



CHAPTER 7

DISTRICT OF COLUMBIA

:

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CONTENTS

Introduction	665
Background	667
Response to Sea Level Rise	671
Stakeholder Review	679
A Note on Horizontal Scale	681
Appendix A: Length of Shorelines by Likelihood of Shore Protection	682
Appendix B: Area of Land by Likelihood of Shore Protection	686
Appendix C: Elevation Uncertainty	687
Acknowledgments	690

MAP

Map 7-1. District of Columbia: Likelihood of Shore Protection.....	680
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FIGURES

Figure 7-1. L'Enfant's Plan for the City of Washington	669
Figure 7-2. Elevations of Lands Close to Sea Level in Downtown Washington, DC	669
Figure 7-3. Elevations of Lands Close to Sea Level, District of Columbia	670
Figure 7-4. Overview Goal for Shoreline Protection in the District of Columbia	674
Figure 7-5. Planned Buffers Along the Anacostia River.....	674
Figure 7-6. District of Columbia Plans to Restore Natural Shores Along Anacostia River.	675

TABLE

Table 7-1. Area of Land Vulnerable to Sea Level Rise in Washington, DC.....	666
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PHOTOS

Photo 7-1. Boathouse and row houses along Potomac River in Georgetown	666
Photo 7-2. Buzzard Point	669
Photo 7-3. Shoreline armoring in Georgetown, with Key Bridge in the Background.....	672

INTRODUCTION

One of the first academic studies of the possible implications of a greenhouse warming and rise in sea level examined the impact of a deglaciation of the West Antarctic Ice Sheet, which would raise sea level about 20 feet. In a widely cited passage, the authors pointed out that people would be able to row a boat from the grounds of the White House to the foot of the U.S. Capitol.¹ Although that passage vividly illustrated one scenario of how life might change with a large rise in sea level, the authors assumed that Congress and the Government of the District of Columbia would passively allow the low areas of the Nation's Capital to be submerged.² This study examines that issue explicitly, concluding that very few areas within Washington, D.C., are likely to be given up to a rising sea.

This analysis is part of a series of similar assessments being conducted by the U.S. Environmental Protection Agency for all the states along the U.S. East Coast from Massachusetts to Florida. Because Washington has the smallest amount of shoreline and is less vulnerable, this chapter omits the extensive methodological discussions included in the other studies. (We refer the reader to the companion studies of Maryland in Chapter 6 and Virginia in Chapter 8.) Instead, we focus on the assumptions and basis for the shore protection scenario maps.³ Table 7-1 shows preliminary

estimates of the land that could potentially be inundated from a 2-ft rise in sea level.

As with Maryland and Virginia, our study area is all land that is either within 1,000 feet of the shore or below the 20-ft contour depicted on USGS 1:24,000 scale maps. 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.*⁴

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

Brown: areas that will almost certainly 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

¹ Schneider, S.H., and R.S. Chen, 1980, "Carbon dioxide flooding: Physical factors and climatic impact," *Annual Review of Energy* 5:107–140.

²As we discuss below, it actually was possible to navigate from the White House to the Capitol during the first half of the 19th century.

³For a discussion of the motivation and general methods of this study, the reader should see the companion chapter for

Maryland. For context, the reader should review the Northern Virginia portion of the companion chapter on Virginia, as well as a few example county-specific sections from the Maryland chapter, especially the sections on Anne Arundel, Baltimore, Calvert, Charles, and Prince George's counties.

⁴For example, the quantitative results reported in Appendix B estimate the land area within approximately 3 feet (1 meter) above the tides.

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 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, land values, or both increase beyond what is currently expected, the brown, red, and blue areas might all be protected.

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. (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.)

TABLE 7-1. AREA OF LAND VULNERABLE TO SEA LEVEL RISE IN WASHINGTON, DC (SQUARE MILES)^a

Jurisdiction	Vulnerable land ^b	Tidal wetlands	0-2 feet elevation ^c		0-4 feet elevation ^c		0-8 feet elevation ^c	
			Dry land	Nontidal Wetland	Dry land	Nontidal Wetland	Dry land	Nontidal Wetland
DC	1.3	0.3	1.0	0.02	1.6	0.03	3.1	0.05

^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 J.G. Titus and E. 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.

^b The area of tidal wetlands plus the area of land within 2 feet above spring high water.

^c 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.

BACKGROUND

Article 1, Section 17 of the U.S. Constitution states: “The Congress shall have the power.... to exercise exclusive Legislation ... over such District (not exceeding ten Miles square) as may...become the Seat of the Government of the United States....” Congress and President Washington chose a district that encompassed the small towns of Georgetown, Maryland, and Alexandria, Virginia, as well as the confluence of the Potomac and Anacostia rivers just south of the Port of Bladensburg.

As with most major coastal cities, the shore protection, wetland loss, and environmental impacts caused by the construction of Washington, D.C., itself have been great compared with the expected impacts of sea level rise. As Figure 7-1 shows, the Potomac River originally covered the area occupied today by East Potomac Park, Hains Point, Washington Channel, the Tidal Basin, and the Reflecting Pool. The mouth of Tiber Creek was at the southwest corner of the White House grounds near what is now 17th and Constitution. To improve navigation between Georgetown and Bladensburg, George Washington and Pierre L’Enfant envisioned a canal from Tiber Creek to the approximate vicinity of what later became the Washington Navy Yard. The Washington City Canal eventually ran east from the Potomac River along what is now Constitution Avenue, with a lock at 6th Street and a connection to James Creek, which flowed into the Anacostia.⁵ The area in Southwest that was cut off from the rest of the District was known as Tiber Island.

During the following decades, soil erosion from upstream farming led to the creation of wide mudflats below Georgetown, and the success of railroads made canals less important. The canals

had gradually become conduits for wastes rather than navigation. During the early 1870s, for sanitary purposes, Boss Shepherd had the canals filled and replaced with drain pipes.⁶ A large dredge-and-fill operation created Washington Channel, and the material was used to create the land on which the Lincoln Memorial, Tidal Basin, Jefferson Memorial, East Potomac Park, and Hains Point sit today.⁷ These areas were bulkheaded from the start because it was most efficient to construct a retaining wall and place material on one side of the wall.

Most of the shores of the District of Columbia are publicly owned. The most important exceptions are for water-dependent facilities, including boathouses in Georgetown (Photo 7-1), several marinas along Washington Channel and the Anacostia River, two power plants, an oil terminal, and a soon-to-be-closed cement factory.

Photo 7-1. Boathouse and row houses along Potomac River in Georgetown. June 2007



⁵For a brief history of the canal, see, e.g., the web page for the Washington Canal Park: accessed on July 22, 2005, at: <http://www.washingtoncanalpark.org/history.html> .

⁶See, e.g., Farquhar, M., 2000, “The City’s Pretty New Face ‘Boss’ Shepherd Got the Job Done—at a Steep Price.” *Washington Post*, November 28, p. A01.

