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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 document is
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# CHAPTER 2

# NEW YORK

Prepared by:
Jay Tanski[i]

[i] New York Sea Grant Extension Program, Stony Brook University, Stony Brook, New York

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# EDITOR'S SUMMARY

Sea level is rising approximately 1 inch about every 8 years along the coast of New York. Ocean shores are eroding along the Atlantic coast. Marshes are eroding in Jamaica Bay, and high tides now flood some streets in developed areas. 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 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 the New York. Bulkheads are common along the shores of New York City and Long Island. The Corps of Engineers has placed sand onto ocean beaches on the south shore of Long Island. Homes have been lost to retreating ocean shores in Southampton.

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 areas 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 people will yield the right of way to the inland migration of wetlands and beaches, and where we will hold back the sea. 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.

The author obtained land use and planning data from Suffolk, Nassau, and Westchester counties and New York City. He also consulted with planners representing the state, New York City boroughs, and the three counties along the Atlantic Ocean, Long Island Sound, and the Hudson River as well as the Town of Hempstead in Nassau County. The result is a statewide series of maps that uses existing data, filtered through the town, borough, and county governments who coordinate land use planning activities.

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 does it 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 17–18 feet (5 meters) above the tides. (Jay Tanski did not project the fates of secured federal installations 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.

Map 2-1 shows our assessment of the likelihood of shore protection for the coastal zone of New York, and adjacent areas in New Jersey, Connecticut, and Rhode Island. Table 2-1 quantifies the area of land within approximately 3 feet (1 meter) above the tides for each of the shore protection categories by county. Table 2-2 quantifies the length of shoreline along the Atlantic Ocean, Long Island Sound, and Hudson River/New York Harbor.

## Conclusions

1. *Shore protection is likely or certain along most of the New York coast.*

- All but 9 miles of the state's 119-mile Atlantic shore is likely or certain to be protected.
- All but 9 miles of the state's 148-mile Long Island shore is likely or certain to be protected.
- Of the 63 square miles of dry land within approximately 3 feet (1 meter) above the tides, 56 square miles is likely or almost certain to be protected.

2. *Lightly developed barrier islands in New York are likely to be protected*

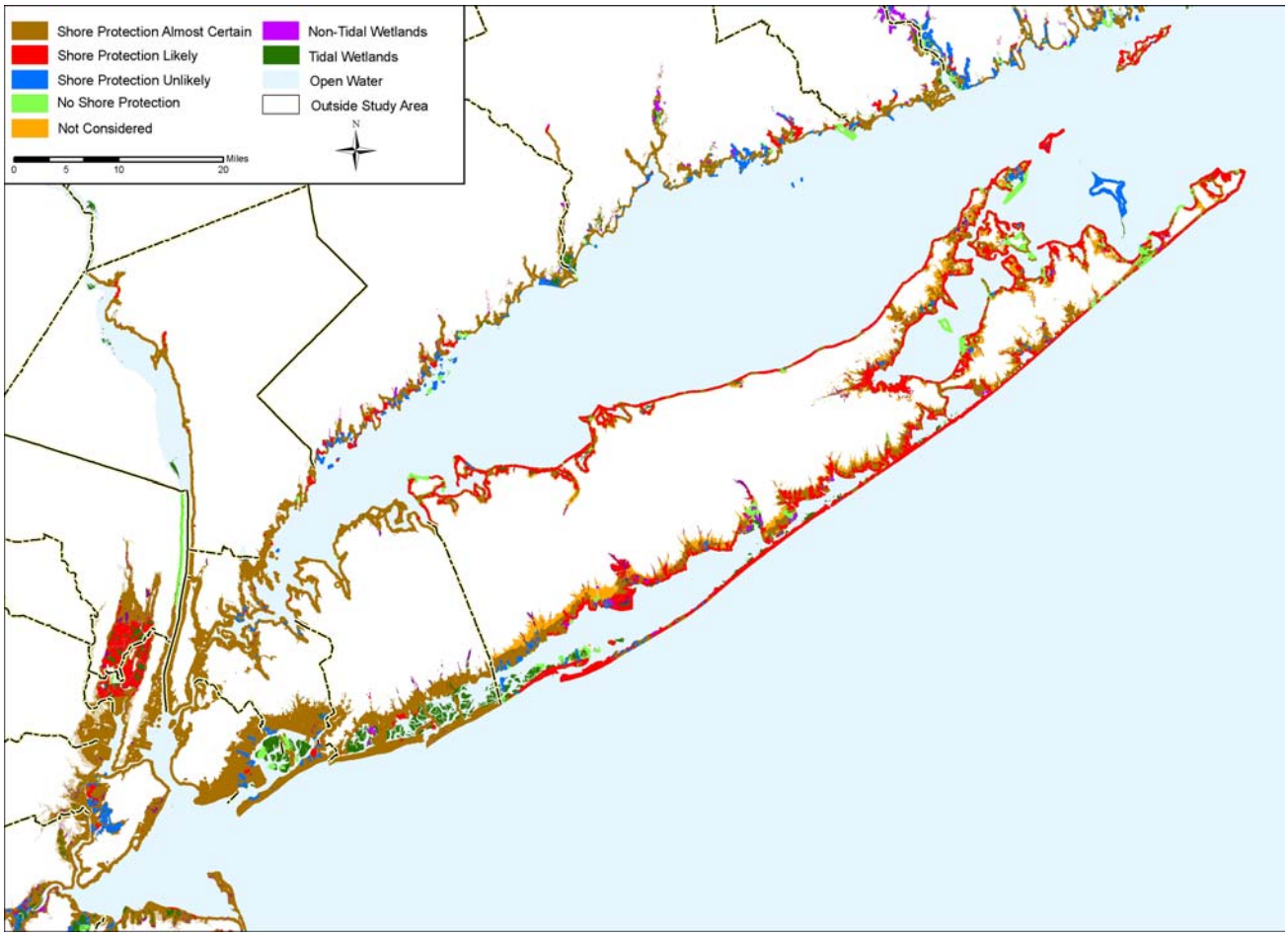
- Although some shore erosion will be tolerated, the major through highways along these islands make some sort of shore protection likely (but not certain).

- The mainland behind these barrier islands is densely populated. Therefore, officials are unlikely to allow the barrier islands to disintegrate, which would expose low-lying mainland communities to hazardous flooding.

3. *Wetland migration is possible along many of the shores that our maps depict as likely or certain to be protected.*

- Unlike most other mid-Atlantic states, New York's regulations do not provide riparian property owners with a right to hold back the sea.
- New York's tidal wetland regulations extend 300 feet inland of the wetlands. State officials believe that the regulations could potentially facilitate a landward migration of wetlands as sea level rises.

Our maps were designed to provide a broad scale depiction of what would occur given current policies and practices. Site-specific variations from the overall trends may occur, and policies may change over time.




**Map 2-1. New York: Likelihood of Shore Protection.** The map illustrates each shore protection category for lands within the study area, defined as land under 11.5 feet (3.5 meters), or within 1,000 feet of the shore (except Nassau County, which is limited to the 500-year floodplain). This map is based on data published between 1991 and 2003 (with the exception of wetlands data, which were published in 1974), and site-specific changes suggested by planners in 2004.

**Table 2-1.**
**Area of Land within 3.3 feet (1 meter) above Spring High Water by Likelihood of Shore Protection (square miles)**

| Jurisdiction | Likelihood of Shore Protection | | | | Nontidal Wetlands | Total[1] | Elevation Error[2] (inches) | Tidal Wetlands |
|---|---|---|---|---|---|---|---|---|
| | Almost Certain | Likely | Unlikely | No Protection | | | | |
| Long Island Sound and Peconic Estuary | | | | | | | | |
| Suffolk [3] | 4.9 | 4.9 | 0.4 | 1.3 | 1.1 | 13.5 | 19 | 14.4 |
| Nassau | 1.0 | 0.02 | 0.0 | 0.0 | 0.0 | 1.1 | 38 | 1.9 |
| Queens | 1.3 | 0.0 | 0.04 | 0.0 | 0.0 | 1.4 | 25 | 0.2 |
| Westchester | 0.8 | 0.02 | 0.0 | 0.01 | 0.0 | 0.9 | 25 | 0.4 |
| Bronx | 1.4 | 0.01 | 0.06 | 0.0 | 0.0 | 1.5 | 25 | 0.5 |
| Total | 9.3 | 4.9 | 0.5 | 1.4 | 1.2 | 18.2 | | 17.3 |
| Atlantic Coast | | | | | | | | |
| Suffolk | 8.2 | 5.5 | 0.5 | 1.4 | 2.0 | 18.1 | 16 | 17.4 |
| Nassau | 10.5 | 0.4 | 0.04 | 0.01 | 0.2 | 11.1 | 19 | 14.9 |
| Queens | 6.2 | 0.1 | 0.3 | 0.5 | 0.1 | 7.3 | 16 | 2.7 |
| Brooklyn | 4.2 | 0.03 | 0.2 | 0.2 | 0.03 | 4.8 | 16 | 1.4 |
| Total | 29.1 | 6.0 | 1.1 | 2.1 | 2.3 | 41.3 | | 36.4 |
| New York Harbor | | | | | | | | |
| Westchester | 0.7 | 0.03 | 0.0 | 0.0 | 0.02 | 0.8 | 31 | 0.3 |
| Bronx | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 25 | 0.0 |
| Manhattan | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 25 | 0.0 |
| Brooklyn | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 25 | 0.0 |
| Staten Island | 3.5 | 0.3 | 0.6 | 0.01 | 0.3 | 4.7 | 25 | 2.1 |
| Total | 6.3 | 0.3 | 0.6 | 0.01 | 0.3 | 7.5 | | 2.4 |
| **New York** | **44.7** | **11.3** | **2.2** | **3.5** | **3.8** | **67.0** | | **56.1** |

1. Total Land includes the five categories listed plus land for which no data was available.
2. 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.
3. Statistics do not reflect a correction to the Suffolk County map for Gardiners Island, which was incorrectly identified as shore protection likely (instead of shore protection unlikely).

See Table B-2 in Appendix B for details.

## Table 2-2. Shoreline Length by Major Water Body and Likelihood of Shore Protection (miles)[1]

| Jurisdiction | Likelihood of Shore Protection | | | | Nontidal Wetlands | Outside Study Area | Totals |
|---|---|---|---|---|---|---|---|
| | Certain | Likely | Unlikely | No Protection | | | |
| Hudson River | 53 | 1 | <0.1 | <0.1 | <0.1 | <0.1 | 54 |
| Bronx | 3 | 0 | 0 | 0 | 0 | 0 | 3 |
| New York | 16 | 0 | 0 | 0 | 0 | 0 | 16 |
| Westchester | 34 | 1 | 0 | 0 | <0.1 | 0 | 35 |
| Long Island Sound | 88 | 49 | 0.4 | 8 | <0.1 | 4 | 149.4 |
| Bronx | 6 | <0.1 | 0 | 0 | 0 | 0 | 6 |
| Nassau | 35 | 0.2 | 0 | 0.7 | 0 | 0 | 35.9 |
| Queens | 3 | 0 | <0.1 | 0 | 0 | 0 | 3 |
| Suffolk | 30 | 48 | 0.3 | 7 | 0 | 4 | 89.3 |
| Westchester | 13 | 0.8 | 0 | 0 | 0 | 0 | 13.8 |
| Raritan Bay | 17 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 17 |
| Kings | 5 | 0 | 0 | 0 | 0 | 0 | 5 |
| Richmond | 12 | 0 | 0 | 0 | 0 | 0 | 12 |
| Back Barrier Bays | 110 | 85 | 5 | 9 | 10 | 16 | 235 |
| Kings | 8 | 0 | 0.3 | 0 | 0 | <0.1 | 8.3 |
| Nassau | 33 | 0.6 | 0 | 0 | 0 | 15 | 48.6 |
| Queens | 15 | 0.5 | 2 | 0.6 | 0 | 0.2 | 18.3 |
| Suffolk | 55 | 84 | 3 | 9 | 10 | 0.6 | 161.6 |
| Atlantic Ocean | 48 | 61 | 0.8 | 8 | 0 | 0.7 | 118.5 |
| Nassau | 17 | 0 | 0 | 0 | 0 | 0.7 | 17.7 |
| Queens | 10 | 0 | 0 | 0 | 0 | 0 | 10 |
| Suffolk | 21 | 61 | 0.8 | 8 | 0 | 0 | 90.8 |
| **State Total[1]** | **1268** | **518** | **55** | **148** | **38** | **115** | **2142** |

1 Includes tributaries to the major water bodies.

# INTRODUCTION

With almost 12 million inhabitants in the New York City metropolitan area (for the purposes of this study, metropolitan area refers to New York City, Long Island, and Westchester County), New York has one of the most densely developed and heavily used coasts in the United States. The demands of the growing population for residential, recreational, and commercial uses of the state's 1,400 miles of marine shoreline are considerable and will increase in the future. Between 1970 and 1989, Suffolk County, which covers the eastern half of Long Island, ranked as one of the top 10 counties in the country in residential construction growth.[1] Area beaches are a prime recreational resource, attracting tens of millions of additional visitors every year, and are the foundation of a multibillion dollar regional tourism industry.

Highly desirable for a variety of uses, these coastal areas are also extremely dynamic and subject to significant erosion and flooding hazards caused by both natural processes and human activities. Historical rates of relative sea level rise in the metropolitan area, over the last century, were 2 to 3 mm/year.[2] Continuation of these historical rates would imply a sea level rise of 20 to 30 cm over the next 100 years. Global warming due to greenhouse gas emissions, however, may result in a two- to fourfold increase in rates of global sea level rise.[3] This increase will exacerbate existing flooding and erosion hazards. The impact of sea level rise on coastal areas will depend to a large extent on the response to the problem, which in turn will be controlled by existing and projected land use patterns, development trends, and state and local coastal policy and regulations. Management strategies promoting either protection or abandonment of lands will impose significant costs on both the state of New York and its coastal population.

Table 2-3 shows preliminary estimates by county of the land that could potentially be inundated from a 2-ft rise in sea level. Figure 2-1 shows lands vulnerable to sea level rise in New York.[4]

## Purpose of this Study

This study develops maps that distinguish the areas likely to be protected[5] as the sea rises from the areas where shores will probably retreat naturally assuming that current policies and economic trends continue. 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.

[1]Culliton, T.J., J.J. Mcdonough III, D.G. Remer, and D.M. Lott, 1992, Building along America's coasts: 20 years of building permits, *Coastal Trend Series*, National Oceanic and Atmospheric Administration, National Ocean Service, Washington D.C.

[2]Douglas, B.C., 2001, Sea level change in the era of the recording tide gauge, in *Sea Level Rise: History and Consequences*, B.C. Douglas, M.S. Kearny, and S.P. Leatherman (eds.), Academic Press, San Diego, CA, pp. 37–64.

[3]Intergovernmental Panel on Climate Change, 2001, *Climate Change 2001: The Scientific Basis*, Technical Summary of Working Group 1.

[4]See box on "Reference Elevations and Sea Level Rise" for an explanation of spring high water and sea level rise.

[5]For purposes of this study, "protect" generally means some form of human intervention that prevents dry land from being inundated or eroded. The most common measures include beach nourishment and elevating land with fill, rock revetments, bulkheads, and dikes.

**TABLE 2-3. AREA OF LAND VULNERABLE TO SEA LEVEL RISE IN NEW YORK (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 |
| Suffolk | 50.5 | 31.8 | 16.8 | 1.9 | 33.9 | 3.6 | 68.5 | 5.8 |
| Nassau | [e] | 16.7 | [e] | [e] | 14.9 | 0.2 | 31.7 | 0.5 |
| Queens | 8.8 | 2.9 | 5.9 | 0.1 | 10.1 | 0.1 | 18.9 | 0.2 |
| Staten Island | [e] | 2.1 | [e] | [e] | 5.4 | 0.3 | 9.4 | 0.5 |
| Brooklyn | 4.8 | 1.4 | 3.4 | 0.03 | 6.2 | 0.04 | 13.2 | 0.1 |
| Bronx | [e] | 0.5 | [e] | [e] | 2.2 | 0.01 | 4.6 | 0.02 |
| Westchester | [e] | 0.7 | [e] | [e] | 1.8 | 0.03 | 3.5 | 0.05 |
| Manhattan | [e] | 0.0 | [e] | [e] | 1.5 | 0.0 | 3.0 | 0.0 |
| Dutchess[f] | 0.0 | 0.03 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Rockland[f] | 0.9 | 0.9 | 0.0 | 0.01 | 0.0 | 0.01 | 0.0 | 0.02 |
| Orange[f] | [e] | 0.1 | [e] | [e] | [e] | [e] | 0.0 | 0.0 |
| Ulster[f] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Putnam[f] | [e] | 0.5 | [e] | [e] | [e] | [e] | 0.0 | 0.0 |
| Ellis Island | 0.0 | 0.0 | 0.02 | 0.0 | 0.03 | 0.0 | 0.1 | 0.0 |
| **Statewide totals** | **65** | **58** | **38** | **2** | **76** | **4** | **153** | **7** |

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 Titus, J.G., 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, D.C.:U.S. EPA,

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.

f Not included in this study.

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 small town survives, that coastal wetlands are able to migrate inland,[6] 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.[7] For the last 25

[6]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, 2008, Site-Specific Scenarios for Wetlands Accretion as Sea Level Rises in the Mid-Atlantic Region, Section 2.1 in Titus and Strange, 2008 (see Table 2-3 for full reference). .

[7]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.

years, EPA has attempted to accelerate the process by which coastal governments and private organizations plan for sea level rise, and evaluated whether the nation's wetland protection program will achieve its goals as sea level rises.[8] 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, and such an assessment depends to a large degree on the extent to which local coastal area governments will permit or undertake sea level rise protection efforts.[9] 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.

## 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[10]
- 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.

[8]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.

[9]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., 1991 "The cost of not holding back the sea: Toward a national sample of economic vulnerability," *Coastal Management* 18:403–431.

[10]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.

## 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, county-specific policies and responses, result appendices, and other appendices as needed.

Some subsections appear verbatim in each of the eight chapters, 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.

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 (written by John Herter and Daniel Hudgens);

(B) best estimates of the area of land at various elevations by likelihood of shore protection (written by John Herter and Daniel Hudgens); and

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

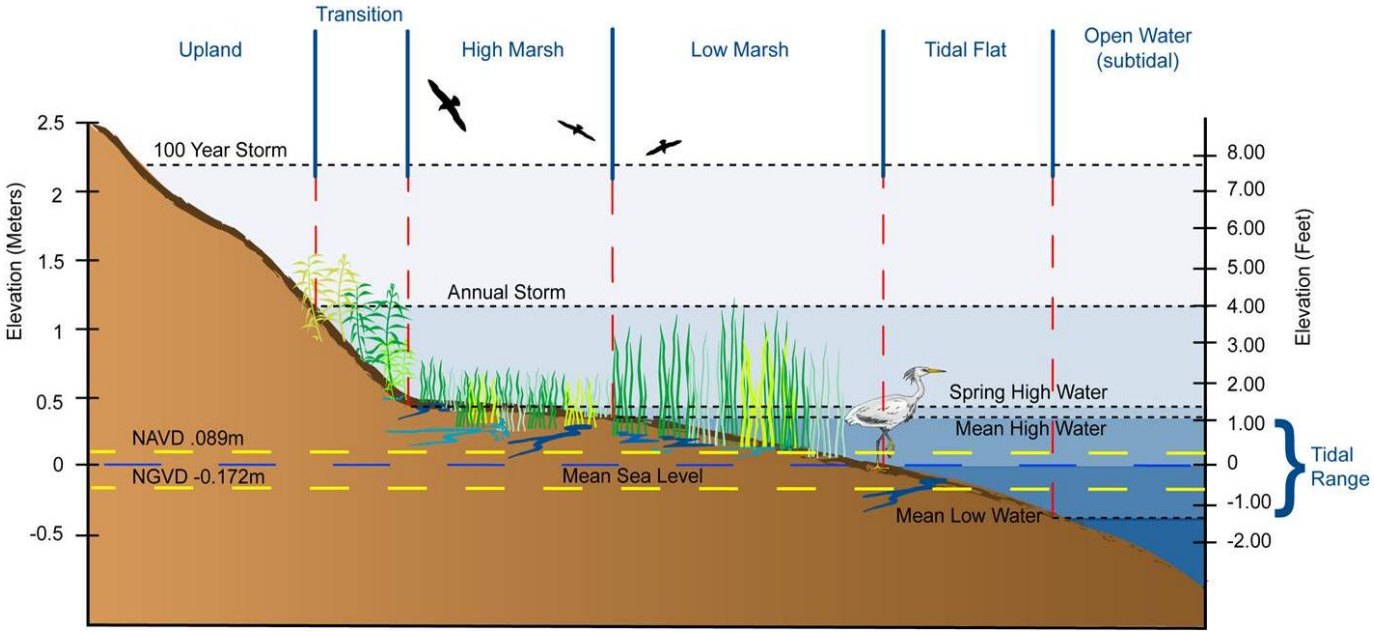
Because the quantitative results were developed after this study was complete, those results are not integrated into the text of this report, other than the summary.

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

## 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 also called *nanotidal wetlands*.




The 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 .

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. 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.

**Figure 2-1. Lands Vulnerable to Sea Level Rise.**

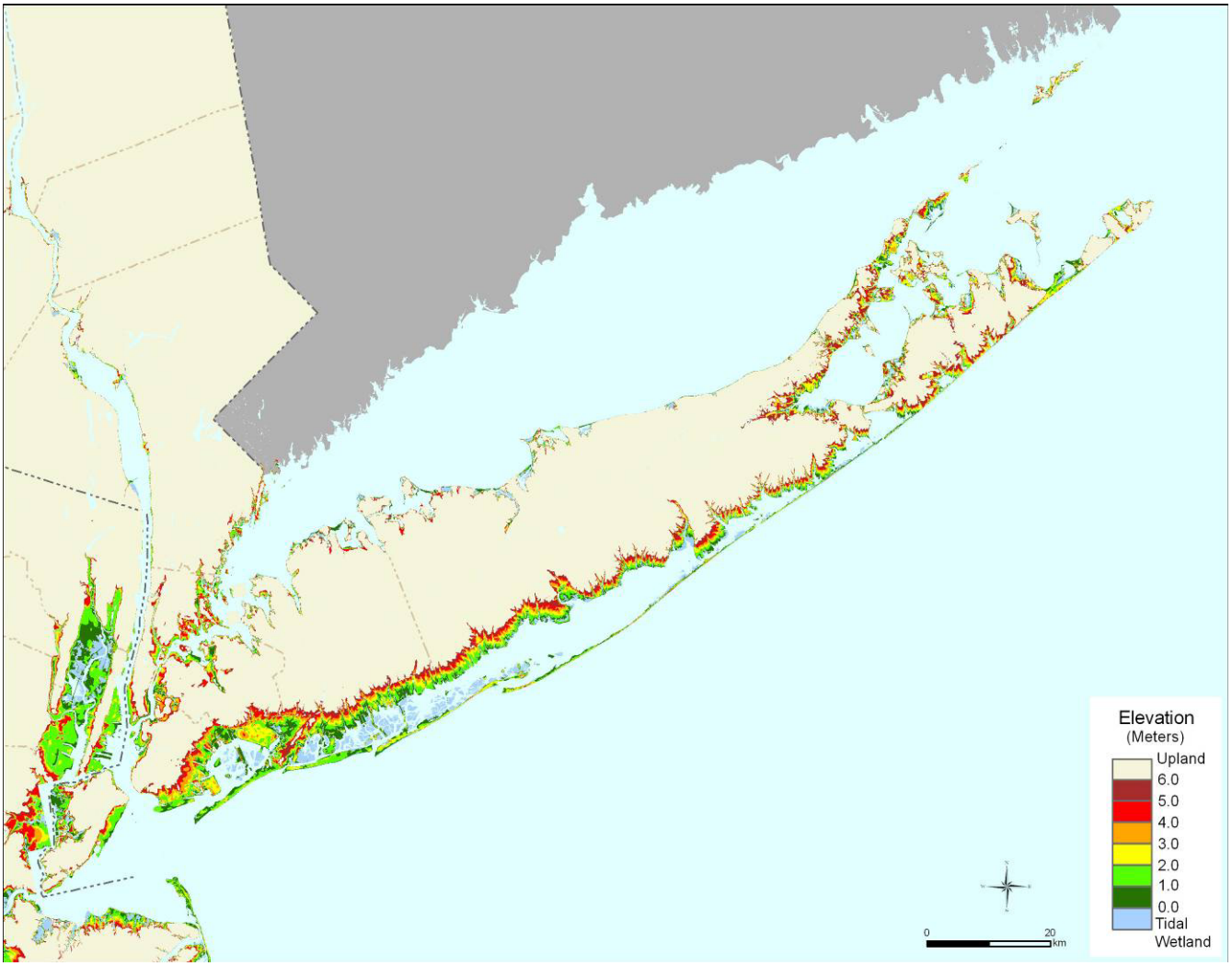



**Figure 2-1. Lands Vulnerable to Sea Level Rise.** Source: Titus and Wang (2008; see Table 2-3 for full reference) based on USGS topographic maps, published wetlands data, and NOAA data on tidal elevations. County elevation data sets were not available. Actual elevations are usually within 1 meter of the value indicated by this map. In portions of New York City and the island of Long Beach, the best available elevation data had a 10-ft contour and actual elevations are within 2 meters of the value shown. For additional details on the accuracy of this map, see Annex 3 of this volume and Appendix C of this chapter. 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.

# METHODS

This section provides detailed information on the approaches employed over the course of this study. We divide the discussion in subsections, which address:

- scope of the study area;
- our approach for gathering information from local planners and developing the likelihood of shore protection maps; and
- the appropriate scale for viewing the resulting maps.

## Study Area

Our study area is all dry land below 11.5 feet (3.5 meters) in elevation. We use the 11.5-ft contour as an inland boundary to ensure that the study area includes the portions of the state that might be affected by rising sea level during the foreseeable future.[11] (Some researchers are beginning to evaluate the possible impacts of the sea rising 5–10 feet or more over a few centuries.) 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 11.5-ft contour, those using our results need not include the higher elevations.*[12]

Our study area also includes all dry land within 1,000 feet of tidal wetlands or open water to account for possible erosion[13] and to ensure that the study area is large enough to be seen on maps depicting a county on a single sheet of paper. We found that maps without a 1,000-ft study area along bluffs were difficult to read and did not convey the anticipated response.

For Nassau County, however, the study area is limited to the lands located within the 500-year floodplain. As described in the Nassau County Response section below, county personnel provided the input data for the response map only for lands within this area.

## Overall Approach

To better understand New York's likely sea level rise responses, relevant laws and regulations were researched and reviewed and discussions were conducted with state and local managers and planners familiar with coastal regulations as well as land use patterns and trends. Managers received an overview and summary of the project purpose and goals before the meetings.

Because of the inherent uncertainties associated with global climate change and predicting its impacts, we did not try to quantify the magnitude of sea level rise when looking at the different scenarios and responses. Rather, managers were asked to consider lands potentially vulnerable to sea level rise on a more generic basis. To focus discussions, we provided digital maps depicting inundation zones associated with Category 1, 2,

[11] In the other states, the study area is all land below the USGS 20-ft contour.

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

[13] Like the 11.5-ft contour, the 1,000-ft buffer is conservatively overinclusive. Rates of shoreline erosion vary. But given the format of most land use data, extending the study area 1,000 feet inland did not require us to obtain data or engage in discussions that we would not have undertaken otherwise.

and 3 hurricanes based on the SLOSH[14] numerical model developed by the National Weather Service to indicate areas already vulnerable to flooding and erosion hazards. The location of the 11.5-ft (3.5-m) contour based on digital elevation data provided by the EPA was also superimposed on these maps to indicate areas that could broadly be considered vulnerable to sea level rise.

Through conversations with state and local planners and managers, we develop decision guidelines that identify a land use or type and its likelihood to be protected. Next, we discuss area-specific differences anticipated by the planners. Through this approach we attempted to develop maps that divide the dry land within the coastal zone into four categories:

- Lands almost certain to be protected by human intervention (e.g., structural measures or beach nourishment).[15] Shown as brown on the maps.
- Lands that will probably be protected though human intervention, but where protection is not certain. It is possible that shores in these areas may be allowed to migrate. Shown as red on the maps.
- Lands that will probably not be protected. These lands will probably be left to natural processes because, for example, property values are likely to remain low compared to the cost of shore protection but where protection is at least possible because, for example, private property owners have a legal right to hold back the sea or a public purpose might be enhanced by shore protection enough to justify the cost. Shown as blue on the maps.
- Lands almost certain to be left to natural processes, because of a conservation or recreational purpose that either does not require shore protection or may even be impaired by shore protection, or some other public policy that precludes shore protection. Shown in light green on the maps.[16]

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

[14]Sea, Lake Overland Surge from Hurricanes.

[15]Within the report we try to differentiate between protection by nourishment and structural protection where possible. However, for the purposes of our mapping exercise we group these two measures together as "protection." This project does not attempt to answer the question of which method may be used or who will provide the funding for these activities. Although determinations may be made that protection is more likely in areas where money is currently being spent for protection, it is difficult to project the availability of funding in the future because political climate, the economy, and other factors that influence public and private spending are subject to change.

[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.

Some planners found it difficult to distinguish the lands where shore protection is expected regardless of environmental policy, from those lands that might plausibly be available for wetland migration. Given the confusion, the EPA project manager (Jim Titus) modified the scenario definitions after the completion of the initial discussions with planning staff: *Enhanced wetland migration now identifies only the areas that are almost certain to be protected.*

When viewing the initial study maps (which were separate maps for each scenario), it was also difficult to compare and contrast the scenarios for specific areas. As a result, the EPA project manager developed an approach for translating the scenarios to a single map in a way that takes the independent scenarios and combines the information into a cumulative summary. Consequently, the results illustrated as a likelihood of shore protection can be translated to the original scenarios. 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 (Chapter 1)or New Jersey chapter (Chapter 3).

