PEER REVIEW DRAFT

THE LIKELIHOOD OF SHORE PROTECTION ALONG THE ATLANTIC COAST OF THE UNITED STATES

VOLUME 2: NEW ENGLAND AND THE SOUTHEAST

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Chapter 5: NORTHEAST FLORIDA

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INTRODUCTION

Regional Background

The northeastern region of Florida is one of varied natural, geographical, and topographical environments. The region is a part of the Atlantic Coastal Plain and contains an assorted mix of land cover types that span from coastal marshes to upland hammocks and scrub areas. Within these 5,096 square miles of land and water is a diverse network of natural resources, including commercial and natural forest areas, rivers and associated wetlands, springs, and other undeveloped lands, all of which provide economic, environmental, recreational, and aesthetic benefits to the residents and visitors of the region. Eighty-seven percent of the region is land area, and the remaining 13 percent is fresh water.[1]

All of these diverse environments, even inland, are tied to the region's large natural bodies of water in some manner. On the eastern edge of the zone lie the coastal areas of Flagler, St. Johns, Duval, and Nassau counties, along the Atlantic Ocean. Within these four counties, the coastal areas are highly diverse and cannot be depicted just as open-ocean shoreline. A strip of coastal ridges separating the Atlantic Ocean from a narrow lagoon system and the mainland characterizes Northeast Florida's major coastal area, the Upper East Coast Basin. The Intracoastal Waterway connects the lagoon system in the basin. The Tolomato River is one of the major lagoons in this system and runs from Jacksonville in Duval County to St. Augustine in St. Johns County. Another major lagoon is the Matanzas River, running from St. Augustine to the Matanzas Inlet. Running parallel and east of the Tolomato River is the Guana River, which is a separate lagoon from the Intracoastal Waterway.[2]

The other major coastal areas in the region are the St. Mary's River Basin and the Nassau River Basin, both of which are characterized by extensive marsh and wetland areas. The inland portion of Northeast Florida is dominated by the Lower St. Johns River Basin, which contains Duval, St. Johns, and two interior counties, Clay and Putnam.[3] The Atlantic Ocean's tidal effects influence the St. Johns River for 100 statute miles upriver, near the southern border of Putnam County.[4]

In no small part due to Northeast Florida's attractive aquatic amenities, the region has seen a steady increase in population growth over the last 30 years. The 2000 Census showed that population in the region had grown by 22 percent over the 1990 population compared to state and national averages of 23.5 and 13.1 percent, respectively.[5] Historically, the Northeast Florida region has not seen the development that other areas of the state have experienced. This has resulted in the present existence of large tracts of undeveloped and undisturbed native habitats within the region that are home to a wide variety of native flora and fauna. Because the region is still relatively undeveloped and has much available land left, however, projections indicate that

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[1]Northeast Florida Regional Planning Council. (1997). *Strategic Directions: A Strategic Regional Policy Plan for Northeast Florida* (p.79). Jacksonville, FL: Author.
[2]*Ibid.* at 83–84.
[3]*Ibid.* at 81–82.
[4]NOAA. (1999). Currents in the St. Johns River, Florida: Spring and Summer of 1998 (p. 3). Silver Spring, MD: Author.
[5]US Census (2000).

the region will begin to grow faster than the rest of the state, on a percentage basis, through 2010.[6]

Most of this expected population growth will occur in the coastal areas of Northeast Florida. Flagler County, at the southern boundary of the region, is the fifth fastest growing county in the country and ranks first in Florida in population growth. Flagler County grew by 73.6 percent during the 1990–2000 Census period. Another coastal county in Northeast Florida, St. Johns County, is the fifth-fastest growing county in the state. St. Johns County's growth rate from 1990 to 2000 was 46.9 percent. Inland areas are not immune from high growth, though. Clay County, which rests on the St. Johns River, has the eighth largest population growth of any county in the state.[7]

Purpose of this Study

Because of the high population growth rates of coastal and riverine areas, it is imperative that land use planners begin to prepare for the eventual rise of sea levels in these areas. The coastline is highly developed with residential, commercial, and recreational properties. Areas bordering Florida's rivers face similar kinds of development. As Florida's population grows, these properties will only grow more numerous. Almost 25,000 kilometers of Florida's coast is below 3.5 meters in elevation.[8] If sea levels continue to rise, much of this area can be expected to be flooded. Planners must begin to decide which land areas in their counties and municipalities will be protected, if any, against sea level rise and what the cost of holding back the sea will be. Although the sea is not expected to rise in any significant amount in the near future, it is wise to start anticipatory planning on shore protection strategies now.

The Northeast Florida Regional Council (NEFRC) has been contracted by the Southwest Florida Regional Planning Council (SWFRPC), through a grant from the U.S. Environmental Protection Agency (EPA), to participate in a nationwide project promoting planning for and awareness of sea level rise. The other regional planning council's along the Atlantic Coast (East Central Florida, Treasure Coast, and South Florida) are also participating in this study; and the cooperative agreement between EPA and SWFRPC contemplates extending the study to include the entire coast of Florida.

The Florida studies are part of a national effort by the EPA to encourage the long-term thinking required to deal with the impacts of sea level rise issues. With this project, the EPA hopes to ensure the long-term survival of coastal wetlands and to diminish losses to life and property from coastal hazards, such as erosion and inundation. The regional planning councils of Florida share these goals, as do other coastal states, including New Jersey, North Carolina, and Maryland, where similar research has been conducted.

This sea level rise project seeks to stimulate government planning for adaptation to the effects of rising sea levels on uplands and wetlands. This is to be accomplished by creating maps that

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[6]Northeast Florida Regional Planning Council. (1997). *Strategic Directions: A Strategic Regional Policy Plan for Northeast Florida* (p.80). Jacksonville, FL: Author.
[7]US Census (2000).
[8]Titus, G., & Richman, C. (2001). Maps of Lands Vulnerable to Sea Level Rise: Modeled Elevations along the U.S. Atlantic and Gulf Coasts. *Climate Research: 18 (3).*

demonstrate the expected responses of counties and municipalities to sea level rise, based on current land use designations and future planning policies. Governments can then use these created sea level rise maps as guides for future land use and zoning decisions in coastal areas and tide-affected river areas.

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, 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. EPA seeks to accelerate the process by which coastal governments and private organizations plan for sea level rise. The first step in preparing for sea level rise is to decide which areas will be elevated or protected with dikes, and which areas will be abandoned to the sea.

- ***Policy makers and citizens concerned about long-term climate change.*** Governments at all levels and many citizens are considering measures to reduce greenhouse gas emissions. The urgency of doing so depends in part on the consequences of climate change and sea level rise. Those consequences in turn depend to a large degree on the extent to which local coastal area governments will permit or undertake sea level rise protection efforts. In addition, 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.

Approach

Based on research estimates of sea level rise in the next 200 years, the current 5-foot contour line was determined to be the mean sea level shoreline for mapping purposes. Although sea level may not rise exactly 5 feet, 5-foot contour line intervals on maps are common. More specific gradations of contour are not readily available on existing maps. Additionally, astronomical high tides must be accounted for, which means allowing for a few more feet of rise to be added to the 5-foot shoreline. Since only 5-feet interval contour lines are readily available, the 10-foot contour line must be used as the default sea level rise line for mapping purposes. Although such a large rise is unlikely any time soon, it is a mean estimate of the rise expected over the next two centuries, if global warming continues at its present pace.

To make assumptions about shore protection scenarios, determining future land use was necessary to define anticipated responses. To determine the protection scenarios of 0–10 foot upland areas, the generalized land uses were defined based on local government future land use maps. It is generally being assumed that protection is almost certain for existing developed areas and extensively used parks. Protection is assumed to be likely for less densely developed areas, moderately used parks, developed coastal areas, and agricultural areas. Undeveloped areas, coastal high hazard areas, and minimally used parks are assumed to be unlikely to be protected. Conservation lands, both privately and publicly owned, have generally been understood to be No Protection areas.

Table 1 lists areas of land vulnerable to sea level rise in Northeast Florida, and Figure 1 shows the lands vulnerable to sea level rise in the region. (We do not have a single map depicting the results of this study for the entire Northeast Florida Region.)

Table 1. Area of Land Close to Sea Level by County (square kilometers)

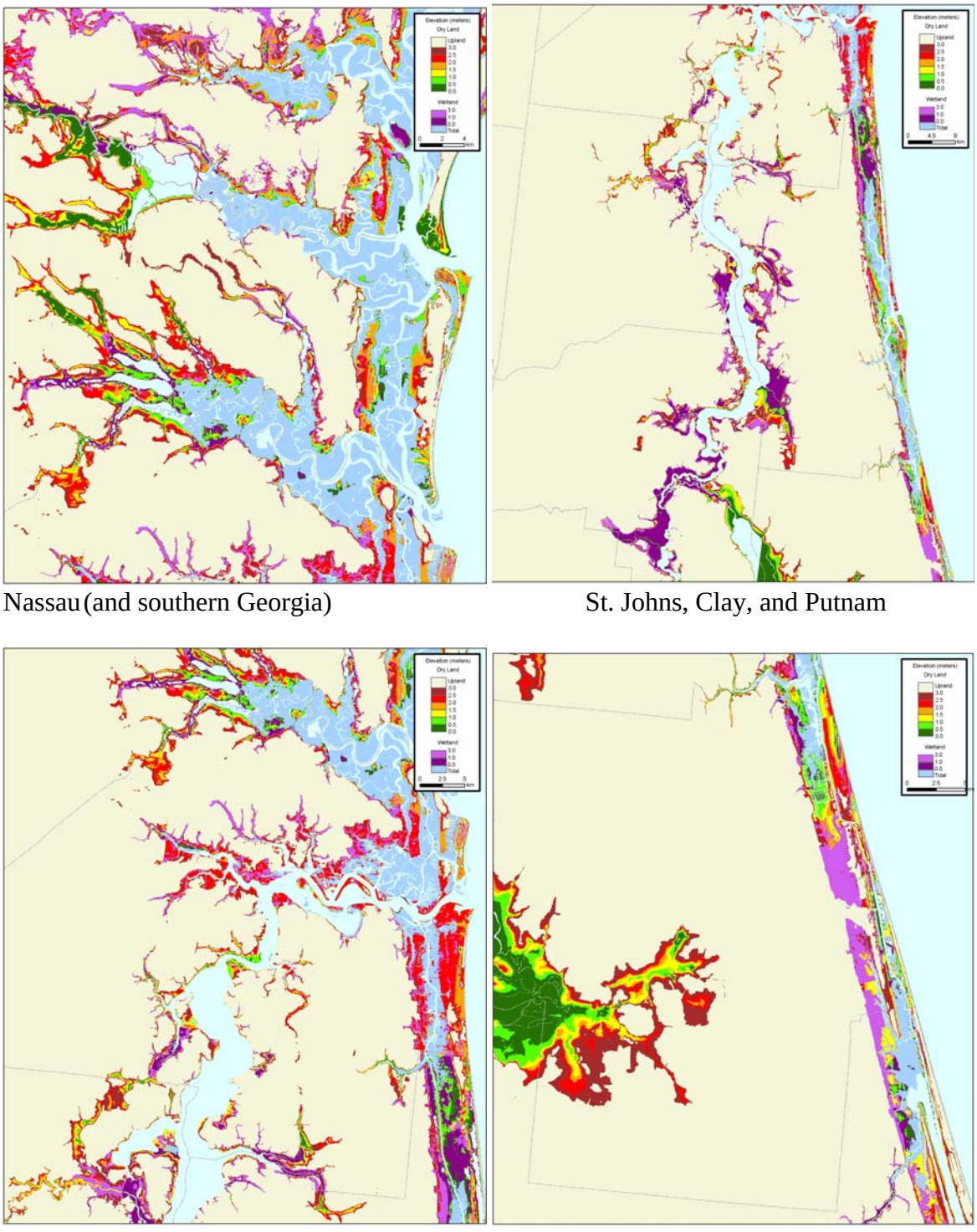
	Elevations (m) above spring high water									
County	**0.50**	**1.00**	**1.50**	**2.00**	**2.50**	**3.00**	**3.50**	**4.00**	**4.50**	**5.00**
Clay	13.4	27.5	45.5	57.9	71.2	94.3	108.5	120.9	143.3	1571
Duval	26.2	44.3	62.5	98.4	210.9	256.5	296.9	357.1	419.5	485.6
Flagler	56.6	80.7	112.8	134.4	165.3	228.8	261.2	312.2	401.4	441.3
Colleton	58.9	122.8	157.3	218.9	296.5	342.3	391.9	464.2	513.6	571.0
Nassau	66.9	98.2	126.8	157.2	208.8	238.5	309.4	3632	459.5	519.0
Putnam	88.4	160.8	198.6	217.5	236.6	274.9	299.2	324.4	374.7	405.5
St. Johns	64.0	134.4	170.7	201.7	247.5	290.5	330.6	386.2	446.2	485.4
Total	374	669	874	1086	1437	1726	1998	2328	2758	4479

Source: National Elevation Dataset and Titus J.G., 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. Section 1.1 in: *Background Documents Supporting Climate Change Science Program Synthesis and Assessment Product 4.1*, J.G. Titus and E.M. Strange (eds.). EPA 430R07004. U.S. EPA, Washington, DC.

Report Outline

The following sections of this report discuss details on these subjects further:

- Sea level rise predictions for northeast Florida;
- Current federal, state, and local coastal management policies;
- The general methodology used for development of county sea level rise maps; and
- Analysis and summary of anticipated sea level rise response scenarios for each county, and sea level rise response maps for each county.



Nassau (and southern Georgia) St. Johns, Clay, and Putnam

Duval Flagler

Figure 1 Elevation maps of the Counties in Northeast Florida relative to spring high water.
Source: See Table 1.

ESTIMATES OF SEA LEVEL RISE

Causes and Indications of Sea Level Rise

Increasing concentrations of carbon dioxide and other gases in the atmosphere have been warming the globe since humans began to release them. This is the process commonly known as the greenhouse effect. The average surface temperature of the planet has risen by approximately 1° F (0.6°C) in the last 100 years, coinciding with the increase in concentration of greenhouse gases in the atmosphere. All of the warmest years on record have happened since 1980. Global warming is expected to raise surface temperatures by a few more degrees within the coming century.[9]

The EPA estimates that there will be a 50 percent chance of a 1°C change in temperature by 2050, and a 90 percent probability of a 0.31°C rise in temperature. There is a 5 percent cumulative probability that temperatures will rise by more than 2°C in 50 years. By 2100, there is a 90 percent chance that a change in temperature equal to last century's will occur (0.6°C). A rise of 2°C by 2100 has a 50 percent probability, while there is a 5 percent prospect of a 4.7%°C increase in global temperatures.[10]

The global change in temperature caused by the greenhouse effect is likely to have a number of consequences that will combine to cause sea levels to rise. As surface temperatures rise, added heat will penetrate the ocean and cause the layers of the ocean to warm and expand by 20 cm by 2100.[11] These warmer temperatures may melt portions of the Greenland Ice Sheet and small glaciers, which could contribute increases of 2.9 cm[12] and 8.7 cm,[13] respectively, to the 22nd century's sea level. The melting of Antarctic ice sheets, however, is not expected to contribute to global sea level rise until after 2100. This is because the Antarctic ice sheets are already floating in the ocean and displacing water. Only if the acceleration of Antarctic ice streams conveying ice into the ocean increases substantially will Antarctic contributions to sea level rise be substantive. This is unlikely, however, because the increased precipitation caused by warmer air temperatures will outpace an acceleration of ice streams.[14]

By 2050, there is a 50 percent probability of average global sea levels rising by 15 cm. There is a 90 percent likelihood that sea level will raise by at least 4.6 cm and a one-in-ten chance of a 28 cm rise. Research results for 2100 finds that the probable sea level rise will be 34 cm. Sea level rise for 2100 at the 90 percent probability is 10 cm, and there is a 10 percent chance of a 65 cm sea level rise. Two hundred years from now, there is a 50-50 likelihood that sea levels will raise by 81 cm. By 2200, there is nine-in-ten chance of a sea level rise of at least 22 cm and a 10

[9]Titus, G., & Narayanan, V. (1995). *The Probability of Sea Level Rise*. Washington, DC: U.S. Environmental Protection Agency.
[10]*Ibid*. at 50.
[11]*Ibid* at 124.
[12]*Ibid* at 82.
[13]*Ibid* at 119.
[14]*Ibid* at 125.

percent probability of 196 cm sea level rise. Although very unlikely, there is a 1 percent chance of sea levels rising 42 cm, 104 cm, and 409 cm in 2050, 2100, and 2200, respectively.[15]

Sea Level Rise Estimates in Northeast Florida

The EPA document, *The Probability of Sea Level Rise*, provides the recommended procedure for estimating sea level rise at a specific location. An estimation of sea level rise at a particular location can be found using the following formula: **local(t) = normalized(t) + (t-1990) * trend,** where (t) is sea level rise. This equation is simply the addition of the normalized sea level projection for a specific year to the current rate of sea level rise from 1990 onward to a specific year in the future. The normalized projections provided in Table 2 "estimate the extent to which future average global sea level rise will exceed what would have happened if current trends simply continued."[16] The current global rate of sea level rise is 1.8 mm/year,[17] while sea level in Northeast Florida (Mayport) is rising at 2.2 mm/year. A historical rise rate of more than 2.5 mm/year is common along much of the U.S. coast.[18] The historical rates of sea level rise at various locations in the United States can be found in Table 3.

As an example, to find the estimation of the 50 percent probability of sea level rise in Northeast Florida in 2100, the following steps would be taken. As noted previously, the historical rate of sea level rise in this region has been 2.2 mm/year. The historical rate of rise (2.2 mm) is multiplied by the number of years from 1990 to 2100 (110). At that rate, sea level can be expected to rise 24.2 cm by 2100. For 2100, Table 2 provides a normalized sea level projection of 25 cm for the 50 percent probability. The rate projected from the current rate of rise of 24.2 cm is added to the normalized projection of 25 cm. This results in a 2100 sea level rise estimate of 49.2 cm at the 50 percent probability. It is important to note the normalized projections provided by the EPA are estimates of future sea rise and not based on hard statistics.[19] Full results for estimates of sea level rise in 2025, 2050, 2075, 2100, 2150, and 2220 can be viewed in Table 4.

[15] *Ibid* at 128.
[16] *Ibid* 144.
[17] *Ibid*
[18] *Ibid.* at 145.
[19] *Ibid.* at 145–146.

