Appendix B. New York Metropolitan Area

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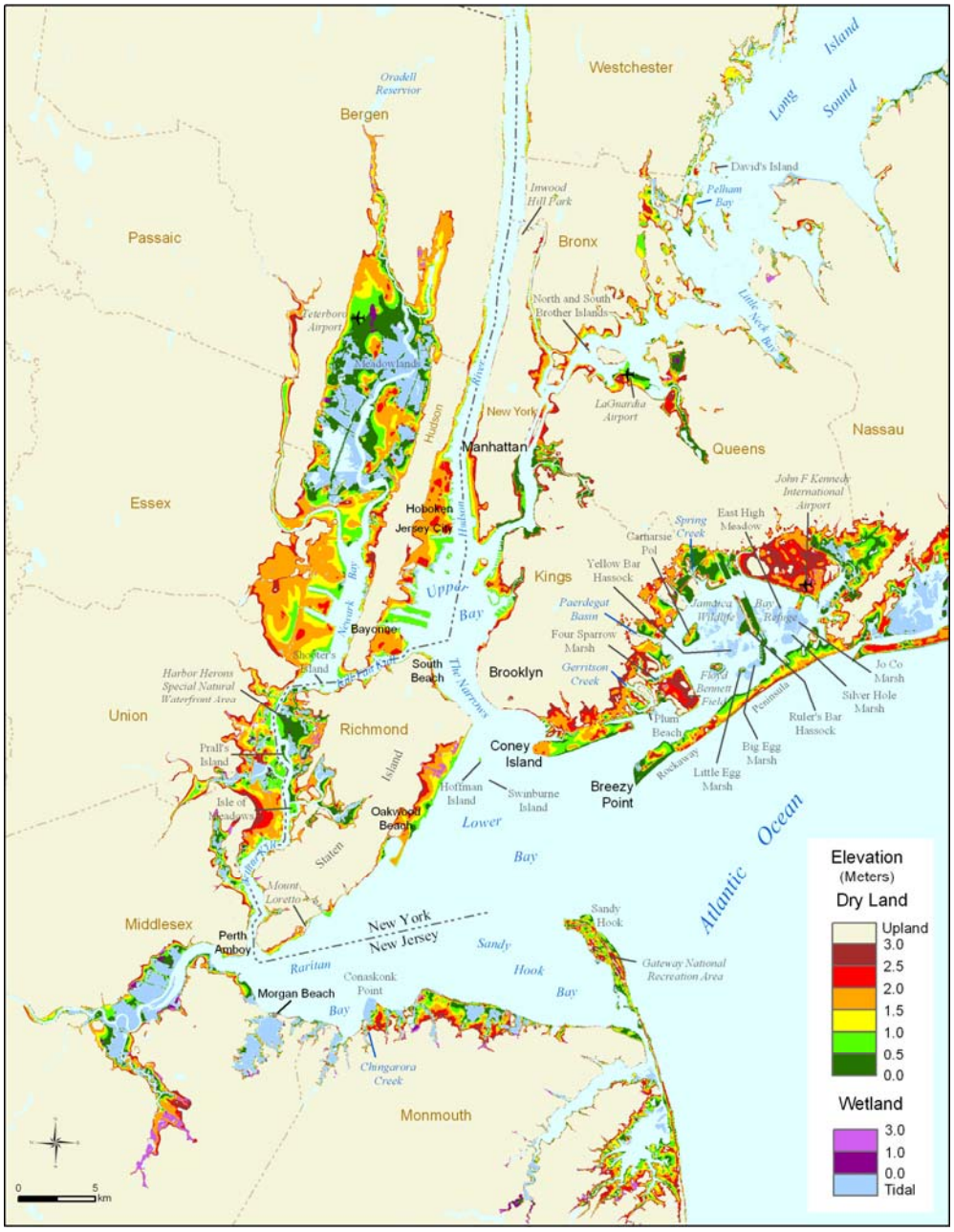
In December 1992, a powerful nor'easter submerged parts of downtown Manhattan in 4 feet of water, shut down significant portions of the city's transportation system, and resulted in coastal flooding that damaged as many as 20,000 homes (NYC OEM, 2007; Gornitz *et al.*, 2002). Given its large population, the effects of hurricanes and other major storms combined with higher sea levels could be particularly severe in the New York Metropolitan Area. With much of the area's transportation infrastructure at low elevation (most at 3 meters or less), even slight increases in the height of flooding could cause extensive damage and bring the thriving city to a relative standstill until the flood waters recede (Gornitz *et al.*, 2002).