Outside the study area, we also show wetlands using dark green and sometimes purple (for nontidal wetlands). 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]

Based on the results of the discussions, the author identified the factors that determine which lands are likely to be protected versus those that are likely to be abandoned as sea level rises. This information was then used in conjunction with available land use and tax map data to develop maps depicting potentially protected areas using Environmental Systems Research Institute's ArcView GIS software application. Unfortunately, statewide land use data at the resolution and level of detail needed for this analysis are not currently available. In most cases, the most up-to-date and comprehensive information is collected and maintained at the county level. These digital data were not available for all areas. In these cases, data were digitized as part of this study. As a result of the limitations and inconsistencies in the available data sets, the method used to create the scenario maps was different for each county considered. Specific data sets and the procedures used for processing and analyzing the information are described for each county in Appendix D.

As a final check on the maps, we sent the draft of this report along with the maps to each of the counties. Doing so was important because even though we followed the decision rules and otherwise depicted the protected areas as suggested during previous meetings, textual adherence to GIS decision rules is no substitute for comparing a map to reality. This final round of meetings identified additional areas for probable shore protection.

The results presented here are based on the author's interpretation of documents, maps, policies, and discussions with state and local agency representatives. Although those participating in the study have had a chance to review the findings, any discrepancies between official positions or policies of the various governmental entities and what is reported here are the fault of the author, as are any misrepresentations, misunderstandings, or inaccuracies.

[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.

## Map Scale

Because our maps are based on decision rules and previously published data, the horizontal resolution at which one should reasonably display our maps is limited by the precision of the input data.

The input data for this study were created at a 1:66,360 or finer scale. The stakeholder and other site-specific edits were mostly based on features that were also available at a 1:66,360 or finer scale, although a few were based on annotations to 1:100,000 scale maps. Those changes constituted less than 5 percent of the polygons; therefore they could not have deteriorated the maps to a scale worse than 1:50,000. The authors have not examined these maps at scales greater 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 will actually transpire in the decades ahead.

## 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 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 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.[18] We rely on local 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, 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.

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 the 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.

[18]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.

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. Therefore, planners expect shore protection.”

# FINDINGS

## State Coastal Policies and Regulations[19]

New York State is a home rule state. Its constitution established a "Bill of Rights" for local governments, which guarantees specific powers, privileges, and protections for town, village, and city governments. The cities, towns, and villages are allowed to draft their own laws, and can even opt out of state laws when there is no explicit or implied conflict in so doing. Often, under this arrangement, state laws serve more as a direction for cities to follow than as a mandate to be enforced.[20] Land use, zoning, and development decisions are made at the local level (city, village, and town). The counties provide technical and advisory assistance. However, the State can and does set minimum requirements for coastal land use management and resource protection through a variety of programs. Local entities may enact more stringent regulations.

New York State does not have written policies or regulations pertaining specifically to sea level rise in relation to coastal zone management, although it is recognized as a factor in coastal erosion and flooding by New York State Department of State (DOS) in the development of regional management plans.[21] Policies regarding management and development in shoreline areas are primarily based on three laws: the Tidal Wetlands Act (Environmental Conservation Law, Article 25), the Waterfront Revitalization and Coastal Resources Act (Executive Law, Article 32), and the Coastal Erosion Hazard Areas Act (Environmental Conservation Law, Article 34). The latter two were developed in tandem and were required for the state to meet the requirements of the Federal Coastal Zone Management Act. None of these laws explicitly mentions sea level rise, but they do provide the framework for managing and regulating activities in erosion and flood-prone coastal areas. As such, they implicitly address the issues caused by current sea level trends and most of the problems expected to accompany a possible acceleration in the rate of sea level rise due to global climate change.

### Tidal Wetlands Act

The State enacted this legislation in the 1970s to protect and preserve tidal wetlands in the counties of Suffolk, Nassau, Westchester, and Rockland south of the Tappan Zee Bridge,[22] and all boroughs of New York City. The law is implemented through the Tidal Wetlands Land Use Regulations (6 New York Code of Rules and Regulations Part 661), which went into effect in 1977 and are administered by the New York State Department of Environmental Conservation (DEC).

Under this program, the DEC classifies various wetland zones and adjacent areas where human activities may have the potential to impair wetland values or adversely affect their function.

[19]The regulations and policies discussed here represent the entirety of New York State's official policies on erosion control activities on the marine coast. In New York, the marine coast is generally thought of as the salt/brackish portion of the tidal areas in the southern part of the state (as opposed to the Great Lakes). The Hudson River has both fresh and saltwater tidal environments. As discussed in the Tidal Wetlands Act section, the State has used the Tappan Zee Bridge as a dividing line between marine and freshwater environments in their regulations and laws. Above the Tappan Zee, Protection of Waters (Article 15, Environmental Conservation Law Implementing Regulations 6NYCRR Part 608) and Freshwater Wetlands (Article 24, Environmental Conservation Law Implementing Regulations 6NYCRR Part 663, Part 664, And Part 665) regulations would control activities along the banks of the Hudson River. State permitting decisions are made on a case-by-case basis following these regulations and policies, which are tailored to the region and specific site conditions. To the extent possible, this has been addressed in the meeting sections both for the state and the counties.

[20]See http://www.law.pace.edu/landuse/stinso.html.

[21]For example, the Draft Environmental Impact Statement on the Long Island Sound Coastal Management Plan prepared by the DOS includes sea level rise in the section describing factors affecting erosion and flooding and includes IPCC estimates of future sea level rise (pp. 114–115).

[22]Rockland County has approximately 5 miles of shoreline below the Tappan Zee Bridge. Because of the limited extent of coastline in this county and the limited resources available for this effort, Rockland was not included in this study.

The regulations govern a variety of activities, including dredging; filling; siting and construction of buildings, roads, and other facilities; and subdividing land in these areas. Tidal wetlands jurisdiction encompasses an area that extends from 6 feet below mean sea level to 300 feet landward of any wetland (except in New York City where the distance is 150 feet) or to an elevation of 10 feet (MSL) or to the seaward edge of the most seaward, substantial artificial structure such as a road or bulkhead constructed before 1977. Because the regulations include nonvegetated intertidal areas as well as wetlands, the jurisdictional area encompasses the entire marine coast, not just vegetated marsh areas.

Permits are required for most activities that take place in this area. The DEC has identified classes of actions that have been deemed "generally compatible," "presumptively incompatible," and "incompatible" with the various categories of wetlands defined in the regulations. Permits are reviewed using these standards. Maps produced by the DEC in the 1970s using photo interpretation show the designated wetland categories on orthophotos. Portions of these maps have been periodically updated. Because wetland boundaries may have changed since the maps were produced, the DEC requires applicants to have the tidal wetland boundaries delineated at the site by a qualified professional. DEC staff check and, if necessary, require modifications to these boundaries as part of the permit review procedure. As a result, these boundaries are updated continually from a functional standpoint.

The regulations require that all new principal buildings and structures greater than 100 square feet (excluding docks, piers, bulkheads, etc.) as well as roads and other infrastructure (utilities, parking areas, etc.) be set back 75 feet (30 feet in New York City) landward of any tidal wetland boundary. Septic tanks, cesspools, leaching fields, and other sanitary system components must be set back 100 feet. In addition, there must be at least 2 feet of soil between these systems and the seasonal high groundwater level (or rock or other impermeable material). The regulations also require that outside of New York City all new building lots must be a minimum of 20,000 square feet if serviced by a public sewage disposal system and 40,000 square feet if individual onsite systems are used. These provisions do not apply to lots legally subdivided before August 20, 1977.

Variances to the tidal wetlands regulations may be granted if the applicant can prove the restrictions pose practical difficulties or would be contrary to the intent of the law; however, variances may not be granted if they would compromise the objectives of the Tidal Wetlands Act.[23] The commissioner of the DEC is empowered to buy tidal wetlands where imposing these restrictions would be a taking that requires "just compensation" under the 5th and 14th Amendments of the U.S. Constitution.

### Waterfront Revitalization and Coastal Resources Act (Executive Law, Article 42)

This act authorizes the DOS to implement the New York State Coastal Management Plan (CMP). The state CMP includes 44 written policies to guide management, protection, and use of the coastal zone. Although these policies do not directly address sea level rise, seven of them (Policies 11 through 17) address flooding and erosion hazards, and sea level rise is considered in application of these policies.[24] Basically, these policies seek to:

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[23]Comment offered by Barry Pendergrass, in email to Jim Titus titled "RE: Sea Level Rise – Wetlands Impacts Projection (Jay Tanski paper)" on 19 September 2007.

[24]The original state policies relating to coastal hazards and flooding contained in the New York State Coastal State Management Program and Final Environmental Statement (1982) read as follows:
POLICY 11. Buildings and other structures will be sited in the coastal area so as to minimize damage to property and the endangering of human lives caused by flooding and erosion.
POLICY 12. Activities or development in the coastal area will be undertaken so as to minimize damage to natural resources and property from flooding and erosion by protecting natural protective features including beaches, dunes, barrier islands and bluffs.
POLICY 13. The construction or reconstruction of erosion protection structures shall be undertaken only if they have a reasonable probability of controlling erosion for at least thirty years as demonstrated in design and construction

- move development away from areas threatened by coastal erosion and flooding hazards,
- protect natural protective features such as dunes,
- ensure that development activities do not exacerbate erosion or flooding problems,
- provide guidance for public funding of coastal hazard mitigation projects, and
- encourage the use of nonstructural erosion and flood control measures where possible.

Currently, the DOS is refining and simplifying the policies and tailoring them more specifically on a regional basis. The thrust of the policies, however, will remain the same. Local governments can also voluntarily participate in the coastal program through the development of Local Waterfront Revitalization Programs (LWRPs), which require municipalities to adopt minimum state policy standards, including those for flooding and erosion. A number of communities in the New York City/Long Island area are in various stages of developing LWRPs, but only a few (the Village of Sag Harbor, Greenport, and New York City) have adopted such programs so far.

Policy implementation is carried out through a process known as consistency review. The DOS's Division of Coastal Resources reviews projects and activities of federal agencies for consistency with the policies of the state CMP. This consistency review is mandatory for all actions requiring a federal permit or using federal funds. A federal permit cannot be issued unless the State determines it adheres to state and, where applicable, local policies. State agencies are also required to ensure consistency of their projects and activities with state and local program policies.

## Coastal Erosion Hazard Areas Law

The Coastal Erosion Hazard Areas (CEHA) program (Article 34 of the Environmental Conservation Law) was developed in conjunction with the Waterfront Revitalization and Coastal Resources Act to address erosion and development problems along the state's higher energy shorelines.[25] The CEHA areas in the marine portion of New York are limited to the open ocean coastlines and the exposed coasts of Long Island Sound (i.e., not in the harbors or bays). The law is implemented under the Coastal Erosion Management Regulations (6NYCRR Part 505) administered by the DEC. The regulations focus on minimizing the impacts of erosion and threats to public property and safety through the use of building setbacks and construction restrictions, preservation of natural protective features, and establishment of guidelines for public expenditures on erosion control projects.

Under the CEHA program the DEC identified areas subject to erosion and established two types of erosion hazard areas (structural hazard and natural protective feature areas) where development and construction activities are regulated. Structural hazard areas are found along those portions of the shoreline where the

standards and/or assured maintenance or replacement programs.
POLICY 14. Activities and development, including the construction or reconstruction of erosion protection structures, shall be undertaken so that there will be no measurable increase in erosion or flooding at the site of such activities or development, or at other locations.
POLICY 15. Mining, excavation or dredging in coastal waters shall not significantly interfere with the natural coastal processes which supply beach materials to land adjacent to such waters and shall be undertaken in a manner which will not cause an increase in erosion of such land.
POLICY 16. Public funds shall only be used for erosion protective structures where necessary to protect human life, and new development which requires a location within or adjacent to an erosion hazard area to be able to function, or existing development; and only where the public benefits outweigh the long term monetary and other costs including the potential for increasing erosion and adverse effects on natural protective features.
POLICY 17. Non-structural measures to minimize damage to natural resources and property from flooding and erosion shall be used whenever possible.

[25]This law focuses primarily on minimizing damage to property and preventing the exacerbation of erosion hazards by restricting or prohibiting activities that may adversely affect natural protective features rather than on protecting the natural features themselves.

long-term average recession rate is 1 foot per year or greater. The boundary of these areas extends inland from the landward edge of a protective feature such as a bluff or dune a distance equal to 40 times the annual average recession rate. Because of difficulties in separating natural shoreline changes from those influenced by human activities, there are no structural hazard areas on New York's marine coast.

Natural protective features include nearshore submerged lands (defined as those lands beginning at mean low water and extending seaward to a point where the water depth at low tide is 15 feet or to a distance of 1,000 feet, whichever is greater), beaches, dunes, bluffs, and wetlands. The required natural protective feature areas include a 25-ft setback from the receding edge of a bluff or the landward toe of a primary or secondary dune and 100 feet inland of the landward edge of a beach where no dune or bluff exists. The enabling legislation requires the commissioner of the DEC to review the maps every 10 years or after major events and to revise the boundaries as necessary. There have been no major systematic reviews, however, since the State produced the original maps in the early 1980s.

CEHA permits are required for most activities in designated natural protective feature areas.[26] New development (building, permanent shed, deck, pool, garage, etc.) is prohibited in nearshore areas, beaches, bluffs, and primary dunes.[27] A permit is required for restoring structures within these areas damaged by erosion or flooding, even if the structure was not within a protective feature area when it was originally built. Such a permit would be denied for rebuilding structures damaged by more than 50 percent if the lot has sufficient land outside the natural protective feature area to permit a landward relocation. Unlike the Tidal Wetlands Act, the CEHA does not include a provision empowering the commissioner of the DEC to purchase property when denying a permit would require just compensation under the takings clause of the U.S. Constitution. Moreover, variances can be granted if the applicant can prove "practical difficulty or unnecessary hardship" without compromising the CEHA regulations. Therefore, if there is not sufficient land outside the natural protective feature area to rebuild the structure inland, the landowner may still be able to obtain a permit by seeking the minimum variance necessary to maintain some lawful use of the property, consistent with the regulations.[28] A representative of the New York Department of State indicates, however, that "there are specific legal requirements for variances in New York and most applicants will have difficulty obtaining variances if the resulting actions are detrimental to the resources the regulates are designed to protect, including tidal wetlands."[29]

Under the law, local municipalities are allowed to enforce the regulations. The locality must adopt regulations that are at least as stringent as the state regulations. If the local municipality (city, village, or town) does not adopt regulations or fails to enforce them, the County (except for New York City, which is treated as a single entity under the regulations) is given the opportunity to implement the regulations. If the County declines, the responsibility shifts to the State and the DEC to control development in

[26] Restoration of existing structures that are damaged or destroyed by events not related to coastal erosion or flooding does not require a CEHA permit.

[27] Erosion protection structures may be permitted in these areas but must "have a reasonable probability of controlling erosion for a period of 30 years," "not be likely to cause any measurable increase in erosion at the development site or other locations," and "minimize, and if possible prevent, adverse effects to natural protective features, existing erosion protection structures, and natural resources…" (6 NYCRR Part 505.9). Furthermore, in natural protective feature areas, the structures "will only be allowed at the seaward toe of primary dunes and must not interfere with the exchange of sand between the primary dunes and their fronting beaches" (6 NYCRR Part 505.8.d.8).

[28] Barry Pendergrass of the New York Department of State's Division of Coastal Resources in email to Jim Titus titled "RE: Sea Level Rise – Wetlands Impacts Projection (Jay Tanski paper)" on 19 September 2007.

[29] Barry Pendergrass of the New York Department of State's Division of Coastal Resources in email to Karen Scott entitled "Sea Level Rise – Wetlands Impacts Projection" on 31 May 2007.

hazard areas. Although no counties in the New York City/Long Island area have adopted the regulations, 24 of the 34 shorefront communities have developed programs that have been approved by the State and a number of the other municipalities are in the process of adopting their own erosion hazard management programs.

There was general agreement among those individuals that participated in the meetings that existing coastal erosion hazard area regulations are conceptually very good, provide a process for addressing problems, and can help maintain natural shores for the short to medium term. They do not, however, address the long-term impact of sea level rise because development along New York's marine coast extends so far inland from the shoreline. Even if the act is used to deny a permit for the reconstruction of a structure located along the waterfront, shoreline protection is likely to be employed at the next already-developed lot.[30]

Since the original meetings were held, however, state planners envision scenarios under which wetlands would be able to migrate onto currently occupied property. Currently, construction and land elevation is regulated up to 300 feet (150 feet in New York City) landward of the mapped wetland boundary. The minimum setback for buildings is 75 feet (30 feet in New York City) from the wetland boundary. Although homeowners can continue to protect their property outside these zones, major storms are likely to lead to erosion and destruction of property. Land that had been between 300 and 600 feet from the wetlands might then be less than 300 feet from the wetland edge. After such an event, the State can enforce the applicable regulations to prevent individuals from rebuilding and the land could be graded down to wetland elevation. Thus, wetlands could migrate inland 300 feet each time there was a devastating storm.[31]

## Septic/Sewer System Regulations

Appendix 75-A of the New York State Sanitary Code contains minimum standards governing the design, installation, and operation of septic systems. New York State Public Health Law 308 authorizes county or local health departments to enact sanitary codes, zoning ordinances, and rules or regulations as long as they are at least as stringent as the state code. Sewage disposal and related subdivision issues pertinent to coastal development and sea level rise are also addressed by the state tidal wetlands regulations. As mentioned previously, septic tanks, cesspools, leaching fields, and other sanitary system components must be set back 100 feet from any tidal wetland boundary. In addition, there must be a minimum of 2 feet of soil between these systems and the seasonal high groundwater level, rock, or other impermeable material. The regulations also require that outside New York City, all new building lots must be a minimum of 20,000 square feet if serviced by public or community sewage disposal system and 40,000 square feet if individual onsite systems are used. These provisions do not apply to lots legally subdivided before August 20, 1977.

Although sanitary system regulations may impede development of some coastal areas, there was general agreement among the officials that these regulations are designed for protecting public health and safety and do not necessarily control where development occurs. Costs associated with installing even relatively expensive centralized package plants or elevated septic systems necessary to meet sanitary regulations are relatively minor compared to the high value of the land, especially coastal land, in the New York City/Long Island area. As an example, the barrier spit east of Shinnecock Inlet was developed despite the fact that it was a

[30]Discussions with William Daley, DEC, and Fred Anders, DOS.

[31]Barry Pendergrass of the New York Department of State's Division of Coastal Resources in email to Jim Titus titled "RE: Sea Level Rise – Wetlands Impacts Projection (Jay Tanski paper)" on 19 September 2007.

federally designated CoBRA (Coastal Barriers Resource Act) area, where federal assistance is prohibited. In this case, local interests provided the necessary infrastructure for the residential development. The value of the coastal lands in New York is so high that developers can afford to construct their own water and waste treatment systems for most projects. Perhaps the only service whose absence could limit development would be the provision of electricity; this has never been an issue. As a result, these regulations are not likely to have a significant impact on future coastal development patterns.[32]

Provisions for on-site septic systems have been used to remove erosion-damaged houses from the beach, but not the dunes. The winter storms of 1992–1993 caused severe shoreline erosion on Fire Island, leaving scores of houses on the beach. The houses were constructed on piles and remained relatively intact. They were declared unfit for habitation, however, because their sanitary systems were destroyed. Under county sanitary regulations, fill could have been used on the beach to build up the elevation necessary to construct a septic system. Tidal wetlands regulations were invoked to prevent the placement of fill, thus preventing the rebuilding of the systems in this situation. These regulations prevented the rebuilding of 50 to 70 houses on the beach on the south shore.[33]

## Public Land Management

The State has significant land holdings in the study area, including parks and preserves. State policies do not explicitly address whether a particular state facility will be protected in the face of rising sea level. Rather, erosion and flooding management measures are largely determined by the primary use of the facility. Because of the density of population, many holdings are prized for the recreational benefits they provide and are heavily used. For instance, the oceanfront Jones Beach State Park on the south shore of Long Island receives 6 to 7 million visitors a year. High demand for these facilities results in management strategies that emphasize maintaining the recreational use and access while, to the extent possible, preserving and protecting the natural processes and resources found there. For example, Robert Moses State Park on the western end of Fire Island has received periodic beach nourishment to maintain and restore recreational beaches and to protect the park infrastructure (roadways, parking lots, pavilions, etc.) that provides access. Other areas such as portions of Connetquot River State Park and Orient Beach State Park are managed in a more natural state as preserves. These areas would most likely not be protected even if they were impacted by rising sea level because the recreational use would not necessarily be affected. Such decisions would be made case by case.[34]

For public lands and public protection projects, two separate coastal task forces assembled by the previous state administration examined and provided recommendations on policies related to coastal protection and development.[35] Reports from both groups contain a variety of recommendations and information on coastal flooding and erosion hazards. Both groups recommended using public funding for beach nourishment to maintain recreational beaches in heavily used areas like Jones Beach, Robert Moses State Park, and the Town of Hempstead parks on the south shore and Sunken Meadow on the north shore of Long Island.[36] These recommendations have not been officially adopted by the present administration; some of the concepts developed as part of these efforts, however, are still being used by state agencies

[32]Discussions with DeWitt Davies, Suffolk County Planning Department; William Daley, DEC; Fred Anders, DOS; and Wilbur Woods, City of New York, Department of City Planning.

[33]Discussions with William Daley, DEC, and Fred Anders, DOS.

[34]Personal communication with Dominic Jacangelo, assistant commissioner, New York State Office of Parks, Recreation and Historic Preservation.

[35]*Now and For the Future: A Vision for New York's Coast*, Recommendation of the Governor's Task Force on Coastal Resources, 1991, and *Governor's Coastal Erosion Taskforce*, Emergency Response to Coastal Storms and Long Term Strategy, 1994.

[36]Those groups also favored beach nourishment to protect developed places such as Rockaway, Coney Island, Long Beach, and Bayville.

for guidance.[37] The state is also in the process of updating its Open Space Plan.[38] The Open Space Conservation Plan guides the state's land acquisition and conservation program. Under state law, this plan must be updated every three years. The plan, which was first adopted in 1992 and revised in 1995 and 1998, includes a description of programs and policies that affect the conservation of the state's open space resources, a list of priority projects for acquisition, and criteria used to determine state spending priorities. This program is used to identify potential sites for purchase using the State Environmental Protection Fund and Environmental Quality Bond Act funds. Although sea level rise is not a criterion used in selecting properties for purchase, the plan has been used to purchase coastal properties for recreation, access, and preservation. Examples of recent acquisitions include the 66-acre Shadmoor property with 2,400 feet of Atlantic Ocean frontage on the south shore of Long Island, 60 acres of wetlands in Nassau County, 145 acres of wetlands on the north shore of Staten Island, and 145 acres of undeveloped open space along Staten Island's south shore.

The effect of an increased rate of sea level rise on the state's tidal wetlands is also of concern. The data are incomplete; however, surveys by DEC show that some areas (e.g., Shinnecock Bay and Moriches Bay) have a net gain of wetlands that is attributed to landward migration of the wetlands boundary. However, wetlands in other parts of Suffolk County and in Nassau County are having net losses, including undeveloped marsh islands on the south shore.[39] Jamaica Bay is reported by DEC to be seeing losses that are "unprecedented and accelerating."[40] Although the causes of these losses have not been definitively established, the losses may be the result of sea level rise in conjunction with other factors such as dredging, loss of natural sediment supply, and erosion. A recent report by the National Park Service documents the problem in Jamaica Bay and recommends measures to try to mitigate the loss.[41] It is unlikely, however, that significant amounts of public money will be spent to maintain wetlands in the face of rising sea level unless the public develops a better understanding of the environmental value of wetlands and supports such efforts. To a certain extent, the decision on whether to protect any area may depend on the economic climate and the availability of funds to undertake protection efforts.[42]

## Summary of the Impact of State Policies on Sea Level Rise Responses

*Meeting with William Daley, director of the DEC Bureau of Flood Protection, and Fred Anders of the DOS Division of Coastal Resources*

Because of population density and the high demand for coastal land in the Long Island and New York City metropolitan area, one has to make the assumption that if land on or near the water is not publicly owned or purchased for preservation by another entity, it will be developed. Under the existing regulations, owners of private property are protecting their coastal land, and this will continue. Private property will not be allowed to become a "wasteland."[43] Over time, this land will become more valuable and, thus, there will be even more incentive to protect it.

The State will continue to try to maintain a wetland boundary fringe, where possible, but retreat is not going to be a feasible response overall, especially on small lots, because of the density of development along most of the coast. Along the mainland bay shorelines, where sea

[37]Discussions with William Daley, DEC, and Fred Anders, DOS.
[38]The draft update of New York's Open Space Conservation Plan was released for public review and comment on October 10, 2001.
[39]NYSDEC http://www.dec.ny.gov/lands/4940.htm, http://www.dec.ny.gov/lands/31989.html

[40]NYSDEC http://www.dec.ny.gov/lands/5489.html, http://www.dec.ny.gov/lands/31989.html

[41]*The Jamaica Bay Blue Ribbon Panel on Coastal Marsh Loss and Coastal Sea Level Rise: A Future Agenda for Mitigation and Pilot Investigations*, National Park Service, Gateway National Recreation Area, 2001.
[42]Discussions with William Daley, DEC, and Fred Anders, DOS.
[43]William Daley, DEC.

level rise is anticipated to have the greatest impact because of the gentle land slopes in these areas, there are few, if any, places where properties are generally large enough to allow structures to be moved back on the lot. The most likely form of protection in these cases is elevation and direct protection from wave forces and inundation. Some form of seawall or bulkhead to fend off direct wave impact forces is needed. This form of protection is going to happen slowly. The value of the property here is such that when the incremental damage to these places gets too great property owners will elevate and protect the land. Where bulkheads and high level of development exist, municipalities will raise infrastructure and homes. This is already happening in communities such as the Town of Hempstead and Freeport on Long Island's south shore, where the village has active program for elevating streets, homes, and commercial structures affected by flooding.[44]

This protection will be implemented incrementally, and timing is an important factor.[45] If the edge of a landowner's property is flooded and it is 100 or more feet from the house, he or she may not be permitted to put in a bulkhead or other protection measure. Under present circumstances, however, when sea level rises and the structure is threatened in 30 or 100 years, the owner may then be allowed to protect.[46]

On the more energetic ocean and sound coastlines, protection by private property owners also continues. The State can keep property owners from hardening, but cannot keep them from rational attempts at protecting property through nourishment as long as there are no excessive adverse environmental impacts and they meet existing wetland regulations. Individuals and community groups have developed and implemented privately financed beach nourishment and dune/bluff restoration projects in these areas in response to storm damage.[47]

Property owners have few, if any, incentives to retreat from the coast and allow sea level rise to inundate their property. Tax relief and acquisition programs are not available for land threatened by flooding or erosion. Without incentives such as tax breaks or funds for acquisition, however, state officials are currently concerned that prohibiting shore protection or rebuilding in areas with adjacent existing development may be viewed as a regulatory taking of private land requiring "just compensation."[48] If acquisition was possible, the State could acquire lots over time, which in turn would help to maintain more natural boundaries

[44]In Freeport, the homeowner paid 25 percent, with federal funds paying most of the rest. In the future, the feasibility of this approach may depend in part on FEMA policies.

[45]The officials that participated in the discussions did not believe that private protection efforts along the entire shore would take place all at once in response to storms, based on their experiences and the fact that this has not occurred in past storms.

[46]One reviewer, Barry Pendergrass of New York's Department of State, Division of Coastal Resources, suggests that despite the potential for a "regulatory taking," permits for nonconforming structures may still be denied. Furthermore, wetlands may be able to migrate inland in the aftermath of storm damages. "State policies aim to protect both natural resources and development." Email from Barry Pendergrass to James G. Titus titled "RE: Sea Level Rise/Tanski - our last phone conversation" October 16, 2007.

[47]In most cases, these privately financed projects are relatively small and designed to provide limited protection over the short term (5 to 10 years).

[48]One reviewer noted that Titus (1998; see footnote 7) pointed out that in Lucas v. South Carolina Coastal Council, the U.S. Supreme Court held that regulations preventing construction (or reconstruction) are takings if they prevent beneficial use of a property. By contrast, regulations that prevent bulkhead construction are not a taking if either (a) the property can continue to be used without the bulkhead or (b) the bulkhead would eventually be inundated by the tides (because wetlands below mean high water and the open water itself belong to the public, and property owners have no common law right to appropriate those public lands for their own use). See, e.g., Titus (1998). Unless a property owner agrees to dismantle an erosion control structure once it is flooded at mean high water, the structure will be on public property. Therefore, Titus argues, communities concerned about possible takings claims from denying bulkhead permits can protect themselves by (1) imposing the condition that the bulkhead be dismantled once it is inundated at mean high water or (2) requiring dedication of an easement allowing a public right of way landward of the bulkhead whenever any tide reaches the bulkhead, preventing access along the shore seaward of the bulkhead.

and wetland fringe conditions. In terms of the coastal zone, however, the state open space plan is not really effective for proactively acquiring coastal properties threatened by erosion or flooding. The purpose of the plan is to get large tracts of land into public ownership. This program could be used effectively to acquire coastal land subject to the threats of flooding erosion and sea level rise on a lot-by-lot basis. State officials, however, doubt that program funding would be used in this manner because of a lack of public support.

There is general agreement that the heavily urbanized shorelines such as those found in New York City and the western portion of Long Island are going to be protected while natural areas with no development or infrastructure would probably not be protected.[49] There is a tremendous gray area in between these scenarios that is not specifically addressed by state policies. The definition of "protected" is somewhat flexible and subject to change over time. For instance, public parks like Jones Beach and Robert Moses will be protected to provide access and recreational benefits. This protection would not necessarily entail maintaining a static line or preclude shoreline migration. They will be functionally protected. Retreat/migration may be possible as long as primary use is not significantly curtailed. This is a different situation than when houses or other development is involved.

There appears to be a growing trend toward at least considering the retreat option for public lands as long as recreational demands can still be met. A meeting to discuss options for an oceanfront Suffolk County Park pavilion was provided as an example. At the meeting there was a general consensus among the state and federal agencies that there could be considerable money, support, and help if the County elected to move the structure. A decision to try to protect it in place, however, would most likely run into opposition from the same agencies.

