising seas begin to inundate the land.

The County plans for future growth to be concentrated within the designated growth areas (based on Smart Growth principles), thus limiting growth in rural coastal areas. This growth will largely take place near the incorporated towns, especially Denton. Given the nature of the shoreline near Denton, however, i.e., relatively high bluffs, along with the minimum setback requirements of the county and town Critical Area programs, it is not likely that a great deal of development will take place below the 20-ft elevation contour. Thus, a continuation of current policies and growth trends will limit Caroline County's future vulnerability to the impacts of sea level rise.

The County examined the stakeholder review draft and found the original maps to be reasonable.[116] Map 6-14 shows the final product depicting the likelihood of shore protection.

During the final review of the maps, the authors realized that county parks had been erroneously listed as conservation lands that will not be protected. Because the County has no specific policy to promote a natural shoreline retreat, we corrected the maps to show county parks as unlikely to be protected.

[116]Elizabeth A. Krempasky, director, Planning and Codes Administration, Caroline County. Letter to Dan Hudgens, IEc, October 22, 2002. A stakeholder review meeting between Peter Johnston and Elizabeth A. Krempasky was held at the Planning and Codes Administration offices on September 3, 2002.

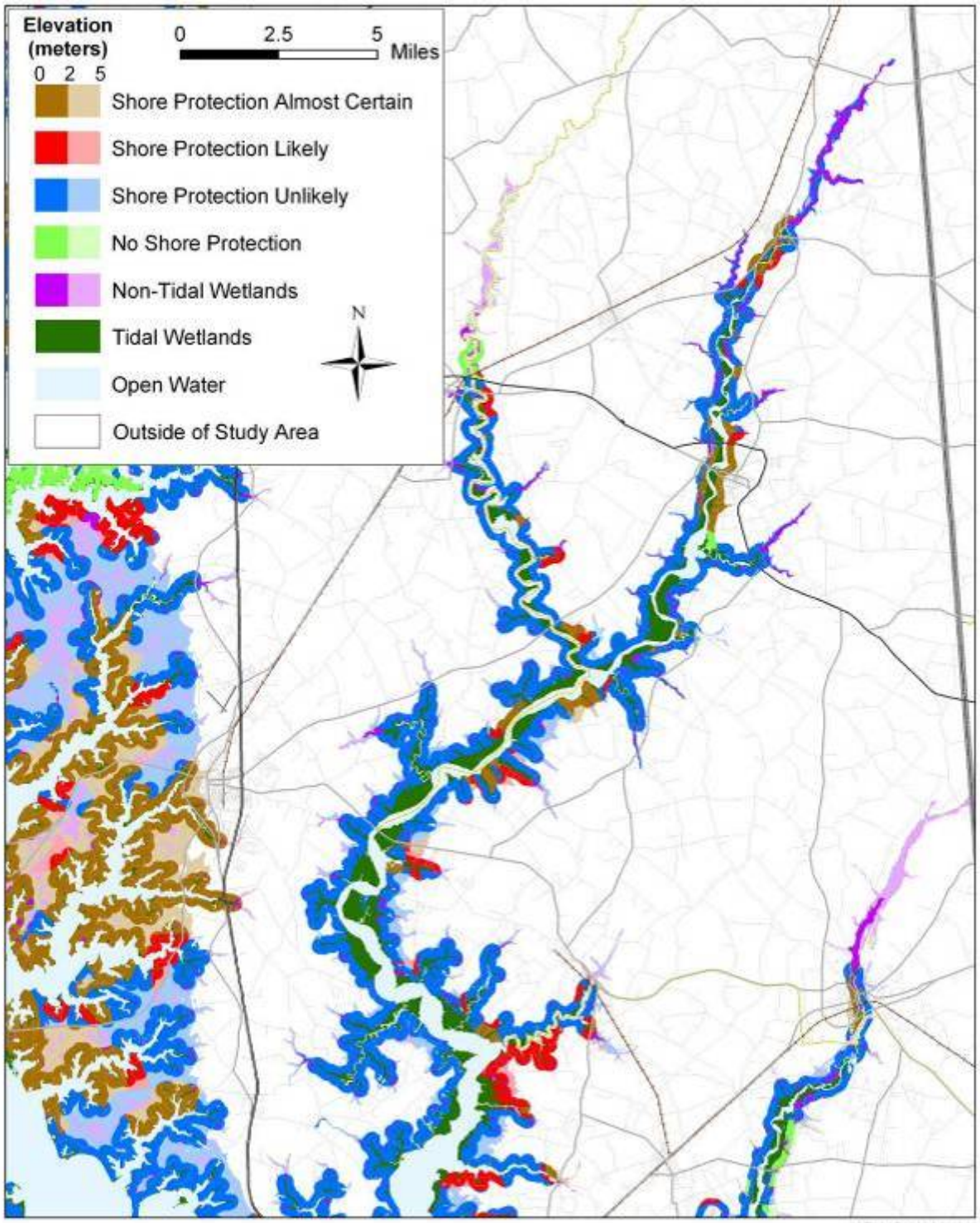
TABLE 6-19. CAROLINE COUNTY ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Area
		No protection	Unlikely	Likely	Certain	
Public	State-owned open space	✓				State-owned lands (DNR MERLIN 2000)
Public	County-owned park and recreation lands[b]		✓			County-owned lands (DNR MERLIN 2000)
Public	County-owned utilities and transportation facilities				✓	MD Property View data (2001)
Mostly private	Land held in conservation easements		✓			Maryland Environmental Trust lands and agricultural easements/districts (DNR MERLIN 2000)
Mostly private	Municipalities (West Denton, Denton, Greenboro, Federalsburg)[c]				✓	MD Property View data (2001)
Mostly private	Areas of current and planned infrastructure investment, priority funding areas (PFA)				✓	MD Property View data (2001)
Mostly private	Existing high- to medium-density residential areas, IDA lands, existing major employment and commercial areas, and planned growth areas				✓	Manual GIS edit per County Comprehensive Plan (2000) and MD Property View data (2001)
Mostly private	Low-density areas already developed, e.g., LDA lands, villages, and enclaves at low densities			✓		Manual GIS edit per County Comprehensive Plan (2000) and MD Property View data (2001)
Mostly private	Agricultural/RCA land (very low-density residential)		✓			Manual GIS edit per County Comprehensive Plan (2000) and MD Property View data (2001)

[a] Where land areas overlap, classifications higher in the table take precedence.

[b] The County originally excluded parks from areas likely to be protected; the stakeholder review draft erroneously included these parks within conservation lands even though the County has no policy precluding shore protection.

[c] This category includes privately owned lands and municipally owned lands contained within the municipalities.



Map 6-14. Caroline County: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2.

Dorchester County

Background

Dorchester County is probably the county most vulnerable to sea level rise in Maryland. Examine a map showing U.S. lands below the 5- and 10-ft contours (e.g., see footnote 2), and the fourth largest area of vulnerable land that one notices is Dorchester County. Dorchester County has lost more land to the sea in the last few decades than all the rest of Maryland. In many areas, the water in the ditches along the road rises and falls with the tides, and marsh is gradually taking over the lawns of many homes.

Dorchester County is the largest county on Maryland's eastern shore. Bordered by Chesapeake Bay and the Choptank River, Dorchester County is easily accessible from Baltimore and Washington, D.C., by way of U.S. 50. U.S. 13 also is a major corridor for travelers from the north.[117] Because of its location in the middle of the eastern shore, the county is frequently referred to as the "Heart of the Eastern Shore" or the "Heart of Chesapeake Country." Dorchester County has more than 1,700 miles of shoreline and is nearly surrounded by Chesapeake Bay and its tributaries. Dorchester County's wetlands account for roughly 25 percent of the county's land area and nearly 40 percent of the entire state's wetlands.[118]

In 2001, more than 30,000 people resided in the county.[119] Between 1970 and 1990, the county's population decreased, but housing units increased by 30 percent. This housing unit growth is attributable to seasonal and second homes, a trend that has been particularly noticeable on Elliott Island, Upper and Lower Hoopers islands, and Taylor's Island.[120] Only 4 percent of Dorchester's total land area is developed.[121] The bulk of the county's developable area is in the northern portion of the county and around the City of Cambridge. Two portions of the county are targeted for future growth: the City of Cambridge and the Hurlock area in the northeastern portion of the county. Future development is limited to one dwelling unit per 20 acres in 90 percent of the Critical Area.[122] Suitable areas for development are those portions of the Critical Area that are adjacent to development districts.

The major industries in Dorchester County are tourism and agriculture. Tourists often seek the exceptional boating opportunities along the Bay and nearby rivers. Meanwhile, agricultural land dominates most of the northeastern portion of the county and accounts for 48 percent of Dorchester County's total land area.

Compared to other Maryland counties, Dorchester has a higher proportion of low- and moderate-income households and a lower effective buying income. In 1990, 14 percent of its population was below the poverty level. Dorchester's economic problems are considered severe. Approximately 1,150 manufacturing and warehouse jobs were lost between 1986 and 1996.[123]

Both the state and the federal government own significant acreage along the county's southern shoreline, but only small amounts in the remainder of the county. The Blackwater National Wildlife Refuge and the Taylor's Island Wildlife Management Area provide habitat for migrating and wintering waterfowl. Wetlands have been rapidly converting to open water in these refuges at a rate exceeded in the United States only by the loss of wetlands in Louisiana, partly because rising sea level drowns the wetlands and partly because rising sea level and wetland loss allow brackish water to flow into

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[117]http://www.dorchester.commissioners.net/History.html
[118]http://www.dnr.state.md.us/greenways/counties/dorchester.html.

[119]U.S. Census Bureau Quick Facts, http://quickfacts.census.gov/qfd/states/24/24019.html.
[120]Dorchester County 1996 Comprehensive Plan.

http://www.dnr.state.md.us/greenways/counties/dorchester.html

[122]Lands designated as Critical Area (see state section earlier in this report) are 50 percent of county lands and wetlands (tidal and nontidal).
[123]Dorchester County 1996 Comprehensive Plan.

Photos 34–37. Blackwater Wildlife Refuge. (34) Waterfowl amidst deteriorating marsh. (35) Water control structure to prevent saltwater intrusion and marsh drowning. (36) A dredge restorer eroded marsh by moving material from newly formed shallow waters to (37) areas marked for marsh creation (October 2002).

Photo 38. Hoopers Island is Narrow. Stone revetments protect the bayside of Lower Hoopers Island. Fish processing and other marine-dependent facilities are on the right side of the photo, along the Honga River (October 2004).

freshwater wetlands, which converts the marsh to open water. The U.S. Fish and Wildlife Service is attempting to rebuild some of these marshes. (See Photos 34 through 37.)

One location of particular concern is Holland's Island. Of historical and environmental value to the county, this island's size has been reduced by erosion from approximately 160 acres in 1915 to approximately 80 acres today.[124] The Maryland Port Administration is considering restoring this island using dredged material.

Anticipated Response to Sea Level Rise

Based on communication with:

Steve Dodd, director, and Karen Houtman, planner, Planning and Zoning

Table 6-10 summarizes the anticipated response to sea level rise in Dorchester County by land classification. Much of the county is experiencing job losses and population decline. Because of the economic difficulties that the county and its residents are experiencing, county planners anticipate that most of the county will not be protected from sea level rise. Although the County will not work to hold back the sea directly, it will work to maintain the road network. As the roads are raised over time, they could serve as dikes in some areas.

Only Cambridge, rural towns, and villages are likely to be protected. Because of the significant development within Cambridge, this area is already extensively armored and will almost certainly be protected. Because it is unclear where shoreline armoring would be built around the city, however, we show the first 500 feet around the city as only likely to be protected.

Hoopers Island is so narrow that the roadway is almost always within the view of either Chesapeake Bay to the east or the Honga River to the west. (Photo 38.) The island is extremely low, and as the sea rises, marsh grass is gradually taking over the lawns along many homes. (See Photos 39 through 43). Nevertheless, county officials believe that the developed part of this island will almost certainly be protected.[125] The state has made a considerable investment in the high bridge connecting Upper and Middle Hoopers islands. Because the area is one of the most scenic places along Chesapeake Bay, the County expects property values to justify shore protection for the foreseeable future.

We show developed lands on Taylor's Island as likely to be protected. This area includes the Taylor's Island Family Campground, which has actively sought state assistance for shore protection. Hurlock, the other major growth area, is on higher ground and therefore out of the study area for this project.

The U.S. Fish and Wildlife Service's Black Water National Wildlife Refuge currently lacks a policy to address sea level rise; innovative methods to raise the elevation of the marshes, however, thereby reducing the net loss from the effects of sea level rise, are being examined. The staff there currently assumes that dry land on the refuge will gradually be inundated, and that adjacent farmlands will not be developed. Because this land is heavily managed, it is possible that some of the freshwater marshes will be managed to remain fresh as the sea rises—such efforts to hold back the sea are outside the scope of this report, however, which focuses on the protection of dry land.

During the stakeholder review process, planners noted the need for additional modifications to the planning maps.[126] First, existing developed land on the peninsula west of Cambridge as well as the land northwest of Rte. 16 is certain to be protected. Also, the planners are uncertain how densely the northwestern corner of the county (near Wrights Wharf Road) will be developed in the future. At this time, the area is considered only likely to be protected (rather than almost certain to be protected as identified in the initial planning maps). More recently, the Dorchester County Council has decided to support a

[124]http://www.intercom.net/local/holland/.

[125]We also show the road and a buffer with 150 feet of land on either side of the center line as certain to be protected.

[126]Stakeholder review comments provided to William Nuckols by Steve Dodd, county planner, at the county planning office on January 29, 2003.

proposed 1,000-acre development along the Little Blackwater River and Egypt Road. The council changed this area from “Natural Resources Area and Agricultural District” to a “Town-Adjoining Areas,” and made the area part of the town of Cambridge. The proposed project is controversial and far from certain. Therefore, we designate this area as “protection likely.” Map 6-15 shows the final product depicting the likelihood of shore protection. Between stakeholder review and publication of this report, Hurricane Isabel submerged the county’s coastal floodplain. In the aftermath, many owners have chosen to elevate their homes (see Photos 44 through 48). Some owners are also reversing the effects of sea level rise by filling the tidal wetlands that have recently taken over their yards (Photo 48).

Photos 39–43. Wetlands Taking over Hoopers Island. Wetlands are gradually taking over the yards and what once were yards of people's homes. (39–40) Ditches along the roadside rise and fall with the tides near the center of Upper Hoopers Island. (41) The driveway is the only part of the front yard not flooded by the tides as one yard was gradually inundated at the northern end of Lower Hoopers Island. (42) Immediately to the west, only the end of the driveway and a stand of trees remains. (43) Trees gradually convert to marsh as sea level rises in Lower Hoopers Island (October 2004 and April 2005).

Photos 44–48. Responding to Sea Level Rise on Hoopers Island. In October 2004, a year after Isabel, people were still living in trailers supplied by FEMA. (44–45) On the Chesapeake Bay side of Upper Hoopers Island, one family elevated their home over the following winter but the trailer remained the following spring. (46–47) On the Honga River side of the island, across from the Waterman's Café, the home on the right had been elevated by October. Over the following winter, the masonry was completed and side entrance steps had been built (not shown), but stacked pallets rather than front steps provided access to the front porch. Only partial repairs had been made to the home on the left as well. (48) Near the south end of Middle Hoopers Island, recently filled tidal wetland are in the foreground; in the background the mowed marsh grasses remain (October 2004 and April 2005).

TABLE 6-20. DORCHESTER COUNTY ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

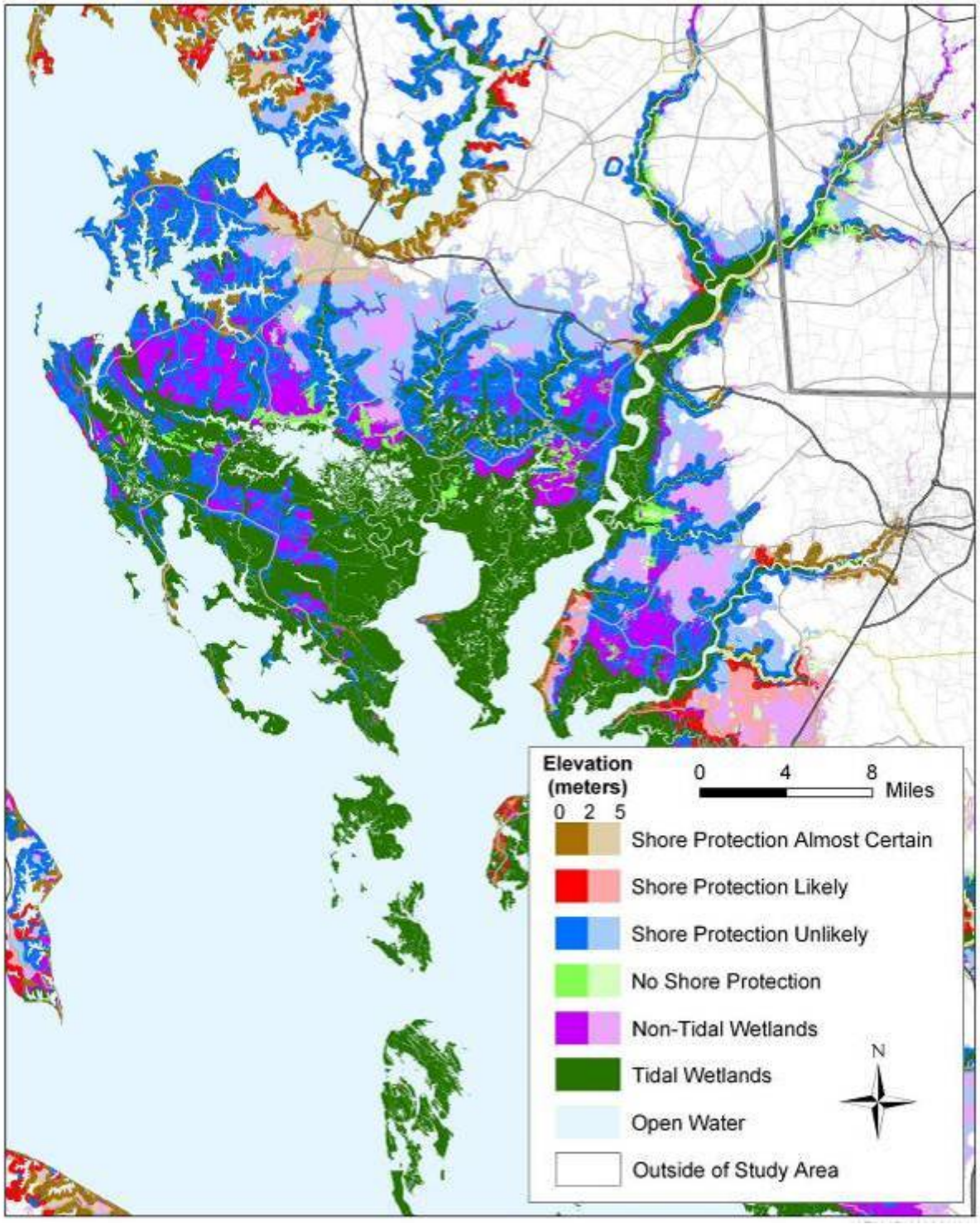
Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Areas
		No protection	Unlikely	Likely	Certain	
Public	County roads[b]				✓	Roads (ESRI 2001)
Public	Other county lands				✓	County-owned lands (DNR MERLIN 2000)
Public	State-owned open space	✓				State-owned lands (DNR MERLIN 2000)
Public	Federal lands—USFWS	✓				Federal lands (DNR MERLIN 2000)
Mostly private	Land held in conservation easements		✓			Maryland Environmental Trust lands and agricultural easements/districts (DNR MERLIN 2000)
Mostly private	Existing development west of Cambridge and northwest of Rte. 16				✓	Manual GIS edits based on the presence of buildings in digital orthophotographs
Mostly private	Cambridge (except for Egypt Road development), rural towns, and villages				✓	Planner input and land use/land cover in Maryland (MDP 1997)[c]
Mostly private	Land bordering Cambridge, plus proposed Egypt Road development			✓		Manual GIS edits[d]
Mostly private	Developed lands on Taylor's Island			✓		Land use/land cover in Maryland (MDP 1997)[c]
Mostly private	Developed land and 250-ft strip of land along MD-335 on Upper and Middle Hoopers islands				✓	Land use/land cover in Maryland (MDP 1997) and roads (ESRI 2001)
Mostly private	Privately owned lands outside Cambridge, rural towns, and villages		✓			Land use/land cover in Maryland (MDP 1997)[c]

[a] Where land areas overlap, classifications higher in the table take precedence.