⁷Bryans, W.B., 1914, *A History of the National Capital from Its Foundation to the Period of the Adoption of the Organic Act.*

Figures 7-2 and 7-3 illustrate the lands close to sea level, based largely on topographic information provided by the District of Columbia. Within the downtown area, most of the lowest land is the area filled during the 1870s, such as Hains Point and the location of the former Tiber and James creeks, as well as the Washington City Canal that joined them together. The very low land between I-295 and the Anacostia River also was open water when the District of Columbia was originally planned.



Photo 7-2. Buzzard Point Boat Yard, Buzzard Point Power Plant, and Frederick Douglas Bridge over the Anacostia River.

June 2007

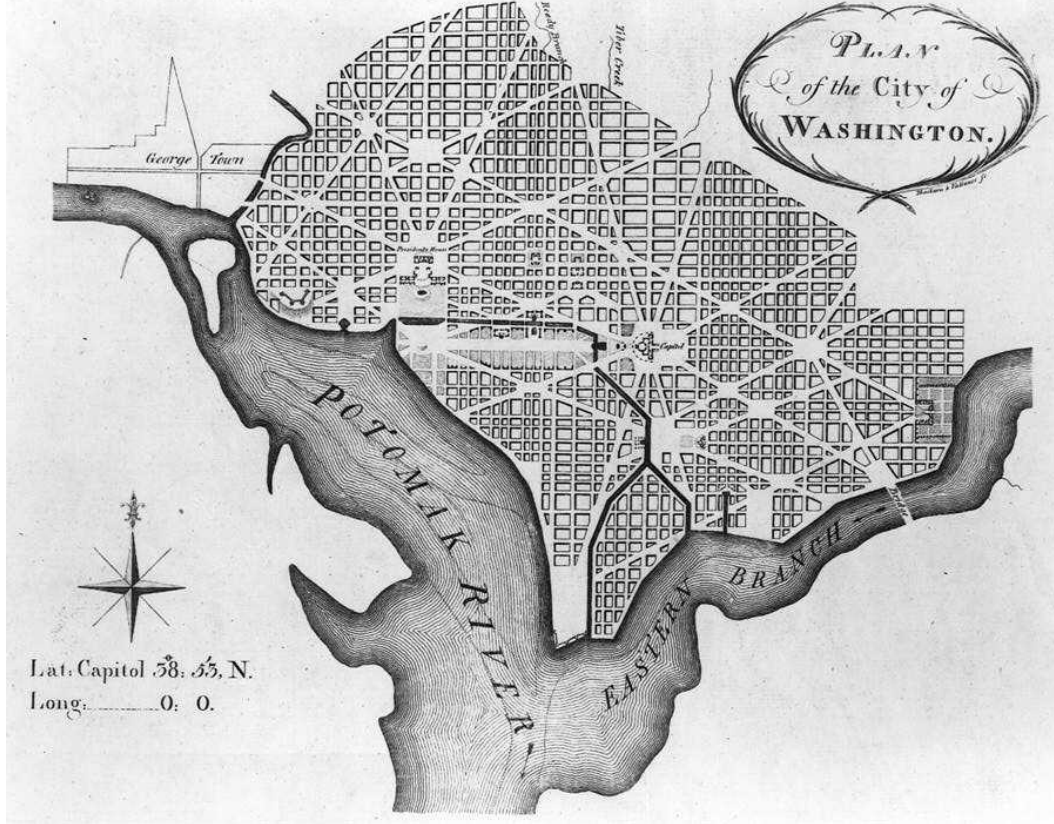


Figure 7-1. L'Enfant's Plan for the City of Washington. Source: Library of Congress

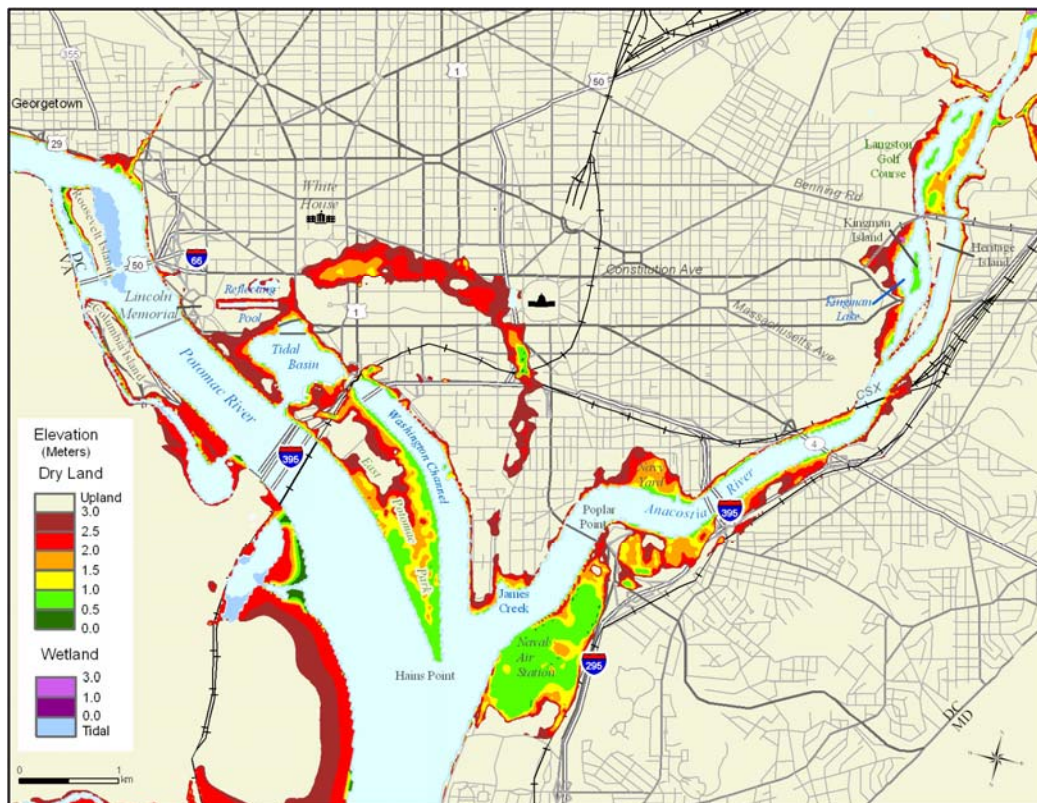


Figure 7-2. Elevations of Lands Close to Sea Level in Downtown Washington. For detailed caption, see Figure 7-3.