A great deal of uncertainty remains regarding what may happen in some other areas like the 8-mile-long wilderness area in the Fire Island National Seashore. Present policy is to essentially leave the wilderness area alone. Preemptive actions will probably not be allowed. State officials think, however, that it will be difficult to maintain this policy if a major event results in a breach of the barrier island, which in turn devastates or threatens property and development on the barrier and along the mainland. There will be a public outcry from a variety of groups to take some action that may lead to some level of protection being applied. Protection might take the form of innovative actions such as filling the breach on the landward side of the barrier. It was noted that there are ways to protect wetlands and property at the same time. Maintaining natural values and providing artificial protection are not necessarily mutually exclusive.

State officials indicate that better information is required before it would be possible to develop a definitive state policy on what should be done to address an increased rate of sea level rise. In

[49]The State has partnered with the federal and local governments to undertake beach renourishment projects at Coney Island, Rockaway, Westhampton, and Jones Beach Island. Cooperative studies are also under way to evaluate the feasibility of such programs at Staten Island, the 86-mile stretch of shoreline between Fire Island Inlet and Montauk Point, and two municipalities on the north shore of Long Island, Bayville and Asharoken. A project on Long Beach is in the engineering and design phase.

particular, detailed, objective economic information is needed to better assess the costs and benefits of trying to protect areas versus allowing them to retreat. This must include a long-term life-cycle analysis, an analysis of the apportionment of cost between public and private sources, and an objective analysis of the costs and benefits of acquisition programs. More refined estimates of the rate of sea level rise (both magnitude and timing) are also necessary.

# COUNTY RESPONSES

Because New York is a home-rule state, land use and zoning decisions are usually made at the village, city, or town level. In addition to having to comply with the state-level tidal wetlands and coastal erosion hazard area regulations and consistency review procedures described previously, many local municipalities have their own wetlands regulations. State law requires these local regulations to meet or exceed state requirements, and in several cases they are more stringent.

Counties generally provide technical guidance and planning support. Although the counties are not usually involved in individual actions such as permits, they are often consulted when large-scale or community actions are proposed or community actions are being discussed. County health departments review and issue permits for water supply and sewage disposal facility plans for all new construction projects to ensure compliance. These departments also review plans for proposed subdivisions of land, including residential or commercial sites. Towns will not issue certificates of occupancy without the necessary county approvals and permits.

Figure 2-2 shows the location of New York's coastal counties. The sections that follow present anticipated responses for each county.

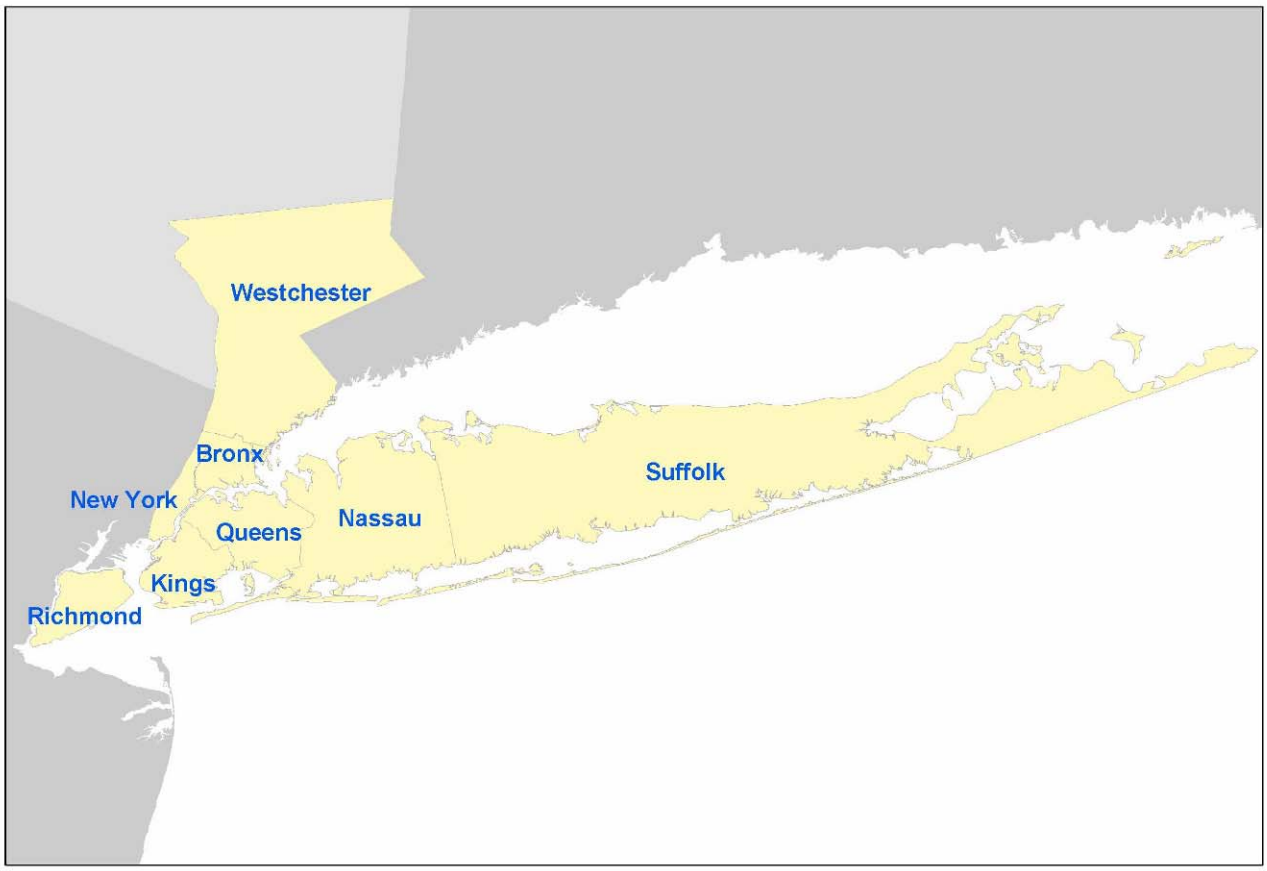



**Figure 2-2. Counties in New York Study**

# SUFFOLK COUNTY

Suffolk County has almost 1,000 miles of coastline along Long Island Sound, the Peconic bays, the south shore bays, and the Atlantic Ocean. The county has a population of 1.4 million in 10 towns and 31 villages. In the 1990 U.S. Census, the five western towns were classified as urban areas.[50] Agriculture is still a major industry in several of the eastern towns.[51] In fact, Suffolk is the state's top agricultural county in market value of crops. Development pressure on farms and other open space, however, is high and increasing in this area. As a result, farmland and vacant acreage have declined despite a number of local and state preservation programs.[52]

The densely populated western part of Suffolk County has several large regional sewage treatment plants and public sewer systems. Although some of the north shore communities and a few random developments throughout the county are also on sewer systems, many properties are served by septic or older cesspool systems. The Suffolk Count Department of Health Services issues sanitary disposal system and water supply permits under Articles 4, 6, 7, and 12 of the Suffolk County Sanitary Code. In general, any proposed project must comply with requirements that an acceptable water source is available (public water or private well) and that an adequate sanitary disposal system can be constructed on the project site or public sewers are available.

## Suffolk County Meeting

*DeWitt Davies, chief environmental planner, Suffolk County Department of Planning*

### Economic Conditions[53]

The eastern end of Suffolk County is rural compared to the more suburbanized/urbanized western portion and has a large amount of agricultural land, some of which is still actively farmed.[54] A significant tourism and resort-based economy exists here. The towns of East Hampton and Southampton, which are on the south fork of the island, are popular (and expensive) seasonal destinations for vacationers and second homeowners. A significant amount of open, subdividable land is still available, which leaves the possibility for a great deal of development. Given the pressure for development on the east end, land not bought specifically for preservation or open space will almost certainly be developed.

On the north shore of the county, commercial areas are usually concentrated around the harbors. Approximately 90 percent of land along this coast, however, is residential, parkland, or vacant lots.

In general, shoreline property values along the entire Suffolk coast are extremely high, even compared to the relatively high costs for all real estate on Long Island. Development is occurring rapidly in the county and is expected to continue for the foreseeable future. A recent study by the

[50]Huntington, Babylon, Smithtown, Islip, and Brookhaven.
[51]Riverhead, Southold, Southampton, East Hampton, and Shelter Island.
[52]*Agricultural and Farmland Protection Plan*, by the Suffolk County Planning Department, 1996.

[53]The primary source for our section on economic conditions was our meeting with the Suffolk County Department of Planning; hence the discussion for this county includes that section in the meeting report, unlike our approach for Nassau.
[54]In 2002 Suffolk County had some 32,500 acres of farmland.

Suffolk County Department of Planning stated that "…it is apparent that the next 10 to 15 years will be the most critical time to acquire the remaining available open space before the County is almost completely built-out."[55]

## Existing Coastal Policies and Practices

Existing regulations do not prevent shoreline property owners from protecting their land against flooding or erosion as long as they apply for the permits at the right time (i.e., before the land becomes wetlands). In some cases, individuals will wait until their house is in imminent danger before applying for a permit, which will almost always be granted in emergency cases. In extreme cases, individuals may wait for damage to occur, at which time the federal government may step in to relieve the burden of reconstruction in severely damaged areas. After major disasters, emergency permits may be issued, allowing applicants to receive approvals without going through a long and often costly permit process.

Local governments discourage using bulkheads and other shore-hardening structures unless the applicant shows that it is the most feasible option for protection. No one will ever be denied the right to nourish an estuarine or ocean beach, but it may take a few failed efforts at nourishment before hardening will be permitted.[56] Setbacks, relocation, and elevated walkways are also encouraged before hardening.[57] Many areas where lots have room for setbacks or relocation, however, are already hardened or will be fully hardened in the future. There is generally less shore hardening as you move from west to east along the island, along both the north and south shores. On large parcels where setbacks or relocation are possible, towns or the State can sometimes stop the construction of hard structures. But, in general, regulators must prove that the shore protection structure in question will restrict the public good in some way and that an overriding public purpose is served by denying the structures.[58] If regulators are unable to make such a demonstration, the only way to stop the construction may be for the town or State to purchase the land, and this is not always possible.

The Comprehensive Coastal Management Plan (CCMP) of the Peconic Bay National Estuary Program Management Plan calls for "no net increase of hardened shoreline in the Peconic Estuary." The intent of this recommendation is to discourage individuals from armoring their coastline, but this document is only a management plan and does not have any legal authority. Towns such as East Hampton are trying to incorporate the plan into their own programs, but they recognize that there are areas where structures will be necessary. No plan has yet been proposed for meeting this goal.[59]

The lack of a public water supply is often thought of as a constraint to development on the east end of the island, and some people are concerned that bringing in public water will encourage development. Because property values are so high, however, the cost of digging a well is usually minimal compared to the economic benefits associated with developing the land. As a result, water supply is not a controlling factor in terms of directing development. Public health issues can also affect decisions regarding water distribution. For example, in the communities of Mastic and Shirley, along Great South and

[55]Suffolk County Department of Planning, 2004, *Draft Open Space Acquisition Policy Plan for Suffolk County*, Suffolk County, New York.

[56]Nourishment is not allowed along shorelines with intertidal vegetation or shorelines composed of mud and clay size sediment. In these cases, hardening would be allowed if protection is needed and vegetative erosion control measures would not be sufficient. Although Dr. Davies was referring to Suffolk, this is generally true along most of the New York marine coast.

[57]New construction requires a setback from the shore. Applicants must consider the feasibility of relocating structures in permits for shore protection. Elevated walkways or docks rather than bulkheads are used for water access.

[58]A reviewer noted that Titus (1998; see footnote 7) points out that shoreline hardening eliminates intertidal habitat and divests the public of its right to walk along the shore or beach a boat. These general impacts on the public interest are not sufficient to stop the general use of hard structures. Specific threats to an endangered species or widely used beach, by contrast, might be a sufficient restriction of the public good to deny a permit for a hard structure.

[59] Titus et al. (2000) identify a number of strategies for meeting a no net armoring goal.

Moriches bays, there was an area of land consisting of thousands of vacant lots mostly situated in floodplains and wetlands. There has been some development, but currently limited public water supply is available. Despite the fact that it will encourage further development in an area that the County would like to discourage development, a public water supply will be provided for health and public relations reasons.

Sanitary waste system regulations are also not an effective tool for discouraging or redirecting development away from the coast. In coastal areas near wetlands or in floodplains where the site may not be suitable for septic systems, elevated septic systems are allowed. Most lots can be made suitable for septic systems. Although systems designed to meet the requirements may be expensive, the high land values can justify the expenditure. On barrier islands, if a structure or property has been largely destroyed and the tanks have been left exposed, there may be some question as to whether the owner will be allowed to occupy the structure again. As discussed previously, permission to rebuild depends on the structure's specific location. Although structures on a beach may not be rebuilt because of wetlands regulations, owners in former dune areas would be allowed to simply bring in fill and cover the tanks again.

The decision to protect publicly owned coastal property will largely depend on the type and intensity of use. Heavily used recreational areas and other infrastructure such as roads and bridges will be maintained until it is physically or financially impossible to do so. In Patchogue, a shorefront park on Great South Bay was raised to reduce the risk of flooding. Landward retreat of the park is not economically or politically feasible because the areas inland of the park are already developed with public infrastructure and residences and commercial establishments. Here and elsewhere, public coastal land protection efforts are likely to be more frequent as development increases.

Nevertheless, in areas where retreat may be feasible, local officials are increasingly taking a longer view in making decisions about protecting coastal public facilities. For example, the Smith Point County Park, one of the most heavily used county parks, is on a south shore barrier and has a pavilion with 6 miles of beach to the east and a wilderness area to the west. The pavilion, built in 1960, is now threatened by coastal erosion and in need of remodeling. The County has used fill and armoring as a short-term protection measure. County officials are now planning for a major renovation of this facility and are evaluating relocation of the structure as an alternative to protecting it in place. This type of long-term planning represents a new way of thinking about public facilities. Popular landmarks like the lighthouses at Montauk Point and Plum Island are of major cultural and historical significance on the island; because of these structures' contribution to the character of the island, they will most likely be protected at all costs.[60] Because of the intense pressure for development, Suffolk County has an aggressive open space preservation and land acquisition effort. Several programs focus on acquiring or protecting the 50,000 acres of open space remaining in the county, and hundreds of millions of dollars are being spent in trying to acquire lands that are open but still developable or subdividable.[61] The County is developing a detailed, GIS-based inventory of its lands to support this effort. GIS layers that denote the location of open lands and their current status (agricultural and subdividable, residential and already subdivided, residential and subdividable, etc.) have been developed for the five east end towns and are being used by the county and others to create priority lists for acquisition. Practically every significant piece of existing open land is on an agency or other group's list to acquire or protect.

[60]Relocation of these structures will be probably be evaluated as an alternative, but given the relatively high cost of moving some of these structures (e.g., the relocation of the Hatteras Lighthouse cost some $11 million) compared to the lower initial costs of some of the more commonly used measures, some of the landmarks are likely to be protected in place.

[61]These programs include the Farmland Preservation, Open Space, Drinking Water Protection, Community Greenways, Land Preservation Partnership, review of tax liens for environmental value, and sales tax extension, which have spent or allocated more than $529 million for preservation and acquisition.

In general, the County is interested in acquiring lands that are in floodplains, near streams or creeks, etc., because they do not want development in these areas. In the aforementioned Shirley/Mastic area, the County initiated a land exchange program where owners can exchange property in the floodplain for county-owned land outside of the floodplain. Thirty to 40 owners are participating in the program. Ongoing efforts by the state, county, and local governments are also under way to buy development rights to agricultural lands to prevent them from being developed in the future. But there are many agricultural lands that can still be subdivided and could be targeted for large-scale development.

## Response Scenarios: Suffolk County

### Existing Policies

Under existing state laws and regulations, essentially all property landward of the 75-ft buffer from the tidal wetlands boundary can be developed and protected from erosion and flooding hazards, although the form of protection may be limited to the use of fill or nourishment[62] rather than armoring. This buffer may be extended to 100 to 150 feet by local laws, which vary depending on municipality.

State regulations tend to preclude development or the use of protective measures in designated tidal wetland areas and within 75 feet of wetlands in currently undeveloped areas, allowing the shoreline in these areas to migrate in response to a rise in sea level.[63] Again, local laws may be even more stringent. Development may be allowed with a variance in wetland areas on parcels subdivided before 1977, however, if the parcels do not have adequate room for the necessary setbacks. [64]

### Anticipated Responses

Maps 2-2 and 2-3 illustrate the anticipated response[65] to sea level rise in Suffolk County.[66]

[62]Under the New York tidal wetlands regulations, tidal wetlands include all lands under tidal water seaward to a depth of 6 feet below mean water whether the area is vegetated or not. As a result, tidal wetlands include sandy beaches, shoals, flats, etc.

[63]Although tidal wetlands are outside the focus of this study, the state tidal wetland regulations also cover "adjacent areas," which extend up to 300 feet landward of the tidal wetland boundary. These regulations require new principal structures to be placed a minimum of 75 feet landward of the wetland boundary. During the permitting process new development is sited to avoid the need for protection measures.

[64]Barry Pendergrass of the New York Department of State's Division of Coastal Resources indicated (in email to Jim Titus titled "RE: Sea Level Rise – Wetlands Impacts Projection (Jay Tanski paper)" on 19 September 2007) that variances would be granted only when they are the minimum necessary to preserve a lawful use without undermining the intent of the regulation.

[65]Potential future responses to sea level rise were discussed with both state and local officials. The discussions were speculative given the uncertainty associated with trying to predict future conditions and societal attitudes toward various response alternatives. Consequently, the maps and associated decision rules are based on the planners' general assumptions regarding land use development and protection efforts and do not represent their official position on the likelihood of protection for specific areas.

[66]Maps depicting hypothetical responses to sea level were developed using Suffolk County's GIS tax map parcel data obtained from the Suffolk County Planning Department in the form of ESRI ArcView shape files. Suffolk County GIS provides information on parcel size and land use using 13 basic codes (low, medium, and high density residential; commercial; industrial; recreational and open space); the GIS contained additional information (classified in some 31 separate codes) on ownership (private, federal, state, county, town, village), use (e.g. park or preserve), and program (e.g. drinking water protection, farmland protection, open space etc.) under which land was being managed (for county holdings only); vacant, agriculture; transportation, utilities; and surface waters derived from town assessor data.
The County obtained the data for the western towns of Huntington, Babylon, Islip, Smithtown, and Brookhaven from the towns themselves in 1991 and they have not been field verified or updated. In some towns, not all the parcels had been reclassified using the County's 13 code system. In these cases, the original codes provided by the towns in the "Use" field of the data base were used to determine land use and query the data base. The County updated and verified data from the eastern towns as part of the 1999 land use inventory conducted by the Suffolk County Planning Department. Because of the rapid nature of development, however, especially in eastern Suffolk County, the present existing conditions can be considerably different than when the data were collected, so the maps must be viewed with caution. The planning map shows anticipated responses for all properties within 1,000 feet of the shoreline or below the 11.5-ft (3.5-m) elevation contour derived from digital elevation models. Because of the small scale of the map, it was not possible

Although existing regulations prohibit protective measures in very limited areas, there are coastal lands designated for preservation, conservation, or recreation that will most likely be left unprotected in the face of rising sea level. These lands, depicted in light green on the maps, include:

- Lands purchased by The Nature Conservancy and set aside for preservation (habitat, open space, endangered species);
- Publicly owned wilderness and nature preserves that provide no protection for developed areas or environmentally or economically important habitats or resources and recreation areas with limited infrastructure where intrusion by sea level rise will not limit recreational usage, such as Orient Beach State Park and Connetquot River State Park. These include all lands designated as federal, state, town, and village preserves in the Suffolk County GIS except for those found on the barrier islands east of Fire Island Inlet.

There are also lands where protection efforts would probably not be undertaken for economic reasons. These include unbuildable, undeveloped lots (defined here as vacant lots of less than 6,000 square feet, the minimum buildable size for nonsewered areas with public water[67]); agricultural lands where development rights have been acquired through transfer, purchase, or easements; and county lands under open space and drinking water protection programs. Private agricultural protection properties and private preserves are also included in this category because the specific provisions of their easements may vary. Collectively, these parcels are categorized as protection unlikely and are depicted in blue on the maps.[68]

To identify lands where shoreline protection is more likely (but not certain), the author asked the local officials to distinguish the lands that would be protected from those that might not under a hypothetical scenario with increased emphasis on protecting environmental resources and allowing shoreline migration. Under this scenario, state and county officials indicated that waterfront residential structures could possibly be relocated away from the shore rather than protected in place, where lots were large enough to accommodate the relocation. Officials did not specify a specific lot size that would accommodate relocation because the ability to relocate would depend on the configuration of the lot and local setback restrictions. They indicated, however, that 1 acre was a reasonable starting assumption for the minimum lot size necessary for relocation in developed residential areas. This same minimum lot size was applied to all vacant and agricultural[69] waterfront parcels.[70] Thus, the maps show all waterfront residential, vacant, and agricultural properties

to indicate the 75-ft buffer from wetlands and the shoreline where development would be prohibited. The tidal wetlands shown are based on the DEC's 1974 coverages, which include only the areas from Moriches Bay to Montauk on the south shore and Gardiners Bay between the forks, and DOS wetlands maps prepared for the south shore estuary. Tidal wetlands coverages in digital format are not available at this time for Peconic Bay system or the north shore embayments, so wetlands in those areas are not mapped here.

[67]In their 1999 report *Land Available for Development in Eastern Suffolk County (2000)*, the Suffolk County Planning Department did not include parcels of less than 6,000 square feet in their classification of lands available for development because the Suffolk County Health Department does not usually issue permits for residential development on existing lots of less than 6,000 square feet in areas with no centralized sewer system. Since most of the towns (Huntington, Smithtown, Brookhaven, Riverhead, Southold, Southampton, East Hampton, and Shelter Island) do not have extensive sewer service, it was assumed that building permits would not be issued for lots under 6,000 square feet and these areas would not be protected. This restriction was not applied to Babylon and Islip, where public sewers are more prevalent.

[68]This category includes lands under the following Suffolk County programs: Farmland Preservation Program (1976), Drinking Water Protection Program (open space, water quality protection and restoration and farmland protection components), Land Preservation Partnership, and Community Greenways Program (open space and farmland components but not the active recreation component).

[69]The county database included 56 parcels in the study area of less than 1 acre with a land use designation of agricultural.

[70]Officials indicated that because of the high demand for land, they expected all coastal land not set aside for preservation to be developed in the next 10 to 20 years.

greater than or equal to 1 acre as likely to be protected and colored red.

Other areas designated as only likely to be protected and shown in red on the maps include parks and recreational areas[71] as well as those preserves on the barrier islands that functionally provide protection for developed areas or economically important estuarine habitats or natural resources in the back bay areas. Parks and recreational areas were designated as only likely to protected based on the statements of state and local officials, who indicated that the parks and other active recreation areas are valued by the public and would be protected if sea level rise diminished their capacity or use, but this could possibly be done while allowing some migration of the shore.

Areas designated as preserves that provide protection for other developed areas, important habitats, or resources primarily are conservation lands and preserves on Fire Island and the other barrier islands to the east. This designation reflects policies set forth in the state and federal breach contingency plan mentioned earlier.[72] This plan, which covers the ocean shoreline east of Fire Island Inlet, calls for closing potential breaches in the barrier as they occur and maintaining the integrity of the barrier island with sand nourishment. Stockpiles of sand have been established at several locations. Because the occurrence of breaches, however, is sporadic and unpredictable, there is still some uncertainty about whether protective measures will be needed or actually implemented in this area. Because of this uncertainty and the fact that breach closure efforts may allow for some shoreline migration, the preserves on the barriers in this area are shown in red.

Officials indicated that lands containing buildings and infrastructure that cannot be moved or easily adapted to minimize damage from increased sea level rise, including large public and private buildings, roads, bridges, and parking areas, would be protected. Publicly or privately held coastal landmarks of historic or cultural value would also be protected. For example, the U.S. Army Corps of Engineers constructed a substantial revetment around the Montauk Lighthouse at the eastern tip of Long Island and is currently involved in a $900,000 feasibility study to determine the best options for long-term protection of this facility. On the maps, lands identified as almost certain to be protected are shown in brown and include commercial, industrial, institutional, transportation, utility, and waste handling and management facilities.[73]

Officials also indicated that developed residential waterfront properties as well as undeveloped but buildable or subdividable residential waterfront properties where relocation or setbacks were not feasible because of size constraints would almost certainly be protected given the high land values in this area. Thus, lots in residential use or vacant land of less than 1 acre would be protected and thus are brown on the maps.

Even for large waterfront lots, county and state officials suggested that shoreline migration in developed waterfront areas would occur only if there was room to move the structure inland within the lot. When structures are threatened and relocation is no longer possible, some type of protection will be implemented to save the remainder of the parcel. Similarly, on large, undeveloped (vacant or agricultural) waterfront lots, shoreline migration might continue until the ability to build on the lot was threatened. At that point protective measures would be implemented to preserve the value of the land. As a result, residential and undeveloped parcels landward of these lots would almost certainly be protected even if they exceeded the size threshold

[71]These are the parcels classified as open space and recreation in the county GIS but are not listed as public preserves.

[72]Fire Island to Montauk Point, Long Island, New York Breach Contingency Plan. 1996 U.S. Army Corps of Engineers, New York District, North Atlantic Division.

[73]The planning map shows the parcels with land use classifications of commercial, industrial, institutional, transportation, utility and waste handling and management in the Suffolk County database. In reality, protective measures, if implemented at all, would probably be limited to protect improvements and structures on the properties and not the entire parcels. For this reason, the map probably overestimates the areas were protection would actually occur.

necessary for relocation or setbacks. For this reason, inland residential, vacant, and agricultural lots greater than 1 acre are also shown as almost certainly protected (brown) on the maps.[74] Some of the waterfront lots already have protective measures in place that would prevent shoreline migration. Since the available data allowed working only with whole lots and did not contain information on structures or improvements, the maps probably overstate the area where alternatives to protection are possible.

Although not considered in the mapping exercise, efforts to preserve "natural" areas could potentially extend to the lands that may be lost if no action is taken. Recent DEC surveys[75] show considerable loss of the vegetated wetlands associated with the marsh islands found in barrier lagoon in the southwestern portion of the county (Great South Bay). Although the causes of these losses are not well understood, it does not appear that the wetlands will be able to maintain themselves in the face of a rising sea level. As a result, the State has indicated that the marsh islands may have to be artificially protected to maintain the vegetated wetlands.

## Stakeholder Review

As part of the stakeholder review process, the author met with Dr. Davies of the Suffolk County Department of Planning on April 14, 2004, in the Planning Department offices in Hauppauge to review portions of the report and the draft response maps related to Suffolk County. Comments provided by Dr. Davies on a previous draft had already been incorporated into the text, so no substantive changes to the narrative were needed. Dr. Davies did provide a draft report by the Planning Department entitled "Open Space Acquisition Policy Plan for Suffolk County," which contained updated information and data on development and acquisition trends. This updated information was incorporated into the report as appropriate. In reviewing the maps, Dr. Davies suggested several changes, and the maps were modified as described below.

***Gardiners Island in Gardiners Bay was changed from a designation of protection likely (red) to protection unlikely (blue).*** Gardiners Island is a 3,000-acre parcel with a single owner. The island has been in the same family for centuries and is managed as a private preserve with only one principal structure. Although not aware of any specific environmental easements on the property, Dr. Davies felt it was unlikely that the entire island would be developed or protected based on its history and ownership.

***Robbin's Island and Cow Neck in Little Peconic Bay were changed from a designation of protection likely (red) to no shore protection (green).*** Again, a single owner is using these two parcels as a private preserve. Dr. Davies noted that there are conservation easements and development restrictions in the form of covenants associated with both these properties. Although not familiar with the specific conditions of the easements, he believed that the coastline on these properties would be left in a natural state and not protected, with the possible exception of relatively small boat-access points, based on the existence of the easements and the present management of the properties. Obviously, there may be other similar situations in some of the 85,000 parcels in the study area where easements will preclude protection efforts. Unfortunately, the information to make this assessment is not available in a centralized source.

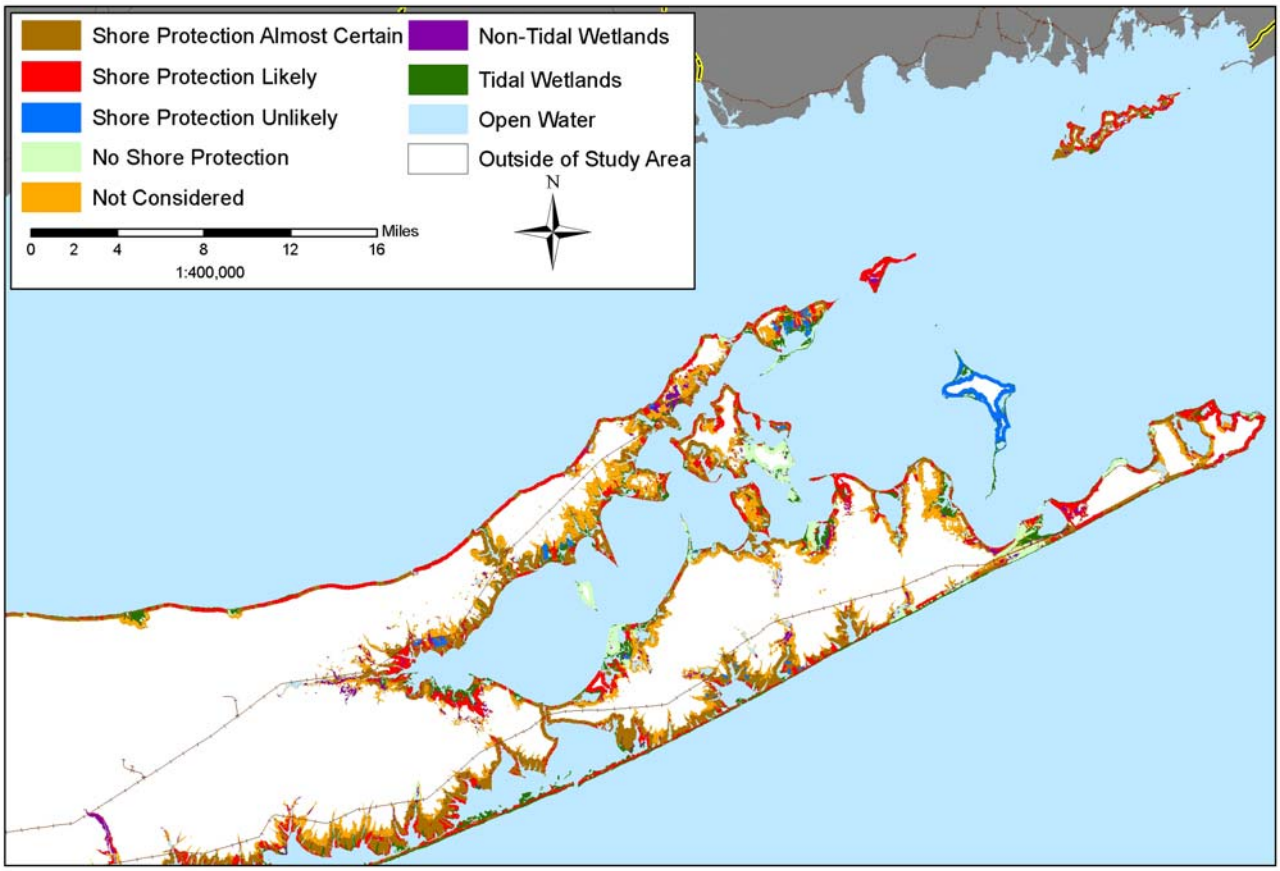
Dr. Davies also indicated that in some cases where there are large parcels designated as protection almost certain because of the land use, it is possible that the protection efforts may not cover the entire parcel. For instance, on Plum Island, which is on the eastern end of Long Island and houses a federal animal disease laboratory, protection is certain, but portions of the island that do not contain facilities or

[74]These protected "inland" properties were identified by using a query statement that selected residential, vacant, agricultural properties greater than or equal to 1 acre and not on the water (i.e., outside a 100-ft buffer from the vector coastal boundary). Where the properties were immediately landward of a preserve, the first row of parcels was classified as only likely to be protected (red) under the assumption that the preserve would not be protected and relocation or setbacks would be employed in response to sea level rise.