B.1 LAND VULNERABLE TO INUNDATION

The New York metropolitan area has a mixture of elevated and low-lying coastlines (Figure B.1). New York's two major airports, LaGuardia and John F. Kennedy International Airport, are located along Queens' northern and southeastern shore, respectively, and both are within 3 meters of spring high water. Much of the recreational

lands along Jamaica Bay's Gateway National Recreation Area (*e.g.*, Floyd Bennett Field, Jamaica Bay Wildlife Refuge, Fort Tilden, Riis Park) have significant low-lying lands. Similarly, on Staten Island, the communities of South Beach and Oakwood Beach have substantial land under 2 meters in elevation. The New York City Department of Environmental Protection is planning "bluebelts" in repeatedly flooded residential neighborhoods; the Bluebelt Program would use remaining open space for stormwater management.



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10221 **Figure B.1** Greater New York area: Elevations relative to spring high water (Source: Titus and Wang,
10222 2008).

In New Jersey, the heavily developed coast of Hudson County (including Hoboken, Jersey City, and Bayonne) is also within 3 meters of spring high water. More than half the low land of North Jersey is in an area known as the Meadowlands. The New Jersey Meadowlands Commission (formerly the Hackensack Meadowlands Development Commission) regulates the portion of the Meadowlands west of US-1/US-9 and east of the NJ Transit Kingland and Pascack lines, south of the Teterboro Airport and north of the Lower Hackensack drawbridge. At the northern end, however, the area between Redneck Road and Moonachie Road south to Moonachie Avenue is excluded from the commission's jurisdiction. This area includes some of the lowest developed lands in North Jersey, with the intersection of Moonachie Avenue and Road at an elevation of 5 feet above NGVD, according to the USGS 1:24,000 scale map. As a result, the area floods regularly.

Table B.1 shows the area of land under specified elevations for the portion of the New York City metropolitan area draining into New York Harbor and Raritan Bay. As shown, between 139 and 230 square kilometers of land are located within 2 meters of spring high water. Staten Island has between 15 and 25 square kilometers of land within 2 meters elevation. The New Jersey counties also have significant quantities of low land, with a range of 115 to 186 square kilometers below 2 meters. Similar data for Queens and the portion of Brooklyn that drain into Long Island Sound and the Atlantic are available in Appendix A.

Table B.1 Low and high estimates for the area of dry and wet land close to sea level New York harbor[1] (square kilometers).