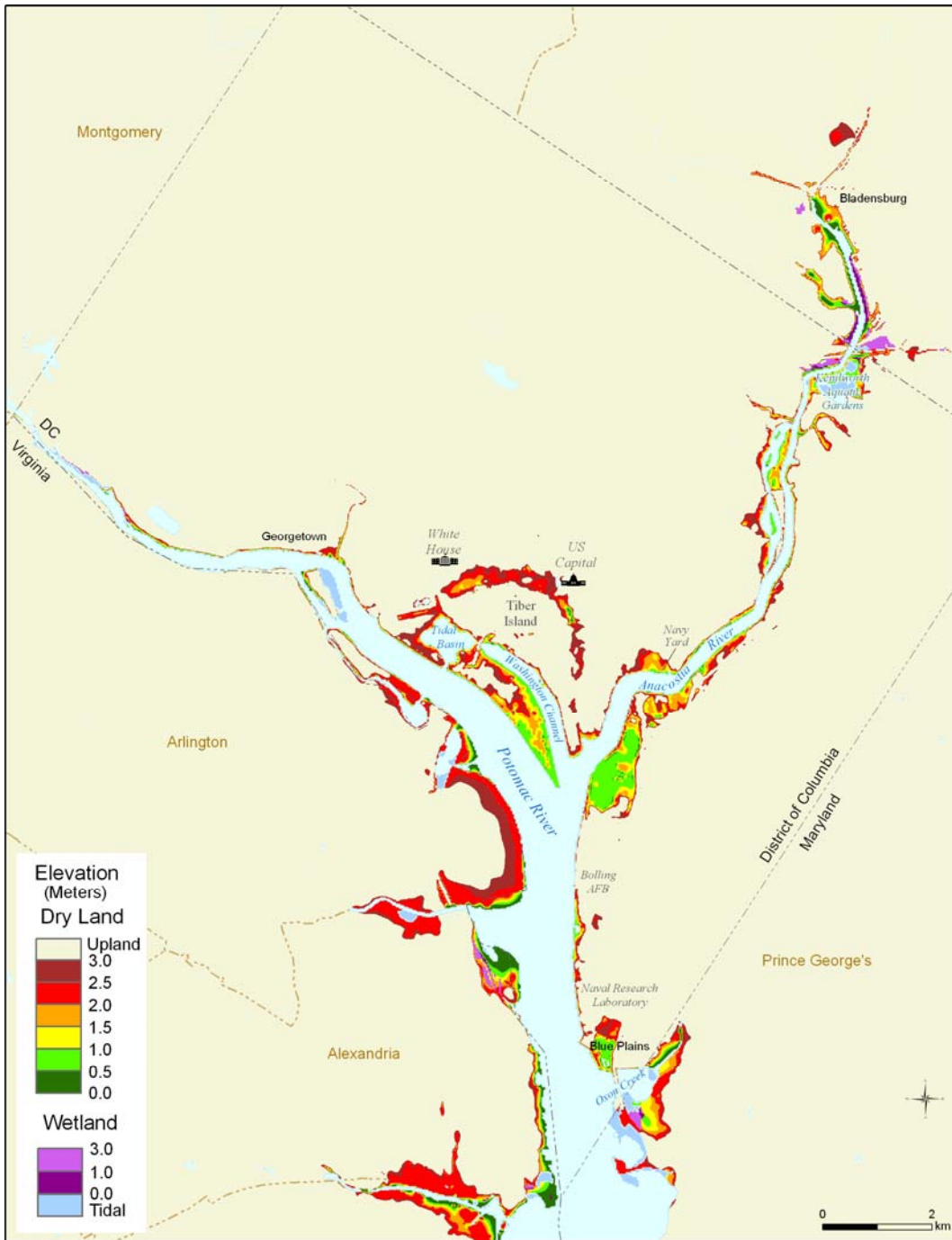


Figure 7-3. Elevations of Lands Close to Sea Level in Washington, D.C. Source: Titus and Wang (2008; see Table 7-1 for full reference) based on DC's 1-m contour elevation data, published wetlands data, and NOAA data on tidal elevations. Actual elevations are usually within the elevation range indicated by this map, but may deviate by 1 meter. For additional details on the accuracy of this map, see Annex 3 and Appendix C. 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.

RESPONSE TO SEA LEVEL RISE

As with Baltimore, New York, and most coastal cities, the primary question regarding the District's response to sea level rise is not whether these valuable lands will be protected, but how.⁸ Because most of the low-lying areas are lands reclaimed from the creeks or rivers through dredge-and-fill operations, a gradual elevation of low-lying areas would seem most probable, with shoreline armoring to prevent high grounds from eroding. Flood-prone areas such as K Street may continue to mitigate flooding through the use of structural solutions such as tide gates and check valves. This study does not, however, attempt to map the particular shore-protection technique that might be expected.

Potomac River

District planners generally expect the entire Potomac River shoreline to be protected. As the south end, the Blue Plains Sewage Treatment Plant, Naval Research Laboratory, Bolling Air Force Base, and the U.S. Naval Station are already armored.⁹ East Potomac Park is also armored, having been created from a dredge-and-fill operation; so to give this area up to a rising river would require reversing decisions made in the 1870s and constitute a return to the shorelines depicted in Pierre L'Enfant's original conception of the city (Figure 7-1). Allowing

rising sea level to inundate filled creeks and canals where office buildings, museums, and the National Mall now sit would be even more implausible. From Georgetown to the Lincoln Memorial the shore is already armored, to prevent erosion of Rock Creek Parkway; a dike protects low-lying areas between the Lincoln Memorial and the White House from flooding.¹⁰ With the exception of a few boat launching areas, Georgetown is also armored (Photo 7-3). Therefore, the draft shore protection map shows the entire Potomac shore from Georgetown to the Maryland line as almost certain to be protected (brown).



Photo 7-3. Shoreline armoring in Georgetown, with Key Bridge in the Background. June 2007

⁸Meeting between Will Nuckols and Uwe Steven Brandes, Anacostia Waterfront Initiative, project manager, Government of the District of Columbia, Office of Planning. Held at 801 North Capitol Street, N.E., Suite 4000, Washington, D.C. 20002. For the most part, the notes indicated that all shores along the Potomac will be protected, and suggested that we review planning documents on the Anacostia Waterfront Initiative and similar shoreline planning activities within D.C. to identify the few shores where protection is unlikely.

⁹Although this study does not predict the fates of specific military bases, these installations are in areas with land values sufficiently great to assume that even if the bases were closed, the land would remain developed.

¹⁰The dike is well-disguised by roads in this vicinity.

The National Park Service owns the Potomac River shoreline from Georgetown to the head of tide at Little Falls near Chain Bridge. The historic Chesapeake and Ohio Canal parallels the river anywhere from 100 to 1,000 feet from the shore. Because preserving the canal and the towpath is the essential mission of the C&O Canal National Historic Park, District and National Park Service planners indicate that these historic facilities will almost certainly be protected. For the most part, however, the National Park Service would not have to armor the existing Potomac River shoreline to protect the canal. Therefore, it is most appropriate to assume that most of the land between the river and the towpath probably will not be protected¹¹; to preserve the integrity of the canal, the draft map assumed that the land within 100 feet of the canal will almost certainly be protected.

The District of Columbia also has two islands in the Potomac River: Columbia and Theodore Roosevelt islands. Columbia Island is across Boundary Channel from the Pentagon, and is often mistakenly assumed to be in Virginia given its proximity to the Virginia shore. The Potomac shore of Columbia Island is occupied by George Washington Parkway and the Mt. Vernon Bicycle Trail; the island also has a marina and a picnic area. Given its heavy use and the fact it is already armored, it will almost certainly be protected for the foreseeable future. Theodore Roosevelt Island, by contrast, has natural shores and is intended as an urban preserve. Therefore, this island will probably not be protected as sea level rises, and thus was depicted in blue.