[b] We identify the county roads by creating a 150-ft buffer on both sides of major roads using data distributed by ESRI.

[c] We identify the boundaries for Cambridge, rural towns, and villages from planner input. To transfer these data into GIS, we identified the location of the boundaries based on the land uses in the vicinity, not the actual town boundary. For example, a town's limit is assumed to end when the land use switches from a developed category (e.g., residential) to an undeveloped category (e.g., forest land).

[d] Because of the uncertainty associated with the location where armoring protection would be employed around the city of Cambridge, we identify the area within 500 feet of the city boundary as likely to be protected while the interior portions are considered certain to be protected. We also include the proposed Egypt Road development.



Map 6-15. Dorchester County: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2.

Wicomico County

Background

Wicomico County is located on Maryland's eastern shore between the Wicomico and Nanticoke rivers. The county has nearly 85,000 residents, most of whom reside in the waterfront community of Salisbury. Additional communities below the 20-ft elevation contour are Fruitland, Sharptown, and Mardela Springs. In addition, population concentrations are located along the north bank of the Wicomico River south of Salisbury. New development is expected to be limited to existing communities and areas adjacent to the incorporate towns.

When updating its comprehensive plan in 1997, Wicomico County recommended a substantial change to agriculture zoning areas (from one dwelling unit per 20,000 square feet to one dwelling unit per 15 acres). This policy was subsequently implemented through amendments to the county zoning ordinance and subdivision regulations. This policy, along with the requirements of the Wicomico Critical Area Program, will limit future development in currently undeveloped coastal areas to agriculture and very low-density residential development.

Anticipated Response to Sea Level Rise

Based on communication with:

David Nutter, planning director

Table 6-21 summarizes the anticipated response to sea level rise in Wicomico County by land classification. The County anticipates that existing developed areas will be protected through a cooperative shoreline protection program and special taxing district. Areas shown in brown (almost certain protection) on the response maps include existing neighborhoods within and near incorporated towns.[127] Additionally, there is a trend toward an expansion of suburban Salisbury along the north side of the Wicomico River, so this future development will also be protected from sea level rise.

Although all property owners can protect their land, it may not always be feasible to do so. The economic cost of installing and maintaining seawalls or other structures is likely to limit their use on nonresidential/commercial properties. Thus, agricultural and forested lands that are not expected to be developed in the future are considered unlikely to be protected.

The County examined the stakeholder review draft, found the maps reasonable, and stated that "it is the consensus of County staff that the map would be a good tool for planning, research, and public outreach."[128] Map 6-16 shows the final product depicting the likelihood of shore protection.

During the final review of the maps, the authors realized that county parks had been erroneously listed as conservation lands that will not be protected. Because the County has no specific policy to promote a natural shoreline retreat, we corrected the maps to show county parks as unlikely to be protected.

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[127] Areas almost certain to be protected include existing coastal villages located along the Wicomico and Nanticoke rivers, such as Wetipquin, Tyaskin, Bivalve, Nanticoke, White Haven, and Upper Ferry, as well as some planned expansion of these villages.

[128] Frank McKenzie, chief, Technical Services, City of Salisbury—Wicomico County Department of Planning, Zoning, and Community Development. Letter to Dan Hudgens, IEc, October 20, 2002. A stakeholder review meeting was also held between Peter Johnston and David Nutter, director of planning at City of Salisbury—Wicomico County Planning at the government office building on September 3, 2002.

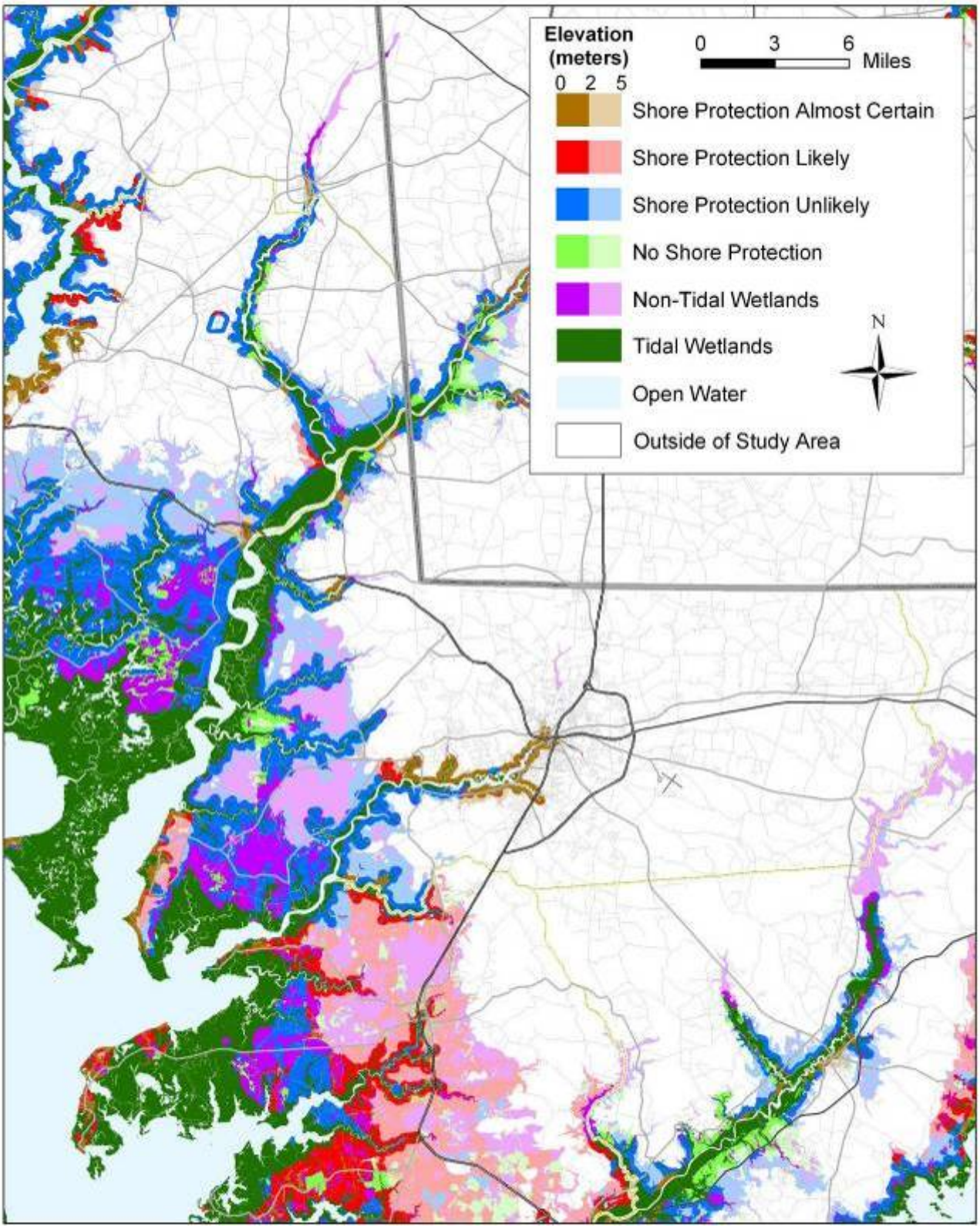
TABLE 6-21. WICOMICO COUNTY ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Areas
		No protection	Unlikely	Likely	Certain	
Public	State-owned open space	✓				State-owned land (DNR MERLIN 2000)
Public	County-owned park and recreation land[b]		✓			County-owned land (DNR MERLIN 2000)
Public	County-owned utilities and transportation facilities				✓	MD Property View data (2000)
Mostly private	Land held in conservation easements		✓			Maryland Environmental Trust lands and agricultural easements/districts (DNR MERLIN 2000)
Mostly private	Municipalities (Sharptown, Mardela Springs, City of Salisbury)[c]				✓	MD Property View data (2000) and manual GIS edit per County Comprehensive Plan (1998)
Mostly private	Areas of current and planned infrastructure investment, priority funding areas (PFA)				✓	MD Property View data (2000)
Mostly private	Existing high- to medium-density residential areas, IDA lands, existing major employment and commercial areas, and planned growth areas				✓	MD Property View data (2000) and manual GIS edit per County Comprehensive Plan (1998)
Mostly private	Low-density areas already developed, e.g., LDA lands, villages, and enclaves at low densities			✓		MD Property View data (2000) and manual GIS edit per County Comprehensive Plan (1998)
Mostly private	Agricultural/RCA land (very low-density residential)		✓			MD Property View data (2000) and manual GIS edit per County Comprehensive Plan (1998)

[a] Where land areas overlap, classifications higher in the table take precedence.

[b] The County originally excluded parks from areas likely to be protected; the stakeholder review draft erroneously included these parks within conservation lands even though the County has no policy precluding shore protection.

[c] This category includes privately owned lands and municipally owned lands contained within the municipalities.



Map 6-16. Wicomico County: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2.

Somerset County

Background

Somerset County is located along Maryland's eastern shore and has nearly 25,000 residents.[129] Approximately 68 percent of the county's 209,000 acres are zoned for agricultural land use.[130] More than 37 percent of the county is classified as wetlands, and just 3 percent is developed. Although Somerset is a predominantly rural county, approximately 41 percent of its population lives within 1,000 feet of the shoreline.[131] Thus, a significant portion of the county's population is vulnerable to sea level rise. Municipalities in the county include Crisfield and Princess Anne.

Sea level rise may also result in problems for homeowners reliant on septic systems. Much of the local soils already have impeded drainage, and homeowners must often use alternative methods (e.g., mounds). Sea level rise will elevate the water table, increasing the potential for septic system failure and reducing the effectiveness of these alternative methods.

Anticipated Response to Sea Level Rise[132]

Based on communication with:

Joan Kean, planning director; Steve Marshall, emergency response planner; Arthur Tawes, chair, Planning Board; Michael Bloom, Nolan Good, William Rice, and Carl Woodson, Planning Board members

Our approach for developing planning maps in Somerset County differs from the land-use decision rules developed for other counties. Specifically, through a series of meetings with the county planners, we developed response maps by identifying the location of existing and anticipated dikes and other shore protection activities. Table 6-22 summarizes the anticipated response to sea level rise in Somerset County. Map 6-17 shows the final product depicting the likelihood of shore protection. The following sections provide more detailed explanations of the anticipated responses in the various communities within Somerset County.

Smith Island

As Maryland's last inhabited island with no bridge connection to the mainland, Smith Island's culture remains deeply rooted in its heritage, making its way of life and traditions unique. Smith Island is economically dependent on the seafood industry for its livelihood. Consequently, the problems of erosion and sea level rise are causing economic hardships within the community. For instance, although Smith Island is served by a comprehensive public sewage and water system, erosion has contributed to major infrastructure damages to roads, sewer pipes, and water pipes.[133]

Because of the extreme circumstances on Smith Island, federal assistance was mandated to study methods to mitigate the problems of erosion and flooding.[134] The study was prompted by concern about the loss of fish and wildlife habitat and the unique human culture. Currently, the Army Corps of Engineers has begun an environmental restoration and protection project on Smith Island. Several plans for restoration were considered, including shoreline protection using backfill and geotextile tubes, construction of

[129]Based on 2001 population data available from http://www.mdbusiness.state.md.us/datacenter/ demographics/.
[130]http://www.dnr.state.md.us/greenways/counties/somerset.html.
[131]Somerset County Chesapeake Bay Critical Area Program: Section 1, December 1995.
[132]County staff and the Planning Board support the general concepts shown on the planning map, but note that individual responses could vary from the generalizations depicted in the planning map. It was noted by the board that even within those low-lying areas that are currently experiencing flooding, there are certain properties that do not flood because of small changes in elevation or geologic conditions particular to those lands; therefore the maps indicate possible responses only in a general sense, and thus it is likely that they would not portray the actions of all property owners.

[133]U.S. Army Corp of Engineers, 1997, *Environmental Restoration and Protection, Maryland: The Smith Island Reconnaissance Report*, Baltimore District, May.
[134]Congress must authorize the Army Corps of Engineers before it can commence any study. On September 28, 1994, the Smith Island Environmental Restoration and Protection Study was authorized to determine the feasibility of improvements on Smith Island in the interest of navigation, flood control, erosion control, environmental restoration, wetlands protection, and other purposes.

jetties to protect channels, construction of offshore breakwaters, and the re-creation of shallow water and submerged aquatic vegetation habitat. Among other things, further study was recommended to mitigate land loss because of sea level rise.

Because of the value associated with this island community, and the sewage and water systems that are already in place, it is assumed that the developed communities on Smith Island will be protected.

Deal Island

The Deal Island community is located just off the county's upper peninsula and is connected to the mainland by Rte. 363. The Deal Island State Wildlife Management Area occupies approximately half of the island's land mass. Residential areas and commercial seafood operations are on the western portion of Deal Island. Because of the island's importance to the commercial seafood industry and the close-knit community fostered by its relatively isolated land mass, it is likely that the upland (i.e., nonwetland) portions of the island will be protected.[135] Dikes would initially be required on the western portion of Deal Island to protect those predominantly residential and commercial areas. Eventually, dikes could be constructed to encircle the majority of Deal Island's upland area.[136,137] Alternatively, it may be feasible to elevate these areas with fill.

Mount Vernon/Monie Neck

The Mount Vernon/Monie Neck area is bordered by the Wicomico River on the north and marshland along the southwest. The surrounding area is relatively high except for Mount Vernon Beach along the Wicomico River, which is below 5 feet in elevation. This area is predominantly residential, with a majority of the homes along Rte. 362 and several along Mount Vernon Beach.

Privately owned property along the Wicomico River is likely to be protected with bulkheads or revetments, if necessary. Dikes may eventually be necessary. In addition, significant portions of marshland surround the Monie Bay and may accrete with sea level rise to overtake much of the land up to the Mount Vernon road (Rte. 362). Therefore, constructing dikes would be most feasible parallel to Rte. 362 on the southern side.[138]

Fairmont Neck

Fairmont Neck is separated into Lower and Upper Fairmont. Lower Fairmont, which consists mainly of agriculture and forest lands, is below the 5-ft contour and surrounded by the Fairmont State Wildlife Management Area. Low-density residential areas exist along the major roads, particularly Rte. 361. If left unprotected, wetlands will accrete as the sea rises and inundate the residential areas. Saltwater intrusion may affect the surrounding farmed and forested lands, destroying these crops. Upper Fairmont, largely above the 5-ft contour, is a medium-density residential area. Both communities have sewage treatment plants and water systems. This fact, coupled with the relative size of the communities, makes abandonment of Fairmont Neck unlikely.

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[135]Communities have more political pull than individuals, but, more important, the efficient and effective construction of tidal dikes requires a community effort.

[136]The eventual construction of dikes around the island will squeeze much of the Deal Island State Wildlife Management Area out of existence. With no room for migration, the wetlands that would normally accrete onto the uplands will be unable to do so, resulting in their eventual disappearance. Theoretically, state and county assistance in construction of these dikes may result in the loss of publicly owned lands.

[137]If Deal Island is to be protected by a series of dikes or levees, sea level rise would still pose a significant problem for the community and county. Currently, Deal Island residents rely on septic systems for their waste disposal. Joan Kean, the director of the Department of Technical and Community Services, stated that Deal Island is an area of concern since it is subject to rising sea levels, has a high population density, and is currently experiencing a high septic failure rate. These problems are not completely debilitating, but the community must invest in proficient pumping system to remove excess groundwater or must acquire a sewage treatment facility.

[138]Marshes will accrete up to Rte. 362, because it is unlikely that the County will remove the road to allow marshes to accrete further. Constructing dikes along a county's infrastructure is desirable since it protects the county's investment. In addition to dikes, roads can act as barriers between the sea and people's homes.

Rumbley and Frenchtown are somewhat isolated from the county's mainland. Most of the land on which the homes are located is below the 5-ft contour. Both towns are currently connected to Fairmont's water system and could be connected to its sewage system.[139] Because the towns are located on narrow strips of land, levees and dikes are impractical; rather, the land could be elevated with fill and individual shoreline protection could be constructed.

Crisfield

As Somerset County's most populated city and important coastal port, Crisfield is certain to be protected from inundation.[140] In fact, 7 miles of tidal dikes already exist. In the early 1900s, a group of local farmers constructed dikes surrounding the Byrdtown and Lawsonia area to protect their land against flooding by tidal surges.[141] Future protection measures would most likely extend the existing tidal dike northward along the Annemessex Canal, covering the Crisfield Municipal Airport. The current tidal dikes could also be extended along the southern border of Somerset County.[142,143]

Southern Somerset County

The southern portion of Somerset County along the Pocomoke Sound and north up to Rte. 667 comprises largely publicly owned wetlands.[144] The area north of the wetlands is rural farmland and commercially forested lands, and is therefore not likely to be protected. Conservation easements would be more feasible than dike protection, implying that the land would be abandoned.

[139]No infiltration/inflow problems exist in Fairmont because the collection system is operated by vacuum.

[140]Roughly one-third of Somerset's total population reside in the Crisfield area.

[141]Greenhorne & O Mara, Inc., 1989, *Crisfield Tidal Dike Study*.

[142]Crisfield has a sewage treatment plant, which was recently expanded to include county populations adjacent to the city because of failing septic systems, particularly in the Byrdtown/Lawsonia area. The director of Somerset County's Department of Technical and Community Services, Joan Kean, noted that Crisfield's current facilities would accommodate all peripheral planned expansion, but infiltration/inflow problems would need to be corrected to deal with the temporary overloads at high tides. This significant problem could be exacerbated by continuing sea level rise.

[143]Because it is anticipated that Crisfield will be protected from sea level rise, wetlands surrounding the area (including Janes Island Marsh, Cedar Island Wildlife Management Area, and Pocomoke Sound Wildlife Management Area) could eventually disappear as they are inundated up against the dikes and levees. Consequently, Crisfield would lose the breeding grounds critical to its seafood industry and the existing buffer to storm surges. These costs have to be weighed against the proposed benefits when decisions are ultimately made.

[144]The Pocomoke Sound Wildlife Management Areas and the Irish Grove Wildlife Sanctuary.