TABLE 4
ESTIMATED SEA LEVEL RISE FOR NORTHEAST FLORIDA

Sea Level Rise Projection by Year, Above 1990 Levels

Probability (%)	2025		2050		2075		2100		2150		2200	
	cm	inches	cm	inches	cm	inches	cm	inches	cm	inches	cm	inches
90	6.7	2.6	12.2	4.8	18.7	7.4	25.2	9.9	38.2	15.0	51.2	20.2
80	8.7	3.4	16.2	6.4	24.7	9.7	34.2	13.5	51.2	20.2	69.2	27.2
70	10.7	4.2	19.2	7.6	28.7	11.3	40.2	15.8	61.2	24.1	83.2	32.8
60	11.7	4.6	21.2	8.3	32.7	12.9	44.2	17.4	70.2	27.6	97.2	38.3
50	12.7	5.0	23.2	9.1	35.7	14.1	49.2	19.4	78.2	30.8	110.2	43.4
40	13.7	5.4	26.2	10.3	39.7	15.6	54.2	21.3	88.2	34.7	124.2	48.9
30	15.7	6.2	28.2	11.1	42.7	16.8	60.2	23.7	100.2	39.4	144.2	56.8
20	16.7	6.6	31.2	12.3	47.7	18.8	68.2	26.9	115.2	45.4	171.2	67.4
10	19.7	7.8	36.2	14.3	55.7	21.9	79.2	31.2	141.2	55.6	220.2	86.7
5	21.7	8.5	40.2	15.8	61.7	24.3	90.2	35.5	169.2	66.6	277.2	109.1
2.5	24.7	9.7	44.2	17.4	68.7	27.0	102.2	40.2	202.2	79.6	342.2	134.7
1	26.7	10.5	48.2	19.0	75.7	29.8	116.2	45.7	245.2	96.5	448.2	176.5
Mean	12.7	5.0	24.2	9.5	36.7	14.4	51.2	20.2	86.2	33.9	127.2	50.1

TABLE 2 ESTIMATING SEA LEVEL RISE AT A SPECIFIC LOCATION
Normalized Sea Level Projections, Compared with 1990 Levels (cm)[20]

Sea Level Projection by Year

Cumulative Probability (%)	2025	2050	2075	2100	2150	2200
10	-1	-1	0	1	3	5
20	1	3	6	10	16	23
30	3	6	10	16	26	37
40	4	8	14	20	35	51
50	5	10	17	25	43	64
60	6	13	21	30	53	78
70	8	15	24	36	65	98
80	9	18	29	44	80	125
90	12	23	37	55	106	174
95	14	27	43	66	134	231
97.5	17	31	50	78	167	296
99	19	35	57	92	210	402
Mean	5	11	18	27	51	81

[20] *Ibid.* at 145.

TABLE 3
HISTORICAL RATE OF SEA LEVEL RISE AT VARIOUS LOCATIONS IN THE UNITED STATES (mm/yr)

Atlantic Coast

Eastport, ME 2.7
Portland, ME 2.2
Boston, MA 2.9
Woods Hole, MA 2.7
Newport, RI 2.7
New London, CT 2.1
Montauk, NY 1.9
New York, NY 2.7
Sandy Hook, NJ 4.1
Atlantic City, NJ 3.9
Philadelphia, PA 2.6
Lewes, DE 3.1
Annapolis, MD 3.6
Solomons Is., MD 3.3
Washington, DC 3.2
Hampton Rds., VA 4.3
Portsmouth, VA 3.7
Wilmington, NC 1.8
Charleston, SC 3.4
Ft. Pulaski, GA 3.0
Fernandina, FL 1.9
Mayport, FL 2.2
Miami Beach, FL 2.3

Gulf Coast

Key West, FL 2.2
St. Petersburg, FL 2.3
Pensacola, FL 2.4
Grand Isle, LA 10.5
Eugene Island, LA 9.7
Sabine Pass, TX 13.2
Galveston,TX 6.4
Freeport, TX 14.0
Padre Island, TX 5.1

Pacific Coast

Honolulu, HI 1.6
Hilo, HI 3.6
San Diego, CA 2.1
La Jolla, CA 2.0
Newport, CA 1.9
Los Angeles, CA 0.8
Santa Monica, CA 1.8
San Francisco, CA 1.3
Alameda, CA 1.0
Crescent City, CA –0.6
Astoria, OR –0.3
Seattle, WA 2.0
Neah Bay, WA –1.1
Sitka, AK –2.2
Juneau, AK –12

CURRENT POLICIES AND TRENDS IN COASTAL MANAGEMENT

Very few policies at any level of government were specifically designed to respond to the effects of sea level rise caused by global warming. Many coastal management, construction, and planning and zoning guidelines, however, can prepare citizens and governments for rising sea levels. The three basic categories of adaptive responses to sea level rise are retreat, accommodation, and protection.

Retreat[21] is the policy of abandoning lands and structures in coastal zones and allowing marine ecosystems to move inland. In this response, there is no effort to protect the land from sea level rise. Governments exercising the retreat option generally prevent development in prone areas, allow development with conditions for abandonment (e.g., rolling easements) and/or withdraw subsidies for construction in danger zones. Governments can restrict development in coastal areas through a variety of policies. These approaches usually include land acquisitions, setbacks, low densities, planning and zoning restrictions on coastal land use, and bans on redevelopment of damaged structures.

Accommodation[22] allows for land use and occupancy of vulnerable areas to continue, but with no attempts to prevent flooding or inundation. It is a hybrid of retreat and protection, because structures are protected while floodplains and shorelines advance farther inland. Governments favoring accommodation can strengthen flood preparations, prohibit activities that may destroy protective coastal resources, and/or deny government flood insurance coverage of inhabitants of vulnerable areas. Strengthened flood preparations may include countering rising seas and high winds through building code requirements, improvement of drainage, and education. Like retreat, accommodation requires advance planning by local governments. Local governments must also accept that valuable land may be lost to rising seas. Although accommodation is a common short-term response, it may be less useful in the long run. Although it may be practical in some circumstances to maintain habitable homes as wetlands advance onto people's yards, eventually the wetlands would become inundated and homes would be standing in the water.

Protection[23] involves using structural, defensive measures to protect the land from the sea so that land use can continue. Shores can be protected by hard structures such as seawalls, revetments, and dikes or by soft structural techniques like beach nourishment and elevation of land surfaces with fill. Unlike the first two options, protection has a dramatic impact on both the immediate environment and ecosystems beyond the immediate area. The costs to wetlands, unprotected uplands, and offshore fisheries must be assessed be protective measures are constructed.

Federal Policies

[21] IPCC Coastal Zone Management Subgroup. (1990) *Strategies for Adaption to Sea Level Rise.*
[22] *Ibid.*
[23] *Ibid.*

Although a few federal policies specifically deal with the problems of sea level rise, several policies address the same effects of sea level rise, such as flooding, erosion, and wetland loss. These policies are included in the Coastal Zone Management Act, the Coastal Barrier Resources Act, the Clean Water Act, the Rivers and Harbors Act, and National Flood Insurance Act.

The Coastal Zone Management Act of 1972[24] is the federal law that created and guides the nation's coastal management programs. Congress created the CZMA to deal with the threats to the country's coastal zone caused by increasing and competing demands on the land and water of the zone. The CZMA establishes the coastal management policy of the United States as preserving, protecting, developing, and, where possible, restoring or enhancing the resources of the nation's coastal zone by encouraging and assisting the states to exercise to develop and implement their own coastal management programs. Congress also specifically addressed the issue of sea level rise in the act:

> Because global warming may result in a substantial sea level rise with serious adverse effects in the coastal zone, coastal states must anticipate and plan for such an occurrence.
>
> The Congress finds and declares that it is the national policy—the management of coastal development to minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard, and erosion-prone areas and in areas likely to be affected by or vulnerable to sea level rise, land subsidence, and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands.

The provisions of the CZMA are realized through the Coastal Zone Management Program (CZMP), which is administered by NOAA. The CZMP is a voluntary federal–state partnership that has provided cost-sharing grants to states to develop and implement their own coastal zone management plans. The CZMP has based eligibility for federal approval of state plans on several factors. Each state's plan is required to define boundaries of the state's coastal zone, identify uses within the area to be regulated by the state plan, the criteria for regulations such uses, and the guidelines for priorities of uses within the coastal zone. Subsequent to approval of the plan by NOAA, grants are awarded for implementation of the state's coastal management plan. In addition to providing financial assistance, the CZMP also supports states by offering mediation, technical services and information, and participation in priority state, regional, and local forums. Thirty-four states and territories with federally approved coastal management programs are participatories in the CZMP. Almost all of the nation's shoreline (99.9 percent) is currently managed by the CZMP. The main effect of the CZMA on the issue of sea level rise is to make state policymakers aware of the matter when they create their own coastal management plans.

Another piece of federal legislation that has a bearing on coastal management policies is the Coastal Barrier Resources Act (CoBRA),[25] enacted in 1982. CoBRA was designed to protect barrier islands along the nation's coast. Coastal barrier islands are located off of

[24]16 USC 1451-1464, Chapter 33; P.L. 92-583, October 27, 1972; 86 Stat. 1280.
[25]Public Law 97-348 (96 Stat. 1653; 16 U.S.C. 3501 et seq.) Coastal Barrier Resources Act (CoBRA).

the mainland coast and protect the mainland by receiving the majority of the ocean's energy contained in winds, waves, and tides. Coastal barriers also protect and maintain productive ecosystems that exist within this protective zone. In drafting the law, Congress found that certain actions and programs of the federal government subsidized and permitted development on coastal barriers and the result was the loss of barrier resources, threats to human life, health, and property, and the expenditure of millions of tax dollars each year.

CoBRA established a Coastal Barrier Resources System, which designated various undeveloped coastal barrier islands for inclusion in the system. The boundaries of the system are contained on maps kept on file by the Department of the Interior. CoBRA prohibits various federal actions and policies from occurring on islands within the system. The following areas in Northeast Florida are within the CoBRA system[26]:

Nassau County: Fort Clinch.

Duval County: Talbot Islands Complex (also in Nassau County).

St. Johns County: Guana River, Usinas Beach, and Conch Island.

Flagler County: Matanzas River (also in St. Johns County) and Washington Oaks Gardens.

The act places several restrictions on federal government spending on expenditures that encourage development or modification of a coastal barrier. No new expenditures or federal assistance can be used on coastal barrier islands for the following projects:

> (1) The construction or purchase of any structure, appurtenance, facility, or related infrastructure;
>
> (2) The construction or purchase of any road, airport, boat landing facility, or other facility on, or bridge or causeway to, any System unit; and
>
> (3) The carrying out of any project to prevent the erosion of, or to otherwise stabilize, any inlet, shoreline, or inshore area, except that such assistance and expenditures may be made available on (certain designated units) for purposes other than encouraging development and, in all units, in cases where an emergency threatens life, land, and property immediately adjacent to that unit.

Notwithstanding the previous restrictions, CoBRA does provide exceptions to limitations on a variety of expenditures with the barrier system. These include military and Coast Guard activities; maintenance of federal navigation channels; maintenance of certain publicly owned roads, structures, and facilities; scientific research; and nonstructural projects for shoreline stabilization that mimics, enhances, or restores a natural stabilization system. (Although shoreline stabilization may immediately bring beach

[26]Found at http://www.fws.gov/cep/cbrunits.html.

nourishment to mind, it is a more ecologically friendly process than simply dumping sand on a beach. Nonstructural shore erosion control projects usually use bioengineering to create protective vegetative buffers, stabilizing stream banks and shorelines and creating near-shore habitats for aquatic species and waterfowl.) Another feature of the act is the prohibition of national flood insurance or HUD assistance to any projects within the barrier system that facilitate an activity that is not consistent with CoBRA's provisions. CoBRA is a good start in the prevention of development in areas that will be most affected by the effects of sea level rise.

The National Flood Insurance Program (NFIP)[27] is another important component of federal coastal management policy. It is administered by the Federal Emergency Management Agency (FEMA), and its primary goals is to save lives and reduce future property losses from flooding. The NFIP is a voluntary program based on a mutual agreement or partnership between the federal government and local communities. This partnership provides that the federal government will make federally backed flood insurance available to home and business owners in communities that agree to adopt and enforce comprehensive floodplain management standards designed to reduce flood damages. NFIP transfers most of the costs of private property flood losses from the taxpayers to people who choose to live within floodplains through insurance premiums and increased construction standards.

Community response to this requirement involves the adoption of land use, zoning, and building code standards that, at a minimum, include the design and construction standards of the NFIP. The minimum NFIP design and construction standards are applicable to all new construction, substantial damages, and substantial improvements to existing structures located in Special Flood Hazard Areas or in Special Flood Hazard Areas that have not yet been identified by FEMA. The Special Flood Hazard Areas represent the statistical chance of a 100-year flood occurring in any given year. The 100-year flood has a 1 percent chance of occurring in any given year.

The NFIP imposes stricter requirements on communities in the V-Zones of Flood Insurance Rate Maps. These are locales in coastal high hazard areas located along coastlines that are subject to high water levels, wave action, and erosion from strong storms and hurricanes. The wind and resultant waves and tidal surges associated with these storms cause water of high velocity to sweep over nearby land. Generally, the V-Zone indicates the inland extent of a 3-foot breaking wave atop a storm surge. These areas are extremely hazardous to life and property.

The NFIP lists a number of building requirements for new construction or substantial improvements in coastal high hazard areas to be able to withstand wind and waves. New buildings and improvements must:

- Obtain and maintain the elevation of the bottom of the lowest horizontal structural member of the lowest floor.
- Be located landward of mean high tide and no new construction is allowed over water.

[27] 44 CFR 60.3

- Be elevated so that the bottom of the lowest horizontal structural member of the lowest floor is at or above the base flood elevation (BFE), on a pile or column foundation.
- Allow the space below the lowest elevated floor to be free of obstruction or must be enclosed with non-supporting breakaway walls, open lattice-work, or insect screening designed to collapse under wind and water loads without causing damage to structural supports or the elevated structure.
- Not use fill for structural support of buildings.
- Prohibit manmade alteration of sand dunes and mangrove stands that would increase potential flood damage.

As previously noted, CoBRA prohibits new NFIP coverage for new or substantially improved structures in any coastal barrier in the CoBRA system. More details on NFIP's influence on state and local policies can be found in following sections.

The Clean Water Act of 1972 is another federal law that has an effect on the health of our nation's coastal areas and wetlands. Section 404 of the Clean Water Act sets national policy for the discharge of dredged or fill material into the nation's navigable waters and adjacent wetlands. The act has even been interpreted to have authority over inland wetlands. Section 404 gives jurisdictional responsibility for issuing dredge permits to the U.S. Army Corps of Engineers (COE). EPA has responsibility for developing and interpreting the criteria used in permit issuances.

The Clean Water Act prohibits the discharge of dredged or fill material at a specific site if there is a practicable alternative to the proposed discharge that would have less adverse impact on the aquatic ecosystem or if the discharge will cause or contribute to significant degradation of U.S. waters. Practicable alternatives, under the act, include activities that do not include a discharge into U.S. waters or discharges into waters other than the specific site requested. Degradation caused to U.S. waters is deemed to be significant adverse effects to human health or welfare, aquatic life stages and ecosystems, ecosystem diversity and productivity, and recreational, aesthetic, and economic values. Discharges from established and ongoing farming, ranching, and forestry activities are exempt from Section 404 provisions.

To receive a permit to discharge dredge materials, the applicant must prove to the COE that he or she has taken steps to avoid wetland impacts where practicable, minimized potential impacts to wetlands, and provided compensation for any remaining, unavoidable impacts through activities to restore or create wetlands. States also have a role in Section 404 decisions, through state program general permits, water quality certification, or program assumption.[28]

An additional federal law that gives the COE additional authority over construction in navigable waters and wetlands is the Rivers and Harbors Act (RHA).[29] Sections 9 and 10 of the act authorize the COE to regulate the construction of any structure or work within navigable waters of the United States. The types of structures the RHA allows the COE to

[28]40 CFR Part 230 – Section 404 (b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material.
[29](33 U.S.C. §§ 401 *et seq.*).

regulate include the following: wharves, breakwaters, or jetties; bank protection or stabilization projects; permanent mooring structures, vessels, or marinas; intake or outfall pipes; canals; boat ramps; aids to navigation; or other modifications affecting the course, location condition, or capacity of navigable waters.

When issuing permits for construction of the aforementioned structures, the COE must consider the following criteria: (1) the public and private need for the activity; (2) reasonable alternative locations and methods; and (3) the beneficial and detrimental effects on the public and private uses to which the area is suited. The COE is also required to consult with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service to protect and conserve wildlife resources.

State Policies

As with federal policies, few state policies specifically address the issue of sea level rise. State coastal guidelines that cover beach management policies can, however, be used to respond to sea level rise concerns. These policies are included in the Coastal Construction Control Line Program, the Beach Erosion Control Program, and Coastal Building Zone and Strategic Beach Management Plans.

The Florida Beach and Shore Preservation Act was enacted by Florida's legislature to preserve and protect Florida's beach and dune system. Beaches and dunes are the first line of defense against storms, acting as a buffer between the sea and coastal development. One of the programs authorized by the Beach and Shore Preservation Act to be an essential element in the protection effort is the Coastal Construction Control Line (CCCL) Program.[30]

The CCCL Program was designed to protect Florida's beach and dune system from irresponsible construction that could weaken, damage, or destroy the health of the dune system. Structures that are built too close to the sea can inhibit the beach and dune system from its natural recovery processes and can cause localized erosion. Improperly constructed structures are a threat to other nearby coastal structures should they be destroyed by storms. The CCCL Program gives the State the jurisdiction to apply stringent siting and design criteria to construction projects within the Control Line. It must be noted that the CCCL is not a setback line, but is rather a demarcation line of the state's authority.

The CCCL is marked at the landward limit of coastal areas that are subject to the effects of a 100-year storm surge. Although wind and flooding may intrude further inward than the 100-year storm surge area, effects landward of the CCCL are considerably less than those within the CCCL. Within the CCCL, the State prohibits the construction or siting of structures that would cause a significant adverse impact to the beach and dune system, result in the destabilization of the system, or destroy marine turtle habitat. To meet these requirements, structures are required to be located a sufficient distance from the beach and frontal dune and must also be sited in a way that does not remove or destroy natural

[30]Beach and Shore Preservation Act, Florida Statutes (s.) Chapter 161.

vegetation. The CCCL also requires all structures to be constructed to withstand the wind and water effects of a 100-year storm surge event. This involves creating structures that meet American Society Civil Engineering 7-88 Section 6 wind design standard for 110 mph winds and 115 mph for the Keys. Water standards include a foundation design to withstand a 100-year storm event—including the effects of surge, waves, and scouring. There is no prohibition against rebuilding under the CCCL Program. Because of highly erosional effects, the CCCL Program discourages the construction of rigid coastal armoring (seawalls) and instead encourages property owners' use of other protection methods such as foundation modification, structure relocation, and dune restoration.

Another similar endeavor to regulate coastal construction is the Coastal Building Zone (CBZ). The CBZ was established as part of the Coastal Protection Act of 1985 to protect coastal areas and to protect life and property. The CBZ is similar to the CCCL Program in that it is a regulatory jurisdiction rather than a setback line. The CBZ envelops land from the seasonal high water line to 1,500 feet landward of the CCCL. In those areas fronting on the ocean but not included within an established CCCL, the Coastal Building Zone includes the land area seaward of the most landward V-zone line, as established by NFIP's flood maps. The V-Zone is an area likely to experience a wave greater than 3 feet high with storm surge or areas within the 100-year storm event used by the CCCL Program. Local governments enforce the Coastal Building Zone, as a part of their building codes, rather than the state. The CCCL and CBZ are referenced in the building codes of Northeast Florida's coastal counties.

Within the CBZ, new construction is required to meet the Standard Building Code 1997 wind design standard of 110 mph, and 115 mph for the Keys. As for water standards, structures are required to meet NFIP requirements or local flood ordinance requirements, whichever are stricter. Foundations must also be designed to withstand a 100-year storm surge. CBZ construction standards are less stringent than CCCL standards. This is because NFIP flood maps have lower base flood elevations for 100-year storm events than do CCCL studies.

Another state effort to protect Florida's beaches, authorized by the Beach and Shore Preservation Act, is the Beach Erosion Control Program (BECP).[31] The BECP is the primary program that implements the Florida Department of Environmental Protection's beach management recommendations. The BECP was created to coordinate the efforts of local, state, and federal governments in protecting, preserving, and restoring Florida's coastal resources. One of the activities of this program is the offering of financial assistance to counties, local governments, and other special districts for shore protection and preservation efforts. The BECP will provide up to 50 percent of project costs. The mix between federal, state, and local funds is different for each project.