Anacostia River

Much of the Anacostia shore is also armored. Along the east bank from Poplar Point to the Potomac, the land reclaimed from the Anacostia River for the Naval Air Station is only a few feet above sea level, and hence is protected with a

¹¹In the other chapters of this report, National Park Service lands in rural areas are often colored light green on the grounds that we can be almost certain that the shore would not be protected—assuming that there is no facility that makes shore protection possible or likely. We assume that the need to protect the canal and recreational use makes it at least possible that the intervening lands might be protected.

dike. On both sides of the river, bulkheads stabilize most of the shore. The federal government is working with the District of Columbia to restore this often-neglected river. Recognizing that the shore is less developed upstream from the CSX railroad bridge, the long-term plan embodied in the City's Anacostia Initiative¹² aspires to achieving maximum ecological integrity upstream of the CSX crossing, with a more modest degree of habitat restoration downstream, as shown in Figure 7-4.¹³ The Anacostia Initiative has integrated the District of Columbia's assessments and plans for the river's shoreline and, as such, provides the basis for the shore protection map of this chapter.

The environment portion of the Anacostia Initiative has two key components that are closely related to the shore protection question. First, the City is specifying buffers of various magnitudes along the waterfront, as shown in Figure 7-5.¹⁴ Second, the City intends to replace the "seawall" along both sides of the river with more environmentally benign shore protection or, where possible, natural shores.¹⁵ Figure 7-6¹⁶ shows the City's plan, which the City has summarized as follows:

- newly constructed bulkhead (Near Navy Yard): 1.1 miles
- other new bulkheads to be constructed: 0.82 miles
- existing bulkhead to be maintained: 2.5 miles
- existing seawall to be converted to bioengineered edge:
- 3.2 miles existing seawall to be removed as needed: 11.0 miles.¹⁷

¹²See District of Columbia Office of Planning, 2003, *The Anacostia Waterfront Framework Plan*, pp. 23–35 (Environment Chapter) (*Anacostia Initiative*).

¹³See *Anacostia Initiative*, p. 31.

¹⁴See *Anacostia Initiative*, p. 33.

¹⁵District of Columbia Office of Planning, 2003, *Anacostia Riverparks Target Area Plan and Riverwalk Design Guidelines*, September 1 (Riverparks Plan).

¹⁶Riverparks Plan, Figure 2-19. See also *Anacostia Initiative*, p. 31.

¹⁷"Riparian Edge Types," p. 18 in *Riverparks Plan*.

Unlike in suburban and rural areas, the conscious decision to maintain natural shores does not necessarily imply that shores will not be protected in an urban area like Washington. Just as the need to keep natural beaches has motivated populated oceanfront communities to use beach nourishment, the District of Columbia is currently inclined to use environmentally sensitive means of shore protection rather than allowing wetlands to migrate inland. Nevertheless, the relatively pristine land cover upstream of the Benning Road power plant, planned buffers, and projects to remove seawalls combine to suggest that shore retreat is possible—albeit unlikely—in these areas. Therefore, our shore protection map for the District of Columbia Anacostia Shoreline shows a number of areas in blue or red.

Let us examine the likelihood of shore protection from north to south along the Anacostia River.

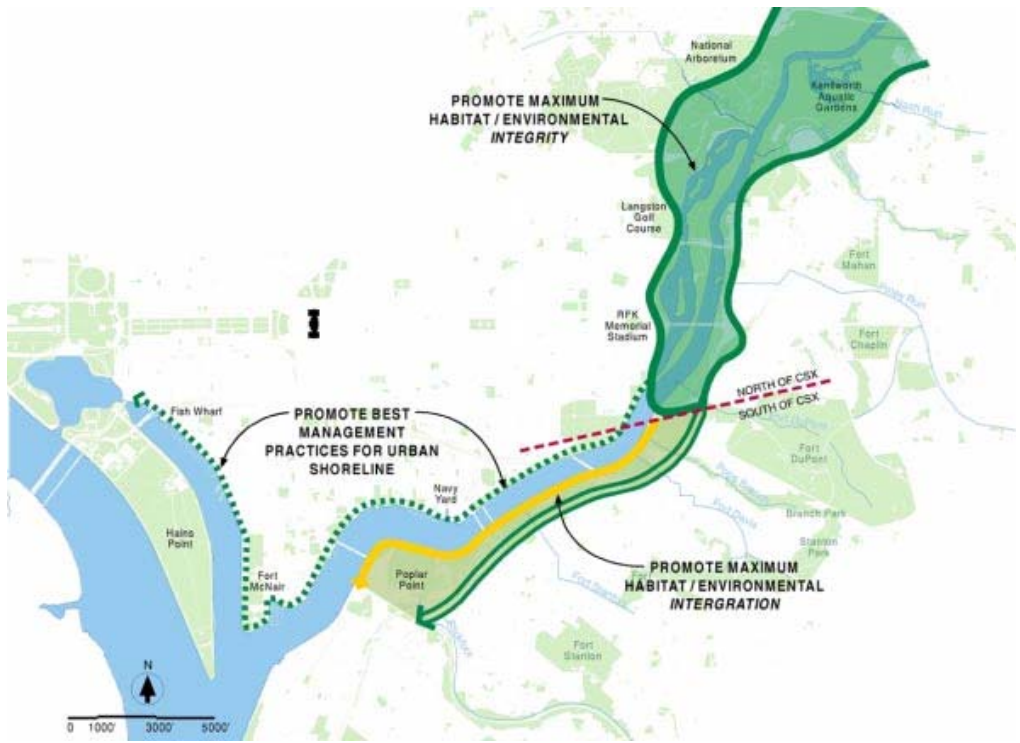
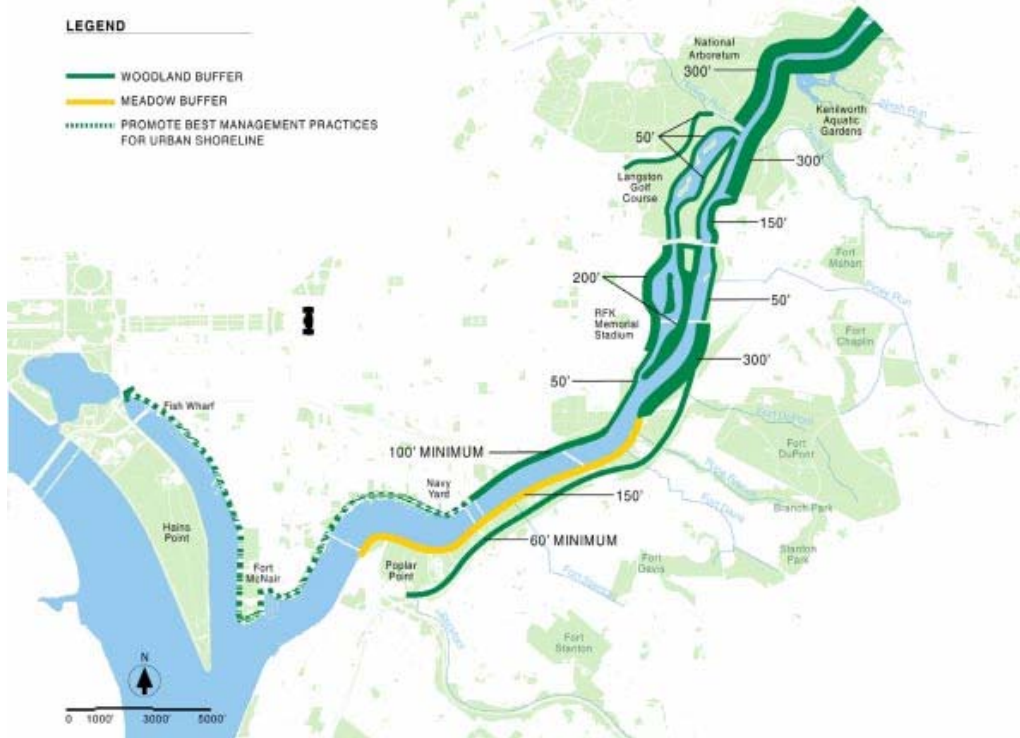


Figure 7-4. Overview Goal for Shoreline Protection in the District of Columbia.