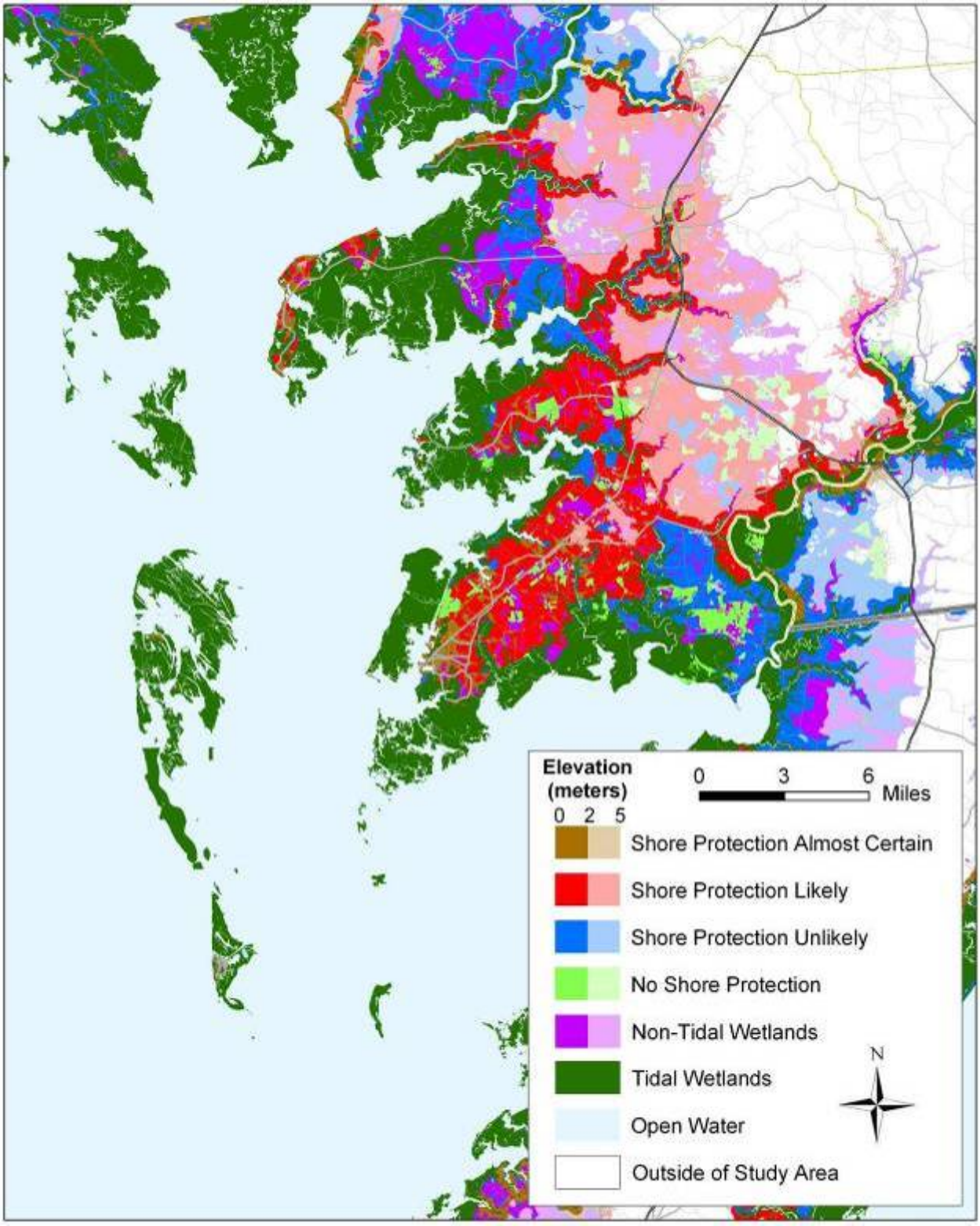
TABLE 6-22. SOMERSET COUNTY ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

Land Area	Protection Likelihood				Data Used to Identify Land Area
	No protection	Unlikely	Likely	Certain	
Land held in conservation easements		✓			Maryland Environmental Trust lands and agricultural easements/districts (DNR MERLIN 2000)
Public and private conservation lands	✓				Private conservation lands, state-owned lands, and county-owned lands (DNR MERLIN 2000)
Deal and Smith islands				✓	Land use/land cover in Maryland (MDP 1997)
Developed land within anticipated shore protection projects				✓	Developed land identified from land use/land cover in Maryland (MDP 1997).[b] Location of shore protection projects identified from discussions with planners.
Underdeveloped land within anticipated shore protection projects			✓		Underdeveloped land identified from land use/land cover in Maryland (MDP 1997).[c] Location of shore protection projects identified from discussions with planners.
Crisfield				✓	Manual GIS edits
Remaining lands		✓			Land use/land cover in Maryland (MDP 1997)

[a] Where land areas overlap, classifications higher in the table take precedence.

[b] Developed land categories include residential, commercial, industrial, and government-owned lands.

[c] Underdeveloped land categories include forest and farmlands.



Map 6-17. Somerset County: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2.

Worcester County

Background

Worcester County is Maryland's only county adjacent to the Atlantic Ocean. More than 46,000 people reside in the county, with more than 7,000 people in the barrier beach community of Ocean City. Approximately 43,430 individual properties are located below the 20-ft elevation contour, and they represent a significant portion of the assessed valuation of the county.[145]

Residential, commercial, and industrial lands account for more than 53 percent of the land uses within the study area. More than 95 percent of the county's assessable base is north of Berlin. The state and county are heavily invested in infrastructure in this area, including regional sewer facilities and transportation systems. Residential land diminishes significantly the farther south in the county one travels.

Tourism is also an important part of the local economy. Peak tourist-season population in Worcester County exceeds 335,000. Along with tourism, agriculture, forestry, and fisheries are significant industries in the local economy. Of the county's 302,879 acres, 37 percent, or 111,835 acres, is classified as farmland. By far the greatest contributor to agriculture is the poultry industry. Worcester County accounts for about 20 percent of broiler and other meat-type chickens sold in the state. The average per farm market value of agriculture products sold was more than $200,000 per farm in 1997, the fifth highest average among counties in Maryland.[146]

According to Maryland's Shore Erosion Task Force Report, 110 miles of shoreline in Worcester County are eroding. Approximately 74 miles are eroding at less than 2 feet per year. About 26 miles of shoreline are eroding at 2 to 4 feet per year, and 10 miles of shoreline are eroding at more than 4 feet per year.[147]

As a result of shore erosion in Worcester County, extensive reaches of shoreline along the coastal bays in the more densely populated areas of northern Worcester County have been armored (including Ocean City, and along shorelines within the incorporated municipalities of Snow Hill and Pocomoke City). This is also the case in communities that have built canals to access interior properties. Many of the county's important community facilities are also located below the 20-ft elevation contour, including Isle of Wight Medical Center, Ocean City Airport, the Ocean City and Worcester County sewer treatment plants, and the Snow Hill and Pocomoke middle schools.

Natural Areas

Located in the geographic province known as the Embayed Coastal Plain, Worcester County links the fragile barrier island system along its eastern coast with the Chesapeake Bay system on the west. Worcester County possesses an extensive variety of ecosystems, including barrier islands, coastal bays, tidal wetlands, cypress swamp, upland fields, and old growth forests. A unique aspect of Worcester County is its coastal bays, the most ecologically diverse but at the same time one of the most threatened regions in Maryland. Publicly owned lands along the coast include the following:

- **Assateague State Park.** This park, along the southern portion of Worcester's barrier island, supports a more than $2 billion tourism industry in Worcester County.[148] Assateague Island contains a combination of swamp and upland that offers a great variety of plant and animal life, including more than 300 species of birds.

[145]Based on the 1999 tax assessment records, the total value of land and improvements in this area is estimated to be more than $6.14 billion. Of this total, slightly more than 80 percent of the assessed value (nearly $4.0 billion) is residential properties. About 19 percent of this value, more than $934 million, is commercial properties. Less than 1 percent, or about $10.9 million, is industrial properties. Assessed value and property information was derived from *Maryland Property View*, Worcester County 1999 dataset, a Maryland Department of Planning data product that includes the Department of Assessment and Taxation property assessment records for Worcester County.

[146]Based on 1997 Census of Agriculture.

[147]*State of Maryland Shore Erosion Task Force Final Report*, January 2000.

[148]National Park Service, http://www.nps.gov/asis/index.html.

- **Sinepuxent Islands Wildlife Management Area.** This state-owned land consists of four islands created from Chesapeake Bay dredge material. These islands provide habitat for many sea birds, including royal terns, black skimmers, brown pelicans, ducks, and herons.
- **Isle of Wight Wildlife Management Area**. This state-owned land consists of 200 acres of marsh and forests on a scenic island in Assawoman Bay.

Important state and federal parks and wildlife management areas located along the Pocomoke River include the following:

- **E.A. Vaughn Wildlife Management Area.** This state-owned land consists of 17,500 acres of forests, fields, and marshes providing habitat for such species as woodcock, hairy and downy woodpeckers, and warblers. The endangered Delmarva fox squirrels thrive in the forest.
- **Pocomoke River Wildlife Management Area.** This state-owned land consists of 500 acres within the Great Cypress Swamp, one of the northernmost cypress swamps in the country. The Pocomoke River's wetlands are also a sanctuary for birds and waterfowl.
- **Pocomoke River State Forest and Park**, **Shad Landing**, and **Milburn Landing.** These areas provide almost 15,000 wooded acres in the southwestern section of Worcester County, between Snow Hill and Pocomoke City.

Historic and archeological sites of significance include Askiminokonson, the old Native American reservation and village straddling the Pocomoke River along Rte. 12 near Snow Hill. Established for several clans and tribes of eastern shore Indians in the late 1600s, it is one of the oldest reservations in the United States. In addition, Worcester County has 28 sites listed on the National Register of Historic Sites, many of which are located within incorporated towns.

County Policies

The state Chesapeake Bay Critical Areas Act protects land and waters within 1,000 feet of the tidal portions of the Pocomoke River corridor and adjacent tidal wetlands during the development process. Most of the county's coastal areas, however, are outside the Chesapeake Bay watershed and hence were outside of the jurisdiction of the act. Recently, however, the Maryland legislature enacted the Atlantic Coastal Bays Protection Act of 2002, which extended the concept of "critical area" to include the watersheds of the coastal bays. Later the same year, the County enacted a Worcester County Atlantic Coastal Bays Critical Area Law.

Under these two statutes, the County requires a minimum 100-ft buffer of naturally occurring or planted vegetation, measured from the mean high water line of tidal waters, in any new development in the Critical Area. The County also requires a 50-ft shoreline protection setback and 25-ft vegetated buffer along tidal portions of the coastal bays watershed.

Worcester County also has a number of other policies that may help protect wetlands as sea level rises. The County is an active participant in the Maryland Coastal Bays program, which lists sea level rise as one of the long-term issues that must be addressed. The County is also actively working with the Lower Shore Land Trust to acquire conservation easements along Chincoteague Bay. Although those conservation easements do not explicitly prohibit all efforts to stop shoreline erosion, protection is extremely unlikely in such areas.

Anticipated Response to Sea Level Rise

Based on communication with:

Ed Tudor, director, Development Review and Permitting

Table 6-23 summarizes the anticipated responses to sea level rise in Worcester County by land classification. The County, along with private property owners, will take all steps necessary to protect areas along the coastal bays that are currently or in the future will be served by county sewer. The County anticipates that land in designated growth areas will also almost

certainly be protected. Developed areas to be protected include Snow Hill, Public Landing, Pocomoke City, and Ocean City.

The less-developed lands located south of MD 376 and South Point will most likely be protected; some areas may be abandoned, however, if protection becomes too costly. Additional private lands that may or may not be protected include areas of small settlements (e.g., areas adjacent to Pocomoke City and Snow Hill) that are continuations of the nearby towns. Any upward shift in the water table could also adversely affect current agriculture drainage systems, resulting in crop damage and increased costs for land maintenance (e.g., water pumping). Consequently, these lands may be less suitable for farming. In some cases, lands may become too costly to maintain and thus lead property owners to abandon the land and, when possible, sell it to developers.

Worcester County and the incorporated municipalities will protect publicly owned land within public sewer service areas, but will not protect park and open space land. The National Park Service will permit natural shoreline processes (erosion, deposition, dune formation, inlet formation, and shoreline migration) to continue without abatement on the southern portion of Assateague Island. The County also anticipates that the state will adopt a policy for Assateague State Park similar to that of the National Park Service for south Assateague Island. State-owned land in wildlife management areas on the Pocomoke River and Chincoteague Bay are also expected to be left to coastal processes.

Additional conservation lands within the county include property for which the state or a private entity possesses a conservation easement. The Maryland Agriculture Land Preservation Program, the Maryland Environmental Trust Program, and private organizations also purchase conservation easements to preserve open space land. For example, several ongoing programs have purchased—or hope to purchase—conservation easements along Chincoteague Bay. We are currently uncertain as to whether any of those easements prevent measures to hold back the sea. As discussed in the section on generalized statewide responses to sea level rise, the standard conservation easement in Maryland specifically allows shoreline armoring and drainage ditches and hence allows landowners to protect their property from sea level rise. Nevertheless, protection is clearly less likely in such areas than adjacent agricultural areas, because zoning might conceivably change to allow development for some of the agricultural lands. On the lands with conservation easements, by contrast, development could not take place unless both the zoning changed and the land trust decided to give up the easement. We show these lands as unlikely to be protected (blue). For conservation easements surrounded by land certain to be protected, however, we show the easement as likely to be protected (red). The only example of this latter case is a Maryland Environmental Trust area south of the Assateague State Park.

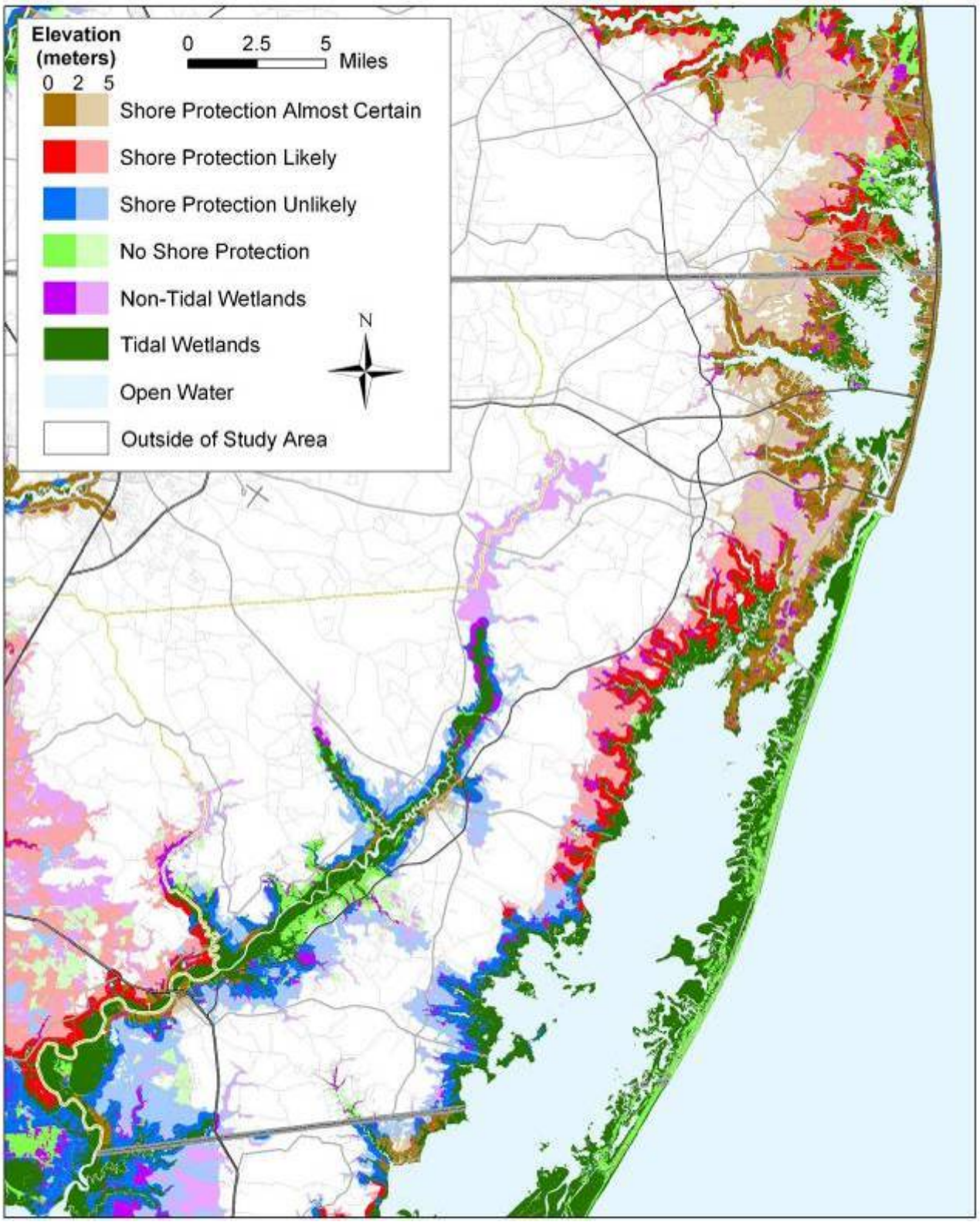
Stakeholder reviewers provided additional modifications to the map to address issues with the GIS data.[149] The peninsula south of Snug Harbor and Ironshire and Public Landing (originally shown as likely to be protected since they are in the less densely developed area compared to lands in and around Ocean City) were noted as developing and are certain to be protected. Also, developed land along Pocomoke River were added as certain to be protected. Map 6-18 shows the final product depicting the likelihood of shore protection.

[149]Stakeholder review comments obtained by Peter Johnston from Sandy Coyman, director of Comprehensive Planning, at the county government center on October 11, 2002.

TABLE 6-23. WORCESTER COUNTY ANTICIPATED RESPONSE TO SEA LEVEL RISE[a]

Ownership	Land Area	Protection Likelihood				Data Used to Identify Land Area
		No protection	Unlikely	Likely	Certain	
Public	Public landing				✓	Manual GIS edit per stakeholder review comment
Public	State and county-owned parks	✓				Worcester County conservation lands (Worcester Regional GIS 2003)
Public	County-owned utilities and transportation facilities			✓		MD Property View data (1999)
Mostly private	Lands subject to conservation easements in areas that are otherwise certain to be protected from erosion and inundation			✓		See data sources for conservation easements and lands certain to be protected
Mostly private	Lands subject to conservation easements		✓			Worcester County conservation lands (Worcester Regional GIS 2003), Maryland Environmental Trust, and agricultural easements/districts (MD DNR 2000)
Mostly private	Conservation land	✓				Privately owned lands (MD DNR 2000)
Mostly private	Municipalities (Public Landing, Pocomoke City, Snow Hill, Ocean City)[b]				✓	MD Property View data (1999)
Mostly private	Areas of current and planned infrastructure investment priority funding areas (PFA)				✓	MD Property View data (1999)
Mostly private	Existing high to medium density residential areas, existing major employment and commercial areas, and planned growth areas				✓	MD Property View data (1999) and manual GIS edit per County Comprehensive Plan (updated 1992)
Mostly private	Low density areas already developed, e.g., villages and enclaves at low densities			✓		MD Property View data (1999) and manual GIS edit per County Comprehensive Plan (updated 1992)
Mostly private	Agricultural (very low density residential)		✓			Manual GIS edits per County Comprehensive Plan (updated 1992) and MD Property View data (1999)

[a] Where land areas overlap, classifications higher in the table take precedence.
[b] This category includes privately owned lands and municipally owned lands contained within the municipalities.



Map 6-18. Worcester County: Likelihood of Shore Protection. For additional details, see the legend and caption accompanying Map 6-2.

Appendix A

LENGTH OF SHORELINES BY LIKELIHOOD OF SHORE PROTECTION

Authors: John Herter and Daniel Hudgens

Table of Contents: List and description of tables included in this appendix

Table Name	Description	Table Number
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Shoreline length by County	Total shoreline length for each county.	A-2
Shoreline length of primary water bodies	Shoreline length reported for Primary Water Bodies by Water Body Name (aggregated across).	A-3
Shoreline lengths for all bodies of water by county	Shoreline length reported by unique County, Water Body Category, and Water Body Name.	A-4
Military lands	Shoreline length reported by unique County, Water Body Category, and Water Body Name where the shoreline is located within a Military Facility.	A-5
Islands with roads	Shoreline length reported by unique County, Water Body Category, and Water Body Name where the shoreline is located on an island that contains roads.	A-6

Notes

This appendix estimates the lengths of tidal shoreline for each of the categories of shore protection likelihood. By “shoreline” we mean the land immediately adjacent to tidal open water or tidal wetlands. We provide several alternative summaries of our tidal shoreline estimates, including shoreline length by county, type of water body, and major body of water. For information on how we created, categorized, and measured the shoreline, see Appendix 1 of this report.