[75]NYSDEC http://www.dec.ny.gov/lands/31989.html.

infrastructure may be left unprotected for economic reasons. He also noted, however, that making this type of determination would require a much more rigorous site-by-site examination of the individual lots, which was beyond the scope of this study. As a result, he felt that designations based on the land use used to develop the maps provided the most consistent and appropriate representation of expected responses.

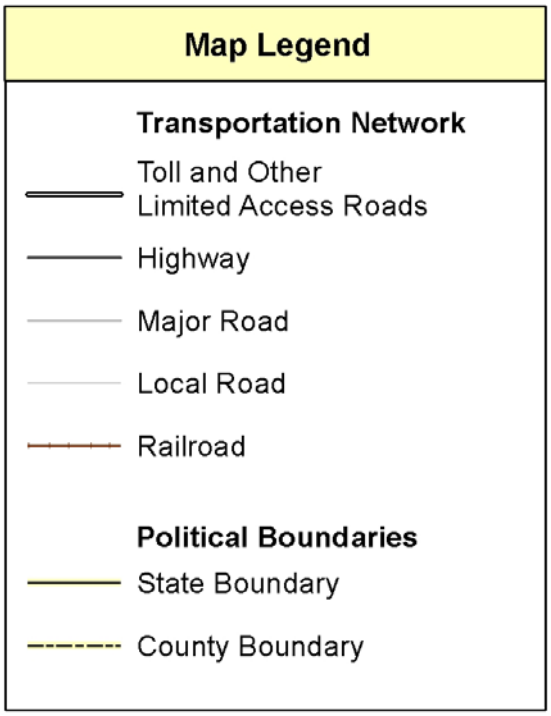
Despite the limitations mentioned above, Dr. Davies indicated that the maps provided a reasonable representation of the potential responses to sea level given the nature of the study and the available data.

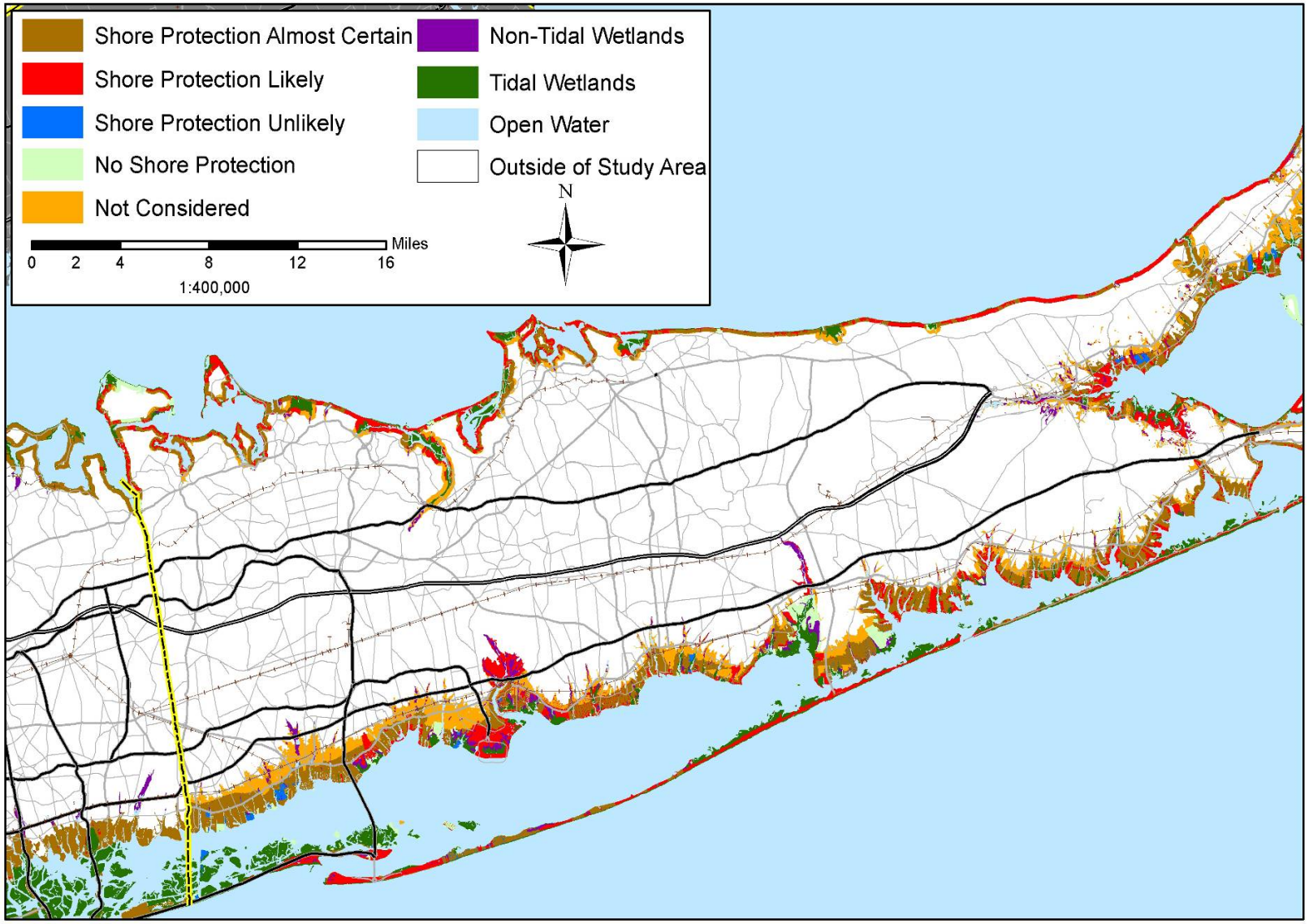



**Map 2-2. Eastern Suffolk County: Likelihood of Shore Protection.** Map created using Suffolk County GIS data (Suffolk County Real Property Tax Service Agency GIS Basemap COPYRIGHT 1991 and 1999, County of Suffolk, N.Y.) The caption and detailed legend for this and the other county-specific maps is located on the following page.

**Caption associated with Maps 2-2 through 2-9:**

The map illustrates each shore protection category for lands within the study area, defined as land under 11.5 feet (3.5 meters), or within 1,000 feet of the shore (except Nassau County, which is limited to the 500-year floodplain). This map is based on data published between 1991 and 2003 (with the exception of wetlands data, which were published in 1974). Although the map also reflects site-specific changes suggested by planners in 2004, the intended use of this map is to convey countywide 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 2-3. **Western Suffolk County: Likelihood of Shore Protection.** Map created using Suffolk County GIS data (Suffolk County Real Property Tax Service Agency GIS Basemap COPYRIGHT 1991 and 1999, County of Suffolk, N.Y.) For additional details, see the legend and caption accompanying Map 2-2.

# NASSAU COUNTY

Nassau County lies between Suffolk County to the east and Queens County to the west. The county is bordered to the north by Long Island Sound and to the south by the Atlantic Ocean and has 348 miles of coastline. Although approximately one-third the size of Suffolk County (300 versus 911 square miles), it has a similar population of almost 1.3 million.[76] The area is very densely developed, with less than 2 percent of the land area vacant. Unlike Suffolk, Nassau is heavily sewered with some 43 domestic and commercial waste treatment plants.[77]

Government is somewhat complex in that the county is composed of three towns, and includes two cities and 64 incorporated villages. The towns, cities, and villages are primarily responsible for land use decisions. The largest of these entities is the Town of Hempstead. The town has a population of 730,000,[78] making it the most populous township in the United States, and encompasses most of Nassau's Atlantic and south shore bay coastal area. The town's Department of Conservation and Waterways has primary responsibility for managing and overseeing its 20,000 acres of wetlands and 180 miles of ocean and bay shoreline. For this reason, the author met with the department's senior staff to determine how municipalities might respond to increased rates of sea level rise on a local level. The issues and problems associated with coastal development faced by Hempstead are similar to other Nassau municipalities, and so the findings presented here are considered representative of the county as a whole.

## Economic Conditions

Nassau County is primarily suburban with urbanized areas. The southern third of the county, where the Town of Hempstead is located, is fully developed. It is primarily residential but also has industrial and commercial uses. The coastal area is characterized by a low-lying, glacial outwash plain fronted by a barrier island system with extensive bays and marsh islands. Much of the residential development along the bay shorelines was built on wetlands filled with dredged material before the implementation of the state Tidal Wetlands Act. The central section also includes a mixture of commercial, industrial, and older residential areas and more urban centers such as Hicksville. Along the north shore, development is less dense and commercial development is centered on the harbors. This area, known as the "Gold Coast," still has many larger properties and estates established in the 1920s.[79] High bluffs of glacial origin are found along much of the shoreline here, making development in this area less susceptible to problems associated with increased sea level. In contrast, in places where marshes are found at the base of bluffs, there is a risk of wetlands loss because the steep terrain may preclude lateral migration.

After a period of explosive growth, between 1940 and 1970, Nassau experienced population losses in the 1980s. These losses have subsided: the county has had modest population growth in recent years accompanied by new home

[76] *Long Island Population Survey 1999*, Long Island Power Authority.
[77] *Areawide Waste Treatment Management Plan, Summary Plan, 1978*, Nassau-Suffolk Regional Planning Board.
[78] *Long Island Population Survey 1999*, Long Island Power Authority.
[79] *Areawide Waste Treatment Management Plan, Summary Plan, 1978*, Nassau-Suffolk Regional Planning Board.

construction, and Hempstead has the highest growth rates.[80]

## Hempstead Meeting

James Browne, Michael Foley, and Robert Wenegenofsky, Town of Hempstead Department of Conservation and Waterways

### Existing Coastal Policies and Practices

The Town of Hempstead has adopted the provisions of the state's Coastal Erosion Hazards Area Act, described earlier, and administers the program through its Department of Conservation and Waterways. Erosion and flooding along the county's ocean coast have been a major concern, and the town has been actively working with the U.S. Army Corps of Engineers to develop a long-term storm damage reduction plan for the heavily developed Long Beach barrier island. Currently, the plan is in the engineering phase, it calls for a combination of beach nourishment and structures to maintain a protective beach.[81] The town has committed funds for their share of the project, which has an estimated initial cost of $85 million (1996 dollars). In addition to Hempstead, Nassau County and the City of Long Beach are local sponsors of the planned project.

State tidal wetlands regulations are enforced by the DEC. Similar to other Long Island towns, Hempstead was granted ownership to all the tidal wetlands and underwater lands in the bays and creeks within town boundaries under several patents.[82] These holdings are managed and controlled by the Department of Conservation of Waterways as agent for the Hempstead Town Board. Under Chapter 164 of Town Law, entitled Public Wetlands Preservation, all tidal wetlands and underwater lands are to be held in the public trust for marine recreation and conservation purposes.[83] Although there are provisions for leasing and using these publicly held areas, the town is committed to protecting and preserving wetlands and would not allow deleterious uses to occur on their holdings.

Although existing wetlands are protected, sea level rise is not yet considered in town law. There is concern about the effects that sea level might have on the extensive marsh islands in the south shore bays. The town, recognizing the importance of these wetland areas, has been monitoring marsh restoration efforts conducted by the National Park Service in Jamaica Bay and has been active in monitoring and research efforts.[84] As indicated in the discussion of Suffolk County, it is likely that efforts would be undertaken to mitigate increased losses of wetlands vegetation due to inundation, should this loss occur.

Because of the intensity of development in Nassau County, much of the shoreline has

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[80] *Long Island Population Survey 1999*, Long Island Power Authority.

[81] *Atlantic Coast of New York, Jones Inlet to East Rockaway Inlet, Long Beach New York Storm Damage Reduction Project Draft Feasibility Report. 1994*, New York District U.S. Army Corps of Engineers.

[82] Colonial patents issued by English Governor Thomas Dongan and Dutch Governor William Kieft conveyed ownership to groups of early inhabitants.

[83] Section 164-4 (Permitted Uses) of Chapter 164 states:

The lands held pursuant hereto shall be used for the following purposes and no others:

A. The promotion of natural propagation and maintenance of desirable species in ecological balance in the town wetlands and waterways.

B. The promotion and maintenance of sound management practices for such propagation and maintenance in such wetlands and waterways, having regard to ecological factors, the compatibility of production and harvesting of fish and wildlife crops with other necessary and desirable land uses, the improvement of fish and wildlife resources for recreational purposes, the requirements for public safety and the need for protection against abuse of the privileges of hunting, fishing or trapping.

C. The preservation, maintenance and improvement of channels, creeks, canals, bays and other waterways of the town in a manner to meet the needs of boatmen but consistent with sound conservation practices, any material removed pursuant to this section to be used for public purposes only.

D. The promotion and maintenance of areas for public marine recreation purposes consistent with sound conservation practices.

E. The construction and maintenance of structures in waterways for the use of abutting private property owners to permit proper docking of boats and access to navigable channels, provided that any and all required municipal permits be obtained.

[84] The department maintains a network of tide gauges and water quality monitoring stations and has worked cooperatively with researchers from Stony Brook University on research projects looking at wetlands processes.

already been protected, primarily by bulkheads. The Nassau County GIS database shows 528 miles of bulkheads. In addition to the provisions of the state tidal wetlands regulations, erosion and flooding control structures are also regulated by localities. Chapter 168 of the Hempstead Town Law, Structures in Waterways, regulates the construction of docks, floats, piles, and bulkheads in town waterways. The law requires a permit from the Department of Conservation and Waterways in addition to permits from all other applicable state and federal agencies. The law also sets standards for the structures, which primarily relate to engineering design and ownership rather than environmental concerns and are directed at providing adequate protection against flooding and minimizing navigation hazards. For instance, the law states: "The top wale of any bulkhead installed pursuant to this chapter of the Code shall be at a minimum elevation of six (6) feet[85] above the datum plane (NGVD 1929)[86] as defined in this chapter."[87] However, the town law also specifically states that the structures must meet the state tidal wetlands regulation requirements.

Although the town developed an open space plan in 1978, there was very little vacant land even at that time. There are few parcels larger than 3 acres available for preservation. A few small, substandard lots are vacant or have been abandoned in certain areas, but most of the shoreline is fully developed. Because most of the area is already sewered, sanitary health codes regarding septic systems will have little effect on limiting coastal development in those areas with vacant lots. Given the demand for housing because of the high population density, it is unlikely that land will be abandoned even in the face of sea level rise.

For the most part, developed areas will be protected in the future if they are not already. Several villages in the town already have active programs promoting elevation of houses and repair, replacement, or construction of bulkheads to minimize flooding threats. Together with the Hempstead Engineering Department, the Department of Conservation and Waterways has fostered the raising of bulkheads (private and public), roads, and drainage systems.

## Response Scenarios: Nassau County

### Existing Policies

Similar to Suffolk County, under present state and local laws, the wetlands and bay bottoms in Nassau are protected from development or disturbance. New structures are prohibited within 75 feet of the wetlands. Because most of this area was developed before the 1960s and on filled land in the coastal areas, however, much of the shoreline has already been bulkheaded. In many areas, the wetlands or high waterline is at the structure and there is no 75-ft buffer over which shoreline migration could occur. Although new principal structures must be 75 feet landward of the wetland or waterline, most of the shoreline especially along the south shore mainland of Long Island is already developed and has some form of existing protection. Existing regulations allow for the repair, maintenance, and replacement of these structures. Thus, legally, almost the entire shoreline, with the exception of the designated wetlands, could be protected.

### Anticipated Response

Maps 2-4 and 2-5 show Nassau County's anticipated response to sea level rise based on

[85] As part of the stakeholder review, department representatives said they have been issuing guidance that suggests a 7-ft elevation is more appropriate.

[86] 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.

[87] Surrounding municipalities such as the Village of Freeport have similar laws setting minimum design requirements for these structures. Rather than being discouraged, use of bulkheads is often encouraged as a means to reduce to flooding. Freeport instituted a program to replace and upgrade bulkheads along its extensive canal system and passed a bond to provide funding that will facilitate the installation of these structures on public and private property.

discussions with local agency representatives. Again, areas where protection is almost certain are shown in brown and include most of the north and south shores of Nassau County.[88] Because so much of the coastal land in Nassau is already developed and because of the present high demand for waterfront property for a variety of uses, there are few areas that would not be expected to be protected in the face of rising sea level from a practical standpoint.

Those involved in the discussions felt that the only land areas that would not be protected from encroaching sea level were the nature areas or preserves where continuation of natural processes has been given a priority. The preserves are shown in light green on the maps. They include eight properties designated as preserves in the park layer of the Nassau County GIS[89] and three park properties, Baldwin Park, Oceanside Marine Nature Study Area, and Lido Beach Nature Area, identified as preserves by Town of Hempstead officials.[90]

The town representatives also indicated that there may be areas where protection is likely but some shoreline migration may be possible, such as passive recreational areas and parks with no infrastructure, assuming that there is sufficient room to allow some shoreline migration without diminishing capacity or use. To identify these areas, the county GIS database was queried to select parks that did not contain infrastructure or recreational facilities such as buildings, pools, and roads in the designated flood zone.[91] This analysis revealed eight parks without infrastructure in the flood area.[92] Shoreline migration may also be allowed on other large open lands under this scenario. The extent of these areas in the county, however, is minimal.[93] The area considered likely but not certainly to be protected is shown in red on the maps and includes all parklands that do not have structures or infrastructure within the 500-year floodplain as well as parcels classified as open grasslands in the Nassau County GIS.

Unlike Suffolk County, lot sizes in Nassau are generally small, especially in many of the most vulnerable areas along the south shore, and are not amenable to allowing for relocation of structures. Some of these densely developed communities facing flooding problems, such as Freeport and Hempstead, have already implemented programs calling for elevating buildings and infrastructure in place and installing bulkheads for flood protection. Municipal representatives in several jurisdictions (Town of Hempstead, Village of Freeport, and Village of East Rockaway) have even proposed

[88]Response maps for Nassau County were developed using information primarily from Nassau County's GIS. The County provided ESRI shape files for various features found within FEMA-designated 500-year floodplains. These boundaries generally correspond to land elevations ranging from 7.7 to more than 16 feet above sea level *(Flood Insurance Study, Nassau County [All Jurisdictions]*, 1997, FEMA) and so represent the areas thought to be most vulnerable to sea level rise. The shape files included parks, planimetric features (such as buildings, recreational facilities, parking lots, cemeteries), major roads, and parcel centroids. The centroids were contained in a point coverage that contained information on the parcel but not the boundaries. Unfortunately, polygon representation of the parcels was not available for the entire study area at the time the study was being done. The wetland coverage was derived by combining wetlands maps prepared by the DOS for the South Shore Estuary Reserve Program based on the 1974 DEC tidal wetlands maps with areas classified as tidal wetlands in the integrated planimetric features layer of Nassau County's GIS.

[89]Mill Neck, Garvies Point, Sands Point, Leeds Pond, William Cullen Bryant, Massapequa, Merrick, and Tackapusha preserves.

[90]During the stakeholder review process, Town of Hempstead representatives noted that three parcels in the Nassau GIS data that contained areas they classified as preserves during the initial meeting (Baldwin Park, Oceanside Marine Nature Study Area, and Lido Beach Nature Area) actually encompassed areas much larger than what they considered the preserve. Closer examination of the GIS data revealed the preserve portions of these parcels were designated as wetlands. They indicated that the areas of the parcels outside the wetlands were active recreation parks and should be designated as protection likely (red) because they would probably be protected but some shoreline migration may be allowed to occur.

[91]This was done by selecting parcels from the parks layer that did not contain infrastructure (buildings, swimming pools, rinks, tennis courts, golf courses, or athletic fields) identified in the planimetric features layer.

[92]South Line Island/Zach's Bay, Smith Pond, Roslyn Beacon Hill, Sagamore Hill Historic Site, Stepping Stone, Sunset, Meadowbrook, and Carmen Pond parks.

[93]In the coastal area considered here, only 15 parcels were identified as open grassland in the Nassau GIS.

installing bulkheads in small, undeveloped lots because bulkhead elevations must be continuous to provide flood protection benefits. Decisions to implement these costly programs indicate that retreat is not viewed as a feasible option and that most areas will be protected, as indicated in brown on the maps. This includes the heavily developed Long Beach barrier island on the south shore, which has a permanent population of 70,000 high-density, year-round residences, commercial business, industry, schools, hospitals, and infrastructure. As mentioned previously, the federal, state, and local governments are currently working on an $85 million protection plan combining beach nourishment and structural elements for most of the length of the island.

Relocating structures may be more feasible along the north shore of the county, where there are larger lots and estates. As indicated by the very limited extent of the 500-year floodplain along the north coast on the maps, however, the high ground elevation associated with the coastal bluffs would tend to minimize inundation problems associated with sea level rise, so it is doubtful this would be an issue in this area. Even in instances where infrastructure (e.g., a road or sewer line) was at the base of a bluff, protection for those features seems likely to be based on the area's history of shoreline stabilization. Much of the north shore coastline is already protected with structures, some of which date back to the early 1900s, that were built to protect the estates. Based on information contained in the county GIS, there are 66 miles of bulkheads and 43 miles of retaining walls within 100 feet of the shoreline along the 117-mile coast of the north shore of Nassau County.[94] Given the history of shoreline protection and the extremely high value of the land here, protection efforts will almost certainly continue in this area.[95] For this reason, the areas not specifically designated as preserves or passive parks, as discussed above, are shown in brown.

The meeting participants indicated that recreational open space with infrastructure is and will be protected because of the intensive use of these facilities by the large county population, visitors from the adjacent metropolitan area, and other tourists. For example, Jones Beach State Park, which comprises almost the entire portion of Jones Island within Nassau County, has an extensive infrastructure of buildings, roads, parkway, parking lots, and sewage system. This park will be protected to maintain capacity even though it is located on a barrier island. Accordingly, Maps 2-4 and 2-5 shows park parcels containing infrastructure[96] as almost certainly protected and colored brown.

### Stakeholder Review, Town of Hempstead

On July 16, 2004, the author conducted a stakeholder review meeting at the department's offices in Point Lookout on the Long Beach barrier island. Attending were James Browne and Michael Foley of the Hempstead Department of Waterways and Conservation, who participated in the original discussions; Mr. Ron Masters, commissioner of the Department of Waterways; and Mr. Reid Berglind, executive assistant in the Office of the Supervisor of the Town of Hempstead. All parties had received and reviewed copies of the draft report and maps.

In reviewing the maps, the town representatives noted that three parcels designated as preserves (Baldwin Park, Oceanside Marine Nature Study Area, and Lido Beach Nature Area) on the response maps were actually active recreation parks and that these areas would be protected

[94]The lengths of the bulkhead and retaining walls are not necessarily representative of the total length of shoreline protected because portions of some of the structures were not necessarily parallel to the shoreline and there was some overlap in the position of a small number of the retaining walls and bulkheads. The shoreline length is based on New York Coastal Management Program data provided by the DEC.

[95]The protected area depicted in the planning map may be slightly overestimated along the north shore. As mentioned previously, the larger estates and parcels found here may allow for some relocation in residential areas in response to sea level. At the time of this study, however, parcel data needed to make this assessment were not available.

[96]Park parcels containing features classified as buildings, docks, water tanks, specified sports facilities or fields, golf courses, roadways, pools, or parking facilities in Nassau's GIS planimetric features layer within the floodplain.

from sea level rise, especially if the lack of protection resulted in damage to adjacent private or public structures. Closer examination of the parcels showed that the areas they considered preserves were actually smaller portions of the county GIS parcels and that the preserve areas were already designated as wetlands. At their request, all three parcels were changed from not protected (light green) to protection likely (red) to reflect the fact that the areas would probably be protected but efforts would be made to accommodate shoreline migration to the extent possible. With this change, they agreed that the maps offered, in a broad view, a reasonable depiction of the likely responses to sea level rise. They noted, however, that determining actual responses would require information and data at a finer resolution than provided here.

The meeting attendees also provided written comments on the text. The changes requested related to updating facts and figures and clarifying passages. They were incorporated into the text but did not significantly change the content or meaning of the narrative nor did they affect the designations on the response maps.

### Stakeholder Review, Nassau County

John C. Armentano, planner II with the Nassau County Department of Planning, met with the author at the planning department's office in Mineola on September 29, 2004, to review the report and maps. After reviewing the report, Mr. Armentano felt the narrative portion accurately portrayed the county's situation and what will be done regarding shoreline management and development. The County is cognizant of the fact that the shoreline is mostly developed, especially along the south shore. Along the north shore, land elevations are high because of the bluffs. Although some of the north shore harbor areas flood now, the primary concern from the County's perspective is the south shore because of the greater potential for problems. Sea level rise can have a greater impact here because of the relatively flat slopes of the land near the water. The County identified the Village of Freeport as one of the biggest areas of concern. The county Department of Public Works has already reacted to flooding problems there by raising infrastructure and utilities. The County believes storm water management, sea level rise, and storms are related because the existing storm water system drains to the bays and creeks. Although not much can be done regarding sea level rise, the County is working on storm water management and has developed regulations requiring the first 8 inches of precipitation be retained on site.

Since the south shore area is already essentially built out, redevelopment of existing marine, manufacturing, and industrial waterfront sites is an important issue. The County is receiving an increasing number of applications to redevelop boatyards and marinas. There is also a push by the DEC and others to clean up and reuse "brownfield" industrial sites. Since the highest paying use is residential, redevelopment projects are primarily directed at converting existing nonresidential waterfront sites to high-density condominiums or senior housing. On the north shore, projects are focusing on redeveloping brownfield sites with mixed uses such as commercial and residential to create or enhance town centers. Although the County does not want to perpetuate unwise use of these areas and would like to minimize flooding related losses, they do not have the ability to regulate development. They are working with local municipalities such as the Town of Hempstead and the Village of Freeport, who have zoning power, to find ways to minimize building in the designated floodplain on redeveloped lots. Mr. Armentano indicated that these lots would be developed, however, given the pressure for more residential units and would be protected because this type of development really constitutes infilling of residential areas that are protected.

As part of the stakeholder review, Mr. Armentano also examined a digital version of the maps showing the anticipated responses to sea level rise based on information provided during the discussions with state and Hempstead agency representatives. Again, he indicated that the maps accurately represented probable responses to sea level rise and suggested only two modifications, one involving reclassifying a preserve in Manhasset Bay from no protection to protection likely because of infrastructure in the

preserve and the other involving changing the designation of a parcel in Oyster Bay that had been acquired by The Nature Conservancy as a preserve.

***South Shore:*** In examining the south shore barrier islands, Mr. Armentano noted that Nassau County has only one oceanfront park, Nickerson Beach on Long Beach Island. Since the County has invested substantial effort in renovating this park, he agreed with the designation of this parcel as protection almost certain. He also agreed that Jones Beach would be protected, given its popularity and extensive infrastructure. Mr. Armentano initially thought that Inwood, a bayside community in the southwestern portion of the county, may have some open land where protection is not be certain. A closer examination of the parcels in question, however, revealed that although they were designated as open grasslands in the county GIS system, the State classifies them as tidal wetlands; thus, they are out of the study area. No modifications were needed for the south shore oceanfront or bay shorelines.