Source: District of Columbia Office of Planning, 2003, *The Anacostia Waterfront Framework Plan*.

Figure 7-5. Planned Buffers along the Anacostia River. Source: District of Columbia Office of Planning, 2003, *The Anacostia Waterfront Framework Plan*.

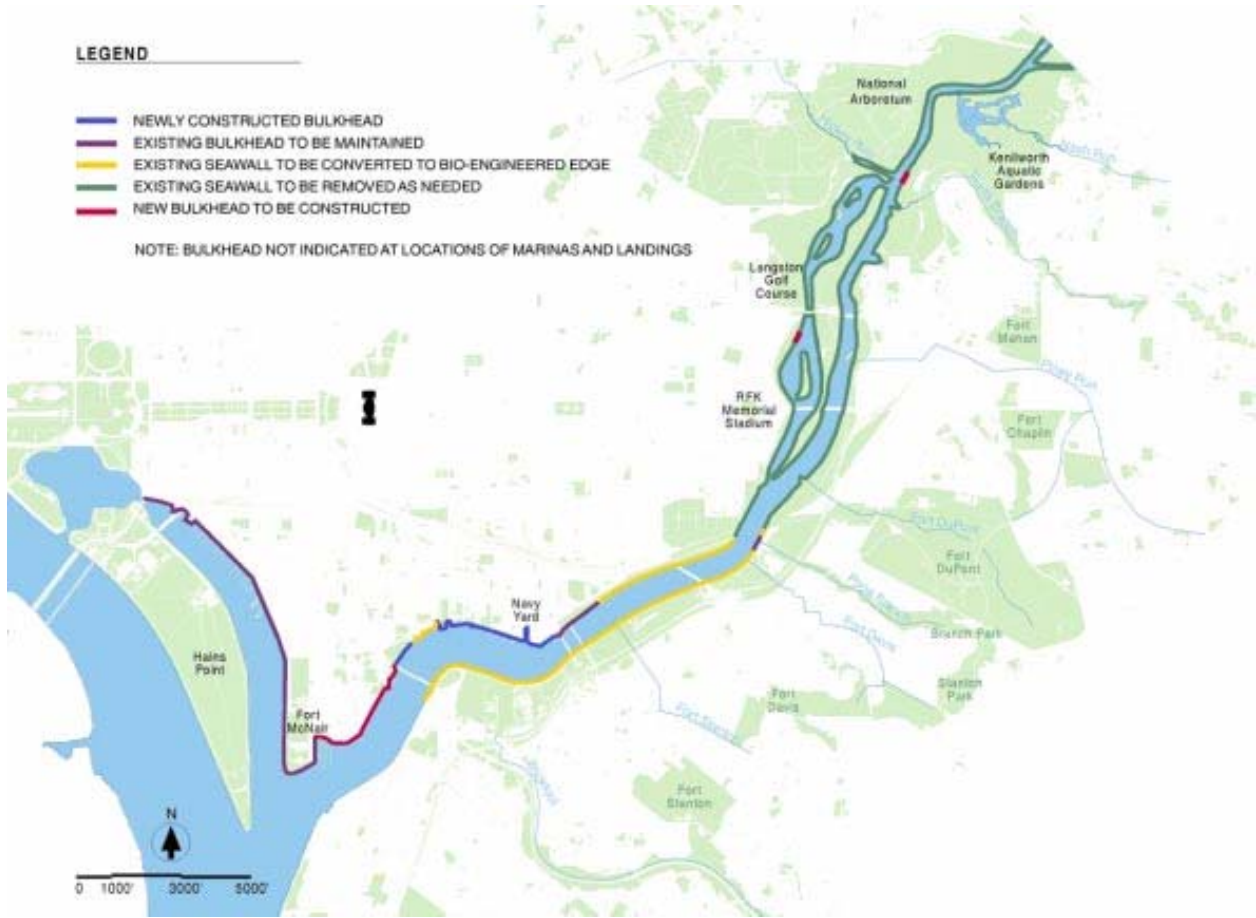


Figure 7-6. District of Columbia Plans to Restore Natural Shores along Anacostia River. Source: District of Columbia Office of Planning, Anacostia Riverparks Target Area Plan and Riverwalk Design Guidelines.

North of Benning Road

North of the CSX bridge, the City plans to promote the maximum habitat and environmental integrity within all the tidal areas and adjacent ecologically important areas.¹⁸ The City also plans to remove the seawall wherever doing so would be beneficial to the environment.¹⁹

The City plans a 300-ft protective buffer from the Maryland line south to Hickey Run on the west side and the Benning Road power plant on the east side.²⁰ This buffer is measured from open water/land shoreline rather than the edge of tidal wetlands that Maryland follows; thus it includes a mixture of wetlands that could not be developed anyway and dry land that might otherwise be converted to environmentally disruptive uses.

Given these policies, our draft map assume that a natural shore retreat is possible, up to a point, in this area.²¹ Most of Kenilworth Aquatic Gardens will probably be protected, albeit in a fashion consistent with its current use for cultivating aquatic plants. Land along the 300-ft buffer probably would not be protected, however, with the possible exception of the walking paths. The park lands between the Aquatic Gardens and the power plant will probably be protected, except for the land within the 300-ft buffer.

On the west side, the National Park Service owns the land between the National Arboretum and the Anacostia River. This strip is 300–500 feet wide from the Maryland line downstream about 4,000 feet, to the bend where the river changes direction from east-west to north-south; below that point, Park Service lands are very narrow down to Hickey Creek. The relatively wide strip is partly wetland. Although a bike path is planned along the shore, it could be relocated inland if necessary. Given the Park Service preference for encouraging natural processes,

along with the City's plan for maximum environmental integrity, the Park Service lands are unlikely to be protected. Although the USDA would not want to harm conservation efforts by D.C. and the National Park Service, the National Arboretum does not have the same mandate to preserve natural coastal environments, and the Arboretum has roads. The maps give effect to both the Anacostia Initiative and the terrestrial mission of the Arboretum by considering both the buffer and the existing road network. Land that is both seaward of the road and within the 300-ft buffer is unlikely to be protected; land that is either landward of the road or outside the buffer will probably be protected; and all land that is both landward of the road and outside the buffer will almost certainly be protected.