Locality	State	Tidal	50 cm		1 meter		2 meters		3 meters		5 meters	
			Low	High	Low	High	Low	High	Low	High	Low	High
			Cumulative (total) amount of dry land below a given elevation									
Monmouth	NJ		2.0	5.4	5.9	10.5	15.8	18.7	22.4	24.7	31.2	32.5
Middlesex	NJ		0.4	8.8	4.3	17.4	14.7	31.2	25.4	43.5	45.6	62.0
Somerset	NJ		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Union	NJ		0.4	6.9	4.2	13.7	12.6	22.7	20.2	29.3	31.7	40.9
Hudson	NJ		0.6	16.2	10.4	32.2	30.6	49.0	46.4	56.9	60.4	67.5
Essex	NJ		0.4	6.1	3.9	12.0	11.3	19.6	17.8	25.3	27.8	32.2
Bergen	NJ		0.9	15.6	10.2	31.0	29.4	44.2	42.5	49.0	51.1	58.2
Passaic	NJ		0.0	0.2	0.1	0.3	0.3	0.7	0.6	1.1	1.3	1.9
Ellis Island	NJ		0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Staten Island	NY		0.3	7.8	5.1	15.5	14.9	24.9	23.3	30.8	33.9	39.0
Brooklyn	NY		0.0	0.8	0.5	1.6	1.6	3.1	2.7	4.5	5.3	6.4
Manhattan	NY		0.0	2.2	1.4	4.3	4.2	8.3	7.2	12.1	14.1	17.5
Bronx	NY		0.0	0.6	0.4	1.2	1.2	2.7	2.2	4.4	5.3	6.9
Westchester	NY		0.0	1.3	0.7	2.6	2.3	4.7	4.1	6.1	6.4	8.3
Total			**5.1**	**71.9**	**47.1**	**142.6**	**138.9**	**230.0**	**214.9**	**288.0**	**314.1**	**373.7**
			Cumulative (total) amount of wetlands below a given elevation									
Monmouth	NJ	7.7	0.1	0.3	0.4	0.6	0.8	0.9	1.1	1.2	1.7	1.8
Middlesex	NJ	21.7	0.1	1.2	0.7	2.3	2.1	3.9	3.5	5.3	5.7	7.8
Union	NJ	2.3	0.0	0.2	0.1	0.3	0.3	0.5	0.4	0.6	0.6	0.8
Hudson	NJ	12.0	0.0	0.2	0.1	0.3	0.3	0.4	0.4	0.5	0.5	0.5
Essex	NJ	0.3	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Bergen	NJ	15.0	0.0	0.6	0.4	1.2	1.1	1.5	1.5	1.5	1.6	2.1
Passaic	NJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Staten Island	NY	4.0	0.0	0.5	0.3	0.9	0.9	1.4	1.3	1.6	1.7	1.9
Bronx	NY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Westchester	NY	0.7	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Rockland	NY	2.3	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2
Orange	NY	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Putnam	NY	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dutchess	NY	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total[2]		**67.6**	**0.2**	**3.0**	**2.0**	**5.8**	**5.6**	**9.0**	**8.6**	**11.1**	**12.2**	**15.5**
Dry and nontidal wetland			5	75	49	148	145	239	223	299	326	389
All land		68	73	142	117	216	212	307	291	367	394	457

Source: Titus J.G., and D. Cacela, 2008: Uncertainty Ranges Associated with EPA's Estimates of the Area of Land Close to Sea Level. Section 1.3 in: *Background Documents Supporting Climate Change Science Program Synthesis and Assessment Product 4.1: Coastal Elevations and Sensitivity to Sea Level Rise*, J.G. Titus and E.M. Strange (eds.). EPA 430R07004. U.S. EPA, Washington, DC.

[1] Does not include portions of Queens and Brooklyn that flow into Jamaica Bay. See Table A.1 at Appendix A.

[2] Brooklyn does not contain a substantial amount of wetlands that flow into New York harbor.

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B.2 ENVIRONMENTAL IMPLICATIONS

Species and habitats in the region encompassing New York City, the lower Hudson River, the East River, and Jamaica Bay are potentially at risk because of sea-level rise. Although the area is heavily urbanized, it also has regionally significant habitats for fish, shellfish, and birds. These include tidal wetlands, estuarine beaches, tidal flats, marsh and bay islands, and shallow nearshore environments.

Tidal wetlands are distributed throughout the region:

- **Staten Island:** The Northwest Staten Island/Harbor Herons Special Natural Waterfront Area (SNWA) is an important nesting and foraging area for herons, ibises, egrets, gulls, and waterfowl (USFWS, 1997). Several marshes, such as Arlington Marsh and Saw Mill Creek Park, Staten Island, provide foraging areas for the birds of the island heronries, and loss of these marshes could have a significant negative impact on these species because of a lack of alternative foraging sites nearby. Hoffman Island and Swinburne Island provide important nesting habitat for herons and cormorants, respectively[59].
- **Manhattan:** Most of the Manhattan shoreline, including Lower Manhattan and the Battery, has been bulkheaded and filled. An exception is the marsh and mudflat at the mouth of the Harlem River at Inwood Hill Park (USFWS, 1997). Great blue herons are found along the flat in winter, and snowy and great egrets are common from spring through fall (NYC DPR, 2001).