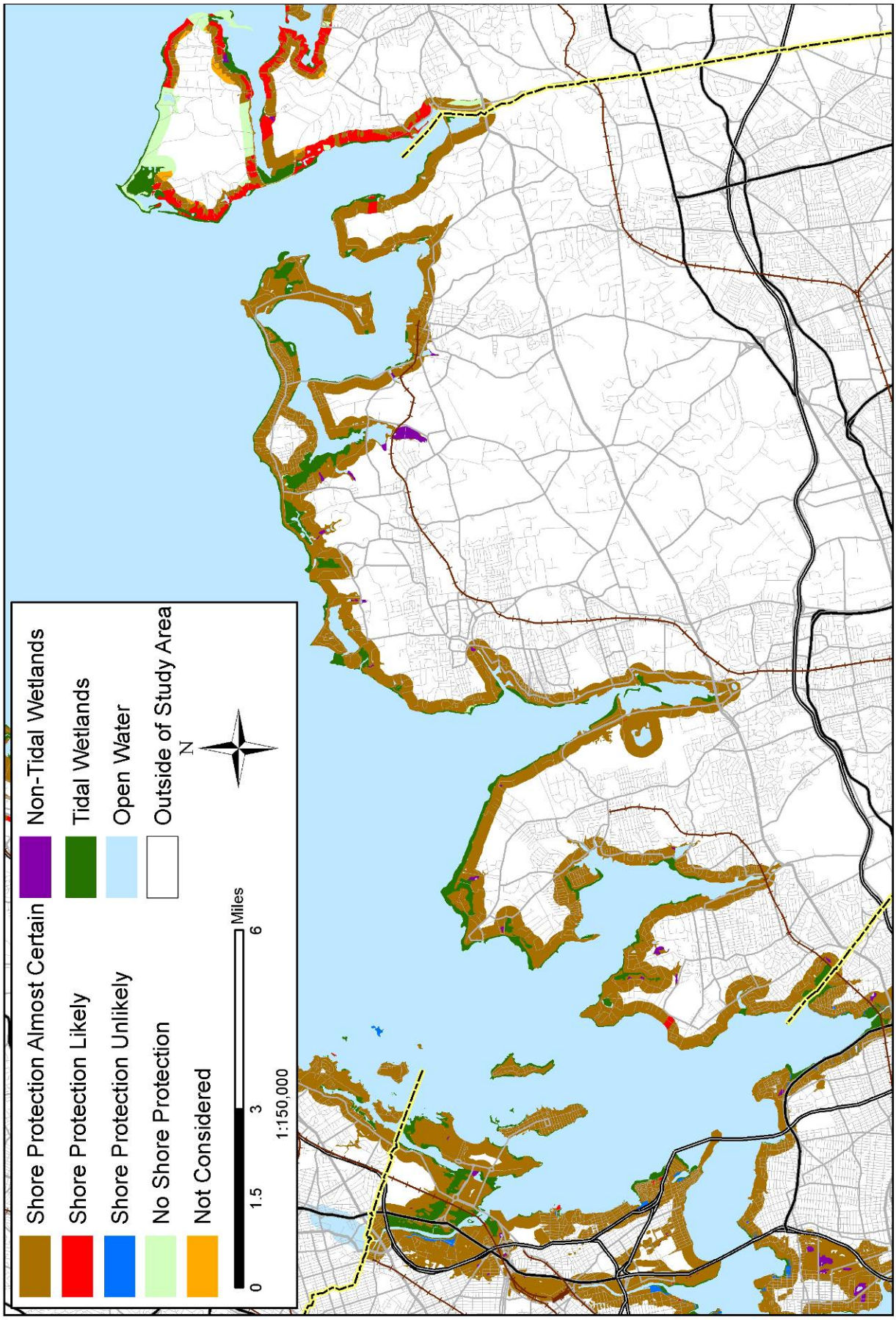
***North Shore:*** Along Little Neck Bay and Manhasset Bay in the west, bulkheads and seawalls already protect most of the shoreline. Mr. Armentano concurred with the assumption that the high value of the homes and properties in these areas would result in continued protection. He also indicated that it was likely that efforts would be made to protect Leeds Pond Preserve, on the eastern side of Manhasset Bay, because of the road and historic structures found in this area. Because some shoreline migration may be allowed, this parcel was changed from no protection to protection likely.

Hempstead Bay has roads running along both sides, and these will almost certainly be protected. The City of Glen Cove is redeveloping a contaminated industrial site on Motts Creek as a town center with residential and commercial buildings and a waterfront esplanade to provide access, which will also be protected. The headlands between the bays are primarily high bluffs with estate properties. Much of this shore is already armored and, because of the high value of the land, protection would continue in this area.

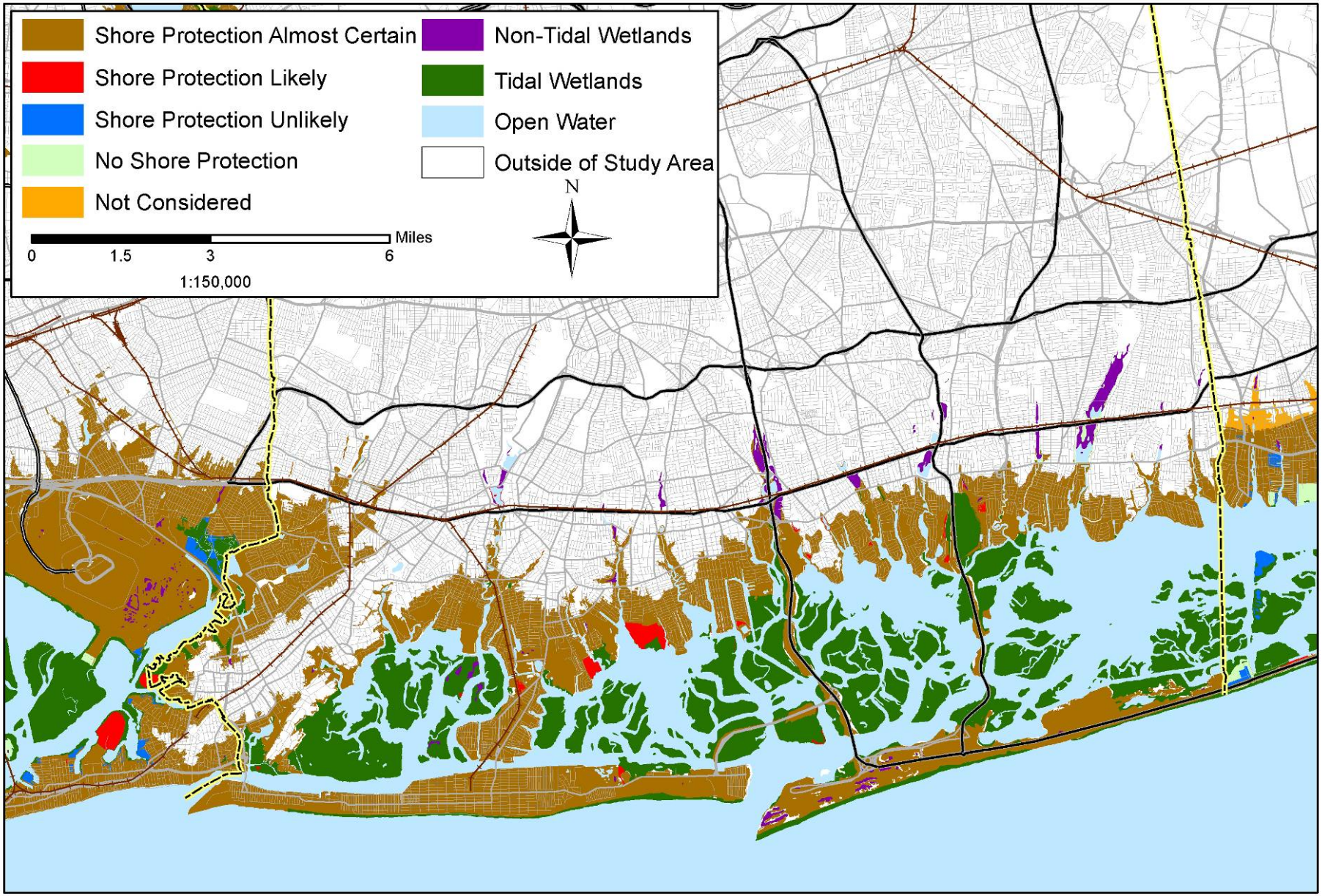
Farther to the west, the County is already elevating county roads subject to flooding in the area of Bayville. In addition, the Corps of Engineers is developing a shore protection plan to mitigate flooding in that community. Therefore, Mr. Armentano agreed that this community would be protected. He also felt the designation of no protection for the Mill Neck Preserve in Mill Neck Bay was correct given that this is a passive park with extensive wetlands where no action would be taken.

Mill Neck, Center Island, and Cove Neck, which constitute most of the remaining shoreline along the county's north shore, are some of the most exclusive residential areas on Long Island and would be protected because of the high value of the land, according to Mr. Armentano. He pointed out the adjacent underwater lands are part of the National Park Service's Oyster Bay National Wildlife Sanctuary, where activities are strictly regulated. This designation, however, does not extend to the upland area. He agreed that the map had correctly designated the Village of Oyster Bay as certain to be protected.

Finally, Mr. Armentano pointed out that The Nature Conservancy had recently acquired property along the western side of the headwaters of Cold Spring Harbor and was managing it as a preserve. Because the purpose is conservation, he concluded that the conservancy will allow natural processes to continue. Therefore, we changed the designation of this land from protection almost certain to no protection.




Map 2-4. **Northen Nassau County: Likelihood of Shore Protection.** Map created using Nassau County GIS data (Basemap COPYRIGHT 1993, County of Nassau, N.Y.) For additional details, see the legend and caption accompanying Map 2-2




Map 2-5. **Southern Nassau County: Likelihood of Shore Protection.** Map created using Nassau County GIS data (Basemap COPYRIGHT 1993, County of Nassau, N.Y.) For additional details, see the legend and caption accompanying Map 2-2

# NEW YORK CITY: COUNTIES OF KING (BROOKLYN), QUEENS, RICHMOND (STATEN ISLAND), NEW YORK (MANHATTAN), AND THE BRONX

New York City is composed of five boroughs: Brooklyn, Queens, Staten Island, Manhattan, and the Bronx, all with waterfront. Although each is technically a separate county,[97] the boroughs are functionally governed under the auspices of New York City and follow the same rules, regulations, and policies regarding coastal land use, construction, and management. In addition, the type and level of coastal development and the issues influencing potential responses to sea level rise are somewhat similar for the five boroughs. For these reasons, we discuss the counties of New York City together in one section.

New York City is a heavily developed area with a diverse and complex shoreline. The five boroughs have approximately 578 miles of waterfront with a wide variety of land uses, including industrial, commercial, residential, institutional, open space, and recreational.

The New York City Waterfront Revitalization Program (WRP) is considered the principal tool for coastal zone management.[98] Originally adopted in 1982 and updated in 1999, the WRP establishes development policies and provides the framework for evaluating proposed development activities in the coastal zone. Based on information contained in the detailed 1992 Comprehensive Waterfront Plan (CWP) and the five accompanying Borough Waterfront Plans developed in 1993–1994, the WRP contains 10 policies that are to be used in evaluating the consistency of all actions requiring planning and zoning review. Under Policies 2[99] and 4,[100] the WRP recognizes and designates two types of coastal areas with special characteristics known as Significant Maritime and Industrial Areas (SMIAs) and Special Natural Waterfront Areas (SNWAs). As the names imply, activities promoting maritime and industrial development (including shoreline protection) are encouraged in the SMIAs, while activities that protect and restore natural features would be considered consistent uses in the SNWAs. There are three SNWAs: East River–Long Island Sound, which includes portions of northern Queens and southern Bronx; Jamaica Bay, which includes most of Jamaica Bay in southern Brooklyn and Queens as well as portions of the Rockaway Peninsula; and Northwest Staten Island/Harbor Herons. There are six designated SMIAs: South Bronx; Red Hook, Sunset Park, and Brooklyn Navy Yard in Brooklyn; Newton Creek on the northern Brooklyn-Queens border; and Staten Island in northern Staten Island.

## New York City Meeting[101]

Wilbur Woods, director, and Edward Greenfield, Waterfront and Open Space Division, City of New York Department of City Planning

[97]Manhattan is New York County, Brooklyn is King County, and Staten Island is Richmond County.

[98]*The New Waterfront Revitalization Program*, Waterfront Revitalization Program, New York City Department of Planning, September 8, 1999.

[99]Policy 2 states: "Support water-dependent and industrial uses in the New York City coastal areas that are well suited to their continued operation."

[100]Policy 4 states: "Protect and restore the quality and function of ecological systems within the New York coastal area."

[101]At the original meeting, planning responses within Manhattan and the Bronx were not discussed. We applied information from this meeting, however, to extend the analysis to these boroughs.

## Economic Conditions

Development pressures along New York City's shoreline are extremely high because of the population density in the area. Staten Island, which is already highly developed, is the state's fastest growing county in terms of the number of new houses being built. Because of the scarcity and cost of land, most areas suitable for development or redevelopment are already being considered for various projects. Almost all the sites targeted for larger development already have some type of existing use, but the price of the land is usually so high some modification of the existing or zoned use is required to make the project feasible. Some of the proposed coastal developments, such as Arverne by the Sea in the Rockaways and the Baths at Brighton Beach on Coney Island, are extremely large projects[102];in reality, though, they represent infilling of existing development in these areas.

## Existing Coastal Policies and Practices

In New York City, both the tidal wetlands and the coastal erosion hazard area regulations are implemented and enforced by the DEC. Projects must, at a minimum, conform to these standards. In addition, the city has its own policies and regulations that are used to review and permit coastal projects.

The 1992 CWP provides a long-range plan to guide future coastal land use decisions. Individual Borough Waterfront Plans developed in 1993–1994 for the five counties provide site-specific recommendations to carry out the goals of the CWP. For the purposes of the CWP, the city's shoreline is divided into 22 separate reaches based on common land use patterns, natural resources, physical boundaries, and community lines. The CWP identifies four principal waterfront functional areas (natural, public, working, and redeveloping) and, depending on the specific area and its present use, promotes resource protection, public access, and landmark preservation; water-dependent and other working waterfront uses; and new residential or commercial development in appropriate waterfront areas. Information developed as part of the CWP process was used to refine the original 56 policies contained in the city's WRP to 10 policies and prioritize these policies in different geographic areas.[103] As mentioned previously, the WRP also designates the six SMIAs and three SNWAs.

The CWP recommendations and WRP policies are implemented through the waterfront zoning regulations adopted in 1993.[104] Waterfront zoning standards and regulations are contained in Chapter 2 of Article 6 of the New York City Zoning Resolution. Although the bulk of these regulations focus on providing and improving public access and visual corridors, two very important issues in the city, for coastal residential and commercial development the regulations also require a minimum 30-ft setback for buildings from the high water line. This setback is different from the previously mentioned 30-ft setback mandated under the state tidal wetlands laws in that the former applies to all areas, including those behind existing structures. The mean high water contour as defined through surveys is used to delineate the boundaries. Because projects usually require new surveys, these boundaries are constantly being updated. Article 10 of New York City's Administrative Code, which is the building code for the city, incorporates FEMA's guidance on elevations and construction procedures (flood proofing) to be used in designated flood zones but does not preclude construction in these areas.

[102]For instance, the proposed plan for Arverne by the Sea is a $350 million mixed use project incorporating 2,300 living units and 250,000 square feet of retail space on a 100-acre parcel next to the Atlantic Ocean (Benjamin-Beechwood Lands Mega Project in Queens, *Long Island Business News*, December 7–13, 2001, p. 4a).

[103]Policy 6 of the WRP deals with erosion and flooding. The purpose of this policy is to "minimize loss of life, structures and natural resources caused by flooding and erosion." Subpolicies under this general policy include:

- Minimize losses from flooding and erosion by employing nonstructural and structural management areas appropriate to the condition and use of the property to be protected and the surrounding area.
- Direct public funding for flood prevention or erosion control measures to those locations where the investment will yield significant public benefit.
- Protect and preserve nonrenewable sources of sand for beach nourishment.

[104]Chapter 6, New York City Zoning Resolution.

The policies and regulations reflect the fact that the city is already densely developed and most of the coastal land is being used for some purpose. Even if sea level rise increases boundaries of the floodplain in developed areas, communities will not be abandoned. Almost all of these areas would certainly be protected. A number of large shore protection projects incorporating beach nourishment are already in progress or in the planning stages for the Rockaways, Coney Island, the south shore of Staten Island, and other areas.

There are virtually no large, open areas in the city that could be abandoned to sea level rise. Even those areas that do not have development are used for city infrastructure or active recreation. For instance, open areas on the south shore of Staten Island have parks, but they are heavily used recreation areas with marinas and ball fields that would be essential to protect. Several large, abandoned, former industrial areas or storage areas along the coast will also eventually be redeveloped. Almost all the properties that are currently unused are being considered for some type of project because of developmental pressure in the area. Sea level rise of 2 to 3 feet will not be enough of a disincentive to not develop these projects. The value of the land is sufficient to warrant protective measures. As a result, almost every area in the city, including very low-lying ones, will be protected.

Under the city's WRP, nonstructural alternatives for shoreline protection, such as beach nourishment, dune construction, and vegetation, are preferred and must be explored before hard structures such as rip rap revetments and seawalls are approved. In addition, the city uses the special natural waterfront and maritime industrial area designations under WRP to review proposed activities in these areas. The SMIAs are considered essential to economic sustainability of the city. In these areas, construction activities such as dredging or structural shore protection may take priority over protection of natural features.

SNWAs make up about 20 percent of the city's waterfront. In these areas, the city uses higher environmental standards in the review of development proposals. This designation does not mean development cannot occur in these areas. Activities that could adversely affect natural features, however, would be more closely reviewed. Most of these areas are publicly owned. For example, substantial portions of the wetlands in the Jamaica Bay SNWA are part of the Gateway National Recreation Area owned by the National Park Service.[105]

The Northwest Staten Island/Harbor Herons SNWA includes the recently closed Fresh Kills Landfill in western Richmond, which will eventually be converted to a park. The wetlands are designated as special habitat areas by the State and will be protected as habitat. Because this is passive use recreation, it would probably not be protected in the face of rising sea level and the shoreline would be allowed to migrate.[106]

The special natural area designation has been effective in attracting state funds to acquire lands for preservation and open space. The State provided $4.3 million to acquire 119 acres of wetlands in the Harbor Herons Complex, and parcels in the other SNWAs are targeted for acquisitions.[107]

In addition to the SNWAs, Policy 4 of the WRP also recognizes other, smaller, ecological resource areas along the south shore of Staten Island (designated as Recognized Ecological Complexes). Although smaller and more fragmented than the SNWAs, natural resources in these areas are also provided extra protection under the WRP during project review and are targeted for public acquisition. The State Environmental Protection Fund provided $25 million to acquire the 145-acre Mount Loretto property on the south shore of Staten Island. The

[105]As previously mentioned, recently collected data suggest a significant loss of wetlands in this area and the National Park Service is currently considering measures to protect vegetated marsh islands here.

[106]Although much of this area was wetlands in the 1940s, it has since been used as a landfill. As a result of the filling, land slopes are relatively steep a few feet from shore, so it is unlikely that marshes or natural shoreline forms would be able to migrate even if the area were not protected.

[107]Conserving Open Space in New York: A Summary of the Draft Plan, October 2001.

State Open Space Plan also identifies a number of coastal properties, known collectively as the Staten Island Blue Belt, as priorities for preservation in this area.

Politically, sea level rise and its potential problems are not a priority in terms of planning and development at the city or state level.[108] The information available on this topic is too general and does not address issues associated with heavily urbanized areas like New York City, Boston, and other historically built-up communities. Unbiased economic analysis and more reliable estimates of the future rate of sea level rise are needed to begin evaluating the cost and benefits associated with the different response strategies for urban areas.

## New York City Response Scenarios

### Existing Policies

Protection of coastal areas in the New York City is primarily regulated through the tidal wetlands and coastal erosion hazard area regulations administered by the DEC and the waterfront zoning regulations contained in Chapter 2 of Article 6 of the New York City Zoning Resolution. Basically, these regulations prevent development in designated wetland areas and require 30-ft setbacks from wetlands or the high water line for most new activities. Under these regulations, property outside these areas could be protected if necessary. Both state and city policies encourage the use of "soft" erosion and flooding control alternatives over structural measures.

### Anticipated Response

Land, and especially coastal land, is at a premium in the New York City metropolitan area; consequently, planning officials indicated most of the city's coastline will almost certainly be protected in the face of a rising sea level.[109] Lands designated as almost certain to be protected are shown in brown on the planning maps (Maps 2-6 [all of New York City, showing results for Manhattan and the Bronx], 2-7 [Queens and Brooklyn], and 2-8 [Staten Island]) and include urban residential, commercial, industrial, and institutional parcels. Open space and recreational areas are relatively limited given the population and are highly valued. Portions of the National Park Service's Gateway National Recreational Area on the Rockaway Peninsula in Queens and Staten Island are already protected through the use of beach nourishment and structures. Many of the larger vacant or abandoned parcels are being considered for development or redevelopment projects, according to planning officials. As a result, most open space and currently vacant areas, with the exception of those parcels in specially designated areas described below, would also almost certainly be protected at some point rather than abandoned to sea level rise; these are also shown in brown on the maps. Possible exceptions might be lands found in the three SNWAs designated by the city. Although development and shore protection measures are not necessarily prohibited, the city's policy is to preserve, protect, and restore natural resources and habitats in these areas. Planning officials thought it was reasonable to assume that protection efforts may be limited to a certain extent, especially on some of the publicly owned passive recreation and open space or vacant land in these designated areas.

Perhaps the only significant area in the city that would not be protected would be the lands in the Jamaica Bay Wildlife Refuge in the Jamaica Bay

[108] This sentence and most of the report were prepared under Governor Pataki's administration. The priorities of the current and future governors may change.

[109] Maps for the New York City area were developed using 1995 land use maps from the Department of City Planning showing the following seven land categories: one or two family residences, multifamily residence or mixed residence and commercial, commercial, industrial, public facility or institution, open space and outdoor recreation, and vacant land. Individual land use categories were digitized, rectified, and converted to ArcView shape files for analysis. Because of limitations in the digitization process, land use parcels of less than approximately 2 acres might not be accurately represented. Where necessary, information on vacant parcel ownership was obtained manually through the New York City Open Accessible Space Information System (http://www.oasisnyc.net). Again, wetlands mapped by the DEC from 1974 aerial photographs are also shown. The map scale is too small, however, to depict the 30-ft buffer zone around the coast where protection would presumably not be allowed.

Unit of the Gateway National Recreation Area. These parcels are managed by the National Park Service, which has a policy of maintaining the natural resources and processes in these areas. For this reason, the map shows upland portions of parcels designated as Nature Areas in the Wildlife Refuge as light green under the assumption that they will be treated as preserves and will not be protected against sea level rise.

To identify areas where protection is not certain, ownership information was obtained from the New York City Open Accessible Space Information System (http://www.oasisnyc.net) for vacant parcels in the East River–Long Island Sound, Jamaica Bay, and Northwest Staten Island/Harbor Heron SNWAs. Based on the city's stated policy of protecting and restoring natural processes in these areas, we assume that protection from sea level rise of undeveloped publicly owned lands within these designations is unlikely. As a result, all publicly owned vacant lands, open space, and recreational areas located in the SNWAs (with the exception of the Wildlife Refuge mentioned above) are shown in blue on the planning maps. It is important to note that portions of these areas would not necessarily be abandoned. For instance, areas with heavy use or infrastructure, such as Floyd Bennett Field or Canarsie Pier in Jamaica Bay, may already be protected or would probably be protected even though they fall in an SNWA. Other sites such as Edgemere Park in Jamaica Bay and Pelham Bay Park in the Bronx, which are located on abandoned landfills, may be protected from erosion for environmental reasons.[110] A more accurate site-by-site evaluation of vacant and open space areas that might be protected would require data collection and analysis efforts that are well beyond the scope of this preliminary assessment effort. The results shown here may underestimate the extent of the protected areas and should be viewed with caution.

No specific restrictions against development in the SNWAs exist, so privately held vacant lands in these areas may be developed in the future. Because these projects will presumably be held to higher standards of environmental review, however, it is possible they may be designed to minimize the need for protective measures or protection measures can be designed to allow some shoreline migration in response to sea level. For this reason, the privately held vacant parcels found in the SNWAs are designated as areas where protection is not certain but likely and are shown in red on the maps.

It is also important to note that an important management issue for the Jamaica Bay area is the apparent rapid loss of vegetated wetlands described earlier. Both the state and federal governments, who have significant holdings in this area, have indicated that some form of artificial manipulation or protection may be required to maintain the environmental integrity of these features. In September 2003, the National Park Service applied sediment to raise the surface of a 2-acre portion of marsh in the nature area as part of an experimental restoration project. For this reason, an accurate depiction of the lands that would be protected under a scenario which assumes greater environmental protection should include the wetland/marsh islands in the Jamaica Bay complex.

## Stakeholder Review

Mr. Woods and Mr. Greenfield of the Waterfront and Open Space Division, City of New York Department of City Planning, participated in a meeting to review the draft text and response maps for New York City in the planning department offices in Manhattan on July 28, 2004. They suggested a number of changes in the maps, which were incorporated. The changes are discussed below and organized by boroughs depicted on the planning maps originally developed for the city.

***Manhattan and the Bronx*** (see Map 2-6)**:** City officials felt the depiction of the entire shoreline of Manhattan as being almost certainly protected was accurate. Present development precludes any opportunity for alternatives other than protection.

[110]During the stakeholder review, planning officials confirmed that these areas and some other, similar, publicly owned areas would indeed be protected because of their recreational value or for environmental reasons even though they were in the SNWAs. Specific areas are discussed in the stakeholder review section that follows.

They did suggest several changes on the response maps in the Bronx. Although Pelham Bay Park, in the northeast corner of the Bronx, is a public park in a designated SNWA, its intensive use and extensive existing infrastructure would result in most of the area being protected. Orchard Beach, a heavily used recreational facility backed by concessions, is already protected through beach nourishment by the U.S. Army Corps of Engineers. A portion of the park is a former landfill that will be protected for environmental reasons. In addition the park contains roadways, parking lots, trails, equestrian facility, concessions, a police firing range, and a mansion that would also be protected. Although a small natural area along the Pelham Bay Lagoon would probably not be protected, they indicated the majority of the park would be more appropriately designated as protection almost certain (brown) rather than protection unlikely (blue), the original designation.

Similarly, the officials felt that Soundview Park, an active use park in an SNWA along the Bronx River in the south Bronx, would also be protected because it contained ball fields and other infrastructure that would be protected to maintain capacity and use levels. As a result, this facility was changed from blue to brown.

In Ferry Point Park, along the East River, there are plans for development of a golf course and major waterfront esplanade. Part of the area is already protected by rip rap and officials felt the planned development and existing protection would result in certain protection in the future. Again, the designation of this park was changed from protection unlikely to protection almost certain.

Shore Haven Estates, on the East River, was the only significant, privately owned vacant parcel within an SNWA in the Bronx on the land use maps. Officials noted that an old seawall already protected the area and a developer has already built the first phase of a residential community at the site. This community will be protected, so the designation of the area was changed from protection likely to protection almost certain.

***Queens and Brooklyn*** (Map 2-7)**:** City officials noted that the shoreline outside the SNWAs in these boroughs would definitely be protected as indicated in the maps. The section along the East River, Newtown Creek, and New York Harbor is being converted from manufacturing to high-density residential use. Protection efforts would continue to preserve the structures and provide public access to the waterfront.

Suggested map changes for these two boroughs were limited to the Jamaica Bay area and primarily involved redesignating public lands in the SNWA from protection unlikely to protection almost certain because of the use. City officials indicated that this change was appropriate in the following areas:

*Floyd Bennett Field:* This parcel on the western side of the bay has numerous buildings and infrastructure and is actively used by a number of groups, including the Navy Reserve, Coast Guard, the city, and the public. Part of the area is already protected by rip rap.

*Brooklyn Marine Park Golf Course:* The golf course, located northwest of Floyd Bennett Field, would be protected.

*Canarsie Pier:* This area is part of the Gateway National Recreational Area but is also used extensively for large boat excursions and dinner cruises. In addition to the pier, the site contains parking lots. The infrastructure and use would be protected.

*Pennsylvania and Fountain Avenue landfills:* The parks at the end of these avenues are actually capped landfills and would be protected to prevent the landfills from introducing contaminants into surrounding wetlands and waters.

*Edgemere Park:* This park located on the north shore of eastern Rockaway Peninsula is also a capped landfill. In addition, the city Sanitation Department has sited a garage/maintenance facility there. Officials felt that these uses would warrant protection.

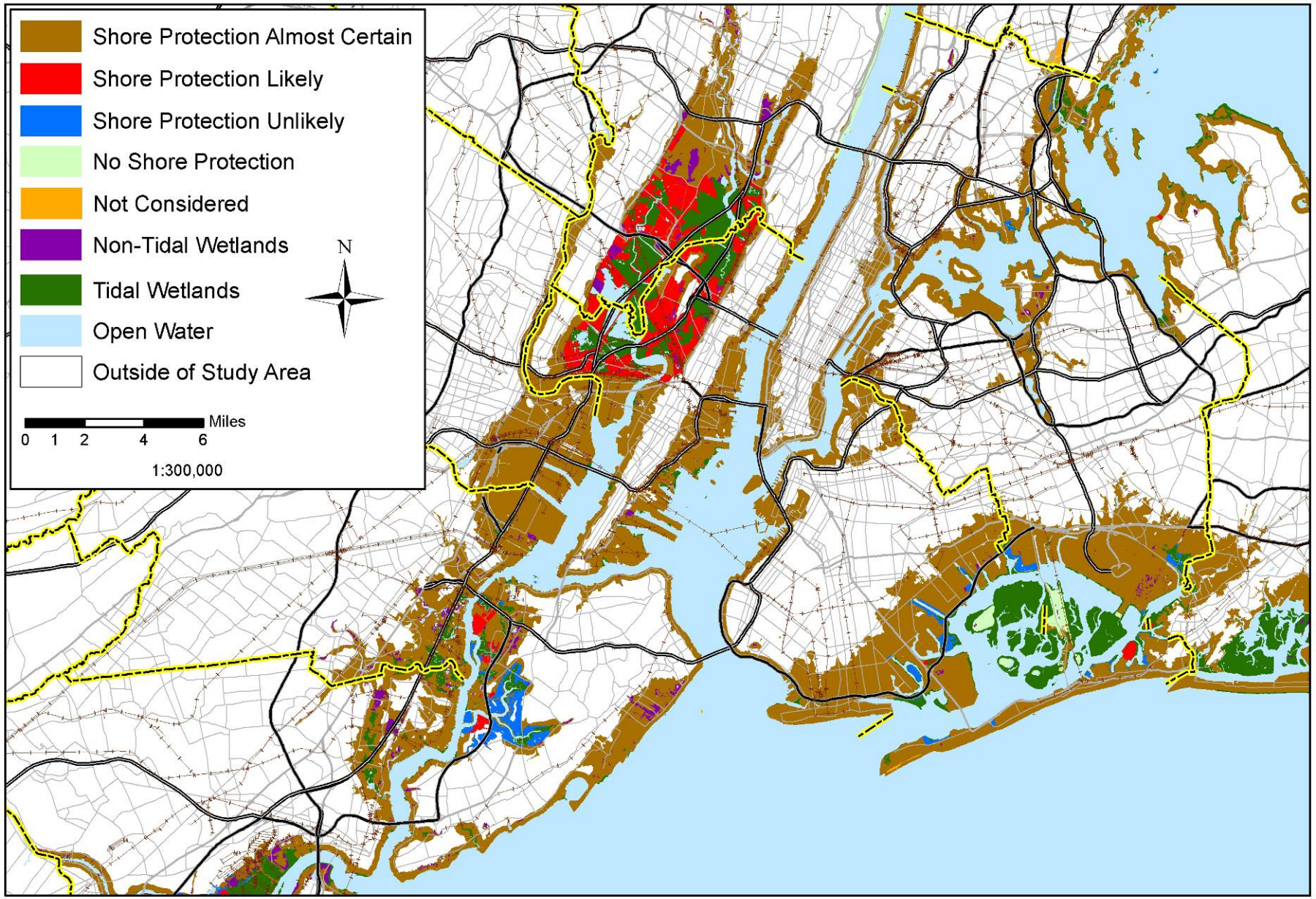
Planning officials also suggested changing the designation of the vacant upland portion of an area on Mill Basin, known as 4 Sparrow Marsh, from protection unlikely to protection likely. The New York City Economic Development

Corporation owns this 77-acre parcel. Although the 65 acres of mapped wetlands will be left alone, the city has recommended that the 12-acre upland portion adjacent to Flatbush Avenue be developed with marina, commercial, and residential use. The protection likely designation reflects the fact that development will be subject to state and federal environmental regulations as well as design guidelines developed by the city that should allow some shoreline migration and minimize the need for protective measures to the extent possible.