Table A-1: Definitions: Water body categories used in this Appendix

Water Body Category[1]	Description
Shorelines Along Primary Water Bodies [2]	
Primary Bay	Shoreline located along a major bay such as Chesapeake Bay.
Barrier/Bayside	The side of barrier islands adjacent to the inner coastal bay.
Primary River	The portion of a major river that flows either into the Atlantic Ocean or a Primary Bay where the river is wider than one kilometer. In this case, a major river is subjectively determined but represents the most significant waterways in the region based on relative size (e.g., Potomac River, Delaware River, Nanticoke River, etc.).
Barrier Bay/Mainland	Shoreline that is located along the major county landmass and, at least partially, shielded by a barrier island.
Barrier/Oceanside	The side of barrier islands adjacent to the Atlantic Ocean.
Ocean Front	Land located immediately adjacent to the Ocean. Excludes land located along a barrier island (which is characterized as Barrier/Oceanfront).
Other Types of Shores	
Dredge and Fill	Shoreline characterized by multiple "finger" canals that run from the primary shoreline area inland and provide access to the water for the local community development.
Other/Road	A general term used for land that might not always be considered to be land. In particular, 1) dry land located at the base of causeways leading to barrier islands and 2) docks and piers that extend into the water are included in this category.
Island	A piece of land completely surrounded by water except for a barrier island. Shores along Primary Water Bodies are not included in the "Island" category.
Secondary Bay	Shoreline located along a smaller bay that is further sheltered from the wave action of a major bay or Ocean.
Secondary River	A river that is smaller in relative size than the major rivers identified as Primary River, or where the width of a major river falls below one kilometer.
Tributary[3]	Small tributaries, creeks, and inlets flowing into a Primary Water Body. The water body name reflected in the GIS data is either the actual name of the tributary or the name of the water body into which the tributary flows.

Notes:

1. With the exception of shoreline identified as "Dredge and Fill", all Water Body Categories are mutually exclusive. Dredge and Fill areas are identified separately and are associated with shoreline that would otherwise be identified as Tributary.

2. For the purpose of this study, "Primary Water Body" distinguishes larger water bodies where the more immediate effects of sea level rise are likely to occur. These areas are less protected by land barriers and offer a more favorable environment for the promotion of wave action caused by wind.

3. When categorizing the shoreline, we identify “Unclassified Tributaries” where the water body name reflects the name of the water body into which the tributary flows. For the results presented in this appendix, we combine the “Unclassified Tributaries” within the “Tributary” category and aggregate the shoreline lengths.

Table A-2: Shoreline length by County*

County	Shoreline Length (Kilometers)					
	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	Totals
Anne Arundel	653	20	242	15	27	**957**
Baltimore	237	100	33	71	6	**446**
Baltimore City	107	0	0	0	0.3	**107**
Calvert	189	18	246	30	20	**503**
Caroline	32	7	171	2	11	**223**
Cecil	144	8	267	18	18	**456**
Charles	83	105	348	57	25	**617**
Dorchester	244	49	1365	125	110	**1894**
Harford	44	326	127	24	26	**548**
Kent	69	44	477	37	38	**665**
Prince George's	80	2	1	60	9	**152**
Queen Anne's	304	36	384	50	59	**833**
Somerset	81	301	417	112	55	**966**
St. Mary's	345	275	394	5	63	**1081**
Talbot	579	109	525	3	20	**1236**
Wicomico	76	4	368	33	37	**519**
Worcester	494	72	154	411	65	**1196**
Totals	**3759**	**1476**	**5520**	**1054**	**588**	**12398**

* Excludes Howard and Montgomery County.

Table A-3: Shoreline length of primary water bodies

Water Body Category	Water Body Name	Shoreline Length (Kilometers)					
		Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	Totals
Barrier Bay/Mainland	Assawoman Bay	7	0	0	0.1	0.2	**8**
Barrier/Bayside	Assawoman Bay	9	0	0	<0.1	0	**9**
Barrier/Oceanside	Atlantic Ocean	15	0	0	36	0	**51**
Primary Bay	Chesapeake Bay	168	62	124	28	21	**403**
Primary River	Chester River	19	2	36	0	7	**64**
Barrier Bay/Mainland	Chincoteague Bay	13	10	16	14	5	**59**
Barrier/Bayside	Chincoteague Bay	0	0	0	36	0.1	**36**
Primary River	Choptank River	33	10	71	0.5	2	**118**
Barrier Bay/Mainland	Isle of Wight Bay	8	0	0	0.1	0	**8**
Barrier/Bayside	Isle of Wight Bay	6	0	0	0.1	0	**6**
Primary River	Nanticoke River	14	0.5	47	5	9	**76**
Primary River	Patapsco River	31	0.7	3	0	0.3	**35**
Primary River	Patuxent River	41	13	51	6	0.6	**110**
Primary River	Potomac River	52	39	55	8	4	**158**
Barrier Bay/Mainland	Sinepuxent Bay	22	<0.1	0	1	1	**24**
Barrier/Bayside	Sinepuxent Bay	0	0	0	24	0	**24**
Primary River	Susquehanna River	10	0	14	6	4	**33**
Primary River	Wicomico River	8	9	30	3	14	**64**
Totals		**455**	**147**	**447**	**169**	**69**	**1287**

Table A-4: Shoreline lengths for all water bodies*

County	Water Body Category	Water Body Name	Shoreline Length (Kilometers)					
			Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	Totals
Anne Arundel	Bodkin Creek	Secondary River	27	3	3	0	0.8	**34**
Anne Arundel	Chesapeake Bay	Dredge and Fill	0.4	0	0	0	0	**0.4**
Anne Arundel	Chesapeake Bay	Island	0	0	0.2	0	0	**0.2**
Anne Arundel	Chesapeake Bay	Primary Bay	51	1	10	0	0.1	**62**
Anne Arundel	Chesapeake Bay	Secondary River	0.7	0	<0.1	0	0	**0.7**
Anne Arundel	Chesapeake Bay	Tributary	86	5	61	0.4	6	**160**
Anne Arundel	Curtis Bay	Secondary River	6	0.2	0.2	0	0	**7**
Anne Arundel	Curtis Creek	Tributary	26	0	8	0	0.3	**35**
Anne Arundel	Magothy River	Island	1	0	1	0	0	**2**
Anne Arundel	Magothy River	Secondary River	105	0	17	0	2	**124**
Anne Arundel	Patapsco River	Dredge and Fill	1	0	0.6	0	0	**2**
Anne Arundel	Patapsco River	Primary River	5	0	2	0	0	**7**
Anne Arundel	Patapsco River	Secondary River	11	0	2	0	0	**13**
Anne Arundel	Patapsco River	Tributary	9	0	1	0	0.3	**10**
Anne Arundel	Patuxent River	Secondary River	6	0	10	0	0.8	**18**
Anne Arundel	Patuxent River	Tributary	0.2	0	3	0	0.9	**4**
Anne Arundel	Rhode River	Island	0.7	0	2	1	<0.1	**4**
Anne Arundel	Rhode River	Secondary River	16	0.9	9	8	3	**37**
Anne Arundel	Rock Creek	Tributary	17	0	4	0	0.3	**21**
Anne Arundel	Severn River	Island	0.5	0.8	0	0	0	**1**
Anne Arundel	Severn River	Secondary River	121	2	27	<0.1	1	**151**
Anne Arundel	South River	Secondary River	103	3	33	0	5	**145**
Anne Arundel	South River	Tributary	0.2	0	0	0	0	**0.2**
Anne Arundel	Stoney Creek	Tributary	25	2	4	0	<0.1	**31**
Anne Arundel	Tracys Creek	Secondary River	10	0	15	0	1	**27**
Anne Arundel	West River	Secondary River	23	1	27	5	4	**61**
Baltimore	Back River	Secondary River	59	15	8	1	<0.1	**84**
Baltimore	Bear Creek	Tributary	37	2	6	0	0	**44**
Baltimore	Chesapeake Bay	Island	9	0	0	2	0	**11**
Baltimore	Chesapeake Bay	Other	0	0	0	0.7	0	**0.7**
Baltimore	Chesapeake Bay	Primary Bay	2	5	0.9	2	0.1	**10**
Baltimore	Chesapeake Bay	Tributary	5	14	3	11	1	**34**
Baltimore	Gunpowder River	Island	0	17	0.1	2	0.8	**19**
Baltimore	Gunpowder River	Secondary River	29	34	6	43	3	**114**
Baltimore	Middle River	Island	1	0	0	0	0	**1**
Baltimore	Middle River	Secondary River	54	11	6	0	<0.1	**71**
Baltimore	Old Road Bay	Secondary Bay	17	0.3	2	1	0	**21**
Baltimore	Patapsco River	Dredge and Fill	12	0	0	0	0	**12**
Baltimore	Patapsco River	Other	2	0	0	0	0	**2**
Baltimore	Patapsco River	Primary River	8	0.7	0.3	0	0	**9**

Table A-4: Shoreline lengths for all water bodies*

County	Water Body Category	Water Body Name	Shoreline Length (Kilometers)					
			Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	Totals
Baltimore	Patapsco River	Secondary River	0.4	2	1	4	0.1	**7**
Baltimore	Patapsco River	Tributary	0.6	0	0.2	5	0.5	**6**
Baltimore City	Curtis Bay	Secondary River	15	0	0	0	0	**15**
Baltimore City	Patapsco River	Dredge and Fill	16	0	0	0	0	**16**
Baltimore City	Patapsco River	Other	7	0	0	0	<0.1	**7**
Baltimore City	Patapsco River	Primary River	18	0	0	0	0.3	**18**
Baltimore City	Patapsco River	Tributary	52	0	0	0	0	**52**
Calvert	Battle Creek	Tributary	11	0	18	<0.1	1	**30**
Calvert	Chesapeake Bay	Primary Bay	28	1	5	13	2	**50**
Calvert	Chesapeake Bay	Tributary	24	0	0.3	2	1	**28**
Calvert	Fishing Creek	Secondary River	22	0	0	0	4	**26**
Calvert	Hunting Creek	Tributary	8	0	21	0	1	**30**
Calvert	Mill Creek	Tributary	34	0	0	0	0.3	**34**
Calvert	Parker Creek	Secondary River	0	0	5	4	1	**10**
Calvert	Patuxent River	Dredge and Fill	0	0	0.8	0	0	**0.8**
Calvert	Patuxent River	Island	0.2	0	0	0	0	**0.2**
Calvert	Patuxent River	Primary River	7	7	41	0	<0.1	**55**
Calvert	Patuxent River	Secondary River	4	0	9	3	0.6	**16**
Calvert	Patuxent River	Tributary	25	9	118	7	8	**168**
Calvert	St. John Creek	Tributary	11	0	0	0	0	**11**
Calvert	St. Leonard Creek	Tributary	14	0	29	0	1	**43**
Caroline	Choptank River	Island	0	0	2	0.6	0	**3**
Caroline	Choptank River	Other	2	0	0	0	0	**2**
Caroline	Choptank River	Primary River	1	0.1	13	0	2	**16**
Caroline	Choptank River	Secondary River	19	2	48	0.8	3	**72**
Caroline	Choptank River	Tributary	8	4	77	0.7	2	**92**
Caroline	Marshyhope Creek	Tributary	0.7	0	5	0.2	1	**7**
Caroline	Tuckahoe Creek	Tributary	0.3	0.5	27	<0.1	3	**30**
Cecil	Bohemia River	Secondary River	13	<0.1	81	2	4	**99**
Cecil	Chesapeake Bay	Primary Bay	7	3	5	5	0.7	**21**
Cecil	Chesapeake Bay	Tributary	0.4	0	0	0	<0.1	**0.4**
Cecil	Elk River	Secondary River	71	0.9	79	12	4	**167**
Cecil	Furnace Bay	Secondary River	3	0	10	0	0	**13**
Cecil	Northeast River	Island	1	0	0.2	0	0	**1**
Cecil	Northeast River	Secondary River	25	2	6	0	0.8	**33**
Cecil	Pond Creek	Secondary River	0.6	0	16	0	1	**18**
Cecil	Sassafrass River	Secondary River	14	2	51	0.4	3	**71**
Cecil	Susquehanna River	Dredge and Fill	0.2	0	0	0	0	**0.2**
Cecil	Susquehanna River	Island	0	0	8	0	2	**10**
Cecil	Susquehanna River	Primary River	8	0	7	0	2	**17**

Table A-4: Shoreline lengths for all water bodies*

County	Water Body Category	Water Body Name	Shoreline Length (Kilometers)					
			Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	Totals
Cecil	Susquehanna River	Tributary	0.2	0	4	0.1	<0.1	**4**
Charles	Chesapeake Bay	Island	4	0	0.3	0	0	**4**
Charles	Chicamuxen Creek	Tributary	2	0	8	3	0.3	**14**
Charles	Mattawoman Creek	Tributary	4	13	7	17	4	**44**
Charles	Nanjemoy Creek	Tributary	3	6	95	0	3	**107**
Charles	Neale Sound	Tributary	1	4	0.4	0	0	**6**
Charles	Patuxent River	Other	0	0	0.5	0	0	**0.5**
Charles	Patuxent River	Primary River	2	0	1	2	0	**5**
Charles	Patuxent River	Tributary	2	0	6	15	1	**24**
Charles	Pomonkey Creek	Tributary	0	0	13	0	0.3	**14**
Charles	Port Tobacco River	Tributary	11	0	32	4	2	**49**
Charles	Potomac River	Dredge and Fill	1	0	0	0	0	**1**
Charles	Potomac River	Island	3	0	0	0	0	**3**
Charles	Potomac River	Other	0	0	0	0.5	0	**0.5**
Charles	Potomac River	Primary River	21	17	49	3	2	**92**
Charles	Potomac River	Tributary	21	34	73	2	8	**138**
Charles	Trent Hall Creek	Tributary	0	0	0	5	0.6	**5**
Charles	Wicomico River	Tributary	7	32	61	6	4	**111**
Dorchester	Blackwater River	Island	0	0	24	15	1	**41**
Dorchester	Blackwater River	Other	0	0	14	0	4	**18**
Dorchester	Blackwater River	Secondary River	8	0	94	36	21	**158**
Dorchester	Chesapeake Bay	Island	11	0	23	0	<0.1	**35**
Dorchester	Chesapeake Bay	Other	0	0	0.3	0	0	**0.3**
Dorchester	Chesapeake Bay	Primary Bay	9	3	31	0	3	**45**
Dorchester	Chesapeake Bay	Secondary River	3	0	0.2	0	0	**4**
Dorchester	Chesapeake Bay	Tributary	6	2	48	0	5	**60**
Dorchester	Chicamacomico River	Tributary	3	0	132	0	3	**138**
Dorchester	Choptank River	Island	0.4	0	0	0	0	**0.4**
Dorchester	Choptank River	Primary River	22	10	19	0	<0.1	**52**
Dorchester	Choptank River	Tributary	63	33	49	0	1	**146**
Dorchester	Fishing Bay	Island	8	0	31	13	1	**54**
Dorchester	Fishing Bay	Other	0.3	0	9	0	0	**10**
Dorchester	Fishing Bay	Secondary Bay	8	0	26	0	14	**47**
Dorchester	Honga River	Island	9	0	73	0	0	**82**
Dorchester	Honga River	Other	3	0	33	0	3	**39**
Dorchester	Honga River	Secondary River	24	0	65	0	7	**96**
Dorchester	Hurlock Creek	Tributary	0	0	37	0	1	**38**
Dorchester	Island Pond	Other	0	0	3	11	5	**19**
Dorchester	Little Blackwater River	Tributary	0.3	0.3	58	5	2	**65**
Dorchester	Little Choptank River	Secondary River	39	0.3	223	0	7	**268**

Table A-4: Shoreline lengths for all water bodies*

County	Water Body Category	Water Body Name	Shoreline Length (Kilometers)					
			Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	Totals
Dorchester	Marshyhope Creek	Tributary	3	0.2	52	6	4	**65**
Dorchester	Meekins Creek	Tributary	0	0	16	0	0.7	**16**
Dorchester	Nanticoke River	Island	<0.1	0	7	13	0	**21**
Dorchester	Nanticoke River	Other	9	0	0	0.8	0	**9**
Dorchester	Nanticoke River	Primary River	4	0.5	27	0.4	4	**35**
Dorchester	Nanticoke River	Tributary	2	0	50	0.4	3	**55**
Dorchester	Parsons Creek	Tributary	3	0	8	0	11	**22**
Dorchester	Slaughter Creek	Other	1	<0.1	47	10	4	**62**
Dorchester	Slaughter Creek	Secondary River	4	0.2	40	14	5	**64**
Dorchester	Transquaking River	Island	0	0	16	0.2	0	**16**
Dorchester	Transquaking River	Secondary River	0.5	0	111	0	0.9	**113**
Dorchester	Transquaking River	Tributary	0	0	3	0	1	**4**
Harford	Bush River	Island	0	6	0.2	0.3	0	**6**
Harford	Bush River	Secondary River	18	91	28	3	3	**142**
Harford	Chesapeake Bay	Island	2	43	6	0	2	**54**
Harford	Chesapeake Bay	Primary Bay	3	25	4	0	2	**34**
Harford	Chesapeake Bay	Tributary	0.4	59	2	0	6	**67**
Harford	Deer Creek	Tributary	3	0	58	8	2	**71**
Harford	Gunpowder River	Secondary River	10	50	6	7	2	**74**
Harford	Romney Creek	Island	0	9	0	0	0	**9**
Harford	Romney Creek	Secondary River	0.1	40	0	0	2	**42**
Harford	Susquehanna River	Dredge and Fill	2	0	0	0	0	**2**
Harford	Susquehanna River	Island	0	0	3	0	6	**9**
Harford	Susquehanna River	Primary River	2	0	7	6	2	**16**
Harford	Susquehanna River	Tributary	<0.1	0	1	0	0	**1**
Harford	Swan Creek	Secondary River	4	4	13	0	0.1	**21**
Kent	Chesapeake Bay	Other	0	0	0	0.9	0	**0.9**
Kent	Chesapeake Bay	Primary Bay	7	5	29	0	1	**42**
Kent	Chesapeake Bay	Tributary	20	0.4	43	0	2	**66**
Kent	Chester River	Island	0.6	0	8	28	9	**45**
Kent	Chester River	Other	0	0	0.9	0.7	0.2	**2**
Kent	Chester River	Primary River	1	0.2	17	0	2	**20**
Kent	Chester River	Secondary River	8	2	29	0	4	**43**
Kent	Chester River	Tributary	8	2	88	0	6	**104**
Kent	Churn Creek	Secondary River	2	0.3	12	0	0.9	**15**
Kent	Fairlee Creek	Island	0	0	0.2	0	0	**0.2**
Kent	Fairlee Creek	Secondary River	0	6	19	0	0.2	**25**
Kent	Gray's Inn Creek	Tributary	6	0.6	23	0	4	**33**
Kent	Langford Creek	Tributary	3	10	103	0	2	**118**
Kent	Sassafrass River	Island	0	0	1	0	0	**1**