Beach management activities eligible for funding from the BECP include beach restoration and nourishment activities, project design and engineering studies, environmental studies and monitoring, inlet management planning, inlet sand transfer,

[31]Found at http://www.dep.state.fl.us/beaches/programs/bcherosn.htm.

dune restoration and protection activities, and other activities related to beach erosion prevention.

Another endeavor of the BECP is the development and maintenance of a Strategic Beach Management Plan (SBMP) for Florida. The SBMP is a multiyear repair and maintenance strategy to carry out the proper state responsibilities of a comprehensive, long-range, statewide program of beach erosion control; beach preservation, restoration, and nourishment; and storm and hurricane protection. The SBMP[32] is divided into specific beach management plans for Florida's coastal regions, including the Northeast Atlantic Coast Region. The Northeast Atlantic Coast Region encompasses the four coastal counties in this study: Nassau, Duval, St. Johns, and Flagler.

Within Northeast Florida, a number of beach restoration projects have been conducted and planned. In Nassau County, the St. Mary's River entrance is dredged annually and the gathered sand is used for beach nourishment projects at Fort Clinch and Fernandina Beach's shoreline. South Amelia Island and Nassau Sound are other areas of Nassau County with periodic beach nourishments. One of Duval County projects is the placement of sand from semi-annual dredging on the south shoreline of the St. Johns River entrance. Another periodic nourishment project includes Duval County's beaches from the mouth of the St. Johns River to the St. John's County line. In St. John's County, the Anastasia State Recreation Area, St. Augustine Beach, and the Matanzas Inlet are involved in recurring beach nourishments.

Florida also has one of the largest land and water (including wetlands) acquisition programs in the country called Florida Forever.[33] The revenue for this program is used for restoration, conservation, recreation, water resource development, historical preservation, and capital improvements on acquired conservation lands. Land acquisition is almost exclusively voluntary, because the State wishes to avoid using its power of eminent domain. The funding for this program comes from $3 billion in bond issues over a 10-year period, which is being paid back from an excise tax. Florida Forever Funds are distributed annually to various governmental agencies for land and water acquisition: Department of Environmental Protection (38 percent), Water Management Districts (35 percent), Florida Communities Trust (24 percent), Department of Agriculture/Forestry (1.5 percent), and the Fish and Wildlife Commission (1.5 percent). Since the program began in 1999, Florida Forever funds have been used to protect more than 270,000 acres of natural floodplains, nearly 500,000 acres of significant water bodies, more than 24,000 acres of fragile coastline, and more than 520,000 acres of functional wetlands.[34] Within northern Florida, the St. Johns River Water Management District (SJRWMD) uses its Florida Forever land acquisition funds primarily on water resource development and restoration projects and for nonstructural flood protection and conservation.

Local Government Policy

[32]Florida Department of Environmental Protection. (2000). *Strategic Beach Management Plan: Northeast Atlantic Coast Region.* Tallahassee, FL: Author.
[33]Found at http://edis.ifas.ufl.edu/FE331.
[34]Found at http://www.dep.state.fl.us/lands/acquisition/FloridaForever/default.htm.

Although no counties reference sea level rise in their building codes or comprehensive plans, all of Northeast Florida's coastal counties have coastal management or conservation elements in their comprehensive plans.

The Coastal Management Element[35] of Nassau County's Comprehensive Plan establishes dune protection as a priority for the county: "…the County shall protect, conserve and enhance the remaining coastal barrier dunes and establish construction standards to minimize the impact of man-made structures on the dunes and beaches.…" The comprehensive plan affirms a number of provisions for protection of the dune system, including site plan review for all beachfront construction, protection of hammock/dune interface areas, requirements for filling and revegetation of any breaches or blowouts in the dune system, prohibition of excavation of dunes (unless no other option exists) and requirements for developers to repair any unpermitted destruction of dunes. The Conservation Element establishes a 25-foot vegetative buffer between wetlands and upland development, or 100 feet within all 100-year floodplains as determined by FEMA.

The City of Jacksonville's (Consolidated Duval County) Comprehensive Plan Conservation/Coastal Management Element[36] states: "The ocean-fronting beaches and dunes within the City's jurisdiction shall be maintained predominantly in their natural state for conservation and recreational uses." The Jacksonville Comprehensive Plan prohibits all new construction seaward of the state's CCCL, except for passive recreation and access structures. It also forbids the construction of any new hardened shore protection structures or the reconstruction of any existing erosion control structures, except for navigation and emergency transportation corridors. Jacksonville's Comprehensive Plan also includes extensive provisions for protection of the city's remaining wetlands. Within saltwater marshes, only conservation and light residential uses, water-dependent port activities, and access to a permitted use are permitted. Septic tanks, drain-fields, and/or grey-water systems must be located outside of the saltwater marsh and not within 75 feet of any wetland or mean high water line.

The St. Johns County Comprehensive Plan's Conservation/Coastal Element[37] discourages the construction of seawalls and other shoreline modifications. Seawalls that are permitted must be set landward of the mean high water line. The Coastal Element also requires the County to minimize the disturbance of natural shoreline resources that provide shoreline stabilization and protect landward areas from the effects of storm events. St. Johns County seeks to have Land Development Regulations in place by 2007 that will address the relocation of habitable structures which have incurred damage from a natural disaster event, where damage is greater than 75 percent of their assessed value, to new locations that are outside the Coastal High Hazard Areas (CHHA), provided that sufficient land is available on the subject parcel for such relocation. Future policies will also address the utilization of improved construction site development practices during redevelopment, in a manner consistent with the land development regulations, to

[35]Nassau County Comprehensive Plan.
[36]Duval County Comprehensive Plan.
[37]St. Johns County 2015 EAR Based Comprehensive Plan Amendment (2000).

minimize the risk of recurrent damage. To protect wetlands, the St. Johns County Comprehensive Plan establishes a 25-foot vegetative upland buffer between wetlands and developments. Along the St. Johns, Matanzas, Guana, and Tolomato rivers, there is a 50-foot upland buffer.

Flagler County's Comprehensive Plan protects beaches and dunes through the coastal building code and the coquina rock protection ordinance. As with the other coastal counties' building codes, buildings are required to be sited so as not to interfere with the stability of the dune system and not to diminish the dunes' ability buffer against storms. The county's coquina ordinance prohibits the theft, vandalism, and destruction of coquina rock. Coquina rock is an essential part of the natural processes protecting the beach and dune system from erosion. The Coastal Management Element of the comprehensive plan places special emphasis on the beach within Flagler Beach's city limits for beach nourishment, given the city's higher level of development and lack of protective dune structure. Flagler County's floodplain ordinance requires structures within the CHHA to have the lowest supporting horizontal member to be located not lower than 1 foot above the base flood elevation level.

The two inland counties included in this study, Clay and Putnam, do not have coastal management elements in their comprehensive plans. They do have wetland protection and floodplain provisions, though. The Putnam County Comprehensive Plan[38] restricts development within FEMA-determined 100-year floodplains and floodways within the floodplain. Residential development is restricted to the lowest density of the future land use category that the land is located in. The only other uses permitted within 100-year floodplains are resource-based recreational facilities, water-dependent components of commercial development, general agriculture, silviculture and mining (with a 500-foot buffer). An average 25-foot, minimum 15-foot, upland vegetative upland buffer is required between jurisdictional wetlands and development.

The Clay County Comprehensive Plan[39] requires a setback of 50 feet landward of the ordinary high water line or mean high water line. The setback is increased to 100 feet for developments on aquatic preserves or Outstanding Florida Waters. A 25-foot vegetative buffer zone is required landward of the high water line. Development within FEMA 100-year floodplains must allow the maintenance of existing flood storage and the allowed development density must not create potential flood hazards or degrade the natural functioning of the floodplain.

[38]Putnam County Comprehensive Plan.
[39]Clay County Comprehensive Plan.

MAP DEVELOPMENT METHODOLOGY

Topographic Study Area

Similar to other sea level rise planning studies in Florida, this study considers all land below the 10-foot (NGVD) contour.[40] The selection of this study area does not imply that we are predicting—or even analyzing the consequences of—a 10-foot rise in sea level**.** Because tidal influence can extend almost to the 5-foot contour, the 10-foot contour is approximately the highest elevation that might be inundated by tides were sea level to rise 5 feet over the next few hundred years—but that is not the primary reason we used the 10-foot contour to delineate the study area.

During the original design of this study, EPA and SWFRPC sought to identify a study area that could be implemented throughout Florida and that would include all land that might be significantly affected by sea level rise during the next century. If possible, they also sought to include land that might be affected over a longer period of time, but that goal had to be balanced against the extra cost of studying a larger study area. All things being equal, it is better to make the study area over-inclusive rather than under-inclusive: If someone later needs a map depicting only land below the 8-foot contour, then it would be very easy to subdivide our data and only show shore protection for land below the 8-foot contour. By contrast, if someone needs a map that includes some areas inland of our original study area, they will have to repeat our study for these higher areas.

The quality of topographic information varies throughout Florida. Some counties have LIDAR, and some water management districts have 2-foot contours. Nevertheless, the best topographic maps for some portions of Florida have 5-foot contour intervals. Therefore, the only realistic choices for a statewide study area were the 5-, 10-, 15- and 20-foot contours.

Considering the criteria, EPA and SWFRPC decided that a 10-foot contour would probably be the most appropriate study area for Florida. Although the land below 5 feet is the most vulnerable, limiting the study area to such low land would exclude many areas that are potentially vulnerable to sea level rise during the next century. Statewide, most of the land between 5 and 10 feet is already below the base flood elevation for a 100-year storm, and hence will experience greater flooding as sea level rises. Finally, topographic contours are only estimates. Under the National Mapping Standards, up to 10 percent of the land can be higher or lower than the map indicates, by more than one-quarter of the contour interval. Thus a substantial amount of land depicted as between 5 and10 feet may in reality be between 3 and 4 feet; using the 10-foot contour to delineate the study area helps ensure that this very low land is considered.

[40]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.

The study area also includes all land within 1,000 feet of the shore, even if it is above the 10-foot contour, for two reasons. First, rising sea level and other coastal processes can cause beaches, dunes, bluffs, and other land to erode even though they may have sufficient elevation to avoid direct inundation by rising water levels. The 1,000-foot extension is somewhat arbitrary; we chose that distance primarily to be consistent with similar studies in other states. Second, extending the study area 1,000 feet inland also ensures that it is large enough to be seen along the entire shore on the county-scale maps produced by this study.

The NEFRC used elevation polygons from the St. Johns River Water Management District to determine the study area within this project.

Protection Scenarios

After all uplands from 0 to10 feet in elevation and lands within 1,000 feet of shore were determined, protection scenarios had to be assigned to the sections in the study area. The protection scenarios in the maps that accompany this study illustrate the areas that planners within this region expect will be protected, or not protected, from erosion and inundation in the future. Those expectations incorporate state policies and regulations, local concerns, land use data, and general planning judgment.

Generally, the first step in assigning a protection scenario is to determine the general land use categories of the uplands within the study area in a particular county. Land use layers were obtained from GIS information gathered at the NEFRC or from data attained from county planning agencies. Counties within Northeast Florida use different land use category classifications, but these categories can generally be summarized as including the following: agricultural, commercial, conservation, industrial, public/recreational, and residential. Generally, residential, commercial, recreational, and industrial lands were determined to be almost certain or likely to be protected. Conservation lands and land with no prospect for development were generally labeled as unlikely to be protected or not to be protected. The protection scenarios for agricultural land uses were based on whether there was a history of specifically protecting such farms or forests.

Three land use categories are typically designated as protection almost certain. The first is existing developed land within extensively developed areas or designated growth areas. The second category is future development within extensively developed areas or designated growth areas, including residential, office/commercial, and industrial uses. It is understood that every effort will be made to protect highly developed land from saltwater intrusion because of the economic value of these lands and the high population density. Another land use category that has been deemed as protection almost certain is parks that are extensively used for purposes other than conservation and have current protection or are surrounded by protected lands, for example, parks with highly used launching ramps or sports venues. Because these parks exist for primarily for recreational and not exclusively for conservation purposes, they are almost certain to be protected from sea rise.

Land uses that are within the scenario of protection likely will probably be protected, but there is a plausible reason to not expect protection. These land uses include less densely developed areas, future development outside of growth areas, extensively developed CoBRA coastal areas, and private beaches. Moderately used parks used for purposes other than conservation, future development where a park or refuge is also planned, agricultural areas with historical shore protection, and military lands where protection is not certain are also included in this approach. As with the previous scenario, it is easy to assume that these mostly privately owned areas are too valuable (whether for economic, recreational, or social reasons) to abandon. Because these areas are not extensively developed yet, however, they have not reached the point of critical mass where it would be inconceivable for policymakers and landowners to be allow them to retreat.

Areas unlikely to be protected are places where lands are probably going to retreat, but where there is no absolute policy against shore protection. Generally, these are areas where land values are low compared with the costs of shore protection. For privately owned nonconservation lands, protection would not be cost-effective compared to the value for the land. Lands expected to become part of a nature reserve, but not guaranteed, are also in this category. protection unlikely areas include undeveloped privately owned lands, unbridged barrier islands or lightly developed coastal high hazard areas, minimally used parks, undeveloped areas where most of the land will be part of wildlife refuge but where development is also planned, and conservation easements that preclude shore protection.

The final protection scenario is termed as no protection. This includes lands that are certain not to be protected because they are conservation lands where protection is absolutely prohibited. Private lands owned by conservation groups, conservation easements that preclude shore protection, wildlife refuges and parks with a policy preference for natural occurring processes, and public lands/parks with little or no prospect for public use are within this category. Also, farmlands and forested uplands have been deemed as no protection in Northeast Florida. The overwhelming majority of agricultural lands within the Northeast Florida study are primarily forested timberlands. The cost of importing pulpwood from Brazil is becoming more economical, thereby making much of Florida's timberlands worthless within the near future. Because of the decline of the timber industry in Northeast Florida, forested uplands would be cost-prohibitive to fortify.

Wetlands were also mapped in this project. Most authors have concluded that wetlands could not keep pace with a significant acceleration in sea level rise and, thus, that the area of wetlands converted to open water will be much greater than the area of dry land converted to wetlands. Moreover, in areas where dikes protect farmland or structures, all the wetlands could be lost.[41]

[41]Titus, J., et al. (1991). Greenhouse effect and sea level rise: The cost of holding back the sea. *Coastal Management: Volume 19.*

Although land use categories were the general determinants for assigning protection scenarios, other factors (such as local planner input and NFIP and CoBRA guidelines) were also authoritative. These factors are included in Table 5, as provided by the EPA and SWFRPC,[42] and modified for a regional approach by the NEFRC. Table 5 contains the matrix used by GIS staff to identify protection scenarios for the study area. County-specific differences in these decisions and site-specific departures from the statewide approach are discussed in the county-specific sections of this report; the results for sea level rise map for each county is included in the county sections.

Within the study area depicted on the maps, the following protection scenarios and accompanying colors were used:

- Protection almost certain: Brown
- Protection likely: Red
- Protection unlikely: Blue
- No protection: Light green
- Wetlands: Dark green.

Local Stakeholder Review

The contract for this project requires local government staff to review the draft sea level rise maps for each county. Local planners are the best authorities to identify whether specific areas of their regions will be protected, or not, against sea level rise. Table 5 recognizes instances where existing land use data formats may not be complete enough to be able to identify a protection scenario for a land area. Local planner input is particularly helpful in determining the future status of currently undeveloped areas. Whether an undeveloped area outside of a growth area will be developed in the future is a determinant of the protection status of the locale. Local planner information is also invaluable in determining whether park areas or conservation lands will, or should, be protected against sea level rise.

On June 22, 2004, the NEFRC held a workshop at the its offices in able to allow local planners to review draft sea level rise maps. The membership of the Local Mitigation Strategy (LMS) workgroups from Nassau, Duval, St. Johns, and Flagler counties were invited to attend the meeting. The LMS workgroups were determined to be the best forums for presenting the draft maps because of their constituencies. The workgroups contain representatives from local planning and emergency management agencies as well as members of nonprofit groups and industry, all in one body. Fifteen members of the workgroups from the four coastal counties attended the workshop. After a review of the project was provided to them, the LMS members were given the draft map from their specific county to review. Jim Titus, EPA, and Dan Trescott, SWFRPC, assisted the groups by conference call. Planners from the NEFRC facilitated each county's discussions and changes to the draft maps were recorded.

[42]Jim Titus of EPA prepared a summary of the approaches taken by other states and Dan Trescott of SWFRPC converted this summary into a table, and then adapted it for the situation in Florida.

Clay and Putnam Counties were included in the sea level rise study after the June 22, 2004, workshop. The NEFRC's GIS coordinator brought draft maps to the planning departments of these two counties for review, where changes were discussed and recorded.

Changes to the draft maps made by local planners are discussed in the county sections.

TABLE 5 REGIONAL APPROACH FOR IDENTIFYING LIKELIHOOD OF LAND USE PROTECTION[1]		
Likelihood of Protection[2]	**Land Use Category**	**Source Used to Identify Land Area**
Protection Almost Certain (brown)	Existing developed land (FLUCCS Level 1–100 Urban and Built-up) within extensively developed areas and/or designated growth areas.	Developed lands identified from water management districts (WMDs) existing Florida Land Use, Cover and Forms Classification System (FLUCCS) as defined by Florida Department of Transportation Handbook (January 1999); growth areas identified from planner input and local comprehensive plans.
	Future development within extensively developed areas and/or designated growth areas (residential/office/commercial/industrial).	Generalized Future Land Use Maps from local comprehensive plans, local planner input, and WMDs.
	Extensively used parks operated for purposes other than conservation and have current protection[3] or are surrounded by brown colored land uses.	County-owned, state-owned, and federally owned lands (based on local knowledge) or lands defined as 180 Recreational on the Level 1 FLUCCS, local planner input, and Florida Marine Research Info System (FMRIS) for current protection measures.
Protection Likely (red)	Existing development within less densely developed areas, outside of growth areas, mobile home development not anticipated to gentrify, not on central water and sewer, and within a coastal high hazard area.[4]	Developed lands identified from WMD existing FLUCCS; growth areas identified from local planner input, local comprehensive plans and current regional hurricane evacuation studies.
	Projected future development outside of growth areas could be estate land use on Future Land Use Map.	Local planner input.
	Moderately used parks operated for purposes other than conservation and have no current protection or are surrounded by red colored land uses.	County-owned, state-owned, and federally owned lands (based on local knowledge) or lands defined as 180 Recreational on the Level 1 FLUCCS, local planner input, and FMRIS.
	Coastal areas that are extensively developed but are ineligible for beach nourishment funding due to COBRA (or possibly private beaches unless case can be made that they will convert to public)	Flood Insurance Rate Maps for CoBRA, local knowledge for beach nourishment.
	Undeveloped areas where most of the land will be developed, but a park or refuge is also planned, and the boundaries have not yet been defined so we are unable to designate which areas are brown and which are green; so red is a compromise between	Local planner input.
	Agricultural areas where development is not expected, but where there is a history of erecting shore protection structures to protect farmland.	Local planner input.
	Military lands in areas where protection is not certain.	FLUCCS Level 173.