***Staten Island*** (Map 2-8)**:** The review meeting resulted in several changes to the map for Staten Island, all in the Northwest Staten Island/Harbor Herons SNWA. The city Sanitation Department is planning to develop a solid waste transfer station on a parcel on the north side of Little Fresh Kills Creek designated as vacant on the 1995 land use maps. Since the transfer facility would be protected, the designation of the parcel was changed from protection unlikely to protection almost certain.

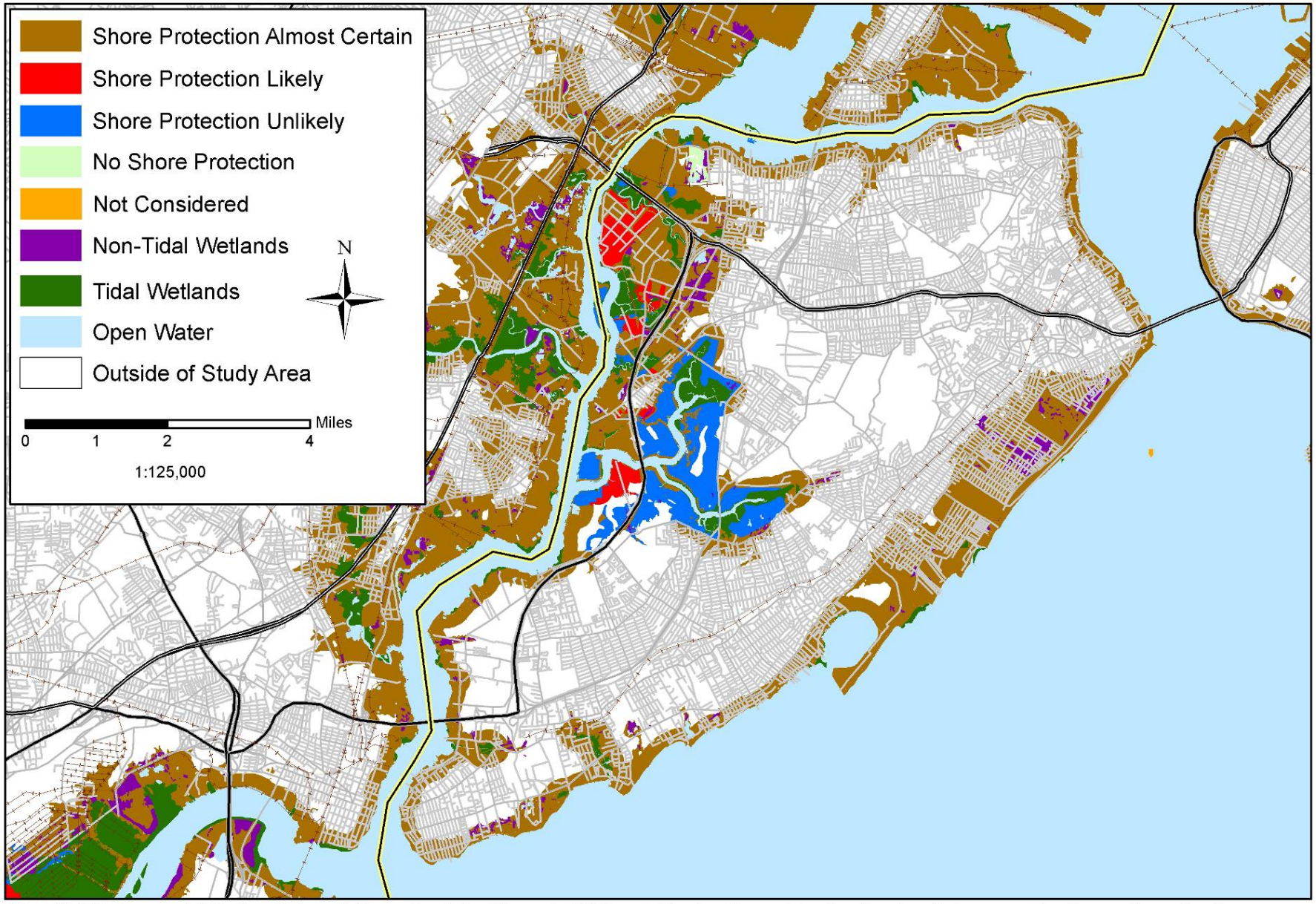
Conversely, Mr. Woods also noted that three large parcels on the Fresh Kills, Richmond, and Main creeks in the SNWA that are designated as protection almost certain on the map should be changed to protection unlikely. The reason for the change is that these parcels, listed as industrial on the 1995 land use map, are now part of the passive use park being developed in the Fresh Kills area and probably would not be protected.

Finally, Mariners Marsh in the northwest corner of Staten Island in the Arlington portion of the Harbor Herons SNWA complex was changed from protection unlikely to no protection. Although it is shown as open space/outdoor recreation on the land use map, planning officials said because this parcel is actually a freshwater wetland, and state and city regulations preclude development. Because the wetland lies on the landward side of Richmond Terrace, however, a major roadway that would be protected, it is unlikely to be threatened by sea level rise.




Map 2-6. **New York City: Likelihood of Shore Protection.** For the basis of shore protection categories in adjacent states, please see Chapter 3 of this volume (New Jersey) and Chapter 2 of Volume 2 (Connecticut).


Map 2-7. **King (Brooklyn) and Queens County: Likelihood of Shore Protection.** For the basis of shore protection categories in New Jersey, please see Chapter 3 of this volume .




Map 2-8. **Richmond County (Staten Island): Likelihood of Shore Protection.** For the basis of shore protection categories in New Jersey, please see Chapter 3 of this volume.

# WESTCHESTER COUNTY

*Editor's note: Unless otherwise noted, material in the introductory and economic condition sections is excerpted from Westchester County Databook, 2000, Westchester County Department of Planning.*

Westchester County is located northwest of New York City. It covers some 450 square miles and is bordered by Long Island Sound to the southeast and the Hudson River to the west. The Sound shoreline is approximately 42 miles long[111] and the Hudson River shoreline covers about 35 miles. More than 920,000 residents live in the county's six cities, 16 towns, and 45 villages. In general, the southern part of the county is more densely developed and populated than the northern portion above Interstate Highway 287. The northern portion has largely low- to medium-density residential development with a small amount of office development. In contrast, the southern part is dominated by medium- to high-density residential development, and commercial/retail and manufacturing, industrial, and warehouse uses in urban centers. Residential use accounts for some 46 percent of the total acreage in the county, nonresidential use (institutional, transportation, utilities, commercial, manufacturing, and office) occupies 13 percent, public and private open space (active and passive parks, preserves, water supply lands, private recreation, and cemeteries) 19 percent, and undeveloped land 18 percent. Most undeveloped, privately owned land and protected open space are in the northern inland portion of the county.

Development patterns along the coast are similar to those found countywide. The Sound coast is dominated by residential use with some open space in the form of public parks, golf courses, and private recreational facilities (beach, hunting, and boat clubs). Commercial, institutional, and industrial uses are limited to small pockets bordering harbors such as New Rochelle Creek, Echo Bay, Larchmont Harbor, and Mamaroneck Harbor. Land use along the Hudson River shoreline reflects its history as a major transportation route and is more mixed, with industrial, commercial, transportation, and utility uses as well as residential. The southern portion of the river in Yonkers is the most densely developed, with manufacturing, industrial, and commercial uses. Residential use increases to the north and there are three major active use parks (Georges Island, Oscawana, and Croton Point), but land use is still primarily nonresidential, like the Indian Point Nuclear Power Plant and the Con Ed and New York Power Authority generating stations in Buchanan. The Metro North and Amtrak railroad tracks also run directly along the river for almost its entire length in the county.

## Economic Conditions

According to U.S. Census figures, Westchester's population increased 5.6 percent from 874,866 to 923,459 between 1990 and 2000. These data also indicate that growth is slowing in suburban areas but increasing in urban centers. There are more than 30,000 businesses and organizations. Five Fortune 500 companies have headquarters in Westchester, but more than 90 percent of the businesses in the county have fewer than 20 employees. Service-based businesses make up a third of the total number of businesses. One-quarter of the working county residents (107,500 people) commute to jobs in New York City, primarily Manhattan or the Bronx. Land values are high because of the proximity to the city, density of the population, and the desirability of the area. The median price of a single-family home in Westchester was $407,000 in 2000. The southern portion of the county is more urbanized, with traditional residential development on

[111]New York State Coastal Management Program, Extent and Jurisdiction of Mainland and Island Shorelines in N.Y.S. Counties and Municipalities.

smaller lots compared to more the suburban type of development and large lot zoning in the north.

## Westchester Meeting

Robert Doscher, principal environmental planner, Westchester Planning Department, Existing Coastal Policies and Practices[112]

Unlike most of New York's marine coast, Westchester has a hard, rocky shoreline. Sand beaches are rare and usually confined to small pockets or coves. As a result, coastal erosion is not really an issue here. Flooding has more of an impact than erosion during storm events. Although some coastal areas are inundated by storm surges, the surge can cause streams to back up and result in inland flooding from storm water runoff. Coastal structures have been employed to protect against flooding and, to a lesser extent, erosion. Seawalls are prevalent along the coast, although they are not continuous. No county or municipal regulations or laws directly address sea level rise or its impacts, but most communities have flood management regulations based on the FEMA program.

"Patterns for Westchester: The Land and the People" is the Planning Department's envisioned master plan for future development for the county adopted in 1995.[113] Developed in conjunction with the municipalities, it is nonbinding but provides a broad policy framework for governmental action to guide the county's future physical development. The plan identifies five subregions, including the Long Island Sound communities and the Hudson River Shore communities, and states that Sound shore waterfront development topics and issues are best addressed on the subregion level by the affected municipalities, which should develop strategies based on their particular economic and environmental needs.

Sanitary regulations administered by the County have a limited effect on controlling development along the shoreline because most of the coastal area is already sewered and the majority of the building along the coast is actually redevelopment of existing developed parcels or infilling and subdivisions of larger parcels such as estates. Only small pockets are currently serviced by septic systems.

Westchester has an aggressive open space plan[114] because, in part, not a good deal of open space is left. Over the last 10 years the County has purchased more than 1,000 acres of land and currently owns about 17,000 acres of land designated as open space. Most of this land is in the less developed northern and inland portions of the county.

Control over Westchester's two coastlines is essentially in the hands of 22 municipalities. Each municipality has home rule authority on all matters relating to planning and zoning. They adopt zoning ordinances, establish their own rules for processing subdivision and site plans, and enact their own environmental regulations, with guidance from the State. Most flood

[112]The meeting took place on June 16, 2004, at the Westchester County Planning Department offices in White Plains, New York.

[113]See http://www.westchestergov.com/patterns/. The plan identifies three major components of Westchester's pattern of development: centers, corridors, and open space. Centers consist of a commercial or mixed-use core and surrounding residential and industrial sectors and are likely to have the principal commercial services on which most communities depend. Corridors are historical paths of movement and development. They contain the county's basic transportation infrastructure: major roads, parkways, interstates, and railroads, each of which influences the economy and environment. Open space includes undeveloped land or shorelines, active and passive parkland, rare or ecologically valuable lands that need permanent protection, and public and private lands with open character, such as golf courses, office campuses, and cemeteries. The overall goal of the plan is to strengthen centers, improve the function of corridors, and protect the county's open space character.

[114]Westchester divides it open space into two types: "definite elements of open space" and "areas of open space character." Definite elements are primarily publicly and privately owned properties intended to be permanently protected from development, such as parks, nature preserves, cemeteries, and school district lands. Areas of open space character are lands that make important contributions to open space character but are not permanently protected. These parcels include golf courses, campuses, and lands that municipal comprehensive plans identify as significant for their open space, ecological, or recreational value. Privately owned lands, although subject to development, can retain their open space function through zoning and design techniques.

mitigation is done at the town and village level. The County protects its own infrastructure. The Westchester Sound coastline is covered by the state coastal erosion hazard area regulations, but, as mentioned before, erosion is not much of an issue because of the rocky nature of the shoreline. The state tidal wetlands regulations also apply to the Sound coast and the Hudson River shoreline up to the Tappan Zee Bridge. As in Nassau and Suffolk counties, these regulations do not explicitly address sea level rise and do not preclude protection of the shoreline.

### Response Scenarios: Westchester County

Because land is so valuable along Westchester's coast, Mr. Doscher felt that very few areas would not be protected from sea level rise. Developed institutional and residential parcels would certainly be protected, as would utility and transportation facilities such as sewage treatment plants, power plants, roads, and railroad tracks. The lower part of the Hudson River shoreline is heavily developed with old warehouses and manufacturing and industrial uses that would be protected. Con Ed facilities and the nuclear power plant in the north would also be protected.

Much of the Metro North and Amtrak railroad tracks along almost the entire length of the eastern shore of the Hudson River is armored, either naturally because the coast is rocky or with artificial revetments. In the face of rising sea level, the protection of the tracks would continue, thus protecting the parcels landward or to the east. The banks of the Hudson in Westchester have some of the steepest slopes in the county, with grades of 25 percent or greater along most of the shoreline. Because of the topography, the majority of the development is on high ground and sea level rise is not a concern in this area. Nevertheless, if sea level rise were to induce significant erosion along these shores, they would also be protected.

The Sound coastline is densely developed, primarily with valuable residential uses that would continue to be protected. There is very little undeveloped coastal land in Westchester. The 1996 land use data identify only 40 undeveloped parcels covering less than 200 acres in the Sound portion of the study area. The only significant undeveloped area is David's Island, a 75-acre island that formerly housed a military installation off the southern portion of the shoreline. This property is currently owned by the City of New Rochelle, which has entertained proposals for developing it with high-rise residential and mixed-use development. More recently, the County proposed to buy it from the city and turn it into parkland. Although the city eventually agreed to this offer, concerns about the potential cost of cleaning up pollution problems resulting from its previous use as an Army base have stalled proceedings, and the future of the deal is uncertain at this time. The island is already protected by structures. Although its future is uncertain, Mr. Doscher thought that the island would be protected, either to preserve future development or to contain potential pollutants associated with its former military use.

The few smaller vacant lots remaining are rapidly being developed for residential use. As an example, Mr. Doscher noted that a 7.5-acre parcel adjacent to Davenport Park in New Rochelle, designated undeveloped on the 1996 land use map, had since been developed with single-family homes. This was one of last remaining undeveloped shorefront properties in Westchester, and the County and others were interested in acquiring the parcel for open space because it was adjacent to a park. Local property owners, however, opposed the acquisition for open public space, preferring the residential development.

Not all of the vacant property would necessarily be protected. Huckleberry Island, adjacent to David's Island, is a small, low island that has a bird rookery. It is owned by the New York Athletic Club and maintained in a natural state. Mr. Doscher thought this area was unlikely to be developed because of the low-lying topography. Although protection would probably be legal, the difficulty in getting permits would dissuade development efforts and, thus, protection in the future. Similarly, he thought Hen Island in Rye, a summer cottage community with a small, undeveloped area, would not be protected since this area is not sewered and the difficulty and

cost of developing a workable sanitary system would discourage development efforts.[115] These are unique cases, however, in that they involve relatively small, inaccessible islands that are not already serviced by sewers and have high habitat values.

Mr. Doscher indicated that there is uncertainty regarding the fate of parkland, noting that protection efforts would depend on the magnitude of the problem and the level of effort required to address it, making it difficult to predict exactly how the county, town, or local entities will react to sea level rise in the future. He indicated, however, that some of these areas would be protected. Playland, a large amusement park in Rye, is on the National Historic Register and already has bulkheads and seawalls protecting a boardwalk. The County would continue to try to protect this area. In 1992, a grass parking area adjacent to the Playland Park was inundated by a severe nor'easter. Officials responded by building a berm composed of concrete rubble to protect the area. Although there was no long-term plan for this area, this is probably representative how the County and local municipalities might respond to sea level rise in the future. Officials would react to damages from specific storms and not necessarily relate these to impacts from long-term sea level rise. As part of a restoration effort, the County subsequently removed the rubble and constructed a dune to provide flood protection. Glen Island County Park in New Rochelle includes a catering hall leased from Westchester that generates considerable revenue. This facility would also be protected.

Mr. Doscher felt that active recreation areas and parks with infrastructure would be protected because of the high demand for these facilities. The County and local municipalities are already protecting some of the facilities such as Harbor Island Park and Flint Park, where seawalls protect ball fields. These would continue to be protected.

Protection is less certain for passive parks than for the active recreation areas. In the passive parks, some shoreline migration might be allowed before the municipalities initiated protection measures. The County and the municipalities would probably not employ protective measures until sea level rise started affecting access to or capacity of these facilities. Mr. Doscher indicated that nothing would probably be done in two county facilities in Rye, Edith G. Reid Wildlife Sanctuary and the Marshlands Conservancy, even though there is no specific restriction preventing protection efforts.[116] The Reid Sanctuary has very little infrastructure and is primarily in a natural state. Aerials have shown that the wetlands in the Marshlands Conservancy have been shrinking but the cause is not known. The shoreline landward of the wetlands is rocky and not subject to erosion, so Mr. Doscher felt no action would be taken to protect this area. The saltmarsh would be lost but nothing would be done to protect the shoreline in the face of sea level rise.

Areas in the county designated as private recreation are primarily private beach, boat, and hunting clubs. Where necessary, Mr. Doscher felt, these clubs would undertake protection efforts for their facilities, but some shoreline migration would probably be allowed, given the size of the parcels, the limited use, and the usually low level of development.

Areas designated as nature preserves in Westchester are, by the County's definition, privately owned. According to the 1996 land use data, there are only three designated nature preserves in the study area, two in the Hudson River area and one on Sound coast. These preserves encompass a total of approximately 60 acres. The Nature Conservancy owns the one on the Sound coast, Otter Creek. It would not be protected. Neither of the designated preserves on the Hudson River is directly on the shoreline.

Map 2-9 illustrates the anticipated response to sea level in Westchester based on discussions

[115]Tidal wetlands map show this area as a high marsh. Thus, by definition, it is out of the study area.

[116]In the county generalized land use map, these two parks are listed as active recreation areas.

with Mr. Doscher and on the available land use data.[117]

**Protection Almost Certain (Brown):** Areas indicated as almost certain to be protected are shown in brown on the map and include parcels designated as residential, institutional, mixed use, office, manufacturing, commercial, or transportation/utility on the 1996 generalized land use GIS data base. The undeveloped parcels (with the exception of Huckleberry and Hen Island parcels, which are discussed below) are also included in this category, reflecting the value of the land and the County's observation that most of these lots are being developed for residential use. Active use parks such as Playland and Glen Island county parks would also be protected because of the high demand for these facilities, according to the County. Parcels identified as active public parks in the county GIS[118] are also shown in brown, except for the Marshlands Conservancy and the Edith G. Reid Wildlife Sanctuary.[119]

**Protection Likely (Red):** Passive use parks are included in this category. The high demand for and use of parks and public open space would probably result in protection of these facilities, if threatened. The authorities would not implement protective measures, however, until access or capacity was adversely affected, so some shoreline migration may be allowed. The designation of protection likely, as opposed to protection almost certain, reflects the higher level of uncertainty associated with these facilities compared to the more heavily used active parks.[120] Private recreation areas would also be protected if necessary, but, as discussed above, the type and relatively low level of use would allow for some shoreline migration even if protection measures were employed. As a result, all private recreation uses are shown in red on the map.

**Protection Unlikely (Blue):** Private parcels on Huckleberry Island and a small portion of Hen Island are designated as protection unlikely because the County indicated that, owing to the physical nature of these parcels, the cost of making these areas buildable would preclude development and, thus, protection efforts.

**No Protection (Light Green):** The three designated nature preserves would not be protected from rising sea level and are shown as light green on the map. The two parks on the Sound portion of the coast, Edith G. Reid Wildlife Sanctuary and the Marshlands Conservancy, are also included in this category. As discussed above, this designation is based on the County's observations that because of their size, geology, and limited use, sea level rise would not limit use of or access to these areas. As a result, no efforts would be made to protect them. Mr. Doscher indicated these areas would essentially be treated as preserves, so they are shown as no shore protection.[121]

[117]This map was based on digitized map prepared by the Westchester County Department of Planning showing generalized land uses in Westchester County as of 1996 (available at http://www.westchestergov.com/planning/). Mr. Doscher also provided copies of maps showing generalized land use, generalized zoning, environmental features, and open spaces, which provided more detailed legends and descriptions of mapped features.

[118]The county land use map GIS data base has separate classifications for passive public parks (PPP) and active public parks (PPA).

[119]During the discussions, Mr. Doscher indicated that the Edith G. Reid Wildlife Sanctuary and the Marshlands Conservancy would probably not be protected because the nature of their use, even though there is no specific restriction preventing protection efforts. Both facilities are designated as active parks in the county GIS, indicating that the use of this classification to identify potential responses may not always be accurate. He also pointed out that many of the 94 parks in the study area fall under the jurisdiction of the 22 coastal towns, villages, and cities, making it difficult to determine whether they would be protected or not without contacting each municipality, a task beyond the limited resources of this effort. As a result, the author felt this was still the best available data and used the GIS classifications as an indication of the response, unless information provided during the discussion or stakeholder review suggested otherwise.

[120]According to Mr. Doscher, because of the level of use and the lack of local resources, some municipalities may choose not to initiate any protection efforts in some of these parks and they would be more accurately classified as protection unlikely. This, however, would require surveying all the separate entities controlling these holdings, a task beyond the scope of this effort.

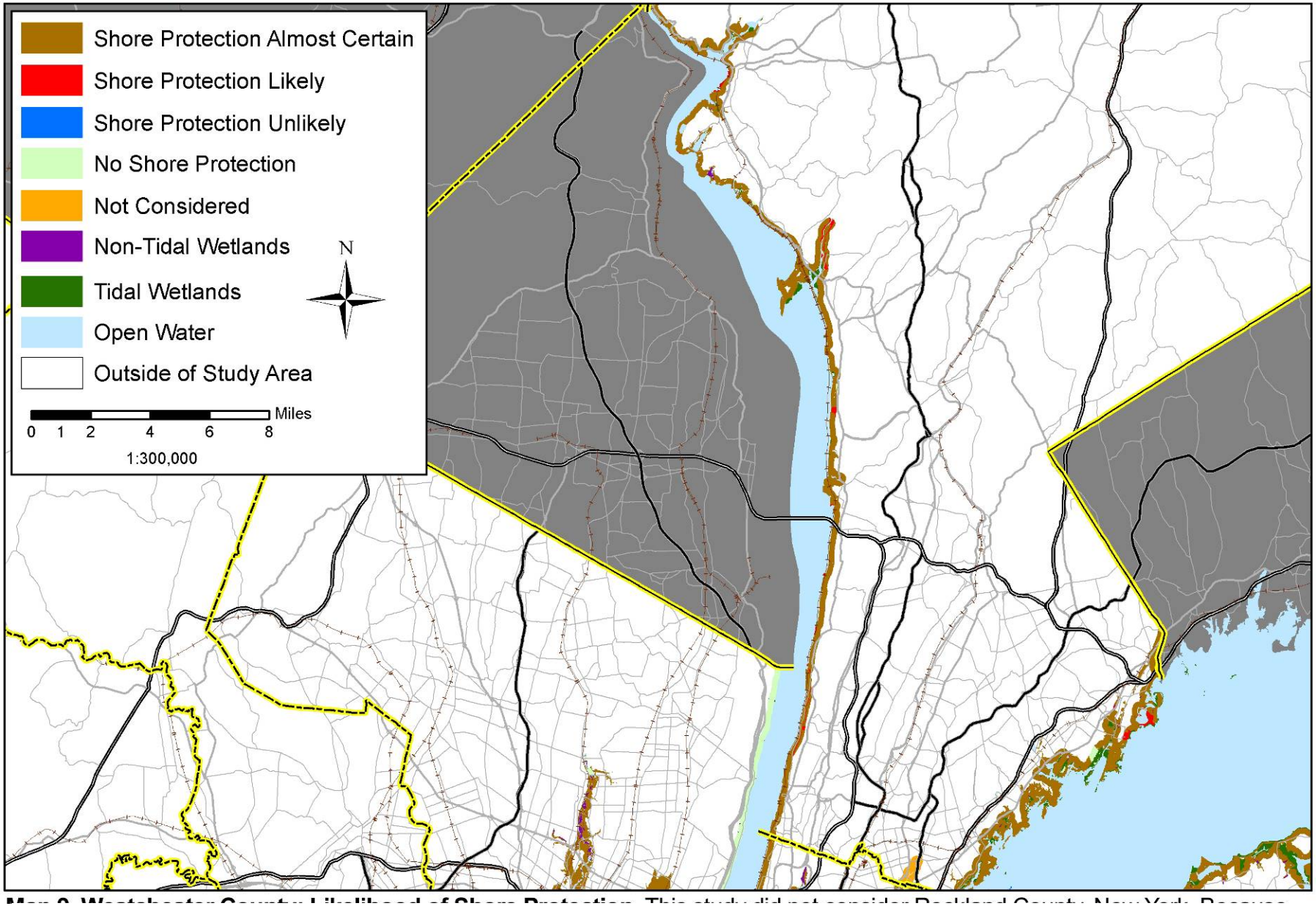
[121]During the stakeholder review, Mr. Doscher indicated the classification of the Reid Sanctuary should be changed from no protection to protection likely after reviewing the

## Stakeholder Review

After the initial meeting, Mr. Doscher received drafts of the report and the map showing potential responses to sea level rise in Westchester County for review. He provided comments and suggested revisions to the author via telephone on September 13, 2004. He suggested two changes. The first involved a parcel in Rye that was classified as a passive use park in the county land use GIS database and initially designated as protection likely on the planning map. This parcel was actually the Playland Parkway, the major roadway providing access to the heavily used Playland Park. Because the roadway would be protected, the designation on the map for this parcel was changed to protection almost certain. Mr. Doscher also suggested that the parcel containing the Reid Wildlife Sanctuary should be changed from no protection (green) to protection likely (red). The sanctuary is managed as a natural area but he felt that county and local interests may take steps to protect the area if it were threatened by sea level rise for several reasons. The Town of Rye would most likely want to protect the nature center in the sanctuary and maintain access and use of the area. The spit of land the sanctuary is on also provides protection for Playland Lake, a small embayment bordered by the Playland Amusement Park and expensive residential properties. If sea level threatened to breach the spit and adversely affect conditions in Playland Lake and adjacent areas, the County and local entities would be likely to initiate protection efforts. Mr. Doscher also pointed out, however, that the actual response is difficult to determine because it would depend on the magnitude of the problem, the level of resources needed to address it, and the ability of the various entities to provide these resources. The protection likely designation reflects the fact that the degree of certainty that protection would be implemented is somewhat less that for the areas designated protection almost certain and that efforts would be made to maintain the natural character and allow some shoreline migration in the sanctuary.

On a larger scale, he noted that the county and local governments may not be able to afford to protect everything if the impacts of sea level are particularly severe, rapid, and widespread. Because there has been little, if any, planning regarding potential responses at the local or county level, Mr. Doscher reiterated that the classifications indicated on the map have to be considered an “educated guess” and could change as more is known about the actual impacts of sea level rise on specific areas and resources and measures required to mitigate these impacts. He also indicated, however, that these classifications do provide a reasonable representation of the responses that may be expected in the future based on existing policies and practices.

maps. Reasons for this change, which was incorporated in the map, are discussed in the stakeholder review section.




Map 2-7. **Westchester County: Likelihood of Shore Protection.** This study did not consider Rockland County, New York. For the basis of shore protection categories in adjacent states, please see Chapter 3 of this volume (New Jersey) and Chapter 2 of Volume 2 (Connecticut) .

# APPENDICES AND CREDITS

## 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**



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 | Not Considered | Totals |
| Bronx | 116 | 0.6 | 5 | 0 | 0 | 0.4 | 122 |
| Kings | 137 | 3 | 10 | 0 | 0 | 3 | 154 |
| Nassau | 394 | 10 | <0.1 | 2 | 5 | 80 | 490 |
| New York | 75 | 0 | 0 | 0 | 0 | 0.2 | 75 |
| Queens | 175 | 4 | 12 | 25 | <0.1 | 0.5 | 216 |
| Richmond | 136 | 8 | 25 | 0 | 1 | 0.5 | 170 |
| Suffolk | 834 | 766 | 71 | 209 | 55 | 101 | 2036 |
| Westchester | 172 | 8 | 1 | 3 | 0.1 | <0.1 | 184 |
| **Totals** | **2038** | **800** | **124** | **238** | **61** | **186** | **3447** |

* Excludes Dutchess, Orange, Putnam, Ulster, and Rockland Counties along the tidal Hudson River as well as Ellis and Liberty Islands.