Below Hickey Creek, Langston Golf Course occupies both the mainland on the west side of the river and Kingman Island. The plan calls for a 50-ft buffer in this area. On the east side of the river, the plan calls for a 150-ft buffer along the power plant. The golf course and the power plant will almost certainly be protected. Nevertheless, it is possible that the buffers themselves would be allowed to convert to wetland, because the marsh grasses would have similar—though different—benefits for water quality. Depending on scale, our printed map may or may not show these buffers; but they are included within the digital maps used to calculate the statistics associated with this chapter.

Benning Road to CSX Tracks

The City plans to remove the seawall and promote the maximum environmental and habitat integrity for this stretch of the river as well.²² On the east side of the river between Benning and East Capitol streets, Anacostia Avenue is within 50–200 feet of the river, with River Terrace Park on the water side of the street and the community of River Terrace on the east side of the street. The City plans for a 50-ft buffer between the river and the park. Even

¹⁸Riverparks Plan, p.15.

¹⁹Riverparks Plan, p.18

²⁰Riverparks Plan, p.16.

²¹After reviewing the draft maps, District planners indicated that shore retreat is not just possible, but likely. See Stakeholder Review section.

²²Riverparks Plan, p. 15. Between the CSX tracks and the point where a continuation of Massachusetts Avenue would cross the river if it went all the way to the river, the City is proposing to promote best management practices for an urban shoreline, not maximum environmental integrity.

though the City plans to remove the old seawall, planners believe that the shore would be protected given the need to retain this park. Nevertheless, the 50-ft buffer might plausibly convert to marsh; so the draft maps assume that the buffer is likely to be protected.²³

South of East Capitol Street, by contrast, all the land between DC-295 and the river is open space, accessible only by the water or by walking along the Anacostia shore from River Terrace Park or Anacostia Park. According to the City's plan, this area is dedicated as a woodland preserve with maximum benefits for wildlife habitat, and the City further proposes a 300-ft woodland buffer.²⁴ The City also plans to "daylight" Fort Dupont Stream within this preserve.²⁵ Given the importance of natural shores and benefits of wetland migration, allowing shores to retreat naturally would be most consistent with the D.C. Anacostia Initiative, and hence our maps show this area as unlikely to be protected.

Heritage Island and the part of Kingman Island below Benning Road are also possible candidates for long-term wetland migration. A nature center with nature trails and canoe launch sites is planned for Kingman Island. The plan proposes a 200-ft buffer along the shores of these islands, in part because the islands are too narrow for 300-ft buffers. Given the nature orientation of these lands, there is some chance that the authorities would allow wetland migration; at the same time, the city is moving forward with light-density development plans that do not contemplate allowing wetland migration.

Given these competing considerations, the draft maps assume that along its Anacostia River shore, Kingman Island will probably be protected; but along Kingman Lake, both Heritage Island and Kingman Island are unlikely to be protected. Our reasoning is as follows: First, historically, Kingman Lake was originally

a marsh, which was dredged during the 1920s and 1930s for recreational boating; the dredge spoils were used to create Kingman Island. Later, the "lake" filled with sediment, and various organizations are gradually restoring wetlands. Second, Heritage Island and the portion of Kingman Island along Lake Kingman are relatively low, while the east side of Kingman Island is relatively high. Therefore, the impact of sea level rise is likely to be inundation and wetland migration along Lake Kingman, and shoreline erosion along the river itself. In light of the environmental mandates for managing these islands, as well as the lack of convenient road access for dump trucks, the City is unlikely to favor either a landfill project or a dike and pumping system for the sole purpose of stopping the growth of wetlands along Lake Kingman. Along the river, by contrast, some sort of bioengineering would be more acceptable. Viewing the issue of shore protection on a broader scale, the map assumes that City officials would probably not be willing to give up all dry-land uses of Kingman Island south of Benning Road; but they would not want to armor the entire island either.

Along the western shore of Kingman Lake, the National Park Service currently maintains a 200-ft buffer between the RFK stadium parking lot and the water, which the Anacostia Initiative plans to continue. Given the urban setting, shore protection is likely; but wetland migration would be feasible given within the buffer. South of the parking lot, the City proposes "best management practices for urban shorelines" rather than maximum environmental integrity. Although the City proposes a 50-ft buffer for this area, shoreline retreat would not be considered a "best management practice for urban shoreline," and hence the maps assume that this area will be protected.

From CSX Tracks to Poplar Point

Along the west side of the river, the City proposes best management practices for urban shoreline rather than maximum environmental integrity. Moreover, the Anacostia Initiative proposes a combination of shore protection measures for the entirety of this shore. As Figure

²³In the stakeholder review, however, the D.C. Office of Planning suggested changing this area to shore protection unlikely (blue).

²⁴Riverparks Plan, p.17.

²⁵Riverparks Plan, p.17. The term "daylight" refers to converting an underground sewer (usually a former creek) into a creek that is out in the open.

7-6 shows, new and existing bulkheads are planned for most of the shore. The area where the existing seawall would be converted to a bioengineered edge has little room for wetland migration because of marinas and the CSX tracks. City planners were unable to articulate any reasons for not assuming that this part of the shore will be protected for the foreseeable future.

The draft maps assumed that along the eastern side of the river, shore protection is likely, but a retreat to accommodate wetlands is conceivable. The City proposes “maximum environmental integration” of the recreational and environmental uses of Anacostia Park, including a 150-ft buffer along the river. It also plans to replace the old seawall with a bioengineered edge along the entirety of the shore. Given the environmental objectives of this area, which may result in a return of the former wetland fringe, it seemed possible that the City would choose to allow wetland migration as sea level rises. Therefore, the draft map showed the 150-ft buffer as likely to be protected.²⁶

Poplar Point to Potomac River

The west side of the river is certain to be protected for the same reasons as the area between Poplar Point and the CSX tracks. The east side is mostly the U.S. Naval Air Station, which occupies land that was reclaimed from the Anacostia River for purposes of runway construction. Most of this land is within 1 meter above the tidal wetlands, and a 2-mile-long dike along the lower Anacostia River protects the land from flooding. Although the airport is now closed, the Navy uses the land for administrative offices.

The convention of this nationwide study is to not speculate regarding the intentions of the U.S. Department of Defense.²⁷ Therefore, the maps depict military bases as red to indicate uncertainty, except for those bases in urban areas where there is not doubt that the land would be

protected even if the base were closed, with the land turned over to state or local governments.

Our initial impression was that, unlike for Bolling Air Force Base and the Naval Research Laboratory, City planners could not say with absolute certainty that they would seek to develop this low reclaimed land in the unlikely event that it was returned to the District of Columbia.²⁸ Within the next century, a large part of this land may be low enough to be flooded by the ebb and flow of the tides. Thus, wetlands would be restored if the dike were dismantled, and keeping the area dry will become increasingly difficult. Therefore, the initial maps showed the Naval Air Station as red.

²⁶However, the D.C. Office of Planning later suggested that we revise the maps to show this area as certain to be protected.

²⁷We intend to modify the maps if we obtain input from the Department of Defense.