Protection Unlikely (blue)	Undeveloped privately owned that are in areas expected to remain sparsely developed (i.e., not in a designated growth area and not expected to be developed).	Undeveloped lands identified from WMD existing FLUCCS Level 1–160 mining , 700 barren land ; nongrowth areas identified from planner input, local comprehensive plans, Flood Insurance Rate Maps for CoBRA and current regional hurricane evacuation studies.
	Unbridged barrier island and CoBRA areas or within a coastal high hazard area that are not likely to become developed enough to justify private beach nourishment.	Flood Insurance Rate Maps for CoBRA, local knowledge for beach nourishment, and local planner input.
	Minimally used parks operated partly for conservation, have no current protection or are surrounded by blue colored land uses, but for which we can articulate a reason for expecting that the shore might be protected.	County-owned, state-owned, and federally owned lands (based on local knowledge) or lands defined as preserve on Future Land Use Map, local planner input, and FMRIS.
	Undeveloped areas where most of the land will be part of a wildlife reserve, but where some of it will probably be developed; and the boundaries have not yet been defined so we are unable to designate which areas are brown and which are green; so blue is a compromise between red and green.	Local planner input.
	Conservation easements (unless they preclude shore protection).	Local planner input.
No Protection (light green)	Private lands owned by conservation groups (when data available).	Private conservation lands.
	Conservation easements that preclude shore protection	Local planner input.
	Wildlife Refuges, portions of parks operated for conservation by agencies with a policy preference for allowing natural processes (e.g., National Park Service).	Local planner input.
	Publicly owned natural lands or parks with little or no prospect for access for public use.	County-owned, state-owned, and federally owned lands (based on local knowledge) defined as preserve on the Future Land Use Map and local planner input.
	Farms and forests with no history of erecting shore protection structures.	Undeveloped lands identified from WMD existing FLUCCS Level 1–200 Agriculture, 300 Rangeland, 400 Upland Forest, and local planner input.

1. These generalized land use categories describe typical decisions applied in the county studies. County-specific differences in these decisions and site-specific departures from this approach are discussed in the county-specific sections of this report.
2. Colored line file should be used in areas where less than 10 foot elevations exist within 1,000 feet of the rising sea or color cannot be seen on ledger paper map.
3. Current protection may include sea walls, rock revetments, beach renourishment, levees, spreader swales, or dikes.
4. Coastal High Hazard Area defined in Rule 9J-5 FAC as the Category 1 hurricane evacuation zone and/or storm surge zone.

COUNTY BY COUNTY MAPPING ANALYSIS

This sea level rise study includes six counties in the Northeast Florida region: Clay, Duval, Flagler, Nassau, Putnam, and St. Johns. The study area consists of approximately 321 square miles of uplands and 254 square miles of wetlands. A 10-foot rise in sea level would inundate about 575 square miles of the Northeast Florida region. The total amount of affected area accounts 14 percent of these six counties.

Table 6 illustrates the breakdown of the various land uses in the study area that are subject to sea level rise. Because Northeast Florida is still largely undeveloped, conservation lands make up the single largest land use that would be affected by sea rise. This category makes up 38 percent (183 square miles) of the upland study area. The next largest upland area subject to inundation is residential use, comprising 26 percent (145 square miles) of the study area. Agricultural use is the third largest category subject to sea rise. This land usage takes up 23 percent (134 square miles) of the affected area. Public/recreational, commercial, and industrial land use categories together encompass only 13 percent (67 square miles) of the area affected by rising seas.

The percentages and acreage of protection scenarios assigned to land uses in the study area can be found in Table 6. Predictably, wetlands make up almost half (47 percent) of the total study area (254 square miles). We estimate that protection is almost certain for about 55 miles (176 square miles) of the dry land within the study area. The Atlantic Coast of Florida continues to be developed, and it can be expected that residential areas will be protected. As a result, shore protection is likely for another 89 square miles (28 percent) of the dry land in the study area. Thus, under current policies, more than 80 percent of the dry land is likely to be protected from rising sea level.

The protection unlikely scenario covers 42 square miles of the total study area, about 13 percent of the dry land. Conservation lands and other areas designated as no protection account for 14 square miles, only 4.4 percent of the dry land in the study area. Thus, the areas where wetlands are likely to migrate inland account for only 18 percent of the study area (56 square miles). A clearer picture emerges if one compares these areas with the 254 square miles of wetlands. The total land that may be submerged, 310 square miles, accounts for approximately 56 percent of the low land in Northeast Florida.

The ultimate net loss of wetlands by any particular year will depend both on landward migration and on the ability of wetlands to keep pace with sea level rise. Nevertheless, in the very long run, existing tidal wetlands would be submerged by a large rise in sea level and thus their continued existence depends on new wetlands forming inland. Viewed in that light, existing policies are almost certain to eliminate about 55 percent the wetlands that might otherwise be sustained as sea level rises and to protect 4percent of those wetlands. We are less certain about the other 41percent. There appears to be a good chance that wetlands will migrate land in another 13percent of the region, and wetland migration is possible albeit unlikely in 28 percent of the region. Planners need guidance from both scientists and policy makers about the importance of ensuring that wetlands

survive in the areas our maps depict in blue and red, compared with the benefits of preventing wetlands from taking over these areas.

Table 6
Northeast Florida Future Land Use Subject To Sea Level Rise (Acres)

Acreage Per Land Use Category								
FUTURE LAND USE	NASSAU	DUVAL	ST. JOHNS	FLAGLER	CLAY	PUTNAM	SQUARE MILES	% OF STUDY AREA
Agriculture	2150	32139	22011	6909	618	22106	134	23%
Commercial	976	4708	3628	224	1285	164	17	3%
Conservation	8325	17839	47061	9556	7041	27632	183	38%
Industrial	436	3453	85	28	184	1070	8	2%
Public/Recreational	2648	9485	10079	752	4496	11	42	8%
Residential	10460	38386	18918	4511	13901	6740	145	26%

Acreage Per Protection Scenario								
SCENARIO	NASSAU	DUVAL	ST. JOHNS	FLAGLER	CLAY	PUTNAM	SQUARE MILES	% OF STUDY AREA
Protection Almost Certain	18160	42036	21433	10519	12661	8431	176	30%
Protection Likely	2336	4973	31004	4753	7226	6796	89	14%
Protection Unlikely	1628	5603	4628	147	5821	9368	42	7%
No Protection	5687	1585	1162	225	436	164	14	2%
Wetlands	33041	41993	43555	9380	1763	33024	254	47%

Percentage of Dry Land Protected							
SCENARIO	NASSAU	DUVAL	ST. JOHNS	FLAGLER	CLAY	PUTNAM	REGION
Protection Almost Certain	65.3	77.6	36.8	67.2	48.4	34.1	54.8
Protection Likely	8.4	9.2	53.2	30.4	27.6	27.4	27.7
Protection Unlikely	5.9	10.3	7.9	0.9	22.3	37.8	13.1
No Protection	20.4	2.9	2	1.4	1.7	0.7	4.4

NASSAU COUNTY

Nassau County is included in the project because of its location on the Atlantic Ocean and the St. Mary's and Nassau rivers. The entire eastern border of the county is included because it is affected by the tidal influence of the ocean. The St. Mary's River defines the northern and western borders of the county, but it is tidally influenced upstream to the Highway 17 bridge.[43] Therefore, the remainder of the river west of the bridge was excluded from the study. The southern border of Nassau County is partially defined by the Nassau River. The Intracoastal Waterway runs parallel to the Atlantic coast, approximately 3 miles inland from the Nassau River to the St. Mary's River. These waterways combine to create approximately 117 linear miles of tidally influenced coastline in Nassau County.

Data Used for Study and Maps

The datasets used for the study of Nassau County were compiled from multiple sources. The maps and analysis were based on the following layers:

Layer	Source
Nassau County Future Land Use	Northeast Florida Regional Council
Street Centerlines	Unites States Census Bureau (TIGER)
Existing Land Use	St. Johns River Water Management District
Elevation Polygons	St. Johns River Water Management District
Digital Ortho Quarter Quads	St. Johns River Water Management District

Future Land Use: The future land use designations in the future land use layer for the Nassau County were generalized into the following designations:

AGRICULTURE	RECREATION
COMMERCIAL	HIGH DENSITY RESIDENTIAL
CONSERVATION	MEDIUM DENSITY RESIDENTIAL
INDUSTRIAL	LOW DENSITY RESIDENTIAL
PUBLIC	WATER

Street Centerlines: The streets layer is used for reference purposes.

Existing Land Use: The St Johns River Water Management District maintains this layer. This layer was used to differentiate uplands, wetlands, and water based on the FLUCCS field values.

Elevation Polygons: The elevation polygons were compiled from the elevation contours maintained by the St. Johns River Water Management District. The Arc View 9 Spatial

[43]Found at http://www.sjrwmd.com/programs/acq_restoration/s_water/stmarys/.

Analyst extension was used to convert the contour line file to a polygon layer based on the elevation field.

Mapping Procedures

The following procedures were performed to create the final layer and maps for Nassau County:

1. Created an Arc GIS map document for the project (slr_nassau_final.mxd).
2. Projected all layers to State plane Florida East Zone 0901, and 1983.
3. Selected the water polygons from the existing land use layer.
4. Buffered the water polygons with a distance of 1,000 feet.
5. Selected the elevation polygons from the elevation layer that were less than 10 feet and intersected the 1,000 foot water buffer polygon.
6. Exported the selected elevation polygons to a new shape file.
7. United the exported elevation polygons with the 1,000 foot water buffer. This resulted in a shape file of the total area of interest for the project (slr_nassau_sea rise_area_of_interest.shp).
8. Clipped the future land use shape file with the area of interest. This resulted in a layer of future land use that comprised polygons only in the area of interest for the project.
9. Clipped the existing land use shape file with the area of interest. This resulted in a layer of existing land use that comprised polygons only in the area of interest for the project.
10. United the clipped existing and future land use layers. This resulted in a layer containing attributes of future and existing land use attributes (slr_sea rise_nassau_draft.shp).
11. Created an attribute field in the draft layer named [SEA RISE]. Populated the sea rise field based on the criteria contained in Table 5.
12. Analyzed the protection scenarios for Nassau County to ensure that the scenarios adhered to the criteria set forth by the overall project standards.

The general approach findings were as follows:

Atlantic Coast (from the St. Mary's River to the Nassau River)

The landmass that sits between the Intracoastal Waterway and the Atlantic Ocean is Amelia Island. At the north end of the island is Ft. Clinch State Park. It has a future land use designation of recreation and is given the scenario of protection almost certain because of its historic significance and its extensive use by visitors. There is a great deal of forested uplands in the park, which future planners may decide to relinquish for wetlands migration, but they are currently designated protection almost certain. South of the Ft. Clinch State Park are the cities of Fernandina Beach and the area of American Beach. The majority of the land use for these two cities is designated as residential with some recreation, commercial, and industrial areas. The commercial areas extend

primarily along the A1A corridor. The commercial, industrial, and residential areas are assigned the scenario of protection almost certain. The recreational areas, which primarily consist of neighborhood parks and public beaches, have been assigned the scenario of protection likely. South of American Beach and extending to the south end of the island is the Amelia Island Plantation Resort. This area consists of high-end home sites as well as residential, commercial, conservation, and recreational (golf courses) future land use. The residential and commercial areas are designated protection almost certain and the conservation areas are designated protection unlikely because they may be allowed for wetlands migration.

Local Stakeholder Changes from Draft Maps
Because of the historical significance of the Fernandina Beach area as well and the fact that the remainder of the Amelia Island is a resort area, the local planners decided that the island should be assigned the scenario of protection almost certain, eliminating the necessity of designating areas bordered by protected areas as protection unlikely. Local planners have, however, designated areas on the island that directly border the wetlands and may be relinquished for wetlands migration as protection unlikely.

Intracoastal Waterway

The Intracoastal Waterway runs from the northern border of Nassau County (St. Mary's River) to its southern border (Nassau River). The majority of the lands along the west coast of the Intracoastal Waterway are residential with some minor areas of commercial. These areas are marked as protection almost certain because the residential sites are mostly high-end. There are some islands in the Intracoastal Waterway that have open space and some forested uplands and are designated as conservation. These areas are deemed as protection unlikely because they will most likely be left for wetlands migration. There were no changes from the draft map.

St. Mary's River

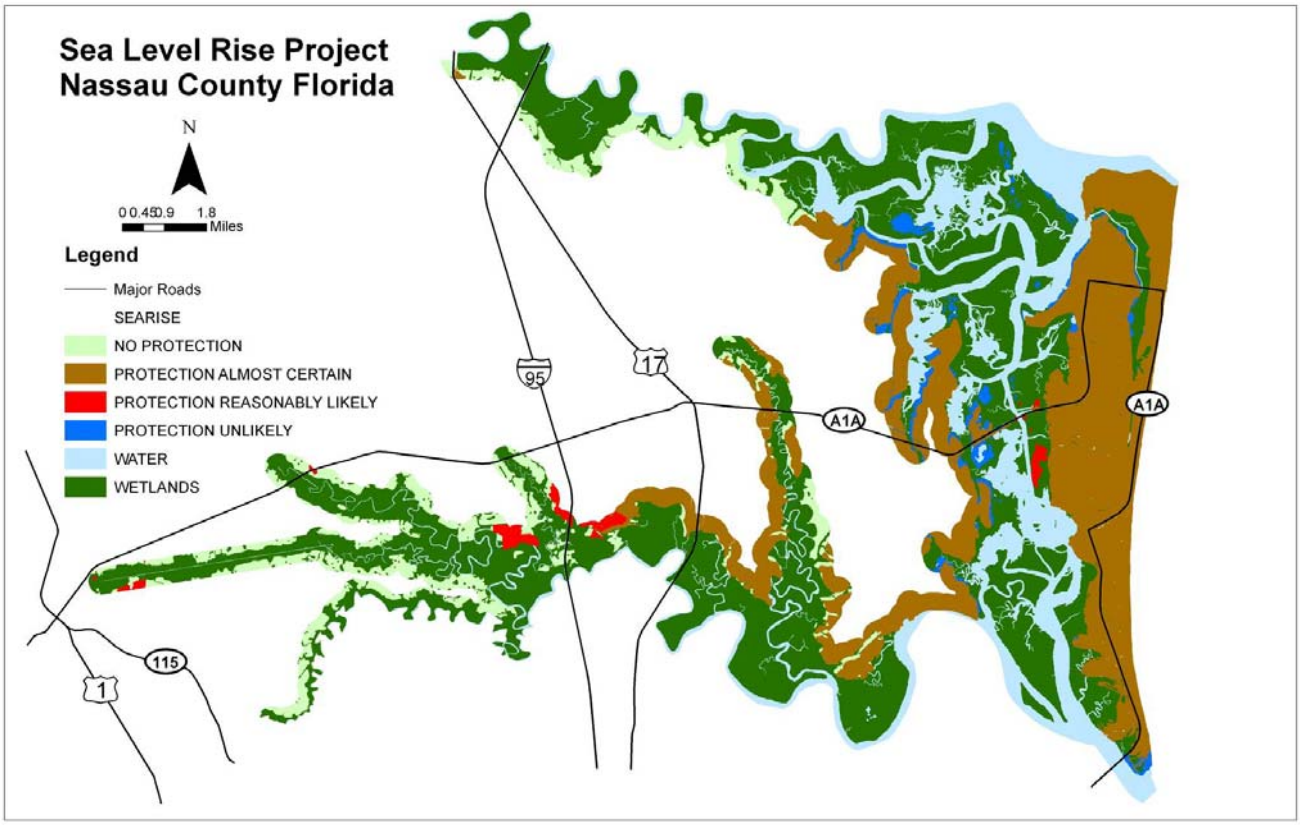
The entrance to the St. Mary's River is at the Atlantic Ocean. The overwhelming majority of the lands along the St. Mary's River are designated as conservation and agricultural with some areas of residential. The areas of residential are deemed as protection almost certain. The areas of conservation and agricultural are deemed as no protection because they will most likely be relinquished for wetlands migration. There were no changes from the draft map.

Nassau River

The Nassau River runs west from the Atlantic Ocean as a portion of Nassau County's southern border. The areas contiguous to this river are split between residential, conservation, and agricultural. The more highly developed residential areas are deemed as protection almost certain, although there are also less developed areas along the river. The conservation areas are deemed as no protection because they will most likely be

relinquished for wetlands migration. The agricultural areas have also been deemed as no protection because of their lack of existing current shore protection structures.

Local Stakeholder Changes from Draft Maps
Local planners recognized that some of the residential areas along parts of the Nassau River are less developed than others and therefore they were changed from protection almost certain to protection likely.
Map 1 shows the study results for Nassau County.



Map 1: Nassau County: Likelihood of Shore Protection.

DUVAL COUNTY

Duval County is included in the project because of its proximity to the Atlantic Ocean and the St. Johns River. The entire eastern border of the county is included because it is affected by the tidal influence of the ocean. The St. Johns River runs through the county from the Atlantic all the way to the county's south border. The St. Johns River, the Intracoastal Waterway, the Nassau River, Dunns Creek, the Broward River, the Trout River, the Ribault River, the Arlington River, Pottsburg Creek, the Ortega River, and Julington Creek combine to create approximately 210 linear miles of coastline influenced by tides. Add this to the 20 miles of beach along the Atlantic coast and Duval County has approximately 230 linear miles of coastline affected by tidal influence.

Data Used for Study and Maps

The datasets used for the study of Duval County were compiled from multiple sources. The maps and analysis were based on the following layers:

Layer	Source
COJ Future Land use	City of Jacksonville Planning Department
Neptune Beach Future Land Use	City of Neptune Beach Planning Department
Atlantic Beach Future Land Use	City of Atlantic Beach Planning Department
Jacksonville Beach Future Land Use	City of Jacksonville Beach
Street Centerlines	City of Jacksonville Sheriff's Office
Existing Land Use	St. Johns River Water Management District
Elevation Polygons	St. Johns River Water Management District
Digital Ortho Quarter Quads	St. Johns River Water Management District

Future Land Use – All of the future land use layers for the Duval County area of interest were merged together as a single layer. The future land use designations in the future land use layer for the Duval County were generalized into the following designations:

AGRICULTURE	RECREATION
COMMERCIAL	HIGH DENSITY RESIDENTIAL
CONSERVATION	MEDIUM DENSITY RESIDENTIAL
INDUSTRIAL	LOW DENSITY RESIDENTIAL
PUBLIC	WATER

Street Centerlines – The streets layer was used for reference purposes.

Existing Land Use – The St Johns River Water Management District maintains this layer. This layer was used to differentiate uplands, wetlands, and water based on the FLUCCS field values.

Elevation Polygons The elevation polygons were compiled from the elevation contours maintained by the St. Johns River Water Management District. The Arc View 9 Spatial

Analyst extension was used to convert the contour line file to a polygon layer based on the elevation field.

Mapping Procedures

The following procedures were performed to create the final layer and maps for Duval County:

1. Created an Arc GIS map document for the project (slr_duval_final.mxd).
2. Projected all layers to State plane Florida East Zone 0901 and 1983.
3. Selected the water polygons from the existing land use layer.
4. Buffered the water polygons with a distance of 1,000 feet.
5. Selected the elevation polygons from the elevation layer that were less than 10 feet and intersected the 1,000 foot water buffer polygon.
6. Exported the selected elevation polygons to a new shape file.
7. United the exported elevation polygons with the 1,000 foot water buffer. This resulted in a shape file of the total area of interest for the project (slr_duval_sea rise_area_of_interest.shp).
8. Clipped the future land use shape file with the area of interest. This resulted in a layer of future land use that comprised polygons only in the area of interest for the project.
9. Clipped the existing land use shape file with the area of interest. This resulted in a layer of existing land use that comprised polygons only in the area of interest for the project.
10. United the clipped existing and future land use layers. This resulted in a layer containing attributes of future and existing land use attributes (slr_sea rise_duval_draft.shp).
11. Created an attribute field in the draft layer named [SEA RISE].
12. Analyzed the protection scenarios for Duval County to ensure that they followed the criteria set forth by the overall Sea Level Rise project standards.

The general approach findings were as follows:

Atlantic Coast (north of the St Johns River inlet to Nassau County)

The Atlantic Coastline land north of the St. Johns River inlet area is all part of the Little Talbot Island State Park. This entire area is assigned the scenario of protection likely because of its moderate use by visitors.