**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 | Not Considered | Totals |
| Barrier/Oceanside | Atlantic Ocean | 67 | 64 | 1 | 4 | <0.1 | 1 | **138** |
| Ocean Front | Atlantic Ocean | 10 | 33 | 0 | 10 | 0 | 0 | **54** |
| Barrier Bay/Mainland | Great South Bay | 22 | 23 | 3 | 7 | 6 | 0.4 | **62** |
| Barrier/Bayside | Great South Bay | 13 | 47 | 1 | 2 | 2 | 0.6 | **67** |
| Primary River | Hudson River | 85 | 2 | 0 | 0 | <0.1 | 0 | **87** |
| Barrier Bay/Mainland | Jamaica Bay | 20 | 0 | 1 | 1 | 0 | 0.4 | **23** |
| Barrier/Bayside | Jamaica Bay | 14 | 0.9 | 2 | 0 | 0 | 0 | **17** |
| Primary Bay | Long Island Sound | 141 | 79 | 0.6 | 13 | 0 | 6 | **239** |
| Barrier Bay/Mainland | Moriches Bay | 15 | 24 | <0.1 | 3 | 3 | 0 | **46** |
| Barrier/Bayside | Moriches Bay | 9 | 6 | <0.1 | 0 | 0 | 0 | **15** |
| Barrier Bay/Mainland | Narrow Bay | 2 | 5 | <0.1 | 0.6 | 0.7 | 0 | **8** |
| Primary Bay | Raritan Bay | 27 | 0 | 0 | 0 | <0.1 | 0 | **27** |
| Barrier Bay/Mainland | Shinnecock Bay | 21 | 19 | 0 | 0.5 | 3 | 0 | **44** |
| Barrier/Bayside | Shinnecock Bay | 6 | 11 | 0 | 0.6 | 0.2 | 0 | **18** |
| Barrier Bay/Mainland | South Oyster Bay | 34 | 0.7 | 0 | 0 | 0 | 13 | **48** |
| Barrier/Bayside | South Oyster Bay | 21 | 0.2 | 0 | 0 | 0 | 10 | **31** |
| Barrier/Oceanside | South Oyster Bay | 0.9 | 0 | 0 | 0 | 0 | 0 | **0.9** |
| **Totals** | | **509** | **315** | **10** | **42** | **16** | **32** | **923** |

**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 | Not Considered | Totals |
| Bronx | Secondary River | East River | 40 | 0.2 | 4 | 0 | 0 | 0.4 | **45** |
| Bronx | Secondary River | Harlem River | 12 | 0 | 0 | 0 | 0 | 0 | **12** |
| Bronx | Primary River | Hudson River | 4 | 0 | 0 | 0 | 0 | 0 | **4** |
| Bronx | Island | Long Island Sound | 13 | 0 | 0 | 0 | 0 | 0 | **13** |
| Bronx | Primary Bay | Long Island Sound | 10 | <0.1 | 0 | 0 | 0 | 0 | **10** |
| Bronx | Tributary | Long Island Sound | 36 | 0.3 | 1 | 0 | 0 | <0.1 | **37** |
| Kings | Secondary River | East River | 24 | 0 | 0 | 0 | 0 | 0.7 | **24** |
| Kings | Barrier Bay/Mainland | Jamaica Bay | 13 | 0 | 0.5 | 0 | 0 | 0.2 | **13** |
| Kings | Tributary | Jamaica Bay | 42 | 3 | 10 | 0 | 0 | 2 | **57** |
| Kings | Secondary Bay | Lower New York Bay | 16 | 0 | 0 | 0 | 0 | 0.5 | **17** |
| Kings | Primary Bay | Raritan Bay | 8 | 0 | 0 | 0 | 0 | 0 | **8** |
| Kings | Secondary Bay | Upper New York Bay | 35 | 0 | 0 | 0 | 0 | 0 | **35** |
| Nassau | Barrier/Oceanside | Atlantic Ocean | 28 | 0 | 0 | 0 | 0 | 1 | **29** |
| Nassau | Barrier/Bayside | Great South Bay | 0.3 | 0 | 0 | 0 | 0 | 0.1 | **0.4** |
| Nassau | Island | Great South Bay | 18 | 2 | 0 | 0 | 0 | 5 | **25** |
| Nassau | Tributary | Jamaica Bay | 20 | 2 | <0.1 | 0 | 0 | 6 | **28** |
| Nassau | Dredge and Fill | Long Island Sound | 0.3 | 0 | 0 | 0 | 0 | 0 | **0.3** |
| Nassau | Island | Long Island Sound | 0.4 | 0.4 | 0 | 0 | 0 | 0 | **0.8** |
| Nassau | Primary Bay | Long Island Sound | 57 | 0.4 | 0 | 1 | 0 | 0 | **58** |
| Nassau | Tributary | Long Island Sound | 97 | <0.1 | 0 | 0.8 | 0.2 | 0 | **98** |
| Nassau | Barrier Bay/Mainland | South Oyster Bay | 32 | 0.7 | 0 | 0 | 0 | 13 | **46** |
| Nassau | Barrier/Bayside | South Oyster Bay | 21 | 0.2 | 0 | 0 | 0 | 10 | **31** |
| Nassau | Barrier/Oceanside | South Oyster Bay | 0.9 | 0 | 0 | 0 | 0 | 0 | **0.9** |
| Nassau | Dredge and Fill | South Oyster Bay | 0.2 | 0 | 0 | 0 | 0 | <0.1 | **0.3** |
| Nassau | Island | South Oyster Bay | 2 | 1 | 0 | 0 | 5 | 3 | **11** |
| Nassau | Other | South Oyster Bay | 0.5 | 0 | 0 | 0 | 0 | 1 | **2** |
| Nassau | Tributary | South Oyster Bay | 118 | 3 | 0 | 0 | 0 | 39 | **160** |
| New York | Secondary River | East River | 25 | 0 | 0 | 0 | 0 | 0.2 | **26** |
| New York | Secondary River | Harlem River | 20 | 0 | 0 | 0 | 0 | 0 | **20** |
| New York | Island | Hudson River | 0.6 | 0 | 0 | 0 | 0 | 0 | **0.6** |
| New York | Primary River | Hudson River | 25 | 0 | 0 | 0 | 0 | 0 | **25** |
| New York | Island | Upper New York Bay | 4 | 0 | 0 | 0 | 0 | 0 | **4** |
| Queens | Barrier/Oceanside | Atlantic Ocean | 17 | 0 | 0 | 0 | 0 | 0 | **17** |
| Queens | Tributary | Atlantic Ocean | 1 | 0 | 0 | 0 | 0 | <0.1 | **2** |
| Queens | Secondary River | East River | 58 | 0 | 0.8 | 0 | 0 | 0.1 | **59** |
| Queens | Barrier Bay/Mainland | Jamaica Bay | 8 | 0 | 0.8 | 1 | 0 | 0.3 | **10** |

## 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 | Not Considered | Totals |
| Queens | Barrier/Bayside | Jamaica Bay | 14 | 0.9 | 2 | 0 | 0 | 0 | **17** |
| Queens | Island | Jamaica Bay | 13 | 0 | 0 | 24 | 0 | 0 | **37** |
| Queens | Tributary | Jamaica Bay | 47 | 3 | 8 | 0 | <0.1 | <0.1 | **58** |
| Queens | Primary Bay | Long Island Sound | 5 | 0 | <0.1 | 0 | 0 | 0 | **5** |
| Queens | Tributary | Long Island Sound | 9 | 0 | 0.6 | 0 | 0 | <0.1 | **9** |
| Queens | Barrier Bay/Mainland | South Oyster Bay | 2 | 0 | 0 | 0 | 0 | 0 | **2** |
| Queens | Tributary | South Oyster Bay | 1 | 0 | 0 | 0 | 0 | <0.1 | **1** |
| Richmond | Secondary River | Kill Van Kull River | 90 | 8 | 25 | 0 | 1 | 0 | **124** |
| Richmond | Island | Lower New York Bay | 0 | 0 | 0 | 0 | 0 | 0.5 | **0.5** |
| Richmond | Secondary Bay | Lower New York Bay | 7 | 0 | 0 | 0 | 0 | 0 | **7** |
| Richmond | Primary Bay | Raritan Bay | 19 | 0 | 0 | 0 | <0.1 | 0 | **19** |
| Richmond | Tributary | Raritan Bay | 13 | 0 | 0 | 0 | <0.1 | 0 | **13** |
| Richmond | Secondary Bay | Upper New York Bay | 7 | 0 | 0 | 0 | 0 | 0 | **7** |
| Suffolk | Barrier/Oceanside | Atlantic Ocean | 23 | 64 | 1 | 4 | <0.1 | 0 | **92** |
| Suffolk | Ocean Front | Atlantic Ocean | 10 | 33 | 0 | 10 | 0 | 0 | **54** |
| Suffolk | Other | Atlantic Ocean | 0.2 | 0 | 0 | 0 | 0 | 0 | **0.2** |
| Suffolk | Tributary | Atlantic Ocean | 19 | 3 | 0.2 | 1 | 0.7 | 1 | **25** |
| Suffolk | Island | Block Island Sound | 19 | 21 | 0.1 | 0.2 | 0 | 0 | **41** |
| Suffolk | Secondary Bay | Block Island Sound | 19 | 28 | <0.1 | 19 | 1 | 3 | **70** |
| Suffolk | Other | Fire Island Inlet | 3 | 9 | 0 | 0.2 | 0 | 0 | **13** |
| Suffolk | Island | Gardiners Bay | 10 | 25 | 36 | 9 | 0 | 0.5 | **81** |
| Suffolk | Secondary Bay | Gardiners Bay | 35 | 24 | 0 | 10 | 1 | 6 | **76** |
| Suffolk | Island | Great Peconic Bay | 0 | 0 | 0 | 7 | 0 | 0 | **7** |
| Suffolk | Other | Great Peconic Bay | 2 | 0.6 | 0 | 0 | 0 | 0 | **3** |
| Suffolk | Secondary Bay | Great Peconic Bay | 57 | 69 | 0.9 | 10 | 3 | 5 | **144** |
| Suffolk | Barrier Bay/Mainland | Great South Bay | 22 | 23 | 3 | 7 | 6 | 0.4 | **62** |
| Suffolk | Barrier/Bayside | Great South Bay | 12 | 47 | 1 | 2 | 2 | 0.6 | **66** |
| Suffolk | Dredge and Fill | Great South Bay | 0.2 | 0 | 0 | <0.1 | 0 | 0 | **0.3** |
| Suffolk | Island | Great South Bay | 5 | 2 | 8 | 19 | 0 | 1 | **35** |
| Suffolk | Other | Great South Bay | 0.6 | 1 | 0 | 0 | 0 | 0 | **2** |
| Suffolk | Tributary | Great South Bay | 156 | 45 | 10 | 20 | 24 | 9 | **264** |
| Suffolk | Island | Little Peconic Bay | 32 | 20 | 0.8 | 22 | 0 | 6 | **80** |
| Suffolk | Secondary Bay | Little Peconic Bay | 41 | 19 | 1 | 3 | 0 | 16 | **80** |
| Suffolk | Secondary Bay | Long Beach Bay | 0.7 | 3 | 6 | 15 | 0 | 1 | **26** |
| Suffolk | Dredge and Fill | Long Island Sound | 0.3 | 0.1 | 0 | 0 | 0 | 0 | **0.4** |
| Suffolk | Primary Bay | Long Island Sound | 48 | 77 | 0.5 | 12 | 0 | 6 | **143** |
| Suffolk | Secondary Bay | Long Island Sound | 4 | 4 | 0 | <0.1 | 0 | <0.1 | **8** |
| Suffolk | Tributary | Long Island Sound | 91 | 69 | 0.7 | 21 | 1 | 16 | **199** |

**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 | Not Considered | Totals |
| Suffolk | Secondary Bay | Mecox Bay | 18 | 11 | 0.8 | 0.5 | 0.2 | 0.8 | **31** |
| Suffolk | Barrier Bay/Mainland | Moriches Bay | 15 | 24 | <0.1 | 3 | 3 | 0 | **46** |
| Suffolk | Barrier/Bayside | Moriches Bay | 9 | 6 | <0.1 | 0 | 0 | 0 | **15** |
| Suffolk | Island | Moriches Bay | 3 | 2 | 0 | 0.9 | 0 | 0 | **6** |
| Suffolk | Other | Moriches Bay | <0.1 | 0.8 | 0 | 0 | 0 | 0 | **0.8** |
| Suffolk | Tributary | Moriches Bay | 49 | 31 | <0.1 | 2 | 1 | 4 | **86** |
| Suffolk | Barrier Bay/Mainland | Narrow Bay | 2 | 5 | <0.1 | 0.6 | 0.7 | 0 | **8** |
| Suffolk | Tributary | Narrow Bay | 9 | 5 | 0.2 | 0.7 | 0.9 | 0 | **16** |
| Suffolk | Secondary Bay | Northwest Harbor | 1 | 15 | 0 | 5 | 2 | 0.4 | **24** |
| Suffolk | Secondary Bay | Noyack Harbor | 5 | 11 | 0.2 | 2 | 0 | 5 | **23** |
| Suffolk | Secondary Bay | Sag Harbor Bay | 19 | 11 | 0.1 | 1 | 0 | 3 | **34** |
| Suffolk | Secondary Bay | Shelter Island Sound | 37 | 12 | 0 | 0.2 | 2 | 16 | **67** |
| Suffolk | Barrier Bay/Mainland | Shinnecock Bay | 21 | 19 | 0 | 0.5 | 3 | 0 | **44** |
| Suffolk | Barrier/Bayside | Shinnecock Bay | 6 | 11 | 0 | 0.6 | 0.2 | 0 | **18** |
| Suffolk | Island | Shinnecock Bay | 0.4 | 0.3 | 0 | 0.6 | 0 | 0 | **1** |
| Suffolk | Other | Shinnecock Bay | 4 | 5 | 0 | 0.3 | 0 | 0 | **9** |
| Suffolk | Tributary | Shinnecock Bay | 24 | 9 | 0 | 0.2 | 1 | 0.4 | **36** |
| Suffolk | Tributary | South Oyster Bay | 0.1 | 0 | <0.1 | 0 | 0 | 0 | **0.2** |
| Westchester | Dredge and Fill | Hudson River | 0.2 | 0 | 0 | 0 | 0 | 0 | **0.2** |
| Westchester | Primary River | Hudson River | 55 | 2 | 0 | 0 | <0.1 | 0 | **58** |
| Westchester | Tributary | Hudson River | 24 | 0.8 | 0 | 0 | 0 | 0 | **24** |
| Westchester | Island | Long Island Sound | 5 | 0.6 | 1 | 0 | 0 | 0 | **7** |
| Westchester | Primary Bay | Long Island Sound | 21 | 1 | 0 | 0 | 0 | 0 | **22** |
| Westchester | Tributary | Long Island Sound | 67 | 3 | 0 | 3 | <0.1 | <0.1 | **72** |
| **Totals** | | | **2038** | **800** | **124** | **238** | **61** | **186** | **3447** |

* Excludes Dutchess, Orange, Putnam, Ulster, and Rockland Counties along the tidal Hudson River as well as Ellis and Liberty Islands.

## Table A-5: 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 | Not Considered | Totals |
| Bronx | Island | Long Island Sound | 12 | 0 | 0 | 0 | 0 | 0 | 12 |
| Nassau | Island | Great South Bay | 16 | 0.7 | 0 | 0 | 0 | 5 | 22 |
| Nassau | Island | South Oyster Bay | 2 | 0 | 0 | 0 | 0 | 2 | 4 |
| New York | Island | Upper New York Bay | 3 | 0 | 0 | 0 | 0 | 0 | 3 |
| Queens | Island | Jamaica Bay | 13 | 0 | 0 | 9 | 0 | 0 | 22 |
| Suffolk | Island | Block Island Sound | 19 | 21 | 0.1 | 0.2 | 0 | 0 | 41 |
| Suffolk | Island | Gardiners Bay | 10 | 12 | 36 | 7 | 0 | 0.5 | 65 |
| Suffolk | Island | Great Peconic Bay | 0 | 0 | 0 | 7 | 0 | 0 | 7 |
| Suffolk | Island | Great South Bay | 3 | 1 | 2 | 6 | 0 | 0 | 11 |
| Suffolk | Island | Little Peconic Bay | 28 | 19 | 0.1 | 15 | 0 | 5 | 67 |
| Westchester | Island | Long Island Sound | 3 | 0 | 0 | 0 | 0 | 0 | 3 |
| **Totals** | | | **109** | **54** | **38** | **43** | **0** | **13** | **257** |

# 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.

The EPA data set used a combination of New York state wetlands data and National Wetlands Inventory 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 portions of Long Island that were inland of the area for which we obtained land use data, as well as Hudson River counties upstream of Westchester County. 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**

New York State

| 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 | 57.3 | 15.1 | 3.0 | 5.0 | 2.1 | 82.4 | 5.0 | 87.4 |
| 0.5 | 1.0 | 58.7 | 14.1 | 2.7 | 4.1 | 1.9 | 81.5 | 4.8 | 86.3 |
| 1.0 | 1.5 | 63.7 | 12.6 | 2.5 | 4.3 | 2.8 | 85.9 | 3.4 | 89.2 |
| 1.5 | 2.0 | 65.0 | 12.1 | 2.3 | 4.1 | 2.9 | 86.4 | 3.2 | 89.6 |
| 2.0 | 2.5 | 58.5 | 11.3 | 1.6 | 3.5 | 3.6 | 78.5 | 2.8 | 81.3 |
| 2.5 | 3.0 | 52.1 | 8.6 | 1.2 | 2.1 | 6.6 | 70.6 | 2.0 | 72.6 |
| 3.0 | 3.5 | 48.9 | 8.4 | 1.1 | 2.0 | 7.0 | 67.5 | 1.9 | 69.4 |
| 3.5 | 4.0 | 43.0 | 8.0 | 1.0 | 1.9 | 7.6 | 61.4 | 1.9 | 63.3 |
| 4.0 | 4.5 | 38.7 | 6.3 | 0.8 | 1.5 | 10.4 | 57.8 | 1.9 | 59.7 |
| 4.5 | 5.0 | 33.0 | 5.8 | 0.7 | 1.4 | 10.7 | 51.7 | 1.8 | 53.4 |
| 5.0 | 5.5 | 19.1 | 4.8 | 0.3 | 1.3 | 9.9 | 35.4 | 1.7 | 37.1 |
| 5.5 | 6.0 | 11.8 | 2.8 | 0.3 | 0.8 | 4.2 | 19.8 | 1.3 | 21.1 |

A peer reviewer noticed that the draft maps showed Gardiners Island as "likely" even though the text said that it had been changed to "unlikely". The effect of that error was to overstate the area of land below one meter where shore protection is likely, and understate the area where shore protection is unlikely, by 0.7, 0.9, and 1.1 square miles for the land within 50, 100, and 200 cm above spring high water. We corrected the maps, but not the quantitative results in this report.

Suffolk

| 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 | 1657 | 1391 | 118 | 343 | 172 | 3680 | 414 | 4094 |
| 0.5 | 1.0 | 1734 | 1312 | 116 | 354 | 180 | 3696 | 402 | 4098 |
| 1.0 | 1.5 | 1896 | 1155 | 102 | 378 | 264 | 3795 | 255 | 4050 |
| 1.5 | 2.0 | 1889 | 1123 | 101 | 366 | 275 | 3755 | 236 | 3991 |
| 2.0 | 2.5 | 1905 | 1087 | 92 | 330 | 343 | 3757 | 227 | 3984 |
| 2.5 | 3.0 | 1702 | 842 | 53 | 188 | 640 | 3425 | 149 | 3575 |
| 3.0 | 3.5 | 1656 | 821 | 46 | 179 | 688 | 3390 | 146 | 3536 |
| 3.5 | 4.0 | 1606 | 778 | 40 | 173 | 741 | 3339 | 144 | 3483 |
| 4.0 | 4.5 | 1226 | 611 | 25 | 142 | 1028 | 3032 | 136 | 3168 |
| 4.5 | 5.0 | 1159 | 570 | 22 | 132 | 1063 | 2947 | 130 | 3077 |
| 5.0 | 5.5 | 1029 | 472 | 19 | 123 | 982 | 2624 | 127 | 2751 |
| 5.5 | 6.0 | 558 | 272 | 10 | 78 | 414 | 1332 | 98 | 1429 |

A peer reviewer noticed that the draft maps showed Gardiners Island as “likely” even though the text said that it had been changed to “unlikely”. The effect of that error was to overstate the area of land below one meter where shore protection is likely, and understate the area where shore protection is unlikely, by 66, 86, and 114 hectares for the land within 50, 100, and 200 cm above spring high water. We corrected the maps, but not the quantitative results in this report.

Nassau

| 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 | 1255.8 | 52.0 | 4.7 | 1.9 | 1.9 | 1316.3 | 28.5 | 1344.8 |
| 0.5 | 1.0 | 1721.8 | 47.8 | 4.7 | 2.0 | 1.6 | 1777.9 | 26.8 | 1804.7 |
| 1.0 | 1.5 | 2059.8 | 46.4 | 4.7 | 4.3 | 1.4 | 2116.7 | 30.6 | 2147.3 |
| 1.5 | 2.0 | 2069.7 | 44.5 | 4.7 | 4.2 | 1.1 | 2124.1 | 35.5 | 2159.6 |
| 2.0 | 2.5 | 1298.0 | 22.8 | 2.6 | 4.0 | 0.8 | 1328.1 | 29.6 | 1357.7 |
| 2.5 | 3.0 | 870.9 | 4.2 | 1.0 | 1.2 | 0.5 | 877.8 | 26.6 | 904.4 |
| 3.0 | 3.5 | 868.8 | 4.2 | 1.0 | 1.2 | 0.5 | 875.6 | 26.6 | 902.2 |
| 3.5 | 4.0 | 850.7 | 3.1 | 1.0 | 1.2 | 0.5 | 856.4 | 25.7 | 882.1 |
| 4.0 | 4.5 | 799.7 | 2.7 | 1.0 | 1.9 | 0.5 | 805.8 | 34.4 | 840.2 |
| 4.5 | 5.0 | 736.5 | 1.3 | 1.0 | 1.6 | 0.1 | 740.5 | 30.8 | 771.2 |
| 5.0 | 5.5 | 378.9 | 0.7 | 0.6 | 1.6 | 0.0 | 381.8 | 30.5 | 412.3 |
| 5.5 | 6.0 | 135.6 | 0.2 | 0.0 | 0.6 | 0.0 | 136.3 | 20.7 | 157.0 |

Brooklyn

| 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 | 664.6 | 5.7 | 24.4 | 36.2 | 11.4 | 742.3 | 6.5 | 748.8 |
| 0.5 | 1.0 | 544.5 | 1.7 | 28.5 | 26.7 | 1.5 | 602.9 | 2.7 | 605.6 |
| 1.0 | 1.5 | 544.5 | 1.7 | 28.5 | 26.7 | 1.5 | 602.9 | 2.7 | 605.6 |
| 1.5 | 2.0 | 620.0 | 1.3 | 24.2 | 20.1 | 1.1 | 666.7 | 2.4 | 669.1 |
| 2.0 | 2.5 | 900.1 | 0.1 | 11.8 | 6.0 | 0.0 | 918.0 | 1.3 | 919.3 |
| 2.5 | 3.0 | 900.1 | 0.1 | 11.8 | 6.0 | 0.0 | 918.0 | 1.3 | 919.3 |
| 3.0 | 3.5 | 820.3 | 0.1 | 10.7 | 4.5 | 0.0 | 835.5 | 1.0 | 836.5 |
| 3.5 | 4.0 | 532.6 | 0.0 | 6.6 | 0.4 | 0.0 | 539.7 | 0.0 | 539.8 |
| 4.0 | 4.5 | 532.6 | 0.0 | 6.6 | 0.4 | 0.0 | 539.7 | 0.0 | 539.8 |
| 4.5 | 5.0 | 483.7 | 0.0 | 6.5 | 0.3 | 0.0 | 490.5 | 0.0 | 490.6 |
| 5.0 | 5.5 | 86.0 | 0.0 | 4.0 | 0.0 | 0.0 | 90.0 | 0.0 | 90.0 |
| 5.5 | 6.0 | 86.0 | 0.0 | 4.0 | 0.0 | 0.0 | 90.0 | 0.0 | 90.0 |

Queens

| 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 | 1116.3 | 14.9 | 63.0 | 117.2 | 13.6 | 1324.9 | 13.5 | 1338.3 |
| 0.5 | 1.0 | 828.3 | 9.1 | 34.2 | 20.1 | 0.7 | 892.4 | 11.8 | 904.1 |
| 1.0 | 1.5 | 828.3 | 9.1 | 34.2 | 20.1 | 0.7 | 892.4 | 11.8 | 904.1 |
| 1.5 | 2.0 | 911.2 | 7.5 | 27.1 | 16.7 | 0.5 | 963.0 | 7.6 | 970.6 |
| 2.0 | 2.5 | 906.1 | 4.4 | 15.3 | 9.1 | 0.0 | 934.8 | 6.7 | 941.6 |
| 2.5 | 3.0 | 906.1 | 4.4 | 15.3 | 9.1 | 0.0 | 934.8 | 6.7 | 941.6 |
| 3.0 | 3.5 | 717.4 | 4.0 | 13.6 | 8.0 | 0.0 | 742.9 | 4.4 | 747.3 |
| 3.5 | 4.0 | 483.7 | 3.0 | 10.8 | 6.5 | 0.0 | 504.0 | 2.3 | 506.3 |
| 4.0 | 4.5 | 483.7 | 3.0 | 10.8 | 6.5 | 0.0 | 504.0 | 2.3 | 506.3 |
| 4.5 | 5.0 | 294.7 | 2.5 | 5.2 | 4.4 | 0.0 | 306.7 | 0.8 | 307.5 |
| 5.0 | 5.5 | 85.8 | 0.9 | 1.1 | 0.6 | 0.0 | 88.4 | 0.1 | 88.5 |
| 5.5 | 6.0 | 85.2 | 0.9 | 1.1 | 0.6 | 0.0 | 87.8 | 0.1 | 87.9 |

Staten Island

| 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 | 455.6 | 36.5 | 77.0 | 0.8 | 2.9 | 572.8 | 33.7 | 606.6 |
| 0.5 | 1.0 | 455.6 | 36.5 | 77.0 | 0.8 | 2.9 | 572.8 | 33.7 | 606.6 |
| 1.0 | 1.5 | 455.6 | 36.5 | 77.0 | 0.8 | 2.9 | 572.8 | 33.7 | 606.6 |
| 1.5 | 2.0 | 396.9 | 27.0 | 64.9 | 1.4 | 2.2 | 492.3 | 28.4 | 520.6 |
| 2.0 | 2.5 | 220.6 | 5.3 | 36.7 | 2.6 | 0.0 | 265.2 | 9.6 | 274.7 |
| 2.5 | 3.0 | 220.6 | 5.3 | 36.7 | 2.6 | 0.0 | 265.2 | 9.6 | 274.7 |
| 3.0 | 3.5 | 220.6 | 5.3 | 36.7 | 2.6 | 0.0 | 265.2 | 9.6 | 274.7 |
| 3.5 | 4.0 | 220.6 | 5.3 | 36.7 | 2.6 | 0.0 | 265.2 | 9.6 | 274.7 |
| 4.0 | 4.5 | 220.6 | 5.3 | 36.7 | 2.6 | 0.0 | 265.2 | 9.6 | 274.7 |
| 4.5 | 5.0 | 199.4 | 4.7 | 31.3 | 2.1 | 0.0 | 237.6 | 8.8 | 246.4 |
| 5.0 | 5.5 | 76.5 | 2.6 | 9.9 | 0.5 | 0.0 | 89.6 | 4.7 | 94.3 |
| 5.5 | 6.0 | 76.5 | 2.6 | 9.9 | 0.5 | 0.0 | 89.6 | 4.7 | 94.3 |

Manhattan

| 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 | 159.0 | 0.0 | 0.0 | 0.0 | 0.8 | 159.8 | 0.0 | 159.8 |
| 0.5 | 1.0 | 159.0 | 0.0 | 0.0 | 0.0 | 0.8 | 159.8 | 0.0 | 159.8 |
| 1.0 | 1.5 | 159.0 | 0.0 | 0.0 | 0.0 | 0.8 | 159.8 | 0.0 | 159.8 |
| 1.5 | 2.0 | 160.3 | 0.0 | 0.0 | 0.0 | 0.8 | 161.1 | 0.0 | 161.1 |
| 2.0 | 2.5 | 173.4 | 0.0 | 0.0 | 0.0 | 0.1 | 173.5 | 0.0 | 173.5 |
| 2.5 | 3.0 | 173.0 | 0.0 | 0.0 | 0.0 | 0.1 | 173.1 | 0.0 | 173.1 |
| 3.0 | 3.5 | 173.0 | 0.0 | 0.0 | 0.0 | 0.1 | 173.1 | 0.0 | 173.1 |
| 3.5 | 4.0 | 173.0 | 0.0 | 0.0 | 0.0 | 0.1 | 173.1 | 0.0 | 173.1 |
| 4.0 | 4.5 | 173.0 | 0.0 | 0.0 | 0.0 | 0.1 | 173.1 | 0.0 | 173.1 |
| 4.5 | 5.0 | 173.0 | 0.0 | 0.0 | 0.0 | 0.1 | 173.1 | 0.0 | 173.1 |
| 5.0 | 5.5 | 51.3 | 0.0 | 0.0 | 0.0 | 0.0 | 51.3 | 0.0 | 51.3 |
| 5.5 | 6.0 | 41.4 | 0.0 | 0.0 | 0.0 | 0.0 | 41.4 | 0.0 | 41.4 |