Table A-4: Shoreline lengths for all water bodies*

County	Water Body Category	Water Body Name	Shoreline Length (Kilometers)					
			Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	Totals
Kent	Sassafrass River	Secondary River	9	8	70	8	5	**101**
Kent	Still Pond Creek	Secondary River	2	4	16	0.2	0.8	**23**
Kent	Worton Creek	Secondary River	2	4	18	0	0.3	**24**
Prince George's	Broad Creek	Tributary	5	0	0	4	0.3	**9**
Prince George's	Patuxent River	Primary River	8	0	0	2	0.3	**11**
Prince George's	Patuxent River	Secondary River	16	1	0	17	1	**35**
Prince George's	Patuxent River	Tributary	27	0	0	17	5	**48**
Prince George's	Piscataway Creek	Tributary	5	0.2	1	8	2	**16**
Prince George's	Potomac River	Island	0.8	0	0	0.6	0	**1**
Prince George's	Potomac River	Primary River	10	0.6	0	5	0	**15**
Prince George's	Potomac River	Tributary	8	0.2	0	7	0.6	**16**
Queen Anne's	Chesapeake Bay	Dredge and Fill	0	0	2	0	0	**2**
Queen Anne's	Chesapeake Bay	Primary Bay	14	0	7	0.3	2	**22**
Queen Anne's	Chesapeake Bay	Tributary	25	0	11	0	4	**40**
Queen Anne's	Chester River	Dredge and Fill	2	0	0	0	0	**2**
Queen Anne's	Chester River	Island	0.6	0	0	0	0	**0.6**
Queen Anne's	Chester River	Other	10	0	0	0	0	**10**
Queen Anne's	Chester River	Primary River	18	2	19	0	5	**44**
Queen Anne's	Chester River	Secondary River	24	0	16	0	2	**42**
Queen Anne's	Chester River	Tributary	42	5	82	0	11	**140**
Queen Anne's	Corsica River	Tributary	11	4	30	0	2	**48**
Queen Anne's	Cox Creek	Secondary Bay	37	11	12	0	13	**72**
Queen Anne's	Crab Alley Bay	Secondary Bay	14	1	12	0	2	**28**
Queen Anne's	Eastern Bay	Secondary Bay	31	2	22	0	3	**58**
Queen Anne's	Greenwood Creek	Secondary River	13	0	8	0	0.5	**21**
Queen Anne's	Prospect Bay	Secondary Bay	14	1	30	0	7	**52**
Queen Anne's	Shipping Creek	Secondary Bay	9	4	2	0	0.7	**16**
Queen Anne's	Southeast Creek	Tributary	0	4	40	0	1	**46**
Queen Anne's	Tuckahoe Creek	Tributary	0	0	0.9	0.2	2	**3**
Queen Anne's	Wye East River	Secondary River	0	0	18	25	3	**45**
Queen Anne's	Wye River	Secondary River	40	0	72	25	2	**140**
Somerset	Annemessex Creek	Island	0	3	22	1	0.7	**27**
Somerset	Annemessex Creek	Tributary	0	4	2	3	<0.1	**9**
Somerset	Back Creek	Island	0	1	2	0	0	**3**
Somerset	Back Creek	Tributary	0	19	14	0.6	0.2	**34**
Somerset	Big Annemessex River	Secondary River	10	51	39	4	2	**106**
Somerset	Chesapeake Bay	Island	19	16	26	35	1	**98**
Somerset	Chesapeake Bay	Other	0.4	0.7	4	1	<0.1	**6**
Somerset	Chesapeake Bay	Primary Bay	11	8	19	7	11	**56**
Somerset	Chesapeake Bay	Tributary	16	38	25	3	8	**90**

Table A-4: Shoreline lengths for all water bodies*

County	Water Body Category	Water Body Name	Shoreline Length (Kilometers)					
			Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	Totals
Somerset	Dames Quarter Marsh	Other	0	0	0.8	31	0	**32**
Somerset	Dividing Creek	Tributary	0.5	9	1	0	0.3	**11**
Somerset	East Creek	Island	0	0	4	2	0	**7**
Somerset	East Creek	Secondary River	3	13	13	7	2	**37**
Somerset	King's Creek	Tributary	0	8	10	0	0.4	**18**
Somerset	Laws Thorofare	Other	3	1	1	3	1	**10**
Somerset	Manokin River	Island	0	0	10	0.3	0	**10**
Somerset	Manokin River	Other	0	0	1	0	0	**1**
Somerset	Manokin River	Secondary River	2	36	59	2	3	**102**
Somerset	Marumsco Creek	Island	0	0	10	0	0	**10**
Somerset	Marumsco Creek	Secondary River	0.2	13	38	2	7	**61**
Somerset	Monie Creek	Tributary	<0.1	10	18	0.3	2	**30**
Somerset	Pocomoke River	Island	0	1	0.7	0	0.3	**2**
Somerset	Pocomoke River	Secondary River	3	17	13	0.7	0.5	**34**
Somerset	Pocomoke River	Tributary	3	25	19	0	0.7	**48**
Somerset	St. Peter's Creek	Island	0	0	0.5	0	0	**0.5**
Somerset	St. Peter's Creek	Tributary	0	5	6	0.3	4	**14**
Somerset	Wicomico Creek	Tributary	0.5	9	11	0	0.6	**20**
Somerset	Wicomico River	Dredge and Fill	0	0	2	0	0	**2**
Somerset	Wicomico River	Island	1	0.4	10	0	3	**14**
Somerset	Wicomico River	Other	0	0.7	4	4	0	**8**
Somerset	Wicomico River	Primary River	7	9	13	2	5	**37**
Somerset	Wicomico River	Tributary	1	4	19	0.9	3	**28**
St. Mary's	Breton Bay	Secondary Bay	25	20	10	0	6	**62**
St. Mary's	Chesapeake Bay	Island	18	2	0.4	0	4	**24**
St. Mary's	Chesapeake Bay	Primary Bay	20	8	5	0	0.6	**35**
St. Mary's	Chesapeake Bay	Tributary	41	41	72	0	14	**168**
St. Mary's	Jutland Creek	Tributary	2	6	17	0	0.3	**25**
St. Mary's	Lake Conoy	Other	9	0.4	0	0	6	**15**
St. Mary's	Patuxent River	Dredge and Fill	0.6	0	0	0	0	**0.6**
St. Mary's	Patuxent River	Island	0.2	0	0.1	0	0	**0.3**
St. Mary's	Patuxent River	Primary River	23	6	9	2	0.2	**40**
St. Mary's	Patuxent River	Tributary	56	50	62	3	5	**176**
St. Mary's	Potomac River	Island	0.2	0	0.2	0	0	**0.4**
St. Mary's	Potomac River	Primary River	22	21	6	0	2	**51**
St. Mary's	Potomac River	Tributary	18	79	37	0	10	**144**
St. Mary's	Smith Creek	Tributary	15	0	7	0	1	**23**
St. Mary's	St. Clement Bay	Secondary Bay	16	20	61	0	1	**98**
St. Mary's	St. George Creek	Tributary	5	2	29	0	6	**42**
St. Mary's	St. Mary's River	Island	0	0	0	0	1	**1**

Table A-4: Shoreline lengths for all water bodies*

County	Water Body Category	Water Body Name	Shoreline Length (Kilometers)					
			Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	Totals
St. Mary's	St. Mary's River	Tributary	43	14	47	0	3	**107**
St. Mary's	Trent Hall Creek	Tributary	4	0	2	0	0.7	**7**
St. Mary's	Wicomico River	Tributary	26	5	28	0	2	**62**
Talbot	Broad Creek	Secondary River	134	16	23	0	1	**174**
Talbot	Chesapeake Bay	Island	2	0	0	0	0	**2**
Talbot	Chesapeake Bay	Primary Bay	12	1	7	0.9	<0.1	**21**
Talbot	Chesapeake Bay	Tributary	14	0.5	9	0	2	**25**
Talbot	Choptank River	Island	14	0	3	0	0	**17**
Talbot	Choptank River	Other	0.8	0	0.2	0.4	0	**1**
Talbot	Choptank River	Primary River	10	0	39	0.5	0.3	**50**
Talbot	Choptank River	Secondary River	2	0.4	11	0	0.4	**14**
Talbot	Choptank River	Tributary	46	4	188	0	4	**242**
Talbot	Eastern Bay	Secondary Bay	9	10	13	0	1	**33**
Talbot	Harris Creek	Secondary River	73	25	16	1	0.7	**116**
Talbot	Miles River	Secondary River	99	11	83	0	2	**194**
Talbot	Skipton Creek	Tributary	0	0	26	0	0.8	**27**
Talbot	Tred Avon River	Secondary River	158	19	35	0	1	**213**
Talbot	Tuckahoe Creek	Tributary	0	0	27	0	3	**30**
Talbot	Wye East River	Secondary River	6	23	39	0	4	**72**
Talbot	Wye River	Secondary River	0	0	5	0	0	**5**
Wicomico	Chesapeake Bay	Island	0	0	1	0	0	**1**
Wicomico	Chesapeake Bay	Primary Bay	3	0	2	0	0	**5**
Wicomico	Green Hill Creek	Tributary	0	0	11	0	<0.1	**11**
Wicomico	Nanticoke River	Dredge and Fill	2	0	8	0	0	**9**
Wicomico	Nanticoke River	Island	0	0	10	3	0	**13**
Wicomico	Nanticoke River	Other	0	0	4	0	0	**4**
Wicomico	Nanticoke River	Primary River	10	0	21	5	6	**41**
Wicomico	Nanticoke River	Tributary	9	0.1	26	6	4	**45**
Wicomico	Quantico Creek	Tributary	0	0	48	6	0.4	**55**
Wicomico	Rewastico Creek	Tributary	0	0	35	8	0.6	**44**
Wicomico	Shiles Creek	Tributary	0	0	13	0	1	**15**
Wicomico	Tyaskin Creek	Tributary	5	0	14	0	0.3	**19**
Wicomico	Wetipquin Creek	Tributary	1	1	52	0.4	1	**57**
Wicomico	Wicomico Creek	Tributary	4	0	18	0	0.4	**22**
Wicomico	Wicomico River	Island	3	0	9	2	0.9	**14**
Wicomico	Wicomico River	Other	0.2	0	5	2	0.4	**7**
Wicomico	Wicomico River	Primary River	0.7	0	17	0.9	9	**28**
Wicomico	Wicomico River	Secondary River	25	2	36	0	2	**64**
Wicomico	Wicomico River	Tributary	13	0.6	40	<0.1	12	**65**
Worcester	Assawoman Bay	Barrier Bay/Mainland	7	0	0	0.1	0.2	**8**

Table A-4: Shoreline lengths for all water bodies*

County	Water Body Category	Water Body Name	Shoreline Length (Kilometers)					
			Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	Totals
Worcester	Assawoman Bay	Barrier/Bayside	9	0	0	<0.1	0	**9**
Worcester	Assawoman Bay	Dredge and Fill	44	0	0	0.5	0	**45**
Worcester	Assawoman Bay	Island	15	0	0	3	<0.1	**18**
Worcester	Assawoman Bay	Other	1	0	0	0.7	0	**2**
Worcester	Assawoman Bay	Tributary	28	0	0	0	0.2	**28**
Worcester	Atlantic Ocean	Barrier/Oceanside	15	0	0	36	0	**51**
Worcester	Chesapeake Bay	Secondary River	0	0	10	0.9	0	**11**
Worcester	Chesapeake Bay	Tributary	1	0	2	0	0	**3**
Worcester	Chincoteague Bay	Barrier Bay/Mainland	13	10	16	14	5	**59**
Worcester	Chincoteague Bay	Barrier/Bayside	0	0	0	36	0.1	**36**
Worcester	Chincoteague Bay	Dredge and Fill	5	<0.1	0	0.8	0	**5**
Worcester	Chincoteague Bay	Island	5	0	24	61	0.4	**90**
Worcester	Chincoteague Bay	Other	0	3	5	3	<0.1	**11**
Worcester	Chincoteague Bay	Secondary Bay	0	0.3	0.4	1	0	**2**
Worcester	Chincoteague Bay	Tributary	29	58	34	78	24	**223**
Worcester	Dividing Creek	Tributary	3	0	8	2	1	**14**
Worcester	Ferry Branch	Tributary	0	0	4	3	0.5	**8**
Worcester	Isle of Wight Bay	Barrier Bay/Mainland	8	0	0	0.1	0	**8**
Worcester	Isle of Wight Bay	Barrier/Bayside	6	0	0	0.1	0	**6**
Worcester	Isle of Wight Bay	Dredge and Fill	60	0	0	0.2	0.3	**61**
Worcester	Isle of Wight Bay	Island	0	0	0	2	<0.1	**2**
Worcester	Isle of Wight Bay	Tributary	55	0	0	1	2	**59**
Worcester	Nassawango Creek	Tributary	3	0	3	9	0.5	**16**
Worcester	Pilchard Creek	Tributary	4	0	9	<0.1	0.9	**13**
Worcester	Pocomoke River	Island	2	0	1	18	0.6	**22**
Worcester	Pocomoke River	Secondary River	36	0	18	49	16	**119**
Worcester	Pocomoke River	Tributary	7	0	19	42	4	**73**
Worcester	Sinepuxent Bay	Barrier Bay/Mainland	22	<0.1	0	1	1	**24**
Worcester	Sinepuxent Bay	Barrier/Bayside	0	0	0	24	0	**24**
Worcester	Sinepuxent Bay	Dredge and Fill	9	0	0	2	0	**12**
Worcester	Sinepuxent Bay	Island	3	0	0	4	0	**6**
Worcester	Sinepuxent Bay	Other	0	0	0	1	0	**1**
Totals			**3759**	**1476**	**5520**	**1054**	**588**	**12398**

* Excludes Howard and Montgomery County.

Table A-5: Military lands

County	Water Body Category	Water Body Name	Shoreline Length (Kilometers)			
			Shore Protection Certain	Shore Protection Unspecified[1]	Non-Tidal Wetlands	Totals
Anne Arundel	Primary Bay	Chesapeake Bay	2	0	0	**2**
Anne Arundel	Secondary River	Curtis Bay	4	0.2	0	**4**
Anne Arundel	Secondary River	Severn River	7	0.2	0	**8**
Anne Arundel	Tributary	Chesapeake Bay	2	0	0	**2**
Anne Arundel	Tributary	Curtis Creek	3	0	<0.1	**3**
Baltimore	Island	Gunpowder River	0	17	0.8	**18**
Baltimore	Secondary River	Gunpowder River	0	6	0.4	**6**
Calvert	Primary Bay	Chesapeake Bay	<0.1	1	0	**1**
Calvert	Primary River	Patuxent River	<0.1	3	0	**3**
Calvert	Tributary	Patuxent River	<0.1	2	0	**2**
Charles	Primary River	Potomac River	0	10	0	**10**
Charles	Tributary	Mattawoman Creek	0	13	0	**13**
Charles	Tributary	Nanjemoy Creek	0	6	<0.1	**6**
Charles	Tributary	Potomac River	0	11	0.1	**11**
Harford	Island	Bush River	0	6	0	**6**
Harford	Island	Chesapeake Bay	2	43	2	**47**
Harford	Island	Romney Creek	0	9	0	**9**
Harford	Primary Bay	Chesapeake Bay	0.2	25	2	**27**
Harford	Secondary River	Bush River	3	91	1	**95**
Harford	Secondary River	Gunpowder River	0.6	50	1	**52**
Harford	Secondary River	Romney Creek	0.1	40	2	**42**
Harford	Secondary River	Swan Creek	2	4	<0.1	**6**
Harford	Tributary	Chesapeake Bay	0	59	6	**65**
St. Mary's	Primary Bay	Chesapeake Bay	5	5	0.1	**10**
St. Mary's	Primary River	Patuxent River	0.2	4	0	**4**
St. Mary's	Tributary	Chesapeake Bay	6	21	2	**28**
St. Mary's	Tributary	Patuxent River	0	3	<0.1	**3**
St. Mary's	Tributary	St. Mary's River	1	6	0	**7**
Totals			**39**	**433**	**18**	**490**

Note:

1. The general approach of this study was to not speculate on the intentions of the military, but to avoid an excessive number of map colors. The protection response maps depict unclassified military lands in red, however, the protection response for the shoreline was classified as "Unspecified". Military lands in urban areas were classified as shore protection certain in those cases where county officials indicated that the land would be developed and protected even if the installation were to close.

Table A-6: Islands with Roads

County	Water Body Category	Water Body Name	Shoreline Length (Kilometers)					
			Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	Totals
Anne Arundel	Island	Magothy River	0.7	0	0	0	0	**0.7**
Anne Arundel	Primary Bay	Chesapeake Bay	2	0	0	0	0	**2**
Anne Arundel	Secondary River	Magothy River	10	0	0.8	0	<0.1	**11**
Anne Arundel	Tributary	Chesapeake Bay	3	0	0	0	<0.1	**3**
Cecil	Island	Susquehanna River	0	0	4	0	0	**4**
Charles	Island	Chesapeake Bay	4	0	0	0	0	**4**
Charles	Island	Potomac River	2	0	0	0	0	**2**
Charles	Primary River	Potomac River	4	0	4	0	0	**8**
Charles	Tributary	Chicamuxen Creek	1	0	4	0	0	**5**
Dorchester	Island	Chesapeake Bay	11	0	10	0	0	**22**
Dorchester	Island	Fishing Bay	2	0	5	0.6	0	**8**
Dorchester	Island	Honga River	7	0	40	0	0	**47**
Dorchester	Other	Blackwater River	0	0	0.6	0	0.3	**0.9**
Dorchester	Other	Chesapeake Bay	0	0	0.3	0	0	**0.3**
Dorchester	Other	Honga River	2	0	8	0	2	**12**
Dorchester	Other	Slaughter Creek	1	<0.1	35	3	2	**42**
Dorchester	Primary Bay	Chesapeake Bay	9	3	19	0	2	**33**
Dorchester	Secondary River	Chesapeake Bay	3	0	0.2	0	0	**4**
Dorchester	Secondary River	Honga River	13	0	20	0	0.6	**34**
Dorchester	Secondary River	Slaughter Creek	4	0.2	33	0.4	5	**42**
Dorchester	Tributary	Chesapeake Bay	5	2	31	0	5	**43**
Dorchester	Tributary	Parsons Creek	3	0	3	0	7	**12**
Harford	Island	Chesapeake Bay	2	26	2	0	1	**32**
Kent	Island	Chester River	0	0	0	28	7	**35**
Kent	Other	Chesapeake Bay	0	0	0	0.9	0	**0.9**
Kent	Other	Chester River	0	0	0	0.6	0.2	**0.8**
Queen Anne's	Dredge and Fill	Chesapeake Bay	0	0	2	0	0	**2**
Queen Anne's	Island	Chester River	0.6	0	0	0	0	**0.6**
Queen Anne's	Other	Chester River	4	0	0	0	0	**4**
Queen Anne's	Primary Bay	Chesapeake Bay	14	0	7	0.3	2	**22**
Queen Anne's	Primary River	Chester River	9	0	2	0	0.8	**12**
Queen Anne's	Secondary Bay	Cox Creek	37	11	12	0	13	**72**
Queen Anne's	Secondary Bay	Crab Alley Bay	14	1	12	0	2	**28**
Queen Anne's	Secondary Bay	Eastern Bay	16	2	14	0	2	**34**
Queen Anne's	Secondary Bay	Prospect Bay	6	1	14	0	4	**26**
Queen Anne's	Secondary Bay	Shipping Creek	9	4	2	0	0.7	**16**
Queen Anne's	Tributary	Chesapeake Bay	25	0	11	0	4	**40**
Queen Anne's	Tributary	Chester River	12	0	3	0	2	**16**
Somerset	Island	Chesapeake Bay	10	15	12	6	0.9	**44**
Somerset	Island	Manokin River	0	0	7	0	0	**7**
St. Mary's	Island	Chesapeake Bay	13	0.8	0.4	0	2	**16**
St. Mary's	Island	Potomac River	0.2	0	0.2	0	0	**0.4**
St. Mary's	Primary River	Potomac River	4	0.7	0.4	0	0.5	**5**
Talbot	Primary Bay	Chesapeake Bay	5	0.7	0	0.9	<0.1	**6**
Talbot	Secondary River	Harris Creek	7	10	1	1	0.3	**20**
Talbot	Tributary	Chesapeake Bay	1	0	0	0	0	**1**
Totals			**276**	**78**	**319**	**42**	**65**	**780**

Appendix B
AREA OF LAND BY SHORE PROTECTION LIKELIHOOD
(Counties in Same Order as Discussed in the Text)

Authors: James G. Titus, Russ Jones, and Richard Streeter

The following tables were created by overlaying the shore protection planning maps developed in this report, with EPA's 30-meter digital elevation data set[150].