59 George Frame, National Park Service, in written communication to EPA, 5/14/07

- **Lower Hudson River:** The estuarine portion of the Hudson River (below the Tappan Zee Bridge) has relatively little marsh. One exception is Piermont Marsh, a 411.6 hectare (1,017 acre) brackish wetland on the western shore of the lower Hudson River that has been designated for conservation management by New York State and NOAA (USFWS, 1997). The marsh supports breeding birds, including relatively rare species such as Virginia rail, swamp sparrow, black duck, least bittern, and sora rail. Anadromous and freshwater fish use the marsh's tidal creeks as a spawning and nursery area. Diamondback terrapin reportedly nest in upland areas along the marsh (USFWS, 1997).
- **Jamaica Bay:** Jamaica Bay, located in Brooklyn and Queens, is the largest area along the U.S. Atlantic Coast of protected wetlands in a major metropolitan area. The bay includes the Jamaica Bay Wildlife Refuge, which has been protected since 1972 as part of the Jamaica Bay Unit of the Gateway National Recreation Area. Despite extensive disturbance from dredging, filling, and development, Jamaica Bay remains one of the most important migratory shorebird stopover sites in the New York Bight (USFWS, 1997).The bay provides overwintering habitat for many duck species, and mudflats support foraging migrant species (Hartig, 2002). The refuge and Breezy Point, at the tip of the Rockaway Peninsula, support populations of 214 species that are state or federally listed or of special emphasis, including 48 species of fish and 120 species of birds (USFWS, 1997). Salt marshes such as Four Sparrow Marsh provide nesting habitat for declining sparrow species and serve 326 species of migrating birds (NYC DPR, unknown). Wetlands in some parts of the bay currently show substantial losses (Hartig, 2002). Loss of these wetlands reduces primary

production as well as the production of fish and shellfish within both the marsh and the surrounding estuary.

Relatively few areas of *beach* remain in the New York City metropolitan area, and most are heavily modified. Beach nourishment is anticipated for beaches at the Rockaways and Coney Island (NYS, DCP 1992). In Jamaica Bay, remaining estuarine beaches occur off Belt Parkway (*e.g.*, on Plumb Beach) and on the bay islands[60]. Although limited in area, the beaches support an extensive food web. Mud snails and wrack-based species (*e.g.*, insects, isopods, and amphipods) provide food for shorebirds (including some protected species such as the federally threatened piping plover)[61]. Horseshoe crabs lay their eggs on the small pockets of beach in the bay, supplying additional shorebird forage. Diamondback terrapin also nest on the bay's sandy habitats; filled wetlands of Jamaica Bay provide most of the nest sites for terrapins in the region.[62] Because of the importance of beach species for estuarine food webs, scientists have raised concerns about the ecological implications of the loss of estuarine beaches (Jackson, 2002).

Tidal flats, like beaches, are limited in the New York City metropolitan region. Large concentrations of shorebirds, herons, and waterfowl use the shallows and tidal flats of Piermont Marsh along the lower Hudson River as staging areas for both spring and fall migrations (USFWS, 1997). Tidal flats in Jamaica Bay are frequented by shorebirds and

60 Don Riepe, American Littoral Society. August 20, 2006 email to E. Strange, Stratus Consulting, entitled "Notes from phone conversation," in which he confirmed his visual observations of intertidal beaches and shoreline armoring along Jamaica Bay as discussed in an earlier phone call with E. Strange on August 11, 2006.
61 Ibid.
62 George Frame, National Park Service, personal observations provided in written communication to EPA, 5/14/07.

waterfowl, and an intensive survey of shorebirds in the mid-1980s estimated more than 230,000 birds of 31 species in a single year, mostly during the fall migration (Burger, 1984). Inundation with rising seas will eventually make flats unavailable to short-legged shorebirds, unless they can shift feeding to marsh ponds and pannes (Erwin, 2004). At the same time, disappearing saltmarsh islands in the area are transforming into intertidal mudflats[63]. This may increase habitat for shorebirds at low tide, but it leaves less habitat for refuge at high tide.