Intracoastal Waterway (north of the St. Johns River to the Nassau River)

The shorelines of the northern Intracoastal Waterway and Nassau Sound consist mostly of wetlands conservation and agricultural designations with some minor areas of residential. It is assumed that the agricultural and conservation areas will not be protected

and will be left alone for wetlands migration. The residential designation of this area is protection almost certain, because many of the properties are high end. The conservation designations in this area are deemed as no protection and will most likely be left to wetlands migration. The exceptions to this are the areas of conservation bordering the Little Talbot Island State Park. These areas may be given a future designation of protection almost certain because they border State Road A1A. If these areas are allowed to flood then SR A1A will also be flooded. It may be more feasible as well as cost-effective to fortify the land as opposed to fortifying SR A1A.

Local Stakeholder Changes from Draft Maps

Because of their moderate visitor usage, the above areas of conservation were originally assigned protection unlikely but the local planners suggested that they should be designated as no protection because they would be land for wetlands.

Atlantic Coast (south of the St Johns River inlet to St. Johns County)

The majority of the areas of land south of the St Johns River inlet to St. Johns County are improved beachfront and designated as residential, commercial, and industrial. This entire stretch of land has been assigned the scenario of protection almost certain. This stretch of coastline comprises the City of Atlantic Beach, the City of Neptune Beach, and the City of Jacksonville Beach.

Local Stakeholder Changes from Draft Maps

There are park/recreation parcels within this area that were originally assigned the scenario of protection unlikely, but these parcels are completely surrounded by commercial and residential parcels, so the local planners decided that by default these parks/recreation parcels should be assigned the scenario of protection almost certain.

Intracoastal Waterway (south of the St. Johns River to St. Johns County)

The Intracoastal shoreline from the St Johns River south to St. Johns County is bordered mostly by wetlands scattered with forested uplands (conservation), high-end residential, and agriculture. The areas of conservation and agriculture are designated as no protection because the majority of land along the Intracoastal is unimproved and these are the only areas for the wetlands to migrate.

Local Stakeholder Changes from Draft Maps

The areas of conservation above were originally assigned protection unlikely because some of it may be developed in the future, but the local planners suggested that they should be designated as land for wetlands migration so their scenario was changed to no protection.

St. Johns River Inlet Area to Sisters Creek

The St. Johns River inlet is bordered to the north by Huguenot State Park. This area is labeled protection likely because it is mainly a sandbar created by the stone embankment

erected to protect the channel from washout. There is an ongoing debate concerning what to do with the northern jetties because of the concentration of sand that is choking off the channel that feeds the Ft George Inlet. This area of the moderate-use park is labeled protection likely but may be changed in the future depending on the outcome of current studies. The south side of the St. Johns River inlet is property owned by the Mayport US Naval Base and is labeled as protection almost certain because it would be protected even if the base were to close and the land changed to other uses. West of the Naval Station is the Mayport Fishing Village. This area is almost all commercial and is designated as protection almost certain. The land to the east of Sisters Creek, Fort George Island, is designated as conservation and agricultural and is assigned the scenario of protection likely. The area of land south of Sisters Creek is known as the Timucuan Preserve and is given the scenario of protection unlikely because it will most likely be left alone for wetlands migration.

Local Stakeholder Changes from Draft Maps
The Ft. George Island area was originally assigned the scenario of protection unlikely, but the local planners decided that it should be deemed as protection reasonably likely because of the existence of a public golf course, Kingsley Plantation (Timucuan Preserve), and a few residential parcels.

St. Johns River (from Sisters Creek to the Trout River)

The large area of wetlands fed by water flowing from Sisters Creek, Cedar Point Creek, and Clapboard Creek is bordered to the north by improved areas designated as residential as well as areas designated as agriculture. These agriculture lands are assigned the scenario of protection unlikely and the improved lands are assigned the scenario of protection almost certain. Further west of the Timucuan Preserve is the Mill Cove area. Uplands in this area are designated as residential, conservation, and parks/recreation. All of these areas that are not wetlands are assigned the scenario of protection almost certain. The study area along the north side of the St. Johns River west of Clapboard Creek consists primarily of improved properties with commercial and residential designations and is assigned the scenario of protection almost certain. The study area along south side of the St. Johns River and west of the Timucuan Preserve is primarily residential with some smaller areas of conservation and recreation. The residential and recreational areas are assigned the scenario of protection almost certain and the conservation area is assigned the no protection scenario. Quarantine Island, which is located in the center of the St. Johns River, is assigned the scenario of protection almost certain because of its navigational necessity. Blount Island, also located in the St. Johns River, is assigned the scenario of protection almost certain because of its mostly industrial use.

Local Stakeholder Changes from Draft Maps
Quarantine Island was originally assigned the scenario of protection unlikely but the local planners decided that it is vital to the directional flow of the St. Johns River and that it should be changed to protection almost certain.

Trout, Ribault, and Broward Rivers and Dunns Creek

The land contiguous to these water bodies is primarily residential with some commercial (boat marinas) and recreation. All of the areas along the Trout River that are designated as residential or commercial are assigned the scenario of protection almost certain. The areas of recreational use are assigned the protection likely scenario.

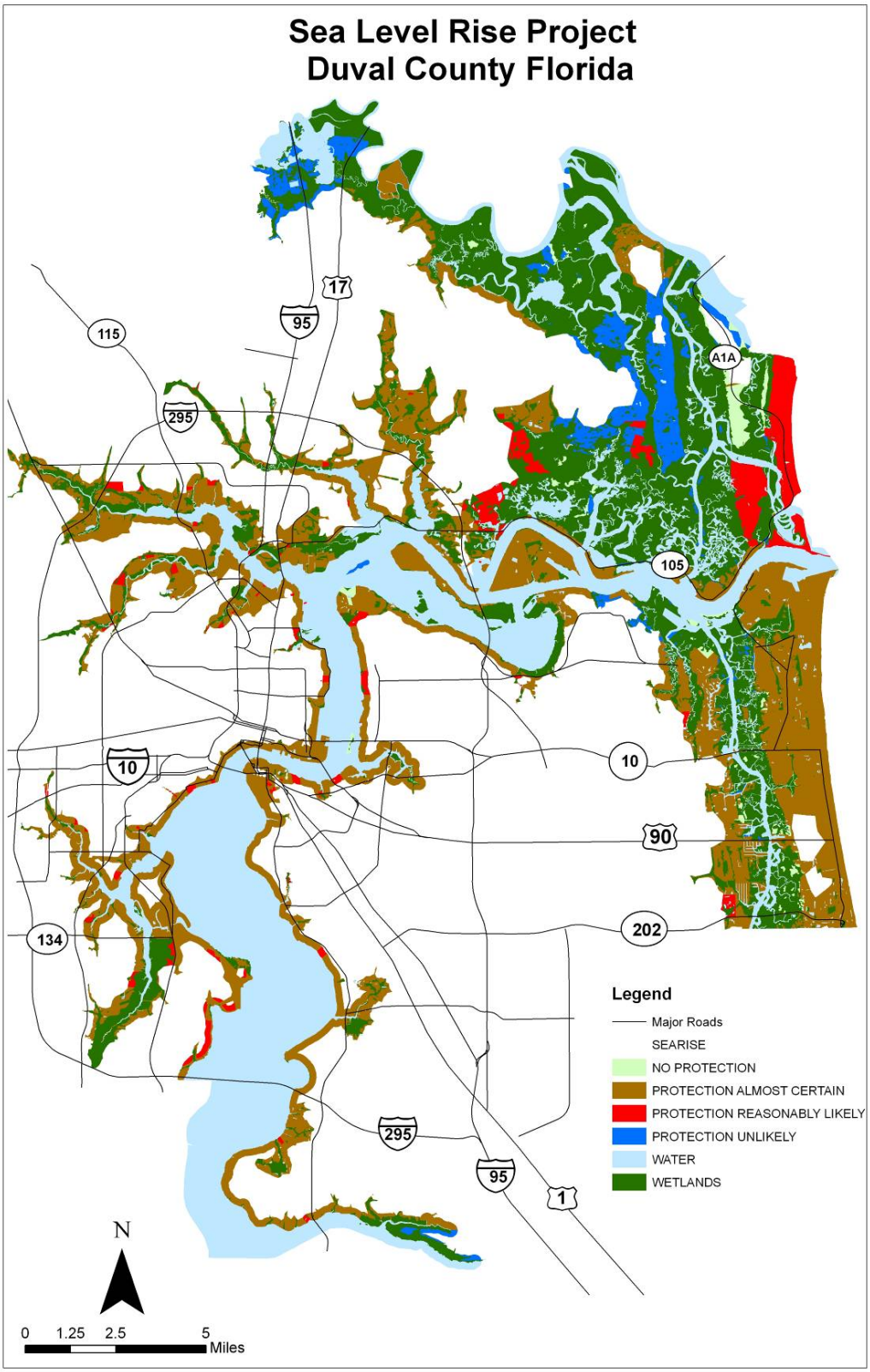
St. Johns River (from the Trout River south to the county border)

Areas of residential, commercial, industrial, public, recreational, and conservation land uses border the remainder of the St. Johns River. The residential areas, which consist of mostly high-end homes, and commercial, industrial, and public lands, including boat ramps and the Jacksonville Naval Air Station, are assigned the scenario of protection almost certain. The recreational areas are deemed as protection likely. The Exchange Club Island located under the Matthews Bridge is assigned the scenario of no protection, but this may need to be analyzed further if the island exists to divert the flow of water. The areas along the Arlington River and Pottsburg Creek are residential and will most likely be protected so they are assigned as protection almost certain. The Ortega River coastline consists mostly of high-end residential properties, and these lands are deemed as protection almost certain. The recreation areas along the Ortega River are deemed as protection likely. The conservation areas are assigned the scenario of no protection because retreat will be allowed for wetlands migration.

Julington Creek (from the St. Johns River to the end)

Julington Creek is bordered by areas of residential, public, and agricultural. The residential homes along the creek are medium to high end and will most likely be protected. Therefore, these areas are assigned the scenario of protection almost certain. The public lands (boat ramp) are deemed as protection likely. The remaining agricultural lands are assigned the protection unlikely scenario because it is believed that it will not be cost-effective to fortify them, thereby leaving them for wetlands migration.

Map 2 shows the study results for Duval County.



Map 2: Duval County: Likelihood of Shore Protection

ST. JOHNS COUNTY

St. Johns County is included in the project for Northeast Florida because of its location on the Atlantic Ocean and St. Johns River, which defines the eastern and western boundaries of the county. The Intracoastal Waterway and the Matanzas River both run parallel to the Atlantic coastline approximately 3 to 4 miles inland and are also included. All of these water bodies represent approximately 150 linear miles of tidally influenced coastline within the county.

Data Used for Study and Maps

The datasets used for the study of St. Johns County were compiled from multiple sources. The maps and analysis were based on the following layers:

Layer	Source
St. Johns County Future Land Use	St. Johns County GIS
Street Centerlines	St. Johns County GIS
Existing Land Use	St. Johns River Water Management District
Elevation Polygons	St. Johns River Water Management District
Digital Ortho Quarter Quads	St. Johns River Water Management District

Future Land Use –The future land use designations in the future land use layer for St. Johns County were generalized into the following designations:

AGRICULTURE	RECREATION
COMMERCIAL	HIGH DENSITY RESIDENTIAL
CONSERVATION	MEDIUM DENSITY RESIDENTIAL
INDUSTRIAL	LOW DENSITY RESIDENTIAL
PUBLIC	WATER

Street Centerlines – The streets layer was used for reference purposes.

Existing Land Use – The St. Johns River Water Management District maintains this layer. This layer was used to differentiate uplands, wetlands, and water based on the FLUCCS field values.

Elevation Polygons The elevation polygons were compiled from the elevation contours maintained by the St. Johns River Water Management District. The Arc View 9 Spatial Analyst extension was used to convert the contour line file to a polygon layer based on the elevation field.

Mapping Procedures

The following procedures were performed to create the final layer and maps for St. Johns County:

1. Created an Arc GIS map document for the project (slr_stjohns_final.mxd).
2. Projected all layers to State plane Florida East Zone 0901 and 1983.
3. Selected the water polygons from the existing land use layer.
4. Buffered the water polygons with a distance of 1,000 feet.
5. Selected the elevation polygons from the elevation layer that were less than 10 feet and intersected the 1,000 foot water buffer polygon.
6. Exported the selected elevation polygons to a new shape file.
7. United the exported elevation polygons with the 1,000 foot water buffer. This resulted in a shape file of the total area of interest for the project (slr_stjohns_sea rise_area_of_interest.shp).
8. Clipped the future land use shape file with the area of interest. This resulted in a layer of future land use that comprised polygons only in the area of interest for the project.
9. Clipped the existing land use shape file with the area of interest. This resulted in a layer of existing land use that comprised polygons only in the area of interest for the project.
10. United the clipped existing and future land use layers. This resulted in a layer containing attributes of future and existing land use attributes (slr_sea rise_stjohns_draft.shp).
11. Created an attribute field in the draft layer named [SEA RISE].
12. Analyzed the protection scenarios for St. Johns County to ensure that they followed the criteria set forth by the overall Sea Level Rise project standards.

The general approach findings were as follows:

Atlantic Coastline

The majority of the area of land along the Atlantic Ocean is high-end residential and recreational (golf courses, state parks, etc.) and is assigned the scenario of protection almost certain. “The Guana Tolomato Matanzas National Estuarine Research Reserve encompasses over 60,000 acres of salt marsh and mangrove tidal wetlands, oyster bars, estuarine lagoons, upland habitat and offshore seas in Northeast Florida. It contains the northern most extent of mangrove habitat on the east coast of the United States.”[44] The majority of the preserve is marked as protection almost certain because of its ecological importance. The open land areas within the preserve are marked as protection likely. Some of the open areas within the preserve that are contiguous to tidally influenced water bodies are marked as no protection. Most of the areas along the cities of St. Augustine and St. Augustine Beach are marked as protection almost certain. The open land areas in these cities contiguous to tidal influenced hydrology are marked as protection likely

[44] Found at http://www.dep.state.fl.us/coastal/sites/gtm/.

because there is a possibility that they may be protected to also protect areas farther inland.

Intracoastal Waterway and Matanzas River

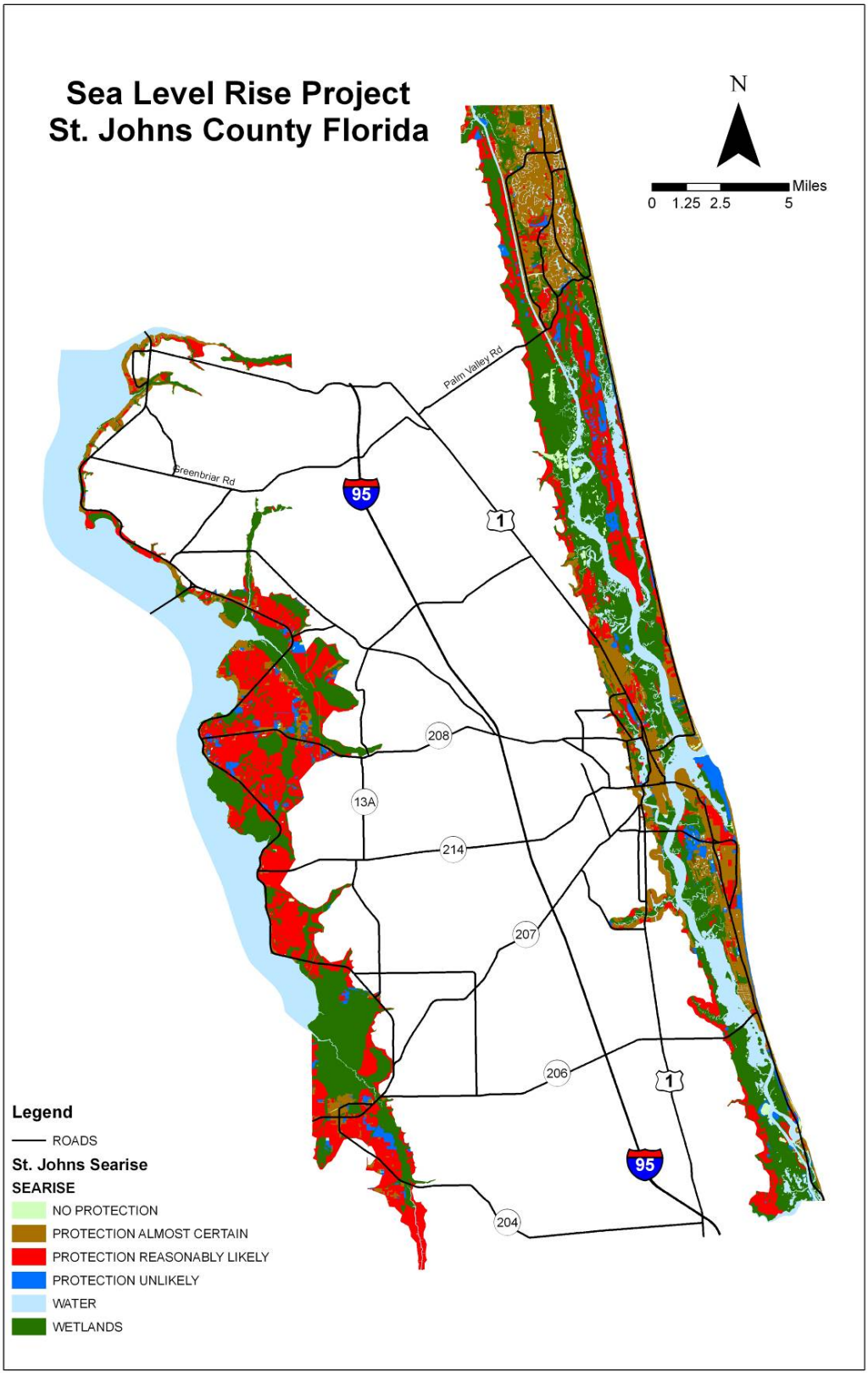
The areas of land around the Intracoastal Waterway consist mainly of agricultural lands. The areas of agricultural lands, either cropland or pasture lands, are deemed as protection likely. The forested areas of agricultural are deemed as protection unlikely. The residential areas near the Intracoastal are primarily high end and are all marked as protection almost certain. The commercial areas along the Intracoastal are also marked as protection almost certain.

Local Stakeholder Changes from Draft Maps
The above -forested and agricultural areas were originally marked as no protection, but the local planners specified that they should be marked as protection unlikely because they may be protected depending on the types of vegetation they contain.

Eastern Bank of St. Johns River

The land along the St. Johns River is largely designated as a mix of agricultural and residential and is identified as protection almost certain. The forested areas are marked as protection likely. Because these particular forested areas are so far inland, they are protected by default because the surrounding residential areas are being protected. Areas of high-end residential uses are marked as protection almost certain.

Map 3 shows the study results for St. Johns County.



Map 3: St. Johns County: Likelihood of Shore Protection

FLAGLER COUNTY

Flagler County is included in the project for Northeast Florida because of its location on the Atlantic Ocean, which defines the eastern boundary of the county. The Intracoastal Waterway runs parallel to the Atlantic coastline approximately 3 miles inland. Flagler County has approximately 63 miles of tidally influenced coastline included in the study.