The EPA data set used a combination of Maryland Department of Natural Resources and National Wetlands Inventory (NWI) wetlands data to distinguish dry land, nontidal wetlands, tidal wetlands, and open water. The boundaries of that wetlands data set do not perfectly match the boundaries of the land use data used in this report. Some areas that the wetlands data treated as dry land, for example, are wetlands or open water according to the land use data sets. This table treats such lands as "not considered" because our planning study did not estimate shore protection likelihood there. Most of these lands are along the shore and are as likely as not to be wetlands or open water today, even if they were still dry land when the wetlands data were created. The "not considered" category also includes some inland portions of Talbot County where we failed to obtain land use data. See Appendix 2 of this report for additional details on how these tables were created.

Table B-1. Area of Land by Shore Protection Likelihood

Maryland

Elevation above Spring High Water (m)		Area (square kilometers)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	31.6	29.4	102.5	20.7	1.0	185.3	64.5	249.7
0.5	1.0	54.4	41.0	148.9	19.9	0.9	265.1	57.2	322.3
1.0	1.5	63.9	45.5	113.5	17.3	0.5	240.7	53.8	294.4
1.5	2.0	83.1	59.1	104.4	18.1	0.3	265.1	57.6	322.8
2.0	2.5	83.1	42.5	89.1	11.4	0.2	226.3	40.8	267.1
2.5	3.0	83.2	51.0	99.5	10.0	0.2	243.9	47.2	291.0
3.0	3.5	71.7	57.2	107.0	9.9	0.3	246.1	53.7	299.8
3.5	4.0	64.6	54.5	102.0	9.9	0.2	231.2	47.0	278.1
4.0	4.5	53.8	42.9	95.5	10.5	0.2	202.9	41.3	244.1
4.5	5.0	49.8	41.4	91.0	12.9	0.3	195.4	39.5	234.9
5.0	5.5	42.7	29.3	79.0	12.8	0.7	164.4	41.6	206.0
5.5	6.0	30.3	16.4	52.3	7.8	1.1	107.9	37.7	145.6

[150]The estimates reported here are based upon elevation data available at the time of the study. Since this study was conducted, Maryland has developed more detailed elevation data from lidar (see: MD Department of Natural Resources geospatial website for information on area coverage and accuracy reports [http://dnrweb.dnr.state.md.us/gis/data/lidar/LIDARStatus.html])

Harford

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	30.1	760.5	100.5	13.5	3.5	908.1	138.7	1046.8
0.5	1.0	31.3	747.4	96.6	12.9	2.9	891.1	134.5	1025.6
1.0	1.5	40.6	539.0	41.1	10.4	0.0	631.1	96.4	727.4
1.5	2.0	40.6	532.0	38.4	10.4	0.0	621.4	95.8	717.3
2.0	2.5	41.9	540.8	40.0	10.2	0.0	632.9	98.0	730.9
2.5	3.0	66.6	713.5	55.3	6.3	0.0	841.7	138.9	980.6
3.0	3.5	66.5	718.8	55.3	6.3	0.0	847.0	140.0	987.0
3.5	4.0	66.7	712.5	56.4	6.7	0.0	842.3	139.1	981.4
4.0	4.5	57.7	397.8	57.8	6.4	0.0	519.7	65.0	584.7
4.5	5.0	57.7	383.6	57.7	6.4	0.0	505.3	61.5	566.8
5.0	5.5	57.8	383.6	58.0	6.4	0.0	505.7	61.5	567.2
5.5	6.0	36.7	202.9	47.9	3.7	0.0	291.2	67.1	358.3

Baltimore County

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	208.0	139.7	32.1	93.2	2.9	475.9	18.4	494.3
0.5	1.0	242.3	186.9	30.0	89.1	2.1	550.4	34.3	584.6
1.0	1.5	305.7	159.4	30.6	100.3	1.3	597.2	31.5	628.7
1.5	2.0	389.9	197.6	31.4	113.0	0.2	732.1	29.8	761.9
2.0	2.5	560.6	191.3	31.3	102.6	0.2	886.1	25.1	911.2
2.5	3.0	696.7	178.6	33.8	100.7	0.4	1010.2	24.1	1034.3
3.0	3.5	752.6	150.8	31.7	89.6	0.2	1024.9	12.3	1037.3
3.5	4.0	560.6	116.7	28.4	76.2	0.0	782.0	15.1	797.1
4.0	4.5	642.8	128.3	30.8	67.1	0.0	868.9	17.6	886.5
4.5	5.0	630.1	144.4	32.3	61.2	0.0	868.0	15.9	883.9
5.0	5.5	564.4	133.7	33.0	45.0	0.0	776.1	13.4	789.5
5.5	6.0	374.2	97.8	29.4	35.8	0.0	537.3	13.2	550.5

Baltimore City

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	91.8	0.0	0.0	0.0	10.8	102.6	1.4	103.9
0.5	1.0	91.8	0.0	0.0	0.0	10.8	102.6	1.4	103.9
1.0	1.5	136.5	0.0	0.0	0.0	5.8	142.3	0.9	143.2
1.5	2.0	144.1	0.0	0.0	0.0	5.2	149.3	0.8	150.1
2.0	2.5	144.1	0.0	0.0	0.0	5.2	149.3	0.8	150.1
2.5	3.0	202.9	0.0	0.0	0.0	8.9	211.7	0.6	212.4
3.0	3.5	209.4	0.0	0.0	0.0	9.3	218.7	0.6	219.3
3.5	4.0	209.4	0.0	0.0	0.0	9.3	218.7	0.6	219.3
4.0	4.5	239.5	0.0	0.0	0.0	2.9	242.4	1.3	243.7
4.5	5.0	244.9	0.0	0.0	0.0	1.5	246.4	1.5	247.8
5.0	5.5	244.9	0.0	0.0	0.0	1.5	246.4	1.5	247.8
5.5	6.0	111.7	0.0	0.0	0.0	0.3	112.0	1.4	113.4

Anne Arundel

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	335.2	12.4	170.1	10.4	0.2	528.3	51.4	579.7
0.5	1.0	335.2	12.4	170.1	10.4	0.2	528.3	51.4	579.7
1.0	1.5	494.8	15.6	216.7	13.1	0.3	740.3	147.1	887.4
1.5	2.0	819.7	22.2	306.7	18.5	0.2	1167.2	319.0	1486.2
2.0	2.5	819.7	22.2	306.7	18.5	0.2	1167.2	319.0	1486.2
2.5	3.0	763.6	19.6	282.5	19.6	0.3	1085.6	262.5	1348.1
3.0	3.5	627.3	13.7	227.6	22.5	0.3	891.3	122.3	1013.6
3.5	4.0	627.3	13.7	227.6	22.5	0.3	891.3	122.3	1013.6
4.0	4.5	632.1	14.0	220.4	20.7	0.1	887.4	120.6	1007.9
4.5	5.0	640.0	15.7	197.0	15.1	0.0	867.9	107.7	975.6
5.0	5.5	640.0	15.7	197.0	15.1	0.0	867.9	107.7	975.6
5.5	6.0	621.0	16.1	189.5	14.4	0.0	841.0	103.1	944.1

Calvert

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	104.6	3.8	77.2	6.2	0.7	192.4	43.1	235.5
0.5	1.0	104.3	3.9	76.9	5.8	0.7	191.5	44.5	236.1
1.0	1.5	54.7	4.1	94.4	2.2	0.1	155.5	35.1	190.6
1.5	2.0	47.1	4.0	93.9	1.9	0.1	146.9	31.1	178.0
2.0	2.5	48.1	4.8	100.5	2.5	0.1	156.0	32.8	188.8
2.5	3.0	129.3	17.7	184.9	8.3	0.2	340.5	74.9	415.4
3.0	3.5	142.6	18.4	188.7	8.7	0.2	358.6	80.7	439.3
3.5	4.0	142.9	18.5	192.5	9.4	0.2	363.5	81.1	444.6
4.0	4.5	144.9	24.9	271.1	19.4	0.4	460.5	95.0	555.5
4.5	5.0	144.3	26.0	274.9	20.5	0.4	466.0	95.9	561.9
5.0	5.5	144.1	26.0	276.4	20.5	0.4	467.3	95.6	562.9
5.5	6.0	146.7	32.2	327.5	23.2	0.2	529.8	73.7	603.5

St. Mary's

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	310	198	304	3	3	818	155	973
0.5	1.0	311	199	303	3	2	817	157	974
1.0	1.5	404	302	389	0	0	1095	210	1305
1.5	2.0	407	310	399	0	0	1116	211	1328
2.0	2.5	407	313	400	0	0	1120	213	1333
2.5	3.0	478	794	813	1	1	2086	386	2472
3.0	3.5	479	817	839	1	1	2137	392	2528
3.5	4.0	479	817	839	1	1	2137	392	2528
4.0	4.5	240	445	449	7	0	1140	301	1441
4.5	5.0	214	415	389	8	0	1027	289	1316
5.0	5.5	214	415	389	8	0	1027	289	1316
5.5	6.0	176	219	248	6	0	648	300	948

Charles

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	57.6	197.2	275.0	42.2	3.6	575.6	185.7	761.3
0.5	1.0	59.0	192.6	277.4	41.9	3.1	573.9	189.1	763.0
1.0	1.5	76.6	224.5	408.6	36.9	0.8	747.4	222.6	969.9
1.5	2.0	76.7	225.3	413.3	36.9	0.7	753.0	223.6	976.5
2.0	2.5	76.7	226.3	419.9	37.2	0.8	760.8	224.5	985.3
2.5	3.0	152.8	348.1	730.5	39.1	1.0	1271.5	236.4	1507.9
3.0	3.5	156.6	354.7	755.3	39.0	1.0	1306.7	237.4	1544.1
3.5	4.0	156.4	355.2	755.0	39.2	1.0	1306.7	236.5	1543.3
4.0	4.5	52.0	107.4	615.3	46.7	0.4	821.9	147.4	969.3
4.5	5.0	42.9	87.2	597.9	46.7	0.3	775.0	140.5	915.6
5.0	5.5	42.7	87.1	594.8	47.0	0.3	772.0	140.0	912.0
5.5	6.0	38.2	44.3	379.0	46.9	0.1	508.5	208.6	717.1

Prince George's

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	42.1	2.8	0.5	61.7	0.1	107.1	38.8	145.9
0.5	1.0	50.5	3.0	1.3	68.1	0.1	123.1	42.1	165.2
1.0	1.5	53.0	4.1	2.8	72.1	0.2	132.1	47.1	179.2
1.5	2.0	53.0	4.1	2.8	72.1	0.2	132.1	47.1	179.2
2.0	2.5	61.5	3.5	2.5	65.7	0.2	133.4	46.8	180.2
2.5	3.0	95.6	3.9	2.1	73.7	0.2	175.5	63.7	239.1
3.0	3.5	95.6	3.9	2.1	73.7	0.2	175.5	63.7	239.1
3.5	4.0	117.5	4.0	1.9	82.2	0.2	205.8	74.4	280.3
4.0	4.5	161.8	5.0	1.5	102.6	0.2	271.1	90.6	361.7
4.5	5.0	161.8	5.0	1.5	102.6	0.2	271.1	90.6	361.7
5.0	5.5	147.7	5.1	1.5	93.7	0.1	248.1	84.9	332.9
5.5	6.0	116.0	10.6	1.2	74.3	0.1	202.2	59.1	261.3

Cecil

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	51.6	3.3	59.9	0.8	2.9	118.5	4.8	123.3
0.5	1.0	64.0	2.7	80.1	1.5	2.1	150.5	15.2	165.7
1.0	1.5	86.9	1.3	114.4	3.9	0.4	206.9	39.2	246.1
1.5	2.0	86.9	1.3	114.4	3.9	0.4	206.9	39.2	246.1
2.0	2.5	104.0	2.3	145.7	6.5	0.4	258.9	41.7	300.5
2.5	3.0	157.1	5.5	243.7	16.8	0.7	423.7	57.3	481.0
3.0	3.5	157.1	5.5	243.7	16.8	0.7	423.7	57.3	481.0
3.5	4.0	155.8	6.2	247.6	18.3	0.7	428.6	59.7	488.4
4.0	4.5	152.1	10.1	271.4	27.7	1.0	462.3	71.8	534.1
4.5	5.0	152.0	10.2	271.5	27.7	1.0	462.3	71.7	534.0
5.0	5.5	148.3	10.3	269.2	26.1	1.0	454.9	68.6	523.5
5.5	6.0	128.0	10.6	246.7	12.5	0.7	398.5	43.2	441.8

Kent

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	128	13	238	9	12	401	49	451
0.5	1.0	151	14	371	53	11	600	123	723
1.0	1.5	164	16	452	33	2	666	133	799
1.5	2.0	181	19	447	30	1	678	123	801
2.0	2.5	156	22	437	21	1	636	102	739
2.5	3.0	127	91	878	23	1	1120	120	1239
3.0	3.5	107	106	886	19	1	1120	108	1228
3.5	4.0	101	106	891	23	1	1122	111	1234
4.0	4.5	94	109	1026	23	0	1253	167	1420
4.5	5.0	95	105	1055	36	0	1291	175	1467
5.0	5.5	94	108	1080	40	0	1323	171	1493
5.5	6.0	75	104	859	43	0	1081	180	1261

Queen Anne's

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	76	4	95	6	5	186	42	228
0.5	1.0	304	31	292	15	6	648	179	826
1.0	1.5	437	58	415	29	7	946	179	1125
1.5	2.0	527	70	480	38	6	1121	167	1288
2.0	2.5	644	88	561	52	6	1349	146	1495
2.5	3.0	811	127	654	80	5	1676	156	1832
3.0	3.5	947	126	713	133	7	1927	165	2093
3.5	4.0	984	109	700	134	3	1929	164	2093
4.0	4.5	775	90	846	143	1	1855	204	2059
4.5	5.0	686	66	895	150	0	1798	220	2017
5.0	5.5	444	50	801	150	0	1445	255	1700
5.5	6.0	268	48	578	45	0	939	195	1134

Talbot

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	187	28	181	0	24	421	14	435
0.5	1.0	699	110	379	2	31	1221	56	1277
1.0	1.5	1444	262	594	4	20	2324	94	2418
1.5	2.0	2761	510	884	6	11	4171	167	4338
2.0	2.5	2942	358	1101	5	3	4410	220	4630
2.5	3.0	2144	330	1227	3	2	3705	211	3917
3.0	3.5	1485	296	1713	2	1	3495	258	3753
3.5	4.0	1010	223	1997	0	0	3230	380	3610
4.0	4.5	596	182	1566	0	0	2344	265	2609
4.5	5.0	482	198	1268	0	0	1948	198	2145
5.0	5.5	376	101	1107	0	0	1584	217	1801
5.5	6.0	182	33	597	0	0	812	93	905

Caroline

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	45.3	4.3	170.8	2.1	0.0	222.6	105.3	327.9
0.5	1.0	48.7	6.6	201.9	3.9	0.0	261.1	100.3	361.3
1.0	1.5	49.0	8.2	206.9	3.7	0.0	267.8	111.2	379.0
1.5	2.0	54.1	15.3	212.7	4.5	0.0	286.6	115.9	402.5
2.0	2.5	67.4	20.8	229.1	8.4	0.0	325.7	97.7	423.4
2.5	3.0	64.1	22.8	226.4	11.4	0.0	324.7	91.9	416.5
3.0	3.5	51.9	27.3	226.2	8.6	0.0	313.9	90.6	404.6
3.5	4.0	52.7	28.8	223.7	10.5	0.0	315.6	92.1	407.7
4.0	4.5	52.8	31.7	234.4	10.6	0.0	329.5	95.5	425.0
4.5	5.0	46.7	30.5	244.9	11.2	0.0	333.2	91.6	424.8
5.0	5.5	44.1	26.4	233.7	11.0	0.0	315.2	109.6	424.7
5.5	6.0	34.0	23.5	227.6	9.4	0.0	294.5	134.4	428.9

Dorchester

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	615	58	6097	619	11	7400	3250	10651
0.5	1.0	1004	112	9673	638	3	11429	3012	14442
1.0	1.5	517	108	5288	317	1	6232	2056	8287
1.5	2.0	353	152	3956	346	1	4808	1624	6432
2.0	2.5	431	280	2783	198	1	3692	1032	4724
2.5	3.0	826	219	2522	134	0	3701	690	4390
3.0	3.5	719	81	2514	84	0	3399	1010	4409
3.5	4.0	690	92	1634	81	0	2497	684	3181
4.0	4.5	381	138	1325	64	0	1908	477	2385
4.5	5.0	357	115	1217	47	0	1736	313	2049
5.0	5.5	278	96	916	55	0	1345	248	1593
5.5	6.0	195	57	535	45	0	833	265	1098

Wicomico

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	86	7	784	121	0	999	844	1843
0.5	1.0	130	12	1113	58	0	1313	340	1653
1.0	1.5	140	25	1235	66	0	1465	729	2194
1.5	2.0	162	52	1193	92	0	1500	769	2269
2.0	2.5	179	84	1091	111	0	1465	523	1987
2.5	3.0	181	102	981	102	0	1366	889	2255
3.0	3.5	148	116	1098	71	0	1433	944	2377
3.5	4.0	163	102	1125	45	0	1435	804	2238
4.0	4.5	200	83	1115	47	0	1446	546	1992
4.5	5.0	198	98	1023	31	0	1351	481	1832
5.0	5.5	193	54	661	13	0	920	435	1356
5.5	6.0	167	21	300	8	0	496	376	871

Somerset

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	459	1429	1439	587	7	3920	1226	5146
0.5	1.0	730	2174	1359	426	8	4697	699	5396
1.0	1.5	407	2460	1289	396	3	4554	722	5276
1.5	2.0	474	3298	998	478	2	5250	1191	6442
2.0	2.5	169	1483	216	122	1	1991	345	2337
2.5	3.0	174	1411	162	98	0	1845	595	2441
3.0	3.5	214	2219	191	156	0	2780	1007	3788
3.5	4.0	276	2198	191	178	0	2843	701	3544
4.0	4.5	343	2074	266	185	0	2868	928	3796
4.5	5.0	190	2109	214	420	0	2933	1094	4027
5.0	5.5	83	1172	40	395	0	1690	1330	3020
5.5	6.0	16	571	13	284	0	884	1072	1956

Worcester

Elevation above Spring High Water (m)		Area (hectares)							
Above	Below	Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
0.0	0.5	336	82	229	495	8	1150	277	1427
0.5	1.0	1083	294	469	560	7	2413	543	2956
1.0	1.5	1575	363	576	644	6	3164	522	3686
1.5	2.0	1732	501	870	562	6	3671	609	4280
2.0	2.5	1458	613	1045	377	3	3496	611	4107
2.5	3.0	1247	712	949	288	1	3198	721	3920
3.0	3.5	810	665	1012	262	3	2753	683	3436
3.5	4.0	664	551	1085	263	5	2567	639	3206
4.0	4.5	612	450	1255	278	9	2604	533	3138
4.5	5.0	639	335	1361	302	19	2656	505	3161
5.0	5.5	550	244	1244	351	62	2451	527	2978
5.5	6.0	340	149	648	133	108	1378	587	1965

Table B-2. Area of Land Vulnerable to a One Meter Rise in Sea Level (square kilometers)
By Watershed and County by Likelihood of Shore Protection

County	Likelihood of Shore Protection						Tidal Wetlands
	Certain	Likely	Unlikely	No Protection	Nontidal Wetlands	Total Nontidal Land[1]	
Chesapeake Bay Western Shore							
Harford	0.6	15.1	2.0	0.3	2.7	20.7	29.4
Baltimore	4.5	3.3	0.6	1.8	0.5	10.8	10.4
Baltimore City	1.8	0.0	0.0	0.0	0.0	2.1	0.2
Anne Arundel	6.7	0.2	3.4	0.2	1.0	11.6	12.1
Calvert	2.1	0.1	1.5	0.1	0.9	4.7	14.5
Chesapeake Bay Upper and Central Eastern Shore							
Cecil	1.2	0.1	1.4	0.0	0.2	2.9	12.6
Kent	2.8	0.3	6.1	0.6	1.7	11.7	18.3
Queen Anne's	3.8	0.3	3.9	0.2	2.2	10.5	21.4
Caroline	0.9	0.1	3.7	0.1	2.1	6.9	14.4
Talbot	8.9	1.4	5.6	0.0	0.7	17.1	26.2
Chesapeake Bay Eastern Shore							
Dorchester	15.1	1.7	157.3	12.6	62.6	249.4	425.3
Wicomico	2.2	0.2	19.0	1.8	11.8	35.0	66.6
Somerset	11.9	36.0	28.0	10.1	19.2	105.4	261.8
Worcester[2]	1.3	0.0	2.1	0.9	1.3	5.7	23.6
Anacostia River							
Prince George's[3]	0.1	0.0	0.0	0.2	0.1	0.5	0.0
Potomac River							
Charles	1.1	3.9	5.3	0.4	3.6	14.4	22.4
Prince George's[4]	0.2	0.0	0.0	0.6	0.2	1.0	1.6
St. Mary's[5]	4.6	2.9	4.3	0.0	1.8	13.7	10.6
Patuxent River							
Prince George's[6]	0.6	0.0	0.0	0.5	0.5	1.6	12.3
Charles	0.1	0.0	0.2	0.4	0.2	0.8	1.3
St. Mary's[7]	1.6	1.0	1.7	0.1	1.3	5.8	7.0
Atlantic Coast							
Worcester[8]	12.9	3.7	4.8	9.6	6.9	38.1	117.1
Maryland	85.0	70.4	251.0	40.6	121.7	570.5	1109.1

1. Total includes the five categories listed plus the "not considered" category.
2. Pocomoke, Dividing Creek, Salisbury, Hallwood, Wango, Ninepin Branch and Whaleyville quadrangles.