Extensive *shallow water habitat* exists in the Hudson River, from Stony Point south to Piermont Marsh, just below the Tappan Zee Bridge (USFWS, 1997). This area features the greatest mixing of ocean and freshwater and concentrates nutrients and plankton, resulting in a high level of both primary and secondary productivity. Thus, this part of the Hudson provides key habitat for numerous fish and bird species. It is a major nursery area for striped bass, white perch, tomcod, and Atlantic sturgeon, and a wintering area for the federally endangered shortnose sturgeon. Waterfowl also feed and rest here during spring and fall migrations (USFWS, 1997). Some submerged aquatic vegetation (SAV) is also found here, dominated by water celery, sago pondweed, and horned pondweed (USFWS, 1997). Sea-level rise will affect this productive area through salinity changes that will influence the composition and diversity of nearshore vegetation and associated fauna, although the ultimate ecological implications are uncertain.

63 George Frame, National Park Service, personal observations provided in written communication to EPA, 5/14/07.

Finally, *marsh and bay islands* throughout the region are vulnerable to sea-level rise. It is estimated that between 1974 and 1994, the smaller islands of Jamaica Bay lost nearly 80% of their vegetative cover (Hartig, 2002). Marsh loss has accelerated, reaching an average annual rate of 18 hectares (44.5 acres) per year between 1994 and 1999 (Hartig, 2002). The islands provide specialized habitat for an array of species:

- Regionally important populations of egrets, herons, and ibises are or have been located on North and South Brother islands in the East River and on Shooter's Island, Prall's Island, and Isle of Meadows in Arthur Kill and Kill van Kull (USFWS, 1997).
- North and South Brother islands have the largest black crowned night heron colony in New York State, along with large numbers of snowy egret, great egret, cattle egret, and glossy ibis (USFWS, 1997).
- Since 1984, an average of 1,000 state threatened common tern have nested annually in colonies on seven islands of the Jamaica Bay Wildlife Refuge.
- The heronry on Carnarsie Pol also supports nesting by great black-backed gull, herring gull, and American oystercatcher (USFWS, 1997).
- The only colonies of laughing gull in New York State, and the northernmost breeding extent of this species, occur on the islands of East High Meadow, Silver Hole Marsh, Jo Co Marsh, and West Hempstead Bay (USFWS, 1997).
- Diamondback terrapin nest in large numbers along the sandy shoreline areas of the islands of Jamaica Bay, primarily Ruler's Bar Hassock (USFWS, 1997).

B.3 EXISTING DEVELOPMENT AND SHORE PROTECTION

New York City. Table B.2 estimates the area of land within 1 meter of spring high water for the portion of New York City metropolitan area that drains into New York Harbor. David's Island, a 75-acre former military installation, is the only undeveloped land in the county; however, it is already protected by structures.

The State Environmental Protection Fund provided $25 million to acquire the 145-acre Mount Loretto property on the south shore of Staten Island (NYS DEC, 2006). The State Open Space Plan also identifies several coastal properties, known collectively as the Staten Island Blue Belt, as priorities for preservation in this area (NYS DEC, 2006).

North Jersey. The coastal areas of Bergen, Essex, Hudson, and Union counties are dominated by dense residential, commercial, industrial, and transportation uses.

Middlesex County has mostly natural shores along Raritan Bay, with substantial dunes. To a large extent, public roads, bike paths, and parks are immediately inland of the beach, with residential development farther inland. Above Perth Amboy along Arthur Kill is a mixture of armored shores and beaches, with dense development inland of the shore. Approximately 85–90% of the area potentially sensitive to erosion or inundation is within planning areas 1, 2, and 3 (see Appendix C for discussion of planning areas). Conservation areas along the South River preserve the Perth Amboy/Runyon and Duhernal water systems. Salt water is likely (but not certain) to advance upstream if sea-level rises enough to inundate these areas. Currently, some of these areas are nontidal

freshwater wetlands, and conversion to tidal freshwater wetlands would not harm the aquifer protection function of these conservation lands. Conversion to salt marsh, by contrast, would contaminate the aquifer, and even occasional tidal flooding from saltwater could cause problems. By the time this area is threatened with sea-level rise, saltwater intrusion through the ground might be so great that protecting this recharge area from inundation would be insufficient to protect the wells[64].