Data Used for Study and Maps

The datasets used for the study of Flagler County were compiled from multiple sources. The maps and analysis were based on the following layers:

Layer	Source
Flagler County Future Land Use	Flagler County Planning / NEFRC
Street Centerlines	U.S. Census Bureau (TIGER)
Existing Land Use	St. Johns River Water Management District
Elevation Polygons	St. Johns River Water Management District
Digital Ortho Quarter Quads	St. Johns River Water Management District

Future Land Use –The future land use designations in the future land use layer for Flagler County were generalized into the following designations:

AGRICULTURE	RECREATION
COMMERCIAL	HIGH DENSITY RESIDENTIAL
CONSERVATION	MEDIUM DENSITY RESIDENTIAL
INDUSTRIAL	LOW DENSITY RESIDENTIAL
PUBLIC	WATER

Street Centerlines – The streets layer was used for reference purposes.

Existing Land Use – The St. Johns River Water Management District maintains this layer. This layer was used to differentiate uplands, wetlands, and water based on the FLUCCS field values.

Elevation Polygons The elevation polygons were compiled from the elevation contours maintained by the St. Johns River Water Management District. The Arc View 9 Spatial Analyst extension was used to convert the contour line file to a polygon layer based on the elevation field.

Mapping Procedures

The following procedures were performed to create the final layer and maps for Flagler County:

1. Created an Arc GIS map document for the project (slr_Flagler_final.mxd).

2. Projected all layers to State plane Florida East Zone 0901 and 1983.
3. Selected the water polygons from the existing land use layer.
4. Buffered the water polygons with a distance of 1,000 feet.
5. Selected the elevation polygons from the elevation layer that were less than 10 feet and intersected the 1,000 foot water buffer polygon.
6. Exported the selected elevation polygons to a new shape file.
7. United the exported elevation polygons with the 1,000' water buffer. This resulted in a shape file of the total area of interest for the project (slr_Flagler_searise_area_of_interest.shp).
8. Clipped the future land use shape file with the area of interest. This resulted in a layer of future land use that comprised polygons only in the area of interest for the project.
9. Clipped the existing land use shape file with the area of interest. This resulted in a layer of existing land use that comprised polygons only in the area of interest for the project.
10. United the clipped existing and future land use layers. This resulted in a layer containing attributes of future and existing land use attributes (slr_searise_Flagler.shp).
11. Created an attribute field in the draft layer named [SEA RISE].
12. Analyzed the protection scenarios for Flagler County to ensure that they followed the criteria set forth by the overall project standards.

The general approach findings were as follows:

Atlantic Coastline

The properties along the Atlantic Coastline consist of high-end residential, commercial, and recreational land use designations. All of the areas contiguous to the ocean, including open and forested lands, are marked as protection almost certain, including the golf courses. Some of these areas are undeveloped but if they were allowed to flood, Highway A1A would have to be fortified or relinquished to flood waters. It would be more cost-effective to fortify the properties rather than raise the highway. SR A1A has recently been designated a scenic highway, making it important to protect from flooding. The areas of recreation include beachfront parks and golf courses, all of which will most likely be fortified if necessary. The towns of Marineland, Beverly Beach, and Flagler Beach are all marked as protection almost certain.

Local Stakeholder Changes from Draft Maps
The local planners decided that the golf courses along the Atlantic Coastline should be marked as protection almost certain because of their popularity with the locals, as opposed to the original designation of protection likely.

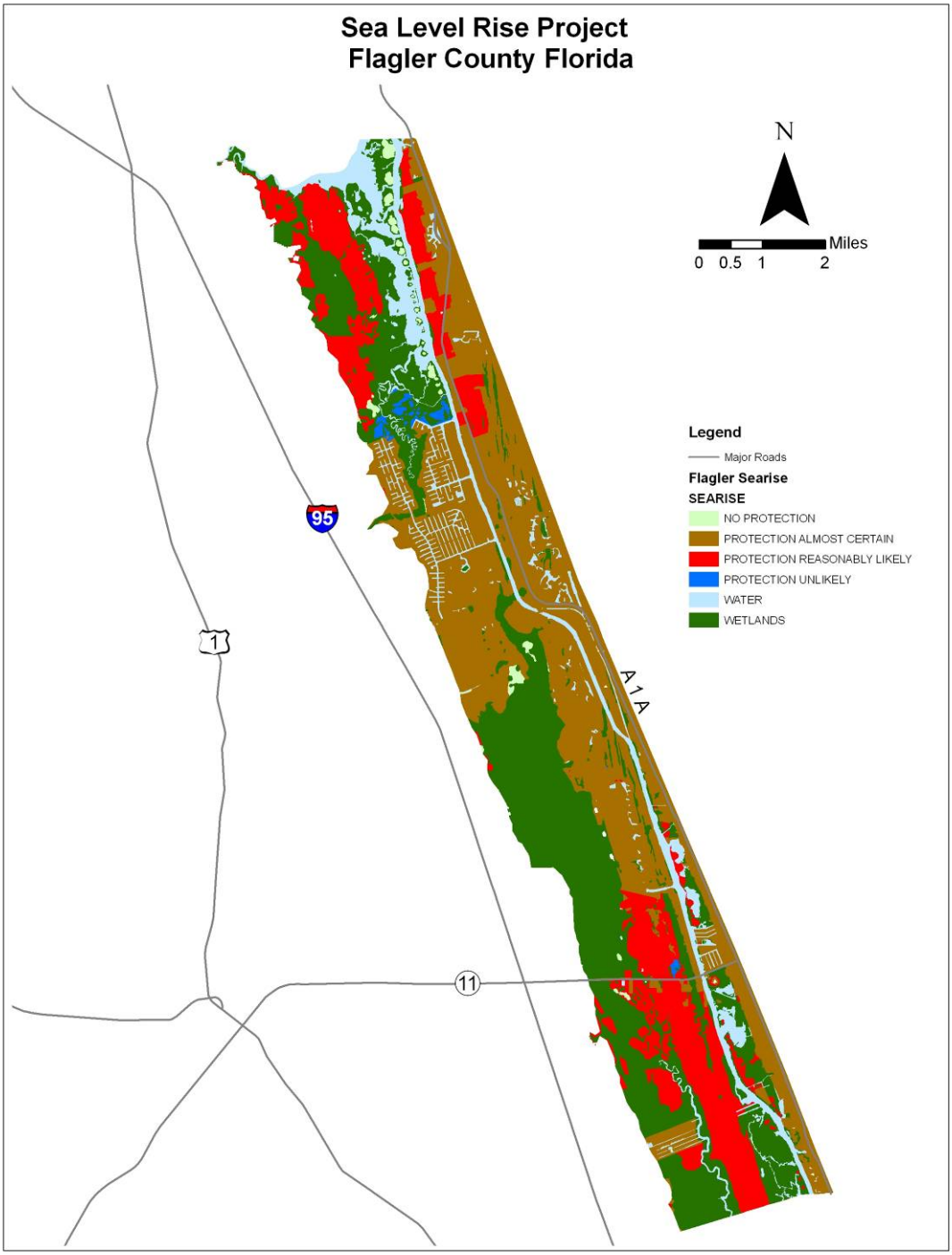
Intracoastal Waterway

There are study lands that border both coastlines of the Intracoastal Waterway. Many of these lands are agricultural and are marked as protection likely. Other areas along the

Intracoastal include commercial, recreational, and residential. The forested areas of parks and public land are marked as protection likely. The commercial, recreational (golf courses), and residential lands are marked as protection almost certain. There are some areas of open lands that are contiguous to developed areas that are marked as protection unlikely, while specific ones targeted by planners are designated as protection almost certain. Some of these areas are surrounded by marsh (wetlands), but they are close enough to developed lands that there may be a possibility for protection in the future. There are islands of open and forested lands along the Intracoastal Waterway that are marked as no protection because of their remoteness; they currently are accessible only via a boat.

Local Stakeholder Changes from Draft Maps
The local planners specified that there are specific forested areas along the Intracoastal that have been targeted for future development. These areas are marked as protection almost certain.

Map 4 shows the study results for Flagler County.



Map 4: Flagler County: Likelihood of Shore Protection

CLAY COUNTY

Clay County is included in the project for Northeast Florida because of its location on the St. Johns River. The St. Johns River is affected by the Atlantic Ocean's tides upstream to the border between Putnam County and Volusia County. The St. Johns River defines the eastern boundary of the county. Doctors Inlet is fed by the St. Johns and flows into a large area of wetlands and forested conservation uplands. Two creeks flow west from the St. Johns: Black Creek flows into the Black Creek Basin and Governors Creek flows west, north of the City of Green Cove Springs. Approximately 67 linear miles of tidally influenced coastline are included in the project for Clay County.

NOTE: The Black Creek Basin is the subject of an extensive study currently being conducted by the St. Johns River Water Management District and the State of Florida and has been excluded from this study.

Data Used for Study and Maps

The datasets used for the study of Clay County were compiled from multiple sources. The maps and analysis were based on the following layers:

Layer	Source
Clay County Future Land Use	Clay County Planning Department
Street Centerlines	Clay County Sheriff's Office
Existing Land Use	St. Johns River Water Management District
Elevation Polygons	St. Johns River Water Management District
Digital Ortho Quarter Quads	St. Johns River Water Management District

Future Land Use –The future land use designations in the future land use layer for Clay County were generalized into the following designations:

AGRICULTURE	RECREATION
COMMERCIAL	HIGH DENSITY RESIDENTIAL
CONSERVATION	MEDIUM DENSITY RESIDENTIAL
INDUSTRIAL	LOW DENSITY RESIDENTIAL
PUBLIC	WATER

Street Centerlines – The streets layer was used for reference purposes.

Existing Land Use – The St Johns River Water Management District maintains this layer. This layer was used to differentiate uplands, wetlands, and water based on the FLUCCS field values.

Elevation Polygons The elevation polygons were compiled from the elevation contours maintained by the St. Johns River Water Management District. The Arc View 9 Spatial Analyst extension was used to convert the contour line file to a polygon layer based on the elevation field.

Mapping Procedures

The following procedures were performed to create the final layer and maps for Clay County:

1. Created an Arc GIS map document for the project (slr_clay_final.mxd).
2. Projected all layers to State plane Florida East Zone 0901 and 1983.
3. Selected the water polygons from the existing land use layer.
4. Buffered the water polygons with a distance of 1,000 feet.
5. Selected the elevation polygons from the elevation layer that were less than 10 feet and intersected the 1,000 foot water buffer polygon.
6. Exported the selected elevation polygons to a new shape file.
7. United the exported elevation polygons with the 1,000 foot water buffer. This resulted in a shape file of the total area of interest for the project (slr_clay_sea rise_area_of_interest.shp).
8. Clipped the future land use shape file with the area of interest. This resulted in a layer of future land use that comprised polygons only in the area of interest for the project.
9. Clipped the existing land use shape file with the area of interest. This resulted in a layer of existing land use that comprised polygons only in the area of interest for the project.
10. United the clipped existing and future land use layers. This resulted in a layer containing attributes of future and existing land use attributes (slr_sea rise_clay_draft.shp).
11. Created an attribute field in the draft layer named [SEA RISE].
12. Analyzed the protection scenarios for Clay County to ensure that the scenarios adhered to the criteria set forth by the overall Sea Level Rise project standards.

The general approach findings were as follows:

St. Johns River (from the north county border to Doctors Inlet)

Seawalls fortify this entire 3.5-mile stretch of coastline along the St. Johns River in Clay County. These seawalls protect areas of high-end residential land use. For this reason these areas are deemed as protection almost certain.

St. Johns River (Doctors Inlet south to the county border)

The majority of the area along the St. Johns from Doctors Inlet to the Green Cove Springs city limits is marked as protection almost certain because many of the parcels are designated as residential and a good portion of those have existing seawalls. The Green Cove Springs area has some residential, commercial, and industrial areas, which have also been marked as protection almost certain. South of Green Cove Springs are areas that are mostly conservation with some rural residential. The conservation areas are

marked as protection unlikely and the residential are marked as protection likely because of possible future development.

Local Stakeholder Changes from Draft Maps:
The local planners changed the above conservation areas from no protection to protection unlikely because there may be a change in future protection.

Doctors Inlet

Doctors Inlet is completely surrounded by medium to high-end residential. Seawalls currently protect many of the homes around the inlet and those properties that aren't will most likely be protected in the future. For this reason, all of the area around the inlet is marked as protection almost certain. One parcel on the inlet has a future land use designation of commercial (restaurant) and it is completely protected by an existing seawall and is also marked as protection almost certain.

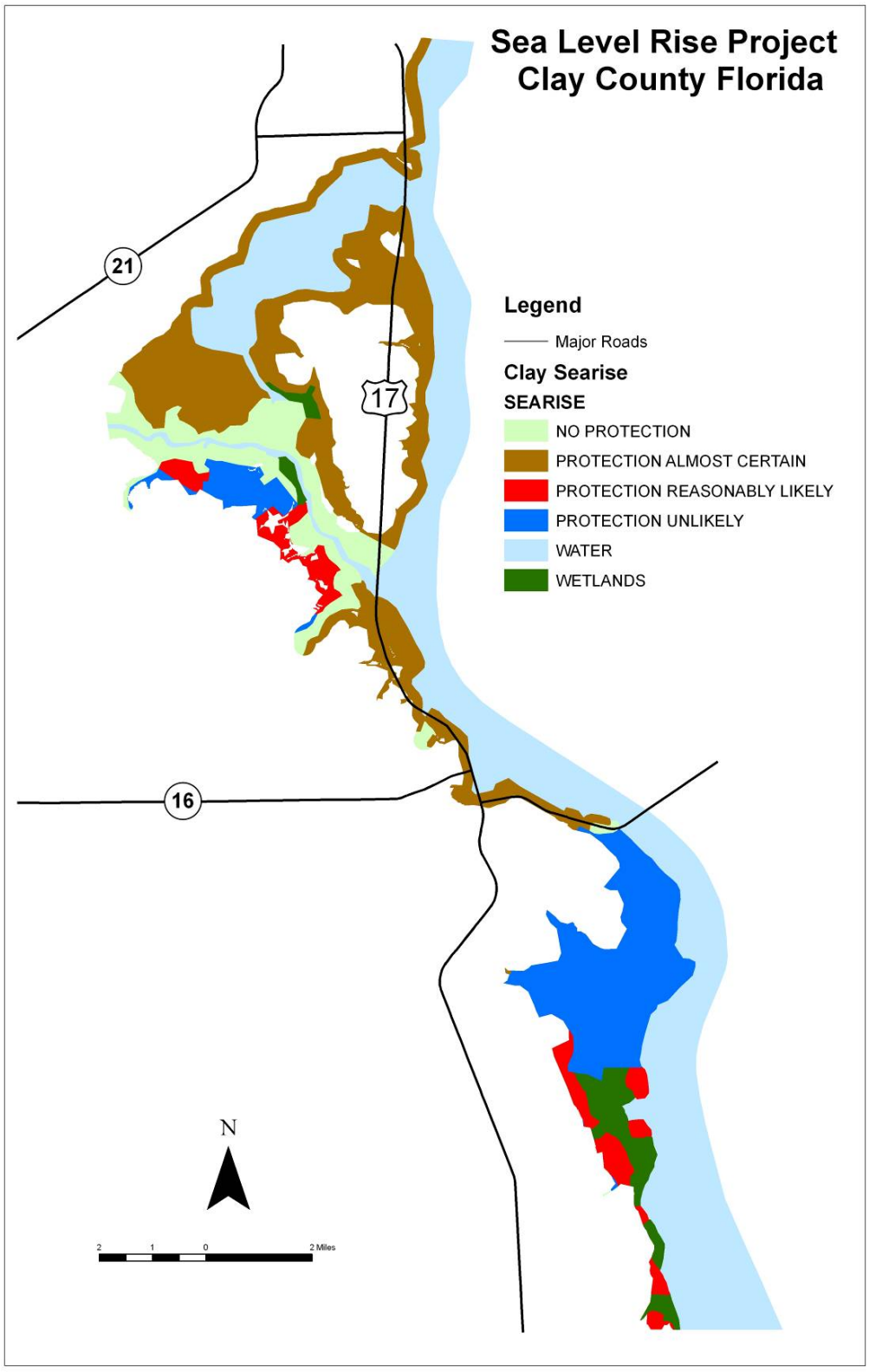
Black Creek

Black Creek extends west from the St. Johns River into the Black Creek basin. There is a considerable amount of conservation land in this area and it is marked as no protection and will most likely be relinquished for wetlands migration. The areas to the north of Black Creek are urban and rural residential. These areas are marked as protection almost certain because of planned future development. On the south side of Black Creek are mining, conservation, and residential areas. The residential areas are defined as protection likely because they are less densely developed but could possibly be protected for future growth. The mining area is abandoned so this area and the conservation areas are defined as no protection for wetlands migration.

Governors Creek

The Governors Creek area is mostly conservation surrounded by residential. The residential areas are marked as protection almost certain and the conservation areas are marked as no protection because they will most likely be allowed to flood.

Map 5 shows the study results for Clay County.



Map 5: Clay County: Likelihood of Shore Protection

PUTNAM COUNTY

Putnam County is included in the project for Northeast Florida because of its location on the St. Johns River. The St. Johns River is affected by the Atlantic Ocean's tides upstream to border between Putnam County and Volusia County. The river defines the eastern boundary of the county. The St. Johns River, along with Rice Creek, provides approximately 115 linear miles of tidally influenced coastline for the study.

Data Used for Study and Maps

The datasets used for the study of Putnam County were compiled from multiple sources. The maps and analysis were based on the following layers:

Layer	Source
Putnam County Future Land Use	Putnam County GIS
Street Centerlines	Putnam County GIS
Existing Land Use	St. Johns River Water Management District
Elevation Polygons	St. Johns River Water Management District
Digital Ortho Quarter Quads	St. Johns River Water Management District

Future Land Use –The future land use designations in the future land use layer for Putnam County were generalized into the following designations:

AGRICULTURE	RECREATION
COMMERCIAL	HIGH DENSITY RESIDENTIAL
CONSERVATION	MEDIUM DENSITY RESIDENTIAL
INDUSTRIAL	LOW DENSITY RESIDENTIAL
PUBLIC	WATER

Street Centerlines – The streets layer was used for reference purposes.

Existing Land Use – The St. Johns River Water Management District maintains this layer. This layer was used to differentiate uplands, wetlands, and water based on the FLUCCS field values.

Elevation Polygons The elevation polygons were compiled from the elevation contours maintained by the St. Johns River Water Management District. The Arc View 9 Spatial Analyst extension was used to convert the contour line file to a polygon layer based on the elevation field.

Mapping Procedures

The following procedures were performed to create the final layer and maps for Putnam County:

1. Created an Arc GIS map document for the project (slr_putnam_final.mxd).
2. Projected all layers to State plane Florida East Zone 0901 and 1983.
3. Selected the water polygons from the existing land use layer.
4. Buffered the water polygons with a distance of 1,000 feet.
5. Selected the elevation polygons from the elevation layer that were less than 10 feet and intersected the 1,000 foot water buffer polygon.
6. Exported the selected elevation polygons to a new shape file.
7. United the exported elevation polygons with the 1,000 foot water buffer. This resulted in a shape file of the total area of interest for the project (slr_putnam_sea rise_area_of_interest.shp).
8. Clipped the future land use shape file with the area of interest. This resulted in a layer of future land use that comprised polygons only in the area of interest for the project.
9. Clipped the existing land use shape file with the area of interest. This resulted in a layer of existing land use that comprised polygons only in the area of interest for the project.
10. United the clipped existing and future land use layers. This resulted in a layer containing attributes of future and existing land use attributes (slr_sea rise_putnam_draft.shp).
11. Created an attribute field in the draft layer named [SEA RISE].
12. Analyzed the protection scenarios for Putnam County to ensure that the scenarios adhered to the criteria set forth by the overall Sea Level Rise project standards.