²⁸For purposes of the public trust doctrine, the District of Columbia holds the tidal waters and tidal wetlands in trust for the people. Therefore, when the federal government filled the Anacostia River, ownership was transferred from the District of Columbia to the federal government.

STAKEHOLDER REVIEW

We created a “stakeholder review map” of the District of Columbia based on the assumptions explained in the previous section, and sent it to the District of Columbia Office of Planning for their comments. Uwe Brandes, Anacostia Waterfront Initiative project manager, suggested the following changes²⁹:

Northeast of Massachusetts Avenue along the Anacostia River: Change all of the buffers along the Anacostia River to "protection unlikely." The District of Columbia has decided against shore protection in this area. Lands behind the buffers, however, were correctly characterized.

Southwest of Massachusetts Avenue: All lands along the Anacostia River are certain to be protected, including the 100-ft buffers. If the federal government ever were to remove its installations from the reclaimed land at the mouth of the Anacostia River (Naval Air Station), the D.C. government would not convert it to parkland but would instead maintain the dikes and protect the shore.

Change the shore along Oxon Bay from protection certain to protection unlikely, except the land immediately along I-295. This area will remain undeveloped.

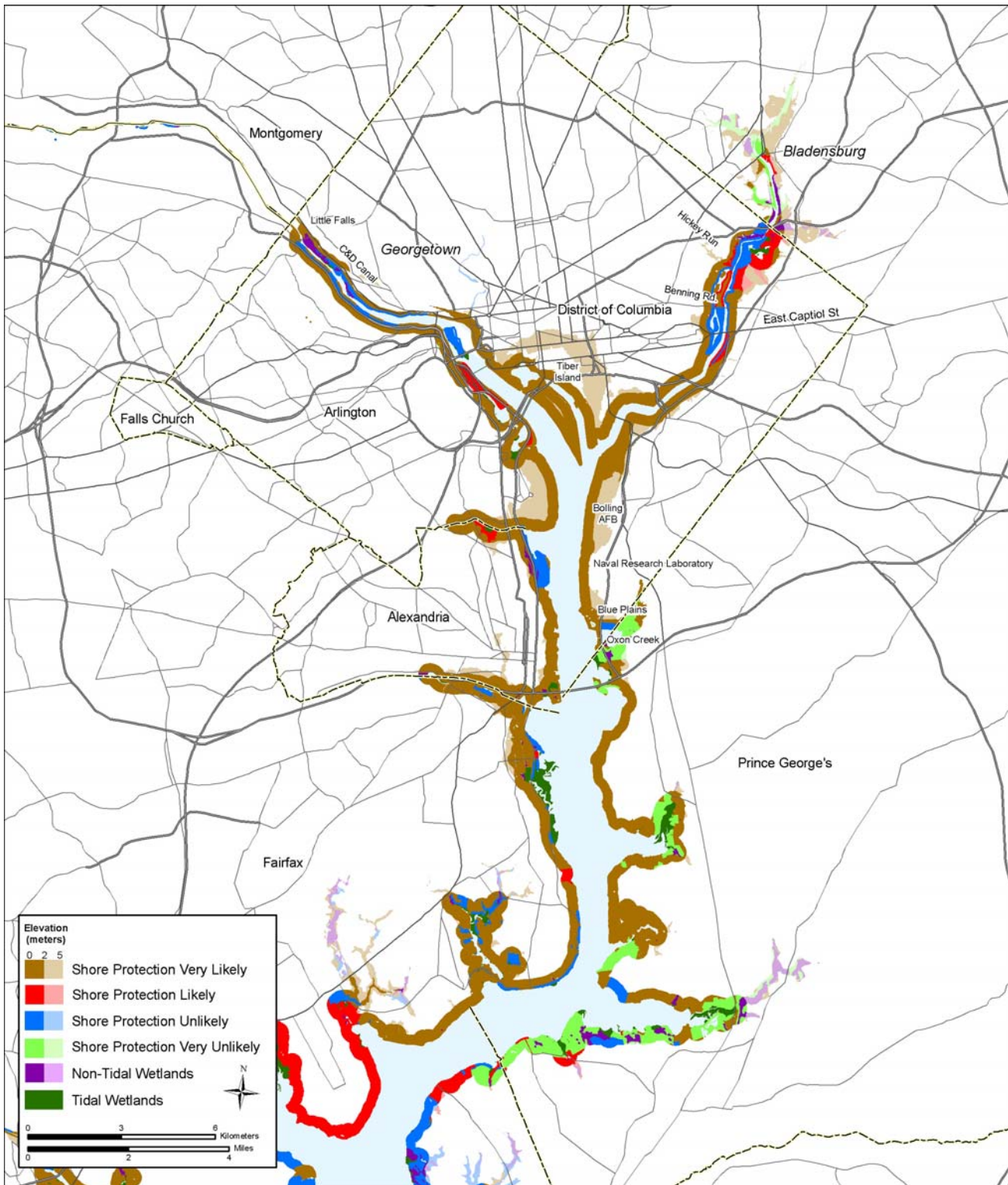
In addition, Mr. Brandes confirmed that other areas were correctly depicted:

- Roosevelt Island and the land along the Potomac River north of Key Bridge are correctly depicted as protection unlikely.
- Park lands above Massachusetts Avenue that are inland from the buffers are likely, but not certain, to be protected.








In addition, the District representative reminded us that D.C. owns the western shore of the Potomac up to mean low water. Therefore, the District has a legal interest in anything done along the Virginia shore, to the extent that shore protection prevents the natural expansion of the tidal waters of the District of Columbia. Nevertheless, he indicated that the assumptions regarding protection of south Arlington and Alexandria seem reasonable. It is very unlikely that the D.C. government would seek to prevent such shore protection on the western side of the Potomac River in those heavily used areas.

We revised the map as Mr. Brandes suggested. Map 7-1 shows the final result of this analysis.

²⁹See email from Jim Titus to Uwe Brandes, February 1, 2005 (listing Mr. Brandes' suggested changes and other issues discussed concerning the sea level rise planning maps for the District of Columbia).



Map 7-1. District of Columbia: Likelihood of Shore Protection. For each shore protection category, the darker shades represent lands that are either less than 6.6 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. For the basis of the shore protection categories in adjacent states, see the companion chapters on Maryland and Virginia. This map is based on discussions with planners in 2005 and is intended to convey 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.

Map Legend	
Transportation Network	
	Toll and Other Limited Access Roads
	Highway
	Major Road
	Local Road
	Railroad
Political Boundaries	
	State Boundary
	County Boundary

Map 2 (continued). **District of Columbia: Likelihood of Shore Protection.** This legend defines the meaning for the transportation network and political boundary symbols used in the map.

A NOTE ON HORIZONTAL SCALE

The shore protection likelihood map developed in this study relies entirely on boundaries and roads as they appear on a USGS 1:24,000 scale map. Allowing for a possible lack of precision in digitizing those boundaries, the map can thus be viewed as valid to a scale of 1:50,000 or better.