B.4 POPULATION OF LANDS CLOSE TO SEA LEVEL

Table B.2 shows estimates of the population that inhabits the land within 50 centimeters, 1 meter, and 2 meters above spring high water. As shown, within the metropolitan area more than 1 million people reside within 2 meters of the water.

64 Personal communication from William Kruse, assistant planning director for Environment, Parks, & Comprehensive Planning, Middlesex County, New Jersey, to Jim Titus, December 1, 2004.

Table B.2 Block level population of the lands close to sea level by various scenarios of sea-level rise — low and high estimates.

County	Population (count)					
	50 centimeters		1 meter		2 meters	
	Low	High	Low	High	Low	High
NY, Bronx	0	79,146	0	87,939	33,330	109,519
NY, Brooklyn	10,398	125,089	10,398	215,673	105,606	355,954
NY, Manhattan	0	161,651	0	186,412	9,729	258,332
NY, Queens	8,000	119,545	8,000	157,433	109,052	215,560
NY, Staten Island	0	45,825	0	53,600	5,377	66,584
NJ, Bergen	0	53,938	0	60,510	10,774	72,904
NJ, Essex	0	21,994	0	28,447	0	38,712
NJ, Hudson	0	107,203	0	126,771	4,951	141,744
NJ, Middlesex	0	32,858	0	41,513	1,379	61,361
NJ, Union	0	21,227	0	23,577	0	38,914
Total	18,398	768,476	18,398	981,875	280,198	1,359,584

B.5 STATEWIDE POLICY CONTEXT: NEW YORK

New York State does not have written policies or regulations pertaining specifically to sea-level rise in relation to coastal zone management, although sea-level rise 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. Policies regarding management and development in shoreline areas are primarily based on three laws. Under the Tidal Wetlands Act program, the Department of Environmental Conservation (DEC) classifies various wetland zones and adjacent areas where human activities may have the potential to impair wetland values or adversely affect their function; permits are required for most activities that take place in these areas. New construction greater than 100 square feet (excluding docks, piers, and bulkheads) as well as roads and other

infrastructure must be set back 75 feet from any tidal wetland, except within New York City where the setback is 30 feet[65].

The Waterfront Revitalization and Coastal Resources Act (WRCRA) allows the DOS to address sea-level rise indirectly through policies regarding flooding and erosion hazards (NOAA, 1982). Seven out of 44 written policies related to management, protection, and use of the coastal zone address flooding and erosion control. These polices endeavor to:

- 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
- Encourage the use of nonstructural erosion and flood control measures where possible (NYS DOS, 2002).

In particular, Policy 13 states that erosion protection structures should be built only if the project is likely to control erosion for at least 30 years (NYS DOS, 2002). Currently, the DOS is refining and simplifying the policies and tailoring them more specifically to regions. The thrust of the policies, however, will remain the same. Local governments can also voluntarily participate in the coastal program by developing Local Waterfront Revitalization Programs (LWRPs), which require municipalities to adopt minimum state policy standards, including those for flooding and erosion.

65 Article 25, Environmental Conservation Law Implementing Regulations - 6NYCRR PART 661.

Under the Coastal Erosion Hazard Areas Act (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[66]. Permits are required for most activities in designated natural protective feature areas. New development (*e.g.*, building, permanent shed, deck, pool, garage) is prohibited in nearshore areas, beaches, bluffs, and primary dunes. These regulations, however, do not extend far inland and therefore do not encompass the broader area vulnerable to sea-level rise.

All five boroughs of New York City 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. 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.

For a discussion of the statewide policy context for areas along Raritan Bay (parts of Union, Essex, Bergen, Middlesex, Monmouth, and Hudson counties) (see Appendix C).

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