The general approach findings were as follows:

St. Johns River (northern county border to the City of Palatka)

The lands along the St. Johns River are largely undeveloped, but these areas have been marked as protection almost certain. These lands are currently the only undeveloped lands that are contiguous to the St. Johns River, and they may be developed in the future. The forested areas are marked as protection likely because they also may be developed in the future. There are some areas of high-end as well as low-end residential that are marked as protection almost certain. Some of the residential areas that contain older, nonmaintained housing may be relinquished to flooding. These areas should be revisited in the future, and their protection scenario may change to protection likely. The Rice Creek area of the study has some agricultural lands that are marked as protection unlikely. There are also areas of conservation lands in the Rice Creek area that are marked as no protection because they are likely to be relinquished to wetlands migration. There are also publicly owned lands in the Rice Creek area that are marked as protection likely. The majority of the lands in the City of Palatka is residential, commercial, and recreation, and these lands are deemed as protection almost certain.

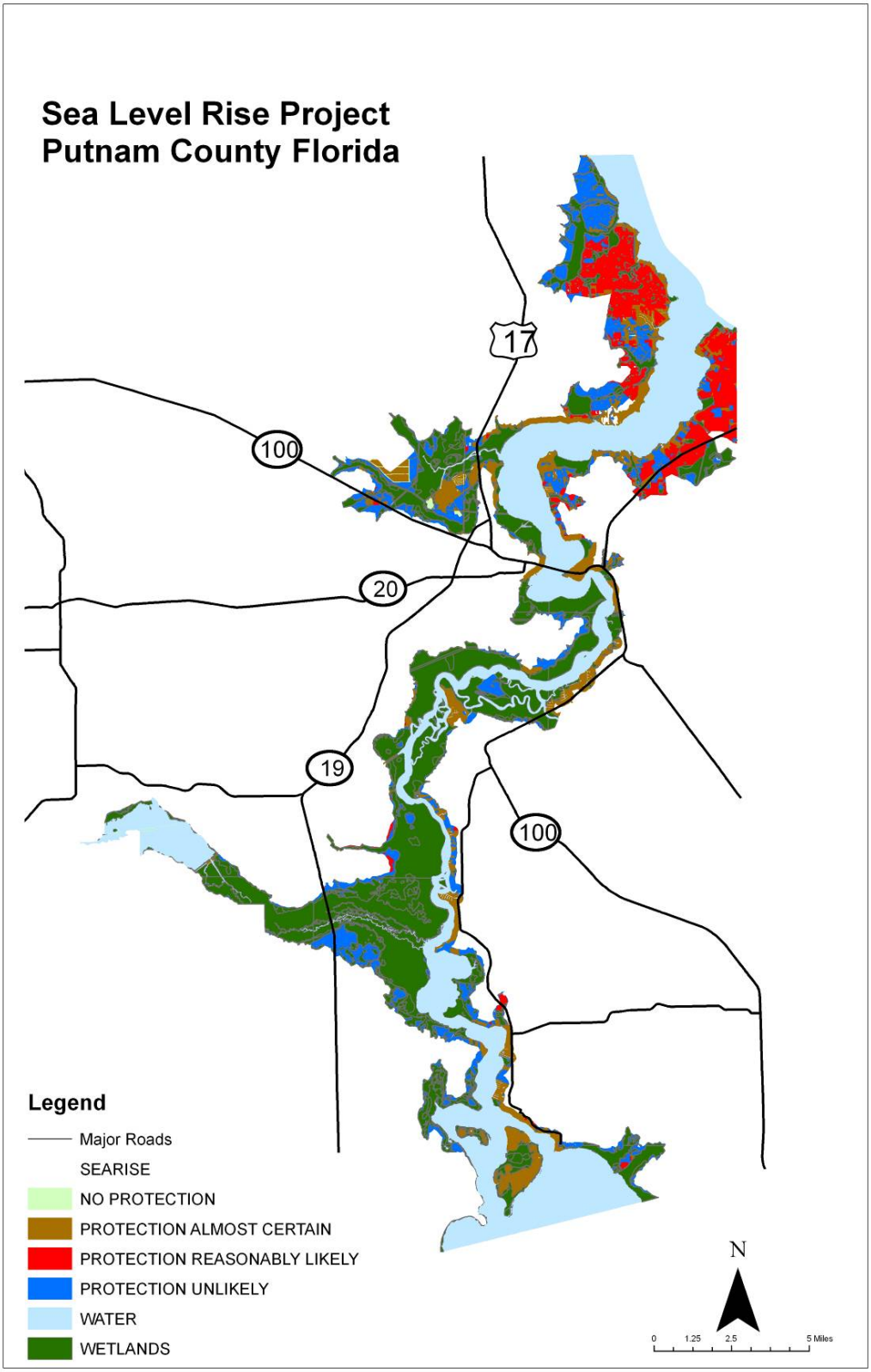
St. Johns River (south of Palatka to the county border)

There are open lands and croplands in this area that are deemed as protection unlikely. The residential areas are marked as protection almost certain. As with the north end of the St. Johns River, many of the residential parcels contain homes that may not be feasible to protect. These areas should be revisited in the future and possibly assigned a different scenario depending on the condition of the properties. The conservation and agricultural lands in this area are deemed as no protection because they will most likely be relinquished to wetlands migration. Some of the agricultural land has been designated as protection likely.

Local Stakeholder Changes from Draft Maps:

The local planners changed the Drayton and Hog Island scenarios from protection likely to protection almost certain because of their populations. They have also changed some of the agricultural lands from no protection to protection likely because of dense housing in some areas.

Map 6 shows study results for Putnam County.



Map 6: Putnam County: Likelihood of Shore Protection

CONCLUSION

This report and the accompanying maps depicting response scenarios are intended to stimulate local government planners and citizens to think about the problem of sea level rise. Although this project covers a timeframe of 200 years, it would be a mistake to assume that thinking about sea levels rising can be put off to a future time. The sea is already rising and some shores are already eroding. Moreover, an effective response may require a lead-time of many decades. If we develop areas where wetland migration is preferred in the long run, it might take a lead-time of 50–100 years to relocate the development. Even in areas that we protect, shore protection measures can take decades to plan and implement.

The relevance of planning for sea rise can also be seen by the events of 2004's hurricane season. As hurricanes headed toward this area, official forecasters predicted that storm surges in some areas would rise above the 10-foot contour mapped for this project. One need only look at areas of Northeast Florida, such as St. Augustine and Flagler Beach, to witness the erosional effects of rising seas. With strong hurricane seasons projected to continue into the future because of warmer ocean waters, the events of the 2004 hurricane season will repeat themselves. High storm surge and erosion are not effects that will wait until 2200. They are occurring now in our region.

The rate of development and the increase in population on the coast of Northeast Florida are other important factors in starting the preliminary stages of planning for sea level rise now. As sea levels continue to rise, much of the currently developed, increasingly populated area can be expected to be flooded. Planners must begin to decide which land areas in their counties and municipalities will be protected, if any, against sea level rise and what the cost of holding back the sea will be. Citizens living in these areas must also know the costs associated with protection against sea rise.

This project's creation of maps is only a depiction of the expected response scenarios to sea level rise, based on the best currently available knowledge. Local planners may decide in the future that it may be wise to retreat from lands currently deemed to be protected lands, due to costs and environmental considerations. It is important to repeat that this project is only a start to anticipatory planning for sea level rise. This is Year One of a 200-year project.

Chapter 6: EAST CENTRAL FLORIDA

by

Tara McCue

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EXECUTIVE SUMMARY

The large number of hurricanes in 2004 reminded us that the coast of Florida is very vulnerable to changes in climate and sea level. During a period of relative calm, development has concentrated along our coasts, with many residents not always aware of the possibility that the climate might return to a period of frequent and intense hurricanes.

It is important to understand that our shorelines constantly change because of erosion, sedimentation, and sea level rise. During the last century, sea level rose approximately 6–9 inches worldwide and 9 inches along the coast of East Central Florida. The U.S. Environmental Protection Agency (EPA) has been analyzing the causes, effects, and possible responses to sea level rise. EPA's 1995 report, *The Probability of Sea Level Rise*, estimates that if humanity continues to emit greenhouse gases into the atmosphere, mean sea level could rise 1–2 feet in the next century and 5 feet over the next 150–300 years.

Rising sea level has the potential to substantially change the U.S. coastal zone. Studies by EPA and others have concluded that such a rise will force coastal communities to make a fundamental decision: preserve the coastal environment by fostering a gradual evacuation along some parts of the nation's coastal zone, preserve coastal development by implementing shore protection measures that eliminate wetlands and shallow water ecosystems, or preserve both coastal development and coastal ecosystems through innovative but expensive land-use planning and new technologies.

The EPA is conducting a nationwide study to provide local governments with a better understanding of the effects of sea level rise on their community and strategies they can use to respond to the anticipated changes along their coastline. The East Central Florida Regional Planning Council (ECFRPC) was contracted by the Southwest Florida Regional Planning Council (SWFRPC) through a grant from the EPA to participate in this study, which includes all coastal states along the eastern seaboard. ECFRPC hopes to increase the level of awareness about sea level rise and implications for Brevard and Volusia counties. Long-term planning strategies are offered as a means of preparing for the predicted sea level rise.

This report includes maps created for the coastal zones of Brevard and Volusia counties that distinguish the shores that are likely to be protected from erosion, inundation, and flooding, from those shores where natural shoreline retreat likely will take place. The maps divide coastal lowlands into four categories: areas where shore protection is almost certain (brown), likely (red), or unlikely (blue), and areas where current environmental policies would preclude shore protection and enable wetlands to migrate inland (light green). The maps also show wetlands (dark green). The study focused on the lowest 240 square miles, using a common mapping benchmark for defining low coastal land: the 10-foot contour. More than 141,000 acres of uplands and almost 96,000 acres of wetlands, almost 15 percent of the Brevard and Volusia combined area, are in this area and hence would be directly affected by a continued rise in sea level.

The maps show that, for all practical purposes, past and planned development have already made it inevitable that property will be protected and the inland migration of wetlands will be blocked and

eventually eliminated along 30 percent of Brevard County and 60 percent of Volusia County shores. Existing conservation lands, however, ensure that wetlands will be able to adjust to rising sea level along the shores of about 45 percent and 15 percent of the two counties, respectively. Perhaps most important, we still have a realistic opportunity to choose between wetland migration and the type of coastal development that causes a gradual loss of wetlands for approximately 25 percent of the land in each county.

The Brevard and Volusia coastline is an important ecological and economical resource for the region and state. Land use is a state and local responsibility, and decisions should be made concerning the protection of developed and undeveloped land before it becomes too expensive or impossible to protect the shoreline and property. The counties and cities are presented, through this study, with options for decision making on land use and the protection of common infrastructure, property, resources, and the economic base of the community from sea level rise.

The decision whether to preserve wetlands or armor the coast in the face of rising sea level must be made within the context of the comprehensive plans of Brevard and Volusia counties, both of which recognize the potential adverse impacts of sea level rise on their communities. The Brevard County comprehensive plan addresses sea level rise in Policy 4.9, stating, "Brevard County shall continue to collect and make available to the public information related to sea level changes." The Volusia County comprehensive plan states, in section 11.4.1.21, "Volusia County should continue to monitor sea level rise science to determine when and if a sea level rise event will affect the County. Based on pertinent data, the county will act accordingly."

This report leaves little doubt that a continuation of rising sea level will affect Brevard and Volusia counties. They key question is, When? The answer depends on our priorities as well as on scientific uncertainties regarding how much the sea level will rise in the next century and beyond. In some cases, it is reasonable to wait and respond as the sea rises. Infrastructure changes, however, may require a lead time of a few decades, and land use decisions last centuries. If we want to preserve more than half of our coastal environment as sea level rises, we must develop policies to ensure such a preservation before the rest of our coastal zone is developed. Doing so need not impair property values; but a failure to act soon would preclude opportunities to preserve the coastal environment in a cost-effective manner.

Even if we are satisfied with preserving approximately one-third of our coastal wetland ecosystems, we are most likely to protect property values, and the commercial, industrial, tourism and residential economies, if we start factoring the implications of rising sea level into the planning process now rather than later. Low-lying developed areas will have to be either elevated or protected by dikes. By deciding now which form of protection is most appropriate, we can ensure that development and redevelopment are consistent with the long-term evolution of our communities, and thereby minimize the cost and community disruptions that might otherwise result from a rising sea.

INTRODUCTION

From the beginning of time through today**,** the Earth has constantly changed through both slow and abrupt changes in atmosphere, geosphere, temperature, and biota. Shorelines are some of the most unique places on Earth because they are the only place on Earth where the geosphere, atmosphere, and hydrosphere meet.[1] Shorelines constantly change depending on sediment deposition and erosion over time from fluctuations in sea level.

Early changes in sea level are believed to be a result of changes in ocean volume and the "glacio-hdyro-isostatic effect," or changes in ice and water loads.[2] The mean surface temperature of the Earth has increased since the Industrial Revolution, coinciding with an increase in the concentration of greenhouse gases in the atmosphere. Whether these recent changes are due to anthropogenic factors or to the natural cycle of the Earth has been discussed and debated for years.[3] One of the debated impacts of this increase in greenhouse gases is the acceleration of sea level rise.[1] If greenhouse gases continue to be released into the atmosphere at the current rate, the EPA estimates that the mean sea level rise in the next 200 years will reach approximately 5 feet.[3]

The East Central Florida Regional Planning (ECFRPC) has been contracted by the Southwest Florida Regional Planning Council (SWFRPC) through a grant from the U.S. Environmental Protection Agency (EPA) to participate in a nationwide project promoting planning for and awareness of sea level rise. The other regional planning councils along the Atlantic Coast (Northeast Florida, Treasure Coast, and South Florida) are also participating in this study; and the cooperative agreement between EPA and SWFRPC contemplates extending the study to include the entire coast of Florida. The Florida studies are part of a national effort by the EPA to encourage the long-term thinking required to deal with the impacts of sea level rise issues.

Each of the studies are developing maps that distinguish the areas likely to be protected[1] as the sea rises from the areas where shores will probably retreat naturally, either because the cost of holding back the sea is greater than the value of the land or because there is a current policy of allowing the shore to retreat. 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, 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.[2] EPA seeks to accelerate the process by which coastal governments and private organizations plan for sea level rise. The first step in preparing for sea level rise is to decide which areas will be elevated or protected with dikes or seawalls and which areas will be abandoned to the sea.
- *Policy makers and citizens concerned about long-term climate change.* Governments at all levels and many citizens are considering measures to reduce greenhouse gas emissions. The

[1]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 are rock revetments, bulkheads, dikes, beach nourishment and elevating land with fill.

[2]Titus, J.G., "Rising Seas, Coastal Erosion and the Takings Clause: How to Save Wetlands and Beaches Without Hurting Property Owners," *Maryland Law Review*, 57:1279-1399, 1998.

urgency of doing so depends in part on the consequences of climate change and sea level rise. Those consequences in turn depend to a large degree on the extent to which local coastal area governments will permit or undertake sea level rise protection efforts.[3] In addition, 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.

This study analyzes present and future land use and various coastal policies. The maps that accompany this study illustrate the areas that planners within this region expect will be protected from erosion and inundation in the coming decades. Those expectations incorporate state policies and regulations, local concerns, land-use data, and general planning judgment. Within the study area, our maps use the following colors:

- Brown—areas that almost certainly will be protected if and when the sea rises enough to threaten them.
- Red—areas that probably will be protected, but where it is still reasonably possible that shores might retreat naturally if development patterns change or scientists were to demonstrate an ecological imperative to allow wetlands and beaches to migrate inland.
- Blue—areas that probably will not be protected, generally because property values are unlikely to justify protection of private lands or the land is not planned for development and is situated to allow for wetland migration or a buffer, but in some cases because managers of publicly owned lands are likely to choose not to hold back the sea.
- Light Green—areas where existing policies would preclude holding back the sea. These areas include both publicly and privately owned lands held for conservation purposes.

We generally show wetlands as dark green.

The East Central Florida Regional Planning Council's study area included Brevard and Volusia County coastal areas. Maps have been developed to illustrate critical areas in the counties that may be affected by a 5 foot rise in sea level rise as well as where the ocean would be held back or where development may retreat. Geographic information systems (GIS) was used to develop the maps and land use impact analysis of the coastal areas below the 10 foot NGVD contour.[4] The 10-foot contour was estimated as the maximum elevation that may periodically be flooded by a 5 foot rise in sea level.[55]

[3] Titus, J.G., et al., "Greenhouse Effect and Sea Level Rise: The Cost of Holding Back the Sea," *Coastal Management*, 19:171–204, 1991; Yohe, G., "The Cost of Not Holding Back the Sea. Toward a National Sample of Economic Vulnerability," *Coastal Management* 18:403–431, 1990.

[4] 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

[5] East Central Florida Regional Planning Council Scope of Work and Methodology, 2004.

The study area, the coastal areas of Brevard and Volusia counties, is divided into uplands (141,410 acres, 221 square miles) and wetlands (95,812 acres, 150 square miles) below 10 feet in elevation. The study area is approximately 237,222 total acres, which comprise 14.5 percent of the combined area of both counties. According to the 2000 census, the current population in the coastal census tracts within the study area is approximately 503,000 in 260,000 dwelling units. Certain census tracts are completely within the study area while others are partial. Therefore, these estimates are high end approximations based on the census tract information. Volusia is expected to have a population of 350,000 in 183,000 dwelling units by 2020, and Brevard's 2020 population is expected to be 199,000 in 104,000 dwelling units.[6,7] Therefore, the study area is expected to have a population of roughly 550,000 residents in 287,000 dwelling units by 2020.

Tourism is Florida's number one industry, bringing in approximately $46.7 billion in 1999.[7] Major tourist destinations such as Daytona Beach, Cocoa Beach, and Melbourne Beach are included in the study area. Therefore, sea level rise will affect not only the residents but tourist destinations as well, which may result in dramatic effects on the economic well-being of the counties.[8]

Sea level rise can have various effects on the coastline. Inundation and higher flood elevations can occur. Shoreline erosion is another effect related to sea level rise. Also, because of higher water tables caused by sea level rise, salt water intrusion and contamination of the aquifer may occur, contaminating wells and thus affecting the local economy.[8,9]

This project is the first detailed study to examine the potential effects of sea level rise on East Central Florida. Currently, land use regulations address flood mitigation and not sea level rise. The comprehensive plans in Brevard and Volusia counties minimally address the issue of sea level rise. Section 11.4.1.21 of the Volusia County comprehensive plan states, "Volusia County should continue to monitor sea level rise science to determine when and if a sea level rise event will affect the County. Based on pertinent data, the county will act accordingly." The Brevard County comprehensive plan addresses sea level rise in Policy 4.9, stating, "Brevard County shall continue to collect and make available to the public information related to sea level changes."

As is discussed in further detail in this report, many regulations designed for flood mitigation also could be used as sea level rise planning. Development continues, however, and more infrastructure is incorporated into coastal areas without adequate planning for the effects or costs of flooding, erosion, and storm damage caused by sea level rise.[10]. According to the USGS, the study area is considered a high vulnerability area since it is contains a barrier island with a low coastal slope. Therefore, this lack of planning for future sea level rise can be costly to the community. The ECFRPC hopes that this report will bring more local awareness to the issue of sea level rise and aid local governments of Brevard and

6 Volusia County MPO 2020 Long Range Transportation Plan-Refinement. Volusia County Metropolitan Planning Organization: November 2000. 4 June 2004. <www.volusiacountympo.com/documents/documents_lrtp.html>

7 Riger, J. "RE: Long Range Plan 2020" jriger@citiesthatwork.com (09 April 2004).

Volusia counties in long-term planning for sea level rise so that both property and the environment can be preserved.