3. Washington East quadrangle.
4. Alexandria, Anacostia, Mount Vernon, Piscataway, and Port Tobacco quadrangles.
5. Charlotte Hall, Leonardtown, Piney Point, Rock Point, Saint Clements, Saint George, Saint Marys City, Stratford Hall
6. Benedict, Lower Marlboro, Bristol, and Bowie quadrangles.
7. Point Lookout, Barren Island, Solomons Island, Hollywood, Broomes, Island, Mechanicsville, Benedict, and Hughesville quadrangle. Also includes Point No Point, which is the county's only quad along Chesapeake Bay that is not along either the Potomac or Patuxent River.
8. Assawoman Bay, Berlin, Boxiron, Girdletree, Ocean City, Public Landing, Selbyville, Snow Hill, Tingles Island, Whittington Point.

Appendix C: ELEVATION UNCERTAINTY

Authors: James G. Titus, Russ Jones, and Richard Streeter

C-1. Low and High Estimates of the Area of Land Close to Sea Level, by County: Maryland[1] (square kilometers)

	Meters above Spring High Water																			
	low	high	low	high	low	high	low	High	low	high	low	high	low	high	low	high	low	high	low	high
County	**0.5**		**1.0**		**1.5**		**2.0**		**2.5**		**3.0**		**3.5**		**4.0**		**4.5**		**5.0**	
	----------Cumulative (total) amount of Dry Land below a given elevation----------																			
Anne Arundel	1.7	7.2	6.7	15	12	26	20	39	32	50	44	59	54	68	63	77	72	86	81	94
Baltimore County	2.3	6.6	7.3	13	14	20	21	27	28	36	37	46	47	56	57	65	66	73	75	81
Baltimore City	0.2	2.1	0.9	3.9	1.7	5.7	2.7	7.5	4.2	9.7	5.7	12	7.4	14	9.6	17	12	19	14	21
Calvert	0.4	3.9	1.7	5.8	3.1	7.6	4.6	10	6.1	14	7.6	17	10.0	21	14	26	17	31	21	36
Caroline	0.7	3.2	2.2	6.1	4.1	9.2	6.9	13	9.9	16	13	20	16	23	19	27	23	30*	26	33*
Cecil	0.2	2.5	1.0	5.2	1.8	7.9	3.7	12	5.7	16	7.8	20	11	25	16	29	20	34	24	38
Charles	0.7	12	4.8	21	9.0	30	15	40	22	53	30	67	40	77	53	85	66	93	77	99
Dorchester	30	120	150	215	231	269	282	313	322	348	358	386	396	416	423	439	445	457	462	474
Harford	0.7	17	7.6	25	15	33	22	40	28	49	34	57	42	64	50	69	59	74	65	78
Howard	0	0.01	0.01	0.03	0.01	0.05	0.02	0.07	0.04	0.1	0.05	0.14	0.07	0.2	0.1	0.2	0.1	0.3	0.2	0.3
Kent	0.2	8.4	4.8	16	10	23	16	33	23	45	29	56	37	68	48	80	59	93	71	105
Prince George's	0.2	2.2	0.9	3.9	1.6	5.6	2.9	7.2	4.3	8.9	5.6	11	7.1	13	8.9	16	11	19	13	21
Queen Anne's	0.6	4.1	5.3	12	14	22	24	35	37	50	52	68	69	88	89	107	107	126	125	143
Somerset	17	58	70	101	113	153	168	193	198	210	215	233	240	260	268	289	297	318	327	345
St. Mary's	2.4	16	8.0	28	14	41	24	58	35	79	46	101	62	118	83	129	104	139	120	148
Talbot	2.2	7.8	11	24	30	54	64	99	110	139	149	175	184	210	218	239	245	260	266	279
Wicomico	5.0	15	18	29	32	43	47	58	62	72	76	86	90	101	105	115	119	129	133	142
Worcester	4.4	21	25	48	53	83	88	119	124	153	158	183	187	209	213	235	239	261	265	288
Statewide	**69**	**307**	**326**	**570**	**560**	**832**	**812**	**1104**	**1053**	**1350**	**1267**	**1596**	**1500**	**1833**	**1737**	**2045**	**1960**	**2243***	**2165**	**2425***

*This value is probably too low because of a data limitation. See Annex 3 of this report

1. Low and high are an uncertainty range based on the contour interval and/or stated root mean square error (RMSE) of the input elevation data. Calculations assume that half of the RMSE is random error and half is systematic error. For a discussion of these calculations, see Annex 3 of this report.

		low	high	low	high	low	high	low	high	low	high	low	high	low	high	low	high	low	high
County		**0.5**		**1.0**		**1.5**		**2.0**		**2.5**		**3.0**		**3.5**		**4.0**		**4.5**		**5.0**	
Wetlands	Tidal	---------Cumulative (total) amount of Nontidal Wetlands below a given elevation---------																			
Anne Arundel	12	0.2	0.7	0.6	1.6	1.1	4.8	3.1	8.1	6.3	11	9.5	12	12	14	13	15	14	16	15	17
Baltimore County	10	0.1	0.3	0.3	0.7	0.7	1.0	1.0	1.3	1.3	1.5	1.5	1.7	1.7	1.8	1.8	2.0	2.0	2.2	2.2	2.3
Baltimore City	0.2	<0.01	0.03	0.01	0.04	0.02	0.05	0.03	0.1	0.04	0.1	0.05	0.1	0.06	0.1	0.06	0.1	0.07	0.1	0.08	0.1
Calvert	15	0.1	0.9	0.4	1.3	0.7	1.7	1.1	2.2	1.4	3.0	1.7	3.8	2.2	4.7	3.0	5.7	3.8	6.6	4.7	7.5
Caroline	14	0.3	1.4	0.7	2.6	1.3	4.0	2.5	5.3	3.5	6.4	4.4	7.5	5.3	8.6	6.2	9.8	7.1	11*	8.0	12*
Cecil	13	0.01	0.2	0.04	0.7	0.1	1.2	0.4	1.7	0.8	2.3	1.2	2.8	1.7	3.5	2.2	4.2	2.8	4.9	3.5	5.5
Charles	24	0.1	3.8	1.5	6.5	2.9	9.2	4.8	12	7.0	14	9.3	16	12	18	14	20	16	21	18	23
Dorchester	425	15	46	53	70	76	90	94	104	107	112	114	121	124	129	131	136	137	139	140	143
Harford	29	0.2	2.5	1.2	3.8	2.3	5.0	3.3	6.2	4.3	7.6	5.2	9.0	6.4	10	7.8	11	9.1	11	10	12
Howard	0	0	0.03	0.01	0.04	0.02	0.04	0.03	0.05	0.04	0.06	0.04	0.06	0.05	0.07	0.06	0.08	0.06	0.09	0.07	0.10
Kent	18	0.1	1.1	0.9	2.6	2.0	4.1	3.3	5.4	4.3	6.8	5.2	7.9	6.1	9.3	7.2	11	8.3	13	9.7	14
Prince George's	14	0.1	0.8	0.3	1.4	0.6	2.0	1.0	2.5	1.5	3.2	2.0	3.8	2.5	4.7	3.2	5.6	3.8	6.5	4.6	7.2
Queen Anne's	21	0.2	1.1	1.5	3.0	3.2	4.8	4.9	6.5	6.5	8.1	7.9	9.6	9.5	12	11	14	13	16	15	18
Somerset	265	6.6	16	17	21	23	31	35	40	41	43	45	52	54	60	62	69	71	78	81	90
St. Mary's	19	0.5	2.8	1.7	5.3	2.8	7.8	4.6	11	6.7	15	8.8	19	12	22	16	25	20	28	23	31
Talbot	26	0.1	0.3	0.5	1.0	1.3	2.1	2.5	4.2	4.8	6.2	6.8	8.5	9.1	12	13	15	16	17	18	20
Wicomico	67	5.4	9.9	11	13	16	22	24	29	30	35	37	44	47	54	56	60	62	66	67	70
Worcester	142	0.7	5.2	6.0	10	11	16	17	22	23	29	30	36	37	42	43	48	49	54	54	58
Statewide	**1116**	**29**	**93**	**97**	**146**	**145**	**207**	**203**	**261**	**249**	**304**	**289**	**355**	**341**	**406**	**390**	**451**	**435**	**490***	**474**	**531***
		Cumulative (total) amount of land below a given elevation																			
Dry Land		69	307	326	570	560	832	812	1104	1053	1350	1267	1596	1500	1833	1737	2045	1960	2243*	2165	2425*
Nontidal Wetlands		29	93	97	146	145	207	203	261	249	304	289	355	341	406	390	451	435	490*	474	531*
All Land	1116	1214	1516	1539	1832	1820	2155	2130	2481	2418	2769	2672	3067	2957	3354	3243	3612	3510	3849*	3754	4071*

*This value is probably too low because of a data limitation. See Annex 3 of this report

C-2. Likelihood of Shore Protection in Maryland, High and Low Estimates of the Land within One Meter above Spring High Water[1] (square kilometers)

County	Likelihood of Shore Protection								Nontidal Wetlands		Total[2]	
	Certain		Likely		Unlikely		No Protection					
	low	high	low	high	low	high	low	high	low	high	low	high
Chesapeake Bay Western Shore	**9.3**	**22**	**8.3**	**26**	**3.8**	**8**	**1.7**	**3**	**2.6**	**6.9**	**26**	**66**
Harford	0.4	0.9	5.9	22	1.1	2.2	0.2	0.3	1.2	3.8	8.8	29
Baltimore	3.2	6	2.2	4	0.5	0.8	1.4	2.3	0.3	0.7	7.7	14
Baltimore City	0.8	3.6	0	0	0	0	0	0	0.01	0.04	0.9	3.9
Anne Arundel	4.2	9.2	0.2	0.3	2.1	4.6	0.1	0.3	0.6	1.4	7.2	15.8
Calvert	0.7	1.9	0	0	0.1	0.4	0.03	0.1	0.4	1.0	1.2	3.4
Chesapeake Bay Upper and Central Eastern Shore	**10**	**26**	**1.3**	**3.4**	**12**	**31**	**0.6**	**1.3**	**3.6**	**10**	**28**	**73**
Cecil	0.4	2.2	0.04	0.08	0.5	2.8	0.01	0.07	0.04	0.7	1	5.9
Kent	1.2	4.4	0.1	0.4	2.9	10	0.4	0.8	0.9	2.6	5.7	19
Queen Anne's	2.5	5.4	0.2	0.6	2.4	5.5	0.1	0.3	1.5	3	6.8	15
Caroline	0.5	1.2	0.04	0.14	1.7	4.7	0.02	0.08	0.7	2.6	2.9	8.7
Talbot	5.7	13	0.9	2.2	4.1	7.6	0.02	0.04	0.5	1	12	25
Chesapeake Bay Eastern Shore	**25**	**36**	**30**	**46**	**165**	**239**	**22**	**28**	**82**	**106**	**325**	**457**
Dorchester	13	19	1.3	2.1	125	180	11	14	53	70	204	285
Wicomico	1.7	2.7	0.1	0.3	15	24	1.6	2	11	13	29	42
Somerset	9.7	13	28	44	24	32	8.8	11	17	21	88	122
Worcester[3]	0.9	1.7	0.02	0.04	1.4	3	0.7	1.1	1	1.6	4.1	7.4
Anacostia River	**0.02**	**0.3**	**0.02**	**0.07**	**0**	**0**	**0.1**	**0.4**	**0.05**	**0.2**	**0.2**	**0.9**
Prince George's[4]	0.02	0.3	0.02	0.07	0	0	0.1	0.4	0.05	0.2	0.2	0.9
Potomac River	**2.6**	**10**	**2.9**	**12**	**4.4**	**17**	**0.4**	**1.8**	**2.3**	**9.8**	**13**	**51**
Charles[5]	0.5	1.9	1.6	6.6	2.3	10	0.2	0.7	1.4	6.2	6	26
Prince George's[6]	0.1	0.3	<0.01	0.03	<0.01	0.05	0.3	1.1	0.1	0.3	0.4	1.8
St. Mary's[7]	2.1	8	1.4	5	2.1	6.7	0	0	0.8	3.3	6.4	23
Patuxent River	**1.5**	**4.8**	**0.6**	**2.2**	**1.6**	**6.1**	**0.4**	**1.4**	**1.1**	**3.5**	**5.3**	**18**
Anne Arundel[8]	0.04	0.09	0	0	0.06	0.13	0	0	0.1	0.2	0.1	0.4
Prince George's[9]	0.3	1	0	0.01	0	0	0.2	0.7	0.2	0.9	0.6	2.6
Calvert[10]	0.3	0.9	0.03	0.1	0.6	2.3	0.03	0.07	0.01	0.3	0.9	3.7
Charles[11]	0.02	0.2	0	0	0.1	0.4	0.2	0.6	0.1	0.2	0.3	1.4
St. Mary's[12]	0.9	2.6	0.6	2.1	0.9	3.2	0.03	0.05	0.8	2	3.3	10
Atlantic Coast	**8.2**	**19**	**2.5**	**5**	**3.5**	**6.3**	**7.5**	**12**	**5**	**8.8**	**27**	**51**
Worcester[13]	8.2	19	2.5	5	3.5	6.3	7.5	12	5	8.8	27	51
Maryland	**57**	**118**	**45**	**94**	**190**	**307**	**33**	**48**	**97**	**146**	**424**	**716**

1. Low and high are an uncertainty range based on the contour interval and/or stated root mean square error (RMSE) of the input elevation data. Calculations assume that half of the RMSE is random error and half is systematic error. For a discussion of these calculations, see Annex 3 of this report.

2. Total includes the five categories listed as well as a small amount of low land the authors did not analyze.

3. Pocomoke, Dividing Creek, Salisbury, Hallwood, Wango, Ninepin Branch and Whaleyville quadrangles.

4. Washington East quadrangle.

5. Charlotte Hall, Colonial Beach North, Indian Head, King George, Mathias Point, Mount Vernon, Nanjemoy, Popes Creek, Port Tobacco, Quantico, Rock Point, Stratford Hall, and Widewater quadrangles

6. Alexandria, Anacostia, Mount Vernon, Piscataway, and Port Tobacco quadrangles.

7. Charlotte Hall, Leonardtown, Piney Point, Popes Creek, Rock Point, Saint Clements Island, Saint George Island, Saint Marys City, and Stratford Hall quadrangles.

8. Bowie and Bristol quadrangles.

9. Benedict, Bowie, Brandywine, Bristol, Lower Marlboro, and Odenton quadrangles.

10. Benedict, Bristol, Broomes Island, Lower Marlboro, Mechanicsville, and Solomons Island quadrangles.

11. Benedict, Hughesville, and Mechanicsville quadrangles.

12. Point Lookout, Barren Island, Solomons Island, Hollywood, Broomes Island, Mechanicsville, Benedict, and Hughesville quadrangles. Also includes Point No Point, which is the county's only quad along Chesapeake Bay that is not along either the Potomac or Patuxent River.

13. Assawoman Bay, Berlin, Boxiron, Girdletree, Ocean City, Public Landing, Selbyville, Snow Hill, Tingles Island, and Whittington Point quadrangles.

C-3. Likelihood of Shore Protection in Maryland, High and Low Estimates of the Land within Two Meters above Spring High Water[1] (square kilometers)

	Likelihood of Shore Protection								Nontidal Wetlands		Total[2]	
County	Certain		Likely		Unlikely		No Protection					
	low	high	Low	high	low	high	low	high	low	high	low	high
Chesapeake Bay Western Shore	**28**	**51**	**24**	**43**	**9.9**	**16**	**4.4**	**5.7**	**8.1**	**17**	**75**	**133**
Harford	1.1	1.7	18	35	2.5	3.1	0.4	0.6	3.3	6.2	25	47
Baltimore	9.9	14	6.1	7.6	1.1	1.4	3.5	4.4	1	1.3	22	28
Baltimore City	2.4	7.1	0	0	0	0	0	0	0.03	0.06	2.7	7.6
Anne Arundel	13.1	26	0.4	0.8	6.0	11	0.4	0.7	2.8	7.6	23	46
Calvert	1.7	2.5	0	<.01	0.3	0.6	0.07	0.1	0.9	1.4	3.1	4.6
Chesapeake Bay Upper and Central Eastern Shore	**58**	**94**	**9.1**	**15**	**45**	**78**	**2.1**	**3**	**14**	**23**	**129**	**214**
Cecil	1.6	4.7	0.07	0.13	1.9	6.4	0.04	0.3	0.4	1.7	4	13
Kent	4.2	8.1	0.4	1.1	10	22	1.1	1.3	3.3	5.4	20	38
Queen Anne's	11	16	1.3	2	11	15	0.7	1.1	4.9	6.5	29	41
Caroline	1.4	2.4	0.2	0.4	5.2	9.6	0.1	0.2	2.5	5.3	9.3	18
Talbot	39	63	7.1	11	17	24	0.1	0.14	2.5	4.2	66	103
Chesapeake Bay Eastern Shore	**50**	**57**	**87**	**107**	**330**	**372**	**40**	**45**	**156**	**177**	**664**	**758**
Dorchester	24	26	3.6	5.2	237	261	18	20	94	104	376	417
Wicomico	4.6	5.8	0.7	1.3	39	48	3	3.8	24	29	71	88
Somerset	19	21	82	100	48	52	18	19	35	40	203	233
Worcester[3]	2.8	3.6	0.07	0.1	6.3	11	1.4	1.7	2.7	4	13	20
Anacostia River	0.2	0.6	0.05	0.09	0	0	0.3	0.5	0.2	0.3	0.7	1.5
Prince George's[4]	0.2	0.6	0.05	0.09	0	0	0.3	0.5	0.2	0.3	0.7	1.5
Potomac River	7.5	19	8.7	24	13	34	1.3	3.2	7.2	19	37	99
Charles[5]	1.4	3.8	4.9	12	7.2	21	0.5	1.3	4.6	11	19	50
Prince George's[6]	0.2	0.8	0.02	0.08	0.03	0.1	0.8	1.9	0.2	0.5	1.3	3.3
St. Mary's[7]	5.9	15	3.7	11	5.3	13	0	0	2.4	7.1	17	46
Patuxent River	4.5	9.7	2.4	5.8	5.8	14	1.2	2.4	3.5	7.3	17	39
Anne Arundel[8]	0.1	0.2	0	0	0.2	0.3	0	0	0.3	0.5	0.5	1.0
Prince George's[9]	0.8	1.8	<0.01	0.03	0	0	0.6	1.4	0.7	1.8	2	5
Calvert[10]	0.7	1.7	0.1	0.3	1.7	4.8	0.06	0.1	0.1	0.8	2.6	7.8
Charles[11]	0.1	0.4	0	0	0.3	0.8	0.5	0.9	0.2	0.4	1.1	2.4
St. Mary's[12]	2.8	5.6	2.3	5.5	3.7	7.7	0.05	0.06	2.2	3.9	11	23
Atlantic Coast	**37**	**50**	**10**	**15**	**11**	**15**	**19**	**23**	**14**	**18**	**92**	**121**
Worcester[13]	37	50	10	15	11	15	19	23	14	18	92	121
Maryland	**186**	**282**	**141**	**209**	**414**	**528**	**68**	**82**	**203**	**261**	**1015**	**1365**

1. Low and high are an uncertainty range based on the contour interval and/or stated root mean square error (RMSE) of the input elevation data. Calculations assume that half of the RMSE is random error and half is systematic error. For a discussion of these calculations, see Annex 3 of this report.