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
Definitions: Water body categories used in this Appendix	Descriptions of the water body categories used in this Appendix.	A-1
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 Bodies²	
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.
<p>Notes:</p> <ol style="list-style-type: none"> 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
District of Columbia	41	7	23	0	3	73
Totals	41	7	23	0	3	73

Table A-3: Shoreline length of primary water bodies

Water Body Category	Water Body Name	Shoreline Length (Kilometers)					Totals
		Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	
Primary River	Potomac River	9	0	0	0	0	9
Totals		9	0	0	0	0	9

Table A-4: Shoreline lengths for all water bodies

County	Water Body Category	Water Body Name	Shoreline Length (Kilometers)					Totals
			Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	
District of Columbia	Island	Anacostia River	1	3	5	0	0	9
District of Columbia	Secondary River	Anacostia River	19	4	11	0	0.3	34
District of Columbia	Primary River	Potomac River	9	0	0	0	0	9
District of Columbia	Tributary	Potomac River	6	0	0.5	0	0	6
District of Columbia	Island	Upper Potomac River	0	0	3	0	0	3
District of Columbia	Secondary River	Upper Potomac River	7	0	4	0	3	13
Totals			41	7	23	0	3	73

Table A-5: Military

County	Water Body Category	Water Body Name	Shoreline Length (Kilometers)			
			Shore Protection Certain	Shore Protection Unspecified ¹	Non-Tidal Wetlands	Totals
District of Columbia	Primary River	Potomac River	3	0	0	3
District of Columbia	Secondary River	Anacostia River	2	0	0	2
District of Columbia	Tributary	Potomac River	0.4	0	0	0.4
Totals			6	0	0	6

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)					Totals
			Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Non-Tidal Wetlands	
District of Columbia	Island	Anacostia River	0	3	3	0	0	6
District of Columbia	Island	Upper Potomac River	0	0	3	0	0	3
Totals			0	3	6	0	0	8

Appendix B

AREA OF LAND BY SHORE PROTECTION LIKELIHOOD

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.

The EPA data set used the National Wetlands Inventory (NWI) 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 NWI 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. See Appendix 2 of this report for additional details on how these tables were created.

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

Elevation above Spring High Water (m)		Area (hectares)							
		Shore Protection Certain	Shore Protection Likely	Shore Protection Unlikely	No Shore Protection	Not Considered	Dry Land	Non Tidal Wetlands	All Land
Above	Below								
0.0	0.5	193.1	10.9	38.5	0.0	0.2	242.7	4.2	246.9
0.5	1.0	99.1	6.7	10.0	0.0	0.1	115.9	2.1	118.1
1.0	1.5	123.3	5.2	11.1	0.0	0.1	139.6	2.6	142.2
1.5	2.0	125.7	5.4	11.0	0.0	0.0	142.2	2.5	144.6
2.0	2.5	163.4	7.3	10.4	0.0	0.0	181.1	1.6	182.6
2.5	3.0	166.7	7.3	10.3	0.0	0.0	184.3	1.6	185.8
3.0	3.5	166.7	7.7	8.2	0.0	0.0	182.6	3.1	185.7
3.5	4.0	164.5	7.7	8.2	0.0	0.0	180.5	3.2	183.7
4.0	4.5	151.4	7.8	8.4	0.0	0.0	167.6	5.3	173.0
4.5	5.0	148.8	7.7	8.4	0.0	0.0	164.9	5.4	170.3
5.0	5.5	123.6	5.6	7.5	0.0	0.0	136.7	1.9	138.5
5.5	6.0	121.6	5.6	7.4	0.0	0.0	134.5	1.8	136.3

District of Columbia also has 78.9 hectares of Tidal Wetland.

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: Washington, D.C.¹ (square kilometers)

		Meters above Spring High Water																			
		low	high	low	high	low	high	low	high	low	high	low	high	low	high	low	high				
		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-----																			
Washington, D.C.	0.0	1.6	3.0	2.8	4.4	4.1	5.8	5.5	7.4	7.0	9.3	8.9	11	11	13	13	15	14	16	16	18
Wetlands	Tidal	-----Cumulative (total) amount of Nontidal Wetlands below a given elevation-----																			
Washington, D.C.	0.5	0.03	0.05	0.05	0.07	0.07	0.1	0.09	0.12	0.12	0.14	0.13	0.16	0.15	0.19	0.18	0.24	0.2	0.3	0.28	0.32
		Cumulative (total) amount of land below a given elevation																			
Dry Land		2	3	3	4	4	6	5	7	7	9	9	11	11	13	13	15	14	16	16	18
Nontidal Wetlands		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All Land	0	2	3	3	5	5	6	6	8	8	10	9	12	11	14	13	15	15	17	17	19

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.

C-2. Likelihood of Shore Protection in Washington, D.C., High and Low Estimates of the Land within One Meter above Spring High Water¹

(square kilometers)

	Likelihood of Shore Protection								Nontidal Wetlands	Total ²		
	Certain		Likely		Unlikely		No Protection					
	low	high	low	high	low	high	low	high	low	high		
Washington, D.C.	2.3	3.6	0.1	0.2	0.4	0.5	0	0	0.05	0.07	2.9	4.5

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.

C-3. Likelihood of Shore Protection in Washington, D.C., High and Low Estimates of the Land within Two Meters above Spring High Water¹

(square kilometers)

	Likelihood of Shore Protection										Total ²	
	Certain		Likely		Unlikely		No Protection		Nontidal Wetlands			
	low	high	low	high	low	high	low	high	low	high		
Washington, D.C.	4.6	6.4	0.2	0.3	0.6	0.7	0	0	0.09	0.12	5.6	7.6

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.

C-4. Area of Land by Elevation by Shore Protection Likelihood, High and Low Estimates: Washington, D.C.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	1.3	2.4	0.07	0.14	0.3	0.4	0	0	<0.01	<0.01	1.6	3.0	0.03	0.05	1.7	3.0
1.0	2.3	3.6	0.1	0.2	0.4	0.5	0	0	<0.01	<0.01	2.8	4.4	0.0	0.1	2.9	4.4
1.5	3.4	4.9	0.2	0.3	0.5	0.6	0	0	<0.01	<0.01	4.1	5.8	0.07	0.10	4.1	5.9
2.0	4.6	6.4	0.2	0.3	0.6	0.7	0	0	<0.01	<0.01	5.5	7.4	0.09	0.12	5.6	7.6
2.5	6.0	8.0	0.3	0.4	0.7	0.9	0	0	<0.01	<0.01	7.0	9.3	0.12	0.14	7.2	9.4
3.0	7.6	9.7	0.4	0.5	0.8	0.9	0	0	<0.01	<0.01	8.9	11	0.1	0.2	9.0	11
3.5	9.3	11	0.5	0.6	0.9	1.0	0	0	<0.01	<0.01	11	13	0.15	0.19	11	13
4.0	11	13	0.5	0.6	1.0	1.1	0	0	<0.01	<0.01	13	15	0.18	0.24	13	15
4.5	13	14	0.6	0.7	1.1	1.2	0	0	<0.01	<0.01	14	16	0.2	0.3	14	17
5.0	14	16	0.7	0.8	1.2	1.3	0	0	<0.01	<0.01	16	18	0.28	0.32	16	18

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.

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