Bronx

| 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 | 219.4 | 1.1 | 8.3 | 0.0 | 2.9 | 231.7 | 0.8 | 232.5 |
| 0.5 | 1.0 | 219.4 | 1.1 | 8.3 | 0.0 | 2.9 | 231.7 | 0.8 | 232.5 |
| 1.0 | 1.5 | 219.5 | 1.1 | 8.3 | 0.0 | 2.9 | 231.8 | 0.8 | 232.6 |
| 1.5 | 2.0 | 255.9 | 0.2 | 3.3 | 0.0 | 2.7 | 262.1 | 0.7 | 262.8 |
| 2.0 | 2.5 | 276.6 | 0.2 | 3.2 | 0.0 | 2.5 | 282.4 | 2.3 | 284.7 |
| 2.5 | 3.0 | 277.2 | 0.2 | 3.2 | 0.0 | 2.5 | 283.1 | 2.4 | 285.4 |
| 3.0 | 3.5 | 277.2 | 0.2 | 3.2 | 0.0 | 2.5 | 283.1 | 2.4 | 285.4 |
| 3.5 | 4.0 | 277.2 | 0.2 | 3.2 | 0.0 | 2.5 | 283.1 | 2.4 | 285.4 |
| 4.0 | 4.5 | 277.2 | 0.2 | 3.2 | 0.0 | 2.5 | 283.1 | 2.4 | 285.4 |
| 4.5 | 5.0 | 137.6 | 0.0 | 0.4 | 0.0 | 1.3 | 139.3 | 1.9 | 141.2 |
| 5.0 | 5.5 | 96.4 | 0.0 | 0.0 | 0.0 | 1.1 | 97.5 | 0.8 | 98.4 |
| 5.5 | 6.0 | 95.5 | 0.0 | 0.0 | 0.0 | 1.1 | 96.6 | 0.7 | 97.3 |

Westchester

| 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 | 199.3 | 5.8 | 0.4 | 1.7 | 3.6 | 210.8 | 3.2 | 214.0 |
| 0.5 | 1.0 | 199.3 | 5.8 | 0.4 | 1.7 | 3.6 | 210.8 | 3.2 | 214.0 |
| 1.0 | 1.5 | 199.1 | 6.1 | 0.4 | 1.6 | 3.7 | 210.9 | 3.1 | 214.0 |
| 1.5 | 2.0 | 197.6 | 8.5 | 0.4 | 1.0 | 9.0 | 216.5 | 2.6 | 219.2 |
| 2.0 | 2.5 | 169.6 | 7.0 | 0.4 | 1.0 | 12.8 | 190.7 | 1.4 | 192.2 |
| 2.5 | 3.0 | 161.0 | 6.5 | 0.4 | 1.0 | 12.6 | 181.5 | 0.7 | 182.2 |
| 3.0 | 3.5 | 161.0 | 6.5 | 0.4 | 1.0 | 12.6 | 181.5 | 0.7 | 182.2 |
| 3.5 | 4.0 | 161.0 | 6.5 | 0.4 | 1.0 | 12.6 | 181.5 | 0.7 | 182.2 |
| 4.0 | 4.5 | 160.7 | 6.4 | 0.4 | 1.0 | 12.6 | 181.3 | 0.7 | 182.0 |
| 4.5 | 5.0 | 119.9 | 2.8 | 0.2 | 1.0 | 9.2 | 133.1 | 2.1 | 135.2 |
| 5.0 | 5.5 | 105.3 | 2.4 | 0.0 | 1.0 | 5.3 | 114.0 | 2.4 | 116.3 |
| 5.5 | 6.0 | 98.2 | 1.9 | 0.0 | 1.0 | 5.0 | 106.1 | 2.7 | 108.8 |

**Table B-2. Area of Land Vulnerable to a One Meter Rise in Sea Level (hectares)**
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] | |
| Long Island Sound and Peconic Estuary | | | | | | | |
| Suffolk[2] | 1270.8 | 1268.3 | 93.3 | 347.6 | 291.3 | 3494.7 | 3724.5 |
| Nassau | 257.7 | 6.2 | 0.0 | 1.2 | 8.6 | 275.4 | 479.2 |
| Queens | 327.5 | 0.0 | 11.1 | 0.0 | 11.3 | 350.0 | 52.4 |
| Westchester[3] | 212.7 | 4.5 | 0.7 | 3.4 | 2.1 | 226.9 | 105.3 |
| Bronx[4] | 350.8 | 2.1 | 16.5 | 0.0 | 1.7 | 375.9 | 123.8 |
| Total | 2419.5 | 1281.1 | 121.7 | 352.2 | 314.9 | 4722.9 | 4485.2 |
| | | | | | | | |
| Atlantic Coast | | | | | | | |
| Suffolk[5] | 2120.1 | 1434.4 | 140.6 | 349.9 | 523.9 | 4696.5 | 4502.1 |
| Nassau | 2719.9 | 93.6 | 9.4 | 2.7 | 46.8 | 2874.2 | 3858.7 |
| Queens | 1617.0 | 24.0 | 86.1 | 137.3 | 14.0 | 1892.5 | 705.7 |
| Brooklyn[6] | 1088.7 | 7.4 | 53.0 | 62.9 | 8.0 | 1232.2 | 351.5 |
| Total | 7545.6 | 1559.4 | 289.0 | 552.8 | 592.7 | 10695.4 | 9418.1 |
| | | | | | | | |
| New York Harbor | | | | | | | |
| Westchester[7] | 186.0 | 7.1 | 0.0 | 0.0 | 4.3 | 197.4 | 71.9 |
| Bronx[8] | 87.9 | 0.0 | 0.1 | 0.0 | 0.0 | 89.0 | 0.8 |
| Manhattan | 316.2 | 0.0 | 0.0 | 0.0 | 0.0 | 317.9 | 0.2 |
| Brooklyn[9] | 120.4 | 0.0 | 0.0 | 0.0 | 1.1 | 122.2 | 0.0 |
| Staten Island | 911.2 | 73.0 | 154.0 | 1.5 | 67.5 | 1213.1 | 543.3 |
| Total | 1621.7 | 80.1 | 154.1 | 1.5 | 72.9 | 1939.6 | 616.2 |
| | | | | | | | |
| New York | 11586.8 | 2920.6 | 564.8 | 906.6 | 980.5 | 17357.9 | 14519.4 |

1. Total includes the five categories listed plus the "not considered" category.
2. A peer reviewer noticed that the maps showed Gardiners Island as “likely” even though the text said that it had been changed to “unlikely”. The effect of that error, for this table, was to overstate the area of land below one meter where shore protection is likely, and understate the area where shore protection is unlikely, by 86 hectares. We corrected the maps, but not the quantitative results in this report. This portion of Suffolk County includes the Central Islip, Gardiner's Island East and West, Greenport, Huntington, Lloyd Harbor, Mattituck, Mattituck Hills, Middle Island, Montauk Point, Mystic, Napeague Beach, New London, Northport, Orient, Plum Island, Port Jefferson, Riverhead, Saint James, Southampton, Southold, Wading River quadrangles.
3. Glenville, Mamaroneck, Mount Vernon quadrangles.
4. Flushing and Mount Vernon quadrangles.

5. Amityville, Bay Shore East and West, Bellport, East Hampton, Eastport, Greenlawn, Howells Point, Moriches, Patchogue, Pattersquash Island, Quogue, Sag Harbor, Sayville, Shinnecock Inlet, West Gilgo Beach quadrangles.
6. Brooklyn, Coney Island, Far Rockaway, Jamaica quadrangles.
7. Haverstraw, Nyack, Ossining, Peekskill, White Plains, Yonkers quadrangles
8. Central Park and Yonkers quadrangles.
9. Jersey City and The Narrows quadrangles.

**Table B-3. Area of Wetlands Close to Sea Level By County**
Jurisdictions not included in study (hectares)

| | | Meters above Spring High Water | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **County** | | **0.5** | **1.0** | **1.5** | **2.0** | **2.5** | **3.0** | **3.5** | **4.0** | **4.5** | **5.0** |
| | Tidal | ---------Nontidal Wetlands, by half meter elevation increment--------- | | | | | | | | | |
| Dutchess | 7.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Orange | 24.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Putnam | 126.6 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Rockland | 228.6 | 1.5 | 1.5 | 1.5 | 1.5 | 0.9 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |

Note: The analysis found no dry land below 5 meters for these jurisdictions.

# 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: New York[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---------- | | | | | | | | | | | | | | | | | | | |
| Bronx | | 0.4 | 3.2 | 2.2 | 6.3 | 4.1 | 9.4 | 5.9 | 13 | 8.1 | 16 | 11 | 19 | 14 | 22 | 17 | 25 | 19 | 26 | 22 | 27 |
| Brooklyn | | 3.1 | 10 | 8.5 | 17 | 14 | 24 | 20 | 34 | 28 | 43 | 37 | 52 | 46 | 57 | 53 | 63 | 59 | 68 | 64 | 69 |
| Manhattan | | 0.03 | 2.2 | 1.4 | 4.3 | 2.8 | 6.4 | 4.2 | 8.3 | 5.5 | 10 | 7.2 | 12 | 8.9 | 14 | 11 | 16 | 12 | 17 | 14 | 17 |
| Nassau | | 2.2 | 19 | 13 | 44 | 31 | 70 | 51 | 85 | 71 | 95 | 85 | 104 | 94 | 113 | 103 | 121 | 111 | 128* | 119 | 132* |
| Queens | | 6.2 | 17 | 15 | 28 | 23 | 39 | 32 | 49 | 41 | 58 | 51 | 67 | 60 | 72 | 66 | 77 | 71 | 80 | 77 | 81 |
| Staten Island | | 0.3 | 7.8 | 5.1 | 15 | 10 | 22 | 15 | 25 | 20 | 28 | 23 | 31 | 26 | 34 | 29 | 37 | 31 | 38 | 34 | 39 |
| Suffolk | | 14 | 51 | 43 | 97 | 78 | 140 | 115 | 181 | 152 | 217 | 189 | 251 | 222 | 286 | 256 | 316 | 289 | 345* | 319 | 371* |
| Westchester | | 0.2 | 2.9 | 1.7 | 5.7 | 3.4 | 8.4 | 5.2 | 11 | 7.1 | 13 | 9.2 | 15 | 11 | 17 | 13 | 19 | 15 | 20* | 16 | 21* |
| Ellis & Liberty Islands | | <0.01 | 0.05 | 0.03 | 0.1 | 0.06 | 0.14 | 0.09 | 0.14 | 0.13 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |
| **Statewide** | | **26** | **114** | **90** | **218** | **166** | **320** | **248** | **405** | **333** | **479** | **412** | **551** | **482** | **615** | **548** | **672** | **608** | **722*** | **665** | **757*** |

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

Note: A peer reviewer noticed that the draft maps showed Gardiners Island as "likely" even though the text said that it had been changed to "unlikely". The effect of that error was to overstate the area of land below one meter where shore protection is likely, and understate the area where shore protection is unlikely, by 0.7, 0.9, and 1.1 square miles for the land within 50, 100, and 200 cm above spring high water. We corrected the maps, but not the quantitative results in 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **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--------- | | | | | | | | | | | | | | | | | | | |
| Bronx | 1.2 | 0.00 | 0.01 | 0.01 | 0.02 | 0.01 | 0.03 | 0.02 | 0.06 | 0.03 | 0.09 | 0.04 | 0.11 | 0.07 | 0.14 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 | 0.2 |
| Brooklyn | 10 | 0.03 | 0.08 | 0.07 | 0.11 | 0.09 | 0.14 | 0.12 | 0.15 | 0.14 | 0.16 | 0.15 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Nassau | 44 | 0.1 | 0.4 | 0.3 | 0.7 | 0.5 | 1.2 | 0.8 | 1.5 | 1.1 | 1.8 | 1.4 | 2.1 | 1.7 | 2.3 | 2.0 | 2.6 | 2.2 | 2.9* | 2.6 | 3.2* |
| Putnam | 1.3 | 0 | <0.01 | 0.00 | <0.01 | <0.01 | 0.01 | <0.01 | 0.01 | <0.01 | 0.01 | <0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.01 | 0.02* | 0.01 | 0.02* |
| Queens | 12 | 0.0 | 0.2 | 0.1 | 0.3 | 0.2 | 0.4 | 0.4 | 0.5 | 0.4 | 0.6 | 0.5 | 0.6 | 0.6 | 0.7 | 0.6 | 0.7 | 0.6 | 0.7 | 0.67 | 0.69 |
| Rockland | 2.3 | 0.0 | 0.02 | 0.01 | 0.04 | 0.02 | 0.06 | 0.03 | 0.07 | 0.05 | 0.08 | 0.06 | 0.09 | 0.07 | 0.09 | 0.07 | 0.10 | 0.08 | 0.11* | 0.1 | 0.2* |
| Staten Island | 4.0 | 0.01 | 0.5 | 0.3 | 0.9 | 0.6 | 1.3 | 0.9 | 1.4 | 1.2 | 1.5 | 1.3 | 1.6 | 1.4 | 1.7 | 1.5 | 1.8 | 1.6 | 1.9 | 1.7 | 1.9 |
| Suffolk | 72 | 1.5 | 5.7 | 4.9 | 9.8 | 8.5 | 13 | 11 | 15 | 13 | 17 | 15 | 18 | 17 | 20 | 18 | 21 | 19 | 23* | 21 | 24* |
| Westchester | 1.7 | <0.01 | 0.04 | 0.03 | 0.08 | 0.05 | 0.12 | 0.08 | 0.13 | 0.10 | 0.14 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 | 0.2 | 0.15 | 0.21* | 0.16 | 0.23* |
| **Statewide** | **149** | **1.7** | **6.9** | **5.7** | **12** | **10** | **16** | **13** | **19** | **16** | **21** | **19** | **23** | **21** | **25** | **23** | **27** | **25** | **29*** | **26** | **30*** |
| | | | | | | | | | | | | | | | | | | | | | |
| | | Cumulative (total) amount of land below a given elevation[3] | | | | | | | | | | | | | | | | | | | |
| | | 26 | 114 | 90 | 218 | 166 | 320 | 248 | 405 | 333 | 479 | 412 | 551 | 482 | 615 | 548 | 672 | 608 | 722* | 665 | 757* |
| Nontidal Wetlands | | 2 | 7 | 6 | 12 | 10 | 16 | 13 | 19 | 16 | 21 | 19 | 23 | 21 | 25 | 23 | 27 | 25 | 29* | 26 | 30* |
| All Land | 149 | 176 | 269 | 244 | 379 | 325 | 485 | 410 | 573 | 498 | 649 | 579 | 722 | 652 | 788 | 719 | 848 | 781 | 899* | 840 | 936* |

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

## C-2. Likelihood of Shore Protection in New York, High and Low Estimates of the Land within One Meter above Spring High Water[1]

(square kilometers)

| | Likelihood of Shore Protection | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **County** | Certain | | Likely | | Unlikely | | No Protection | | Nontidal Wetlands | | Total[2] | |
| | low | high | low | high | low | high | low | high | low | high | low | high |
| **Long Island Sound and Peconic Estuary** | **12** | **33** | **7.1** | **16** | **0.7** | **1.6** | **2** | **4.8** | **1.7** | **4** | **24** | **63** |
| Suffolk[3] | 6.6 | 17 | 7 | 16 | 0.6 | 1.2 | 2 | 4.8 | 1.7 | 3.7 | 19 | 46 |
| Nassau | 0.6 | 3.5 | 0.02 | 0.08 | 0 | 0 | <0.01 | 0.01 | 0.01 | 0.11 | 0.6 | 3.7 |
| Queens | 1.6 | 4.5 | 0 | 0 | 0.05 | 0.15 | 0 | 0 | 0.05 | 0.15 | 1.7 | 4.8 |
| Westchester[4] | 1 | 2.9 | 0.02 | 0.06 | <0.01 | 0.01 | 0.02 | 0.04 | 0.01 | 0.03 | 1.1 | 3.1 |
| Bronx[5] | 1.7 | 4.8 | 0.01 | 0.03 | 0.08 | 0.23 | 0 | 0 | 0.01 | 0.02 | 1.8 | 5.1 |
| | | | | | | | | | | | | |
| **Atlantic Coast** | **43** | **102** | **10** | **19** | **1.8** | **3.6** | **3.8** | **6.8** | **3.7** | **7** | **63** | **141** |
| Suffolk[6] | 13 | 28 | 9.1 | 18 | 0.9 | 1.7 | 2.1 | 4.5 | 3.3 | 6.1 | 29 | 60 |
| Nassau | 12 | 39 | 0.5 | 1.2 | 0.04 | 0.12 | 0.02 | 0.05 | 0.2 | 0.6 | 12 | 41 |
| Queens | 11 | 20 | 0.2 | 0.3 | 0.6 | 1 | 1.2 | 1.5 | 0.1 | 0.2 | 13 | 24 |
| Brooklyn[7] | 7.1 | 14 | 0.06 | 0.08 | 0.3 | 0.7 | 0.4 | 0.8 | 0.06 | 0.09 | 8 | 16 |
| | | | | | | | | | | | | |
| **New York Harbor** | **7.1** | **22** | **0.3** | **1.1** | **0.7** | **2.1** | **0.01** | **0.02** | **0.3** | **1** | **8.5** | **26** |
| Westchester[8] | 0.6 | 2.5 | 0.02 | 0.1 | 0 | 0 | 0 | 0 | 0.02 | 0.06 | 0.7 | 2.7 |
| Bronx[9] | 0.4 | 1.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4 | 1.2 |
| Manhattan | 1.4 | 4.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.4 | 4.3 |
| Brooklyn[10] | 0.5 | 1.6 | 0 | 0 | 0 | 0 | 0 | 0 | <0.01 | 0.01 | 0.6 | 1.7 |
| Staten Island | 4.1 | 12 | 0.3 | 1 | 0.7 | 2.1 | 0.01 | 0.02 | 0.3 | 0.9 | 5.4 | 16 |
| | | | | | | | | | | | | |
| **New York** | **61** | **157** | **17** | **37** | **3.2** | **7.3** | **5.8** | **12** | **5.7** | **12** | **95** | **230** |

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. Central Islip, Gardiner's Island East and West, Greenport, Huntington, Lloyd Harbor, Mattituck, Mattituck Hills, Middle Island, Montauk Point, Mystic, Napeague Beach, New London, Northport, Orient, Plum Island, Port Jefferson, Riverhead, Saint James, Southampton, Southold, Wading River quadrangles.

4. Glenville, Mamaroneck, Mount Vernon quadrangles.

5. Flushing and Mount Vernon quadrangles.

6. Amityville, Bay Shore East and West, Bellport, East Hampton, Eastport, Greenlawn, Howells Point, Moriches, Patchogue, Pattersquash Island, Quogue, Sag Harbor, Sayville, Shinnecock Inlet, West Gilgo Beach quadrangles.

7. Brooklyn, Coney Island, Far Rockaway, Jamaica quadrangles.

8. Haverstraw, Nyack, Ossining, Peekskill, White Plains, Yonkers quadrangles

9. Central Park and Yonkers quadrangles.

10. Jersey City and The Narrows quadrangles.

## C-3. Likelihood of Shore Protection in New York, High and Low Estimates of the Land within Two Meters above Spring High Water[2] (square kilometers)

| | Likelihood of Shore Protection | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **County** | Certain | | Likely | | Unlikely | | No Protection | | Nontidal Wetlands | | Total[2] | |
| | low | high | low | high | low | high | low | high | low | high | low | high |
| **Long Island Sound and Peconic Estuary** | **34** | **63** | **18** | **29** | **1.8** | **2.7** | **5.8** | **9.4** | **4.3** | **7.2** | **67** | **119** |
| Suffolk[3] | 20 | 33 | 18 | 29 | 1.4 | 2.1 | 5.8 | 9.3 | 4 | 6.6 | 52 | 87 |
| Nassau | 2.6 | 7.1 | 0.07 | 0.13 | 0 | 0 | 0.01 | 0.03 | 0.1 | 0.3 | 2.8 | 7.7 |
| Queens | 4.2 | 8.1 | 0 | 0 | 0.1 | 0.2 | 0 | 0 | 0.1 | 0.2 | 4.5 | 8.5 |
| Westchester[4] | 2.7 | 5.3 | 0.1 | 0.2 | 0.01 | 0.02 | 0.04 | 0.07 | 0.02 | 0.04 | 2.9 | 5.9 |
| Bronx[5] | 4.5 | 9.3 | 0.02 | 0.03 | 0.2 | 0.3 | 0 | 0 | 0.02 | 0.03 | 4.8 | 9.8 |
| | | | | | | | | | | | | |
| **Atlantic Coast** | **123** | **194** | **23** | **33** | **4.3** | **5.8** | **8** | **11** | **7.8** | **10** | **169** | **260** |
| Suffolk[6] | 35 | 54 | 21 | 31 | 2.1 | 3 | 5.4 | 7.9 | 6.8 | 8.6 | 73 | 110 |
| Nassau | 47 | 76 | 1.3 | 2 | 0.12 | 0.21 | 0.07 | 0.13 | 0.7 | 1.1 | 49 | 79 |
| Queens | 24 | 36 | 0.3 | 0.4 | 1.2 | 1.5 | 1.6 | 1.8 | 0.2 | 0.3 | 28 | 41 |
| Brooklyn[7] | 17 | 28 | 0.09 | 0.1 | 0.9 | 1.1 | 0.9 | 1.1 | 0.11 | 0.13 | 19 | 31 |
| | | | | | | | | | | | | |
| **New York Harbor** | **21** | **39** | **1** | **1.6** | **2** | **3.4** | **0.02** | **0.07** | **0.9** | **1.5** | **25** | **45** |
| Westchester[8] | 2.2 | 4.5 | 0.1 | 0.2 | 0 | 0 | 0 | 0 | 0.05 | 0.1 | 2.4 | 4.8 |
| Bronx[9] | 1.1 | 2.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 | 1.2 | 2.7 |
| Manhattan | 4.1 | 8.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4.2 | 8.3 |
| Brooklyn[10] | 1.6 | 3.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0.02 | 1.6 | 3.1 |
| Staten Island | 12 | 20 | 1 | 1.4 | 2 | 3.4 | 0.02 | 0.07 | 0.9 | 1.4 | 16 | 26 |
| | | | | | | | | | | | | |
| **New York** | **177** | **296** | **42** | **64** | **8.1** | **12** | **14** | **20** | **13** | **19** | **261** | **424** |

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. Central Islip, Gardiner's Island East and West, Greenport, Huntington, Lloyd Harbor, Mattituck, Mattituck Hills, Middle Island, Montauk Point, Mystic, Napeague Beach, New London, Northport, Orient, Plum Island, Port Jefferson, Riverhead, Saint James, Southampton, Southold, Wading River quadrangles.

4. Glenville, Mamaroneck, Mount Vernon quadrangles.

5. Flushing and Mount Vernon quadrangles.

6. Amityville, Bay Shore East and West, Bellport, East Hampton, Eastport, Greenlawn, Howells Point, Moriches, Patchogue, Pattersquash Island, Quogue, Sag Harbor, Sayville, Shinnecock Inlet, West Gilgo Beach quadrangles.

7. Brooklyn, Coney Island, Far Rockaway, Jamaica quadrangles.

8. Haverstraw, Nyack, Ossining, Peekskill, White Plains, Yonkers quadrangles

9. Central Park and Yonkers quadrangles.

10. Jersey City and The Narrows quadrangles.

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

| Elevation relative to Spring High Water (m) | Area (square kilometers) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dry land: likelihood of shore protection | | | | | | | | | | | | | | | |
| | Shore Protection Certain | | Shore Protection Likely | | Shore Protection Unlikely | | No Shore Protection | | Not Considered | | Dry Land | | Non Tidal Wetlands | | All Land | |
| | low | high | low | high | low | high | low | high | low | high | low | high | low | high | low | high |
| 0.5 | 17 | 79 | 5.4 | 21 | 1 | 4 | 2.3 | 6.6 | 0.7 | 2.8 | 26 | 114 | 1.7 | 6.9 | 28 | 121 |
| 1.0 | 61 | 157 | 17 | 37 | 3.3 | 7.3 | 5.8 | 12 | 2.2 | 5.7 | 90 | 218 | 5.7 | 12 | 95 | 230 |
| 1.5 | 117 | 233 | 30 | 51 | 5.7 | 10 | 9.7 | 16 | 4.2 | 9.1 | 166 | 320 | 10 | 16 | 176 | 336 |
| 2.0 | 177 | 296 | 42 | 64 | 8.1 | 12 | 14 | 20 | 7 | 13 | 248 | 405 | 13 | 19 | 261 | 424 |
| 2.5 | 241 | 351 | 54 | 73 | 10 | 13 | 18 | 23 | 9.8 | 19 | 333 | 479 | 16 | 21 | 349 | 501 |
| 3.0 | 301 | 404 | 65 | 82 | 12 | 14 | 21 | 25 | 13 | 26 | 412 | 551 | 19 | 23 | 431 | 574 |
| 3.5 | 352 | 448 | 73 | 90 | 13 | 15 | 23 | 27 | 20 | 33 | 482 | 614 | 21 | 25 | 503 | 639 |
| 4.0 | 400 | 488 | 81 | 97 | 14 | 16 | 25 | 28 | 27 | 43 | 548 | 672 | 23 | 27 | 570 | 699 |
| 4.5 | 442 | 519* | 89 | 102* | 15 | 17* | 27 | 30* | 35 | 54* | 608 | 722* | 25 | 29* | 633 | 751* |
| 5.0 | 480 | 538* | 95 | 107* | 16 | 17* | 28 | 31* | 46 | 64* | 665 | 757* | 26 | 30* | 692 | 788* |

*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.

## NEW YORK STATE DEPARTMENT OF STATE (DIVISION OF COASTAL RESOURCES)

### NYDOS Wetlands

*Key data elements:* Identifies wetlands areas, based on 1974 aerial photography (same as NYSDEC wetlands information).

*Scale:* 1:2,400

*Date of publication:* early 1990s

## NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

### Draft Tidal Wetlands Jamaica Bay 1974

*Key data elements:* Used to delineate tidal wetlands for Jamaica Bay.

*Scale:* 1:2,400

*Date of publication*: 2000

### Draft Tidal Wetlands New York City 1974

*Key data elements:* Used to delineate tidal wetlands for New York City (Burroughs of Brooklyn, Queens, Manhattan, Staten Island, and Bronx).

Scale: 1: 2,400

*Date of publication:* 2000

### Draft Tidal Wetlands Index Map 5 1974

*Key data elements:* Used to index wetlands data for New York.

Scale: 1: 2,400

*Date of publication:* 2000

## NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

### Shinnecock Bay Tidal Wetlands 1974

*Key data elements:* Identifies tidal wetlands areas for Shinnecock Bay, based on 1974 aerial photography of area.

*Scale:* 1: 2,400

*Date of publication:* 1998-2000

## DEPARTMENT OF CITY PLANNING, NEW YORK CITY

### Land Use for New York City

*Key data elements:* Identifies coastal land use within New York City (Boroughs of Brooklyn, Queens, Manhattan, Staten Island, and Bronx. Where necessary, information on vacant parcel ownership was obtained through the New York Open Space Accessible Space Information System (http://www.oasisnyc.net).

*Scale:* 1: 66,360

*Date of publication:* 1995

## NASSAU COUNTY GIS DEPARTMENT

Nassau County Land Use Features

*Key data elements:* Delineates features including parks, planimetric features (such as buildings, recreational facilities, parking lots, cemeteries, etc.), major roads, and displays parcel centroids. In the absence of parcel boundary information and considering the high population density along coastal areas in Nassau County, all unidentified lands within the study area were considered to be developed (and therefore classified as "Certain to be Protected" unless otherwise specified).

*Scale:* 1: 800

*Date of publication:* 2002

## NASSAU COUNTY GIS DEPARTMENT

### Nassau County Bulkheads

*Key data elements:* Identifies location of bulkheads for Nassau County.

*Scale:* 1: 800

*Date of publication:* 2002

## SUFFOLK COUNTY PLANNING DEPARTMENT

### Suffolk County Parcel Data

*Key data elements:* Delineates parcel boundaries for Suffolk County.

*Scale:* 1: 2,400

*Date of publication:* 1991 for Huntington, Babylon, Islip, and Smithtown; 1999 for all eastern towns

## WESTCHESTER COUNTY DEPARTMENT OF PLANNING

### Land Use for Westchester County

*Key data elements:* Delineates generalized land uses in Westchester County.

*Scale:* 1: 24,000

*Date of Publication:* 1996

## ICF CONSULTING CONTRACT TO EPA

### Study Area

*Key data elements:* Defines landward-boundary of study area by identifying lands that are higher than 3.5 meters in elevation or within 1,000 feet of mean high water based on tidal wetlands data. ICF Consulting created layer using USGS maps based on the National Geodetic Vertical Datum (NGVD) of 1929.

*Scale:* 1:24,000

*Date of publication:* 2003.

## CREDITS AND ACKNOWLEDGMENTS

Jay Tanski prepared this report under the direction of James G. Titus of the U.S. Environmental Protection Agency, Office of Air and Radiation, Global Programs Division, who also served as editor of the document and reviewer of various stages of the GIS processing undertaken by two other EPA contractors. Titus also prepared the Summary section of this chapter. Daniel Hudgens and James Neumann of Industrial Economics, Incorporated (IEc) provided general project oversight for the draft maps of Long Island and New York City; Titus provided oversight for the stakeholder review and Westchester County. Hudgens also assisted in developing the maps that accompany this report. Kevin Wright of ICF Consulting converted the GIS data we provided into a final format, which included a careful review—and occasional correction—of the different projections of various data sets. Andrew Hickok and John Herter of IEc made the final maps.

We greatly appreciated the assistance of Mr. Joseph Jones and Ms. Maryanne Cimino of the Nassau County Geographic Information System and Mr. Carl Lind of the Suffolk County Planning Department, who were extremely helpful in providing the GIS data for their respective counties used in this effort. Most important, the author is indebted to the state and local officials listed in Table 2-4 who provided their valuable time and considerable expertise to assist in this effort:

Finally, David Aubrey, Ellen Hartig, and Barry Pendergrass provided very helpful comments during the peer review of this report.

Table 2-4

State and Local Government Participants

| Name | Organization |
|---|---|
| Bill Daley | New York State Department of Environmental Conservation |
| Fred Anders | New York State Department of State, Division of Coastal Resources and Waterfront Revitalization |
| Dewitt Davies | Suffolk County Planning Department |
| Ron Masters | Town of Hempstead Department of Conservation and Waterways |
| James Browne | Town of Hempstead Department of Conservation and Waterways |
| Michael Foley | Town of Hempstead Department of Conservation and Waterways |
| Robert Wenegenofsky | Town of Hempstead Department of Conservation and Waterways |
| Reid Berglind | Town Of Hempstead, Supervisor’s Office |
| John Armentano | Nassau County Planning Department |
| Robert Doscher | Westchester County Planning Department |
| Wilbur Woods | Waterfront and Open Space Division, City of New York Department of City Planning |
| Edward Greenfield | Waterfront and Open Space Division, City of New York Department of City Planning |