2. Total includes the five categories listed as well as a small amount of low land the authors did not analyze.

3. Pocomoke, Dividing Creek, Salisbury, Hallwood, Wango, Ninepin Branch and Whaleyville quadrangles.

4. Washington East quadrangle.

5. Charlotte Hall, Colonial Beach North, Indian Head, King George, Mathias Point, Mount Vernon, Nanjemoy, Popes Creek, Port Tobacco, Quantico, Rock Point, Stratford Hall, and Widewater quadrangles

6. Alexandria, Anacostia, Mount Vernon, Piscataway, and Port Tobacco quadrangles.

7. Charlotte Hall, Leonardtown, Piney Point, Popes Creek, Rock Point, Saint Clements Island, Saint George Island, Saint Marys City, and Stratford Hall quadrangles.

8. Bowie and Bristol quadrangles.

9. Benedict, Bowie, Brandywine, Bristol, Lower Marlboro, and Odenton quadrangles.

10. Benedict, Bristol, Broomes Island, Lower Marlboro, Mechanicsville, and Solomons Island quadrangles.

11. Benedict, Hughesville, and Mechanicsville quadrangles.

12. Point Lookout, Barren Island, Solomons Island, Hollywood, Broomes Island, Mechanicsville, Benedict, and Hughesville quadrangles. Also includes Point No Point, which is the county's only quad along Chesapeake Bay that is not along either the Potomac or Patuxent River.

13. Assawoman Bay, Berlin, Boxiron, Girdletree, Ocean City, Public Landing, Selbyville, Snow Hill, Tingles Island, and Whittington Point quadrangles.

C-4. Area of Land by Elevation by Shore Protection Likelihood, High and Low Estimates: Maryland[1]

Elevation relative to Spring High Water (m)	Area (square kilometers)															
	Dry land: likelihood of shore protection										Dry Land		Non Tidal Wetlands		All Land	
	Shore Protection Certain		Shore Protection Likely		Shore Protection Unlikely		No Shore Protection		Not Considered							
	low	high	low	high	low	high	low	high	low	high	low	high	low	high	low	high
0.5	11	56	8	52	40	167	10	30	0.4	1.5	69	307	29	93	98	400
1.0	57	118	45	94	190	307	33	48	1.2	2.1	326	570	97	146	424	716
1.5	112	194	86	149	310	419	50	67	2	2.6	560	832	145	207	705	1039
2.0	186	282	141	209	414	528	68	82	2.4	2.9	812	1104	203	261	1015	1366
2.5	270	367	190	258	508	628	82	93	2.7	3.2	1053	1350	249	304	1302	1653
3.0	349	445	230	312	592	732	92	103	2.9	3.4	1267	1596	289	355	1556	1951
3.5	423	514	281	364	690	837	101	113	3.1	3.7	1499	1831	341	405	1840	2237
4.0	492	573	337	408	794	936	111	124	3.4	3.8	1737	2045	390	451	2127	2496
4.5	551	625*	390	451*	893	1029*	121	135*	3.6	4*	1960	2243*	435	490*	2394	2733*
5.0	604	670*	438	486*	986	1115*	133	148*	3.9	4.4*	2165	2425*	474	531*	2638	2955*

*This value is probably too low because of a data limitation. See Annex 3 of this report

1. Low and high are an uncertainty range based on the contour interval and/or stated root mean square error (RMSE) of the input elevation data. Calculations assume that half of the RMSE is random error and half is systematic error. For a discussion of these calculations, see Annex 3 of this report.

APPENDIX D: SUMMARY OF DATA SOURCES

This appendix describes data used to create the GIS-based maps accompanying this report. Data descriptions are organized by data source. Within each section we provide a brief summary of each layer obtained from that source. Summary information includes a description of how the data were developed, identifies the key elements of the data used in our analysis, and provides the date of publication.

MARYLAND DEPARTMENT OF PLANNING (MDP)

Land Use/Land Cover in Maryland

Data consist of county by county layers identifying land use and land cover in Maryland. Land use categories were identified using satellite imagery collected in 1994 and 1997. Land uses were digitized into a vector format. Urban land use types were verified using parcel information available from Maryland Property View.[151]

Key data elements: Each polygon is assigned a land use code according to the USGS Level 2 land use classification system. Exhibit D-1 lists the land use codes and descriptions used for these data.

Scale: 1:63,360.
Date of publication: 1997.

Maryland Property View

For Cecil, Caroline, Wicomico, and Worcester Counties, the data were used to identify the location of private property, land use types, and priority funding areas (PFAs).

Scale: 1:24,000.
Date of Publication: Varies (see Table 1 of above).

EXHIBIT D-1. MARYLAND LAND USE CODES AND DESCRIPTIONS

Land Use Code	Description
11	Low-density residential
12	Medium-density residential
13	High-density residential
14	Commercial
15	Industrial
16	Institutional
17	Extractive
18	Open urban land
20	Agriculture
21	Cropland
22	Pasture
23	Orchards/vineyards/horticulture
24	Feeding operations
25	Row and garden crops
40	Forest
41	Deciduous forest
42	Evergreen forest
43	Mixed forest
44	Brush
50	Water
60	Wetlands
70	Barren land
71	Beaches
72	Bare exposed rock
73	Bare ground
80	Transportation

MARYLAND'S ENVIRONMENTAL RESOURCES & LAND INFORMATION NETWORK (MERLIN)

Maryland Department of Natural Resources, Chesapeake & Coastal Watershed Service, Geographic Information Services Division. Data obtained in 2000.

Critical Area Lands

Maryland's Critical Area is the area within 1,000 feet landward of the state tidal wetlands boundary. To create these data, digital data depicting designated critical habitat areas were produced from hard copy parcel maps originally submitted by the counties as part of the requirements for developing their Critical Area program.

[151]Maryland Department of Planning, Maryland land use/land cover metadata.

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Key data elements: The digital maps produced for each jurisdiction are polygons depicting the Critical Area and the land use classifications recognized by the Chesapeake Bay Critical Area Commission (CBCAC).[152] Each polygon is identified as an intensely developed area (IDA), limited developed area (LDA), resource conservation area (RCA), or water area based on the primary usage of the polygon.

Scale: 1:24,000.
Date of publication: May 2000.

Federally Owned Lands

The data identify lands held by the federal government, including military lands, national parks, and U.S. Fish and Wildlife holdings.

Key data elements: Parcels are identified by their commonly used name. Additional elements include area and perimeter of the parcel.

Scale: 1:24,000.
Date of Publication: May 2000

State Owned Lands

The data consist of all lands owned by the state Department of Natural Resources (DNR) as well as potential/planned acquisition areas that are not actually held by the state at this time. DNR used data from individual county and state records to produce this dataset. Tax maps, project boundary maps, subdivision plots, and deed plots were used to create boundary polygons.[153]

Key data elements: Each parcel is identified according to DNR land use designations as State Parks, State Forests, Natural Environmental Lands, Natural Resource Management Areas, Wildlife Management Areas, Fish Management Areas, or Natural Heritage Conservation purchase. In many cases, a name has been assigned to the property with which the parcel is associated.

Scale: 1:24,000.
Date of publication: May 2000.

Agricultural Easements/Districts

These data identify agricultural lands purchased as easements through the Maryland Agricultural Land Preservation Program. Each polygon represents one parcel and is determined using the tax map number, parcel number, and lot number if applicable.

Key data elements: The Maryland Department of Agriculture assigns a unique easement number to each parcel. This number consists of a county code, election district digit, fiscal year enrolled in program, an application number, and letters identifying actions taken. In addition, each polygon is assigned a "type," which indicates the status of the property as an easement, district, or exclusion.

Scale: 1:63,360.
Date of publication: 2000.

Maryland Environmental Trust Lands

The data identify lands under conservation easements with the Maryland Environmental Trust (MET). An easement ensures that the property will not be developed beyond a point agreed on by the landowner and the Trust. To create the data, DNR located easements in the MET file and database and digitized them at a 1:24,000 scale. Additional data from tax maps, indexes, and additional county databases were added to provide additional descriptive and identification data for each parcel.

Key data elements: Each parcel is assigned a unique easement number by MET. The easement number consists of the ID number of the easement, the owner's name, the year the easement was made, and the county in which the easement resides.

Scale: 1:24,000.
Date of publication: 2000.

County Owned Lands

The data identify parks held by the county and are merged into a statewide layer. These parks include land predominantly used for recreation and open space.

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[152]Maryland Department of Natural Resources, Critical Area lands metadata.
[153]Maryland Department of Natural Resources lands metadata.

Key data elements: Parcels are identified by their commonly used name. Additional elements include area and perimeter of the park.

Scale: Data were compiled at 1:24,000 scale and larger, but were then edited to a map base with a scale of 1:62,500 that was later determined to have significant positional accuracy errors.
Date of publication: 2000.

Private Conservation Lands

These data are a statewide layer consisting of privately held conservation lands.

Key data elements: The data identify the common name of the parcel and the name of the property owner. Where the owner prefers not to be identified by name, the field is populated with a sequential number. Other elements include the area and perimeter of the property.

Scale: Data were compiled at 1:24,000 scale and larger, but were then edited to a map base with a scale of 1:62,500 that was later determined to have significant positional accuracy errors.
Date of publication: 2000.

NATIONAL WETLANDS INVENTORY

These data are a reprojection of the U.S. Fish and Wildlife Service's (FWS) National Wetlands Inventory (NWI) data.

Key data elements: Each polygon is assigned a classification that identifies it according to the FWS hierarchical wetlands classification system. Maryland's reprojection of the data stores these classification data in an "attribute" field. Wetlands are identified as tidal or nontidal based on the first two characters of the classification code. Tidal wetlands include those classification codes beginning with "M1" and "E2" and nontidal codes begin with "PS," "PF," "PE," "R1," "R2," "L2," and "PU" with the exception of any code that includes "OW", which indicates open water.

Scale: Ranges from 20,000 to 132,000.
Date of publication: Ranges from February 1971 to December 1992.

Maryland Department of Natural Resources Wetlands

State developed data layer categorizing wetlands within the state.

Key data elements: Wetland classifications match the codes employed in the NWI data.

Scale: 1:40,000.
Date of publication: Ranges from April 1998 to April 1995.

Forest Legacy Lands

These data identify lands that are part of Maryland's Forest Legacy Easement Program. The program is designed to identify and protect environmentally important forest land using perpetual conservation easements between willing sellers and willing buyers. To create this data layer, the Forest Legacy Easements were located and digitized using tax map images from the Maryland Department of Planning's MD Property View (edition 2000).

Key data elements: Parcels are identified by the name given to the particular tract of land. Additional elements include area and perimeter of the tract.

Scale: 1:24,000.
Date of publication: 2002.

Rural Legacy Lands

These data identify lands that are part of the Rural Legacy Program. This program was designed to protect Maryland's best remaining rural landscapes and natural areas through the purchase of land or conservation easements. Applications for designating an area as Rural Legacy typically include a digital product showing the application boundary or a graphic depicting the area (CAD). These areas are digitized by DNR staff in ArcView 3.2 using sources such as tax maps, roads, streams, and satellite images. All data were then combined

into one state-wide file and checked by a GIS analyst for accuracy.[154]

Key data elements: Parcels are identified by the name given to the particular tract of land. Additional elements include area and perimeter of the tract.

Scale: 1:24,000.
Date of publication: July 2002.

MARYLAND DEPARTMENT OF NATURAL RESOURCES

Digital Orthophotoquads

Color digital orthophotographs are being produced statewide from color infrared aerial photographs by Photo Science Inc. (Gaithersburg, Maryland, U.S.A.) in 3.75' quad series format with a ground resolution of 4 feet per pixel.

Key data elements: Data are RASTAR-based and show the location of structures.

Scale: The digital images and hardcopy meet National Map Accuracy Standards at the production scale of 1:12,000 using the American Society for Photogrammetry and Remote Sensing (ASPRS) method.[155]
Date of publication: 1991–present.

BALTIMORE COUNTY

Baltimore County Land Use

These data provide information on land use in Baltimore County. The data were produced for Baltimore County's GIS 2010 Master Plan.

Key data elements: Each polygon is assigned a land use code according to a code system. These codes and their descriptions are summarized in Exhibit A-2.

Scale: Unable to identify documentation. A visual inspection showed that the boundaries of this layer are similar to or better than 1:24,000 data. However, no information was available to document whether the maps are accurate to such a scale under National Mapping Standards.

Date of publication: 1998.

EXHIBIT D-2. BALTIMORE COUNTY LAND USE CODES AND DESCRIPTIONS

Land Use Code	Description
1	Single family detached
2	Single family attached
3	Multifamily
4	Single family detached rural standard
5	Mixed use commercial
6	Right-of-way
7	Office
8	Regional commercial
9	Industrial
10	Institutions
11	Park/recreation
12	Agriculture/open space
13	Forest

CALVERT COUNTY

Calvert County Cliff Categories

Identifies the location of Calvert County Cliff areas where shoreline armoring is not allowed.

Key data elements: Each polygon is assigned a category in the Cliff Category field. Within Category 1 areas, no erosion control is allowed and new development must be set back from the cliff edge by 300 feet. Within Category 2 areas, shore erosion control is allowed solely for the protection of structures built before 1997. A 200-ft setback for new development is also required. Category 3 comprises all remaining cliff areas on the Chesapeake Bay.

Scale: Unable to identify documentation. A visual inspection showed that the boundaries of this layer are similar to or better than 1:100,000 data.

Date of publication: 2001.

CECIL COUNTY

County Comprehensive Plan

Hard copy of comprehensive plan identifies county zoning, existing development, development plans, and critical area

[154]Maryland Department of Natural Resources, Rural Legacy Areas metadata.
[155]Maryland Department of Natural Resources, digital orthophotoquad metadata.

designations. This information was not available in a GIS format.

Date of publication: 1990.

KENT COUNTY

County Comprehensive Plan

Hard copy of comprehensive plan identifies county zoning, existing development, development plans, and critical area designations. This information was not available in a GIS format.

Date of publication: 1996.

QUEEN ANNE'S COUNTY

County Comprehensive Plan

Hard copy of comprehensive plan identifies county zoning, existing development, development plans, and critical area designations. This information was not available in a GIS format.

Date of publication: 1987.

Talbot County

County Comprehensive Plan

Hard copy of comprehensive plan identifies county zoning, existing development, development plans, and critical area designations. This information was not available in a GIS format.

Date of publication: 1997.

CAROLINE COUNTY

County Comprehensive Plan

Hard copy of comprehensive plan identifies county zoning, existing development, development plans, and critical area designations. This information was not available in a GIS format.

Date of publication: 2000.

WICOMICO COUNTY

County Comprehensive Plan

Hard copy of comprehensive plan identifies county zoning, existing development, development plans, and critical area designations. This information was not available in a GIS format.

Date of publication: 1998.

WORCESTER COUNTY

County Comprehensive Plan

Hard copy of comprehensive plan identifies county zoning, existing development, development plans, and critical area designations. This information was not available in a GIS format.

Date of publication: 1992.

WORCESTER REGIONAL GIS

Worcester County Conservation Lands

Identifies the location of public and private conservation lands that would not receive shoreline protection within the county.

Key data elements: The Regional GIS office provided separate GIS layers with file names denoting the ownership or land type.

Scale: Unable to identify documentation. A visual inspection showed that the boundaries of this layer are similar to or better than 1:24,000 data.

Date of publication: 2003.

ICF CONSULTING CONTRACT TO EPA (2003)

Study Area

Defines landward-boundary of study area by identifying lands that are higher than 20 feet in elevation or within 1,000 feet of mean high water based on tidal wetlands data. Data collected by the U.S. Geological Survey and stored in 1:24,000 maps that ICF Incorporated compiled into a single digital product, under contract to EPA.

Key data elements: Each polygon is categorized as "within" or "outside" the study area. Polygons outside the study area (lands higher than 20 feet in elevation and more than 1000 feet from mean high water) are displayed as white polygons. Polygons within the study area are displayed as clear polygons.

Date of publication: 2003

CREDITS AND ACKNOWLEDGMENTS

This report was prepared under the direction of James G. Titus of the U.S. Environmental Protection Agency, Office of Air and Radiation, Climate Change Division. William Nuckols met with land use planners and other representatives from the state and prepared the state policies section of this report. Mr. Nuckols also met with planning staff from Prince George's Charles, St. Mary's, Calvert, Anne Arundel, Baltimore, Harford, Dorchester, and Somerset counties, as well as Baltimore City, and prepared the corresponding discussion summaries. The Somerset County summary was developed based on initial research by Michele Vanyo, a former EPA intern. Peter Johnston of Redman-Johnston Associates, Ltd., met with planning staff from Cecil, Kent, Queen Anne's, Caroline, Talbot, Wicomico, and Worcester counties and prepared the corresponding discussion summaries and draft response maps. Mr. Titus conducted several "reality checks" on the initial set of maps, based on site visits to most of the coastal counties and a working knowledge resulting from lifelong residence in the state.

Daniel Hudgens of Industrial Economics, Incorporated (IEc) prepared most of this report by compiling and editing the materials prepared by Mr. Nuckols and Mr. Johnston. Mr. Hudgens also performed the GIS work to map the anticipated responses to sea level rise in the counties covered by Mr. Nuckols, and wrote Appendix D. James Neumann of IEc reviewed the draft report and suggested revisions. Mr. Titus wrote the introduction and methods sections. The diagram on tides, wetlands, and reference elevations was produced by a collaboration between EPA and NOAA. Titus prepared the rough sketch and dimensions of the diagram by adapting a graphic originally prepared in 1988 for EPA by Tim Kana of Coastal Science and Engineering. Deb Misch of STG, Inc did the artwork, under contract to NOAA's National Climatic Data Center. Mr. Nuckols and Mr. Johnston conducted the county-level stakeholder reviews for the same counties that each had originally mapped. Mr. Titus briefed the elected commissioners of Worcester and Somerset County on the study, as well as the Planning Commission of Somerset County. Mr. Titus and Mr. Hudgens revised the Worcester County map based on information Mr. Titus obtained during meetings with Worcester County and the Maryland Coastal Bays program. Mr. Titus also revised the report to reflect the results of the stakeholder review. Hudgens and Titus revised the report to take account of the peer review comments.

ICF Incorporated provided GIS data on land elevations and polygons showing all land within 1,000 feet of open water or tidal wetlands, under a separate contract to EPA. The authors wish to thank the individuals who provided their valuable time to assist in this effort. Finally, David Aubrey (Woods Hole Group), Mark Bryer (The Nature Conservancy), and Zoë Johnson (Maryland Coastal Program) provided helpful comments during the peer review of this report.

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