Figure 1 shows the land vulnerable to sea level rise in East Central Florida. Table 1 lists the area vulnerable to sea level rise by county. Map 1 shows the results of this study.

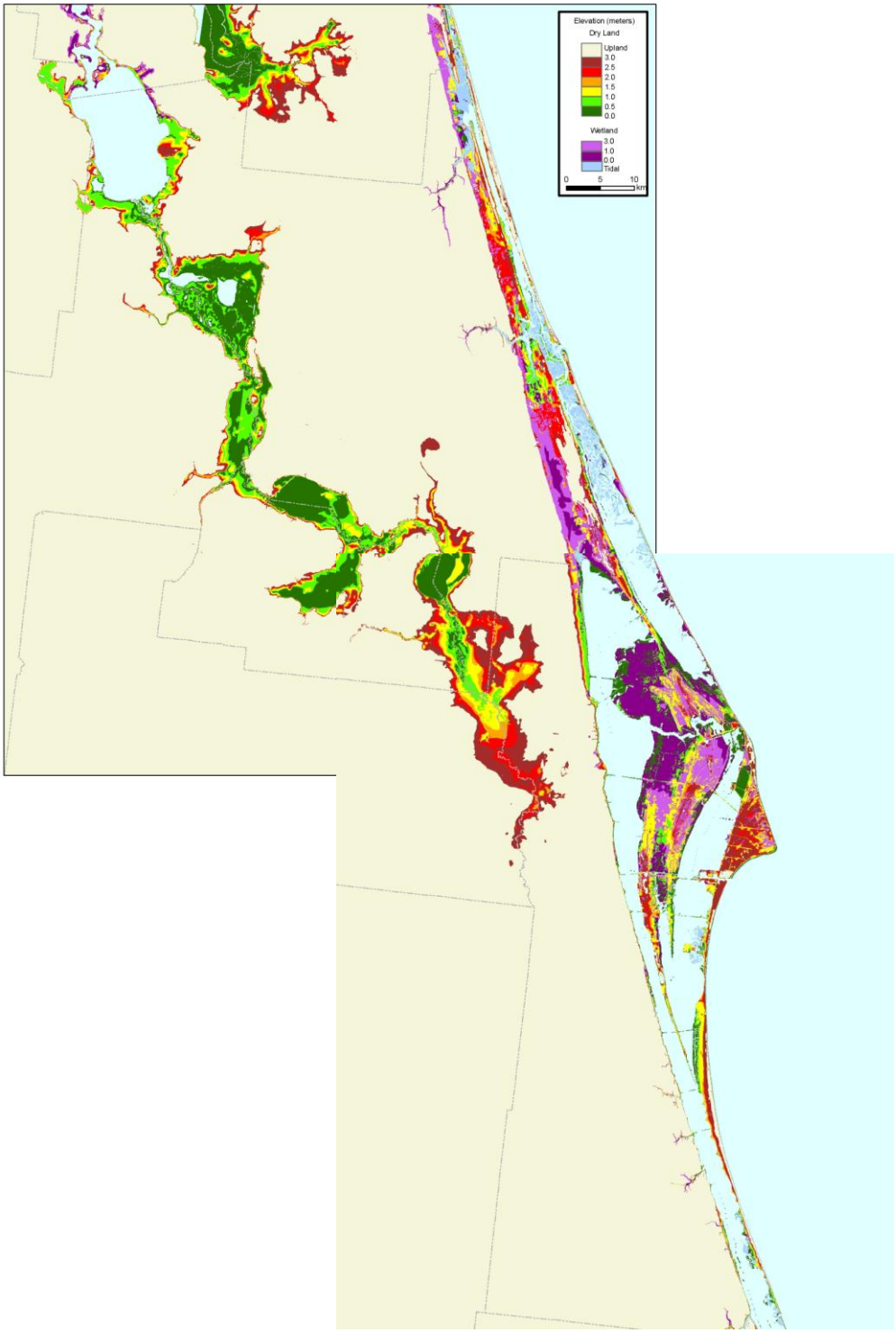


Figure 1. Elevations of Land Close to Sea Level East Central Florida. Elevations are relative to spring high water. Source: See Table 1.

Table 1. Area of Land Close to Sea Level by County (square kilometers)											
	Elevations (m) above spring high water										
County		**0.50**	**1.00**	**1.50**	**2.00**	**2.50**	**3.00**	**3.50**	**4.00**	**4.50**	**5.00**
Volusia		186	307	412	458	556	644	683	728	790	830
Brevard		106	190	351	400	462	582	635	729	912	1029
Total		292	497	763	858	1018	1226	1317	1456	1701	1859

Source: National Elevation Dataset and Titus J.G., 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. Section 1.1 in: *Background Documents Supporting Climate Change Science Program Synthesis and Assessment Product 4.1*, J.G. Titus and E.M. Strange (eds.). EPA 430R07004. U.S. EPA, Washington, DC.

THE CHANGES AND CAUSES OF SEA LEVEL RISE

Evidence from the past 10,000 to 20,000 years indicates sea level variations occurred on the order of every few thousand years. Figure 2 shows the historical Florida shoreline between 1.8 million and 10,000 years ago. Data also indicate that over the past 6,000 years, sea volume increased, causing a sea level rise of 2.5–3.5 meters. The early changes in sea level rise are believed to be a result of changes in the ocean volume and the "glacio-hydro-isostatic effect," or changes in ice and water loads.[2]

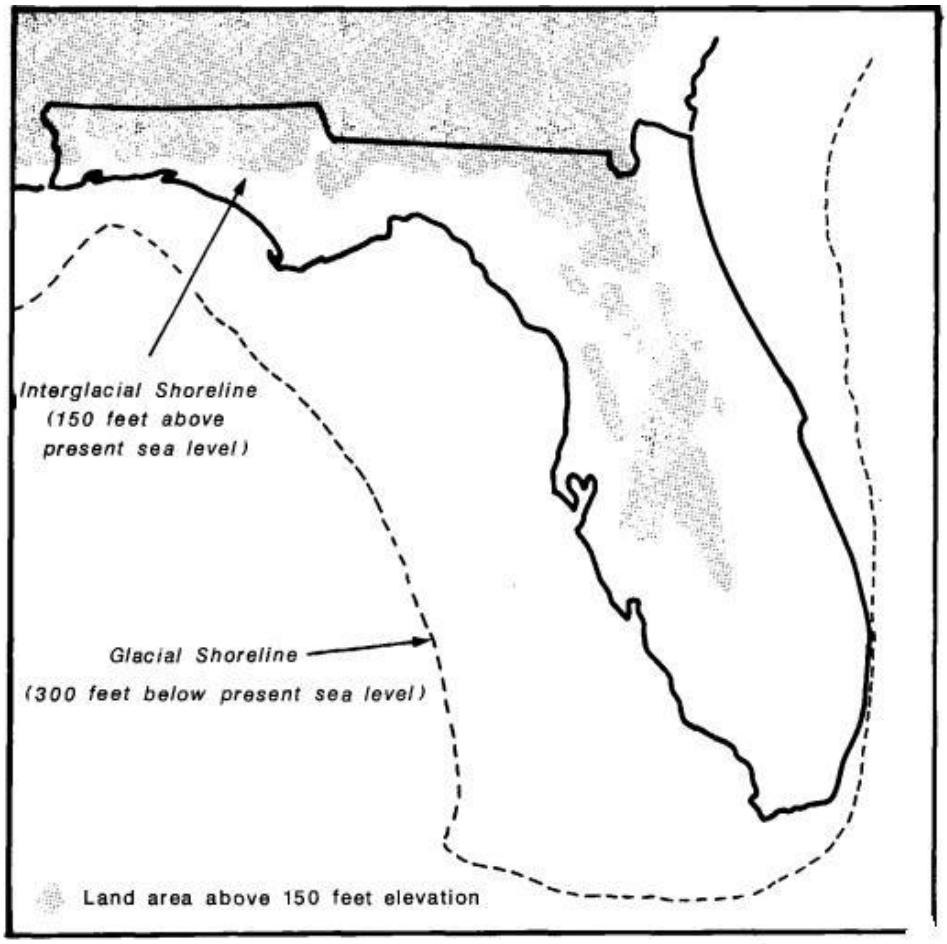


Figure 2: Florida shoreline 1.8 million to 10,000 years ago.[11]

Global Contributors

When comparing data over the past 100 years to that of the past two millennia, the rate of sea level rise has increased as a result of glacial mass changes and thermo-expansion.[2] In addition, tectonic movements and netotectonics (postglacial rebounds) are also possible contributors to changes in the global ocean volume.[8] These causes of sea level rise may be a result of or accentuated by the debated global climatic change possibly accelerated by human impacts.

Data have shown the mean surface air temperature of the Earth has increased by 0.5°C over the past 100 years, coinciding with the increase in concentration of greenhouse gases in the atmosphere.[3] Although the climate of the Earth has always fluctuated, the increased concentration of certain gases in the atmosphere may be accelerating the warming processes.[12] Figure 3 illustrates the atmospheric temperature increase from 1861 to 1988, relative to 1950 to 1979. The boxes in the graph represent temperature anomalies in the 5 year period and the line represents the 5 year mean.

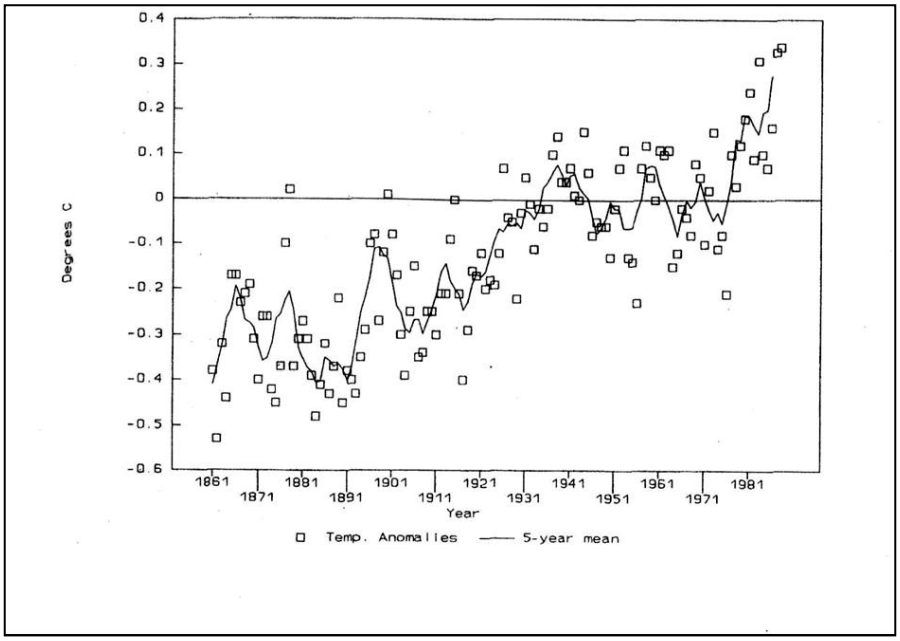


Figure 3: Global Mean Temperature Change: Combined land, air, and sea surface temperatures, from 1861 to 1981, relative to 1950 to 1979 (Daniels, 1992).

If conditions continue as the current trend indicates, air temperature may increase by 1.5°C to 4.5°C over the next 100 years.[13] The EPA estimates that by 2050, air temperature will rise 1°C to 2°C by 2100. There is only a 10 percent chance that the temperature will increase more than 4°C over the next 100 years. There is, however, a 90 percent probability that temperature will rise 0.6°C over the temperature rise of the previous century.[3] Also, according to Peter Clark (2003) of Oregon State University, global warming may also cause the disruption of North Atlantic currents, resulting in the cooling of Europe. The atmospheric warming, in turn, would then eventually melt the Antarctic ice sheet and cause the currents to move again, resulting in sea level rise and inundated coastal regions.

Another contributor to sea level rise could be thermal expansion and glacial changes.[2] Thermal expansion, the expansion of water due to heating, depends on the amount of heat penetrating into the deeper and intermediate waters. As Figure 4 depicts, mean sea level fluctuates closely with the sea surface temperature as thermal expansion would indicate. There is, however, a delay in thermal expansion when compared to the increase in air temperature. This results in a larger thermal expansion than increase in air temperature at a certain time. The EPA estimates that, by 2100, thermal expansion of the ocean will reach approximately 20 cm.[3]

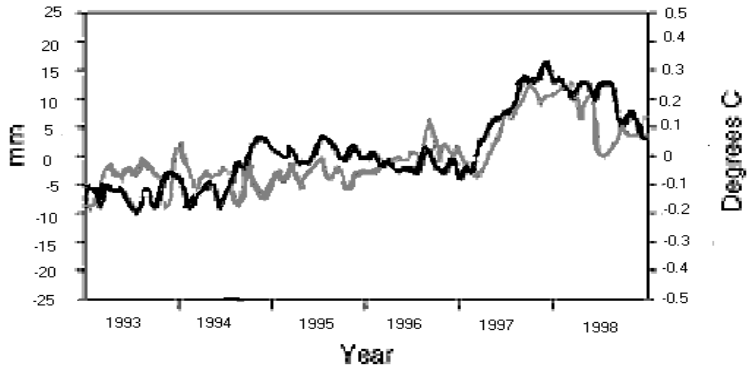


Figure 4: Global mean sea level variations (light line) computed from the TOPEX/POSEIDON satellite altimeter data compared with the global averaged sea surface temperature variations (dark line) for 1993 to 1998 (Cazenave et al., 1998, updated). The seasonal components have been removed from both time-series.[2]

Figure 5 illustrates the probability distributions of the melting of various glaciers from greenhouse effects on sea level rise. The Daniels et al. graph shows that, when comparing the above, Greenland may have the greatest probability of contributing to sea level rise and Antarctica has the least. Changes in glacial volume can affect sea level in two ways. Some water from the glaciers enters the sea, thus increasing the volume of the ocean. Also, by changing the volume of the glaciers, there is less displacement of the water; thus sea level rises although the ocean volume may not.[14]

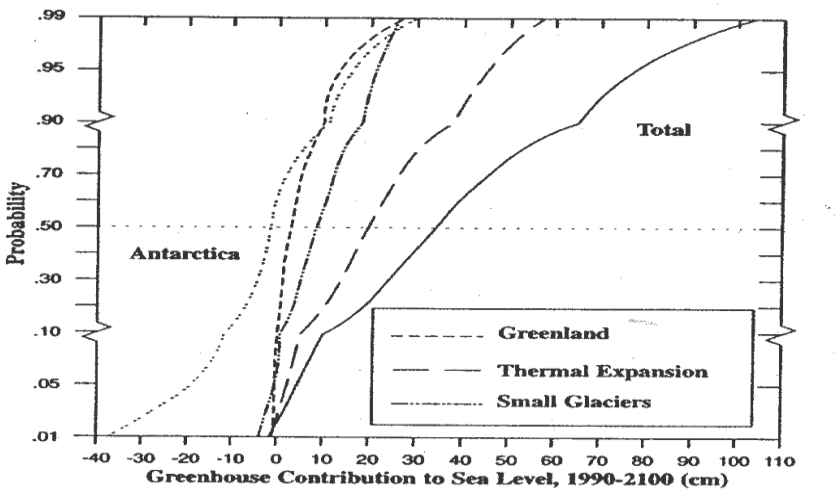


Figure 5: Cumulative probability distributions showing the contribution of thermal expansion, small glaciers, Greenland, and Antarctica to sea level from 1900–2100.[13]

Sea Level Rise in East Central Florida

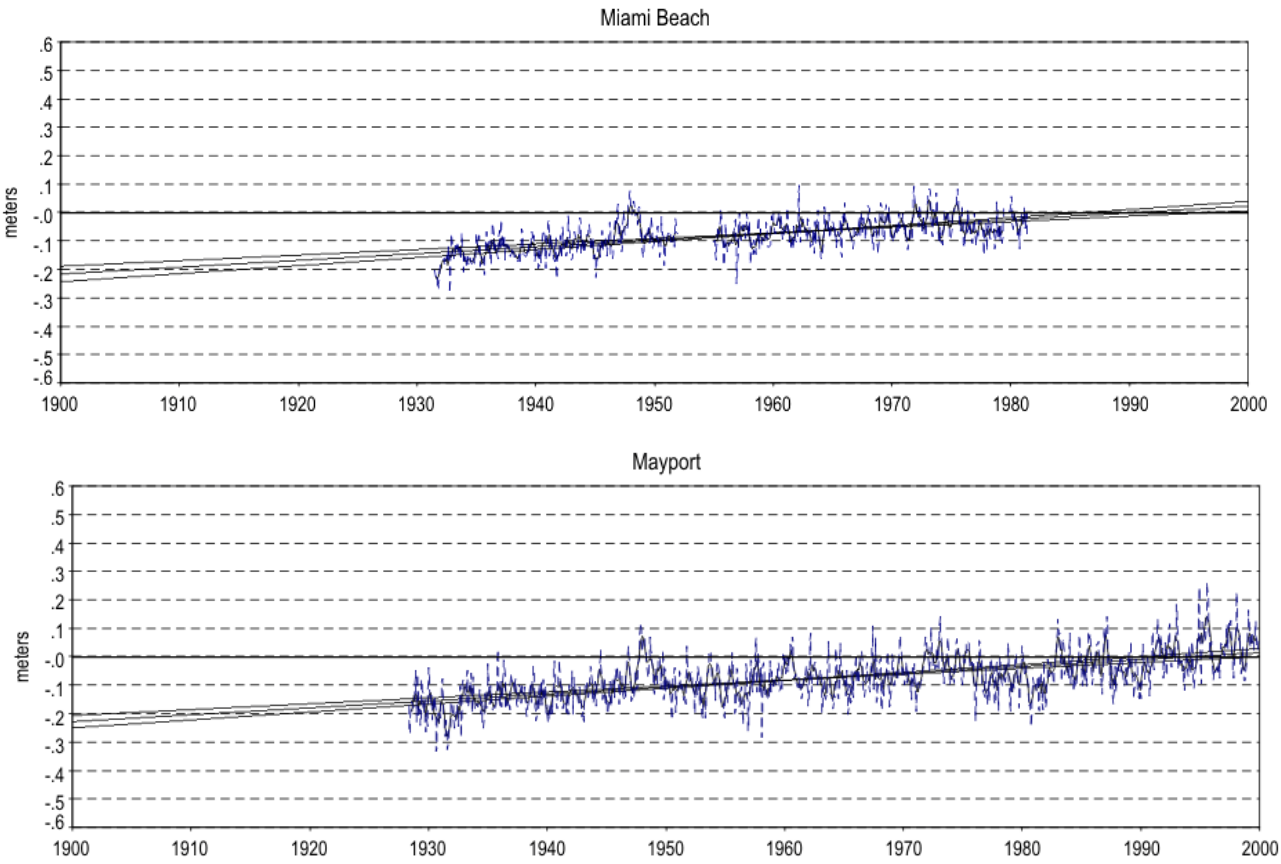
Table 2, provided by the SWFRPC, is the probability of sea level rise in East Central Florida based on Tables 9-1 and 9-2 from the EPA publication "The Probability of Sea Level Rise." Table 2 predicts the probability of various sea level rise scenarios over the next 200 years along the coastline of east central Florida. For example, there is a 90 percent probability there will be more than a 1 foot rise in sea level by 2150 along the Florida coast. However, there is a 50 percent probability that this rise could be seen by 2075. The table also suggests a 30 percent chance that sea level will rise 2 feet in the next century and 5 feet in the next 200 years.

Table 2: Estimated sea level rise for East Central Florida

	Sea Level Projection by Year											
Probability (%)	**2025**		**2050**		**2075**		**2100**		**2150**		**2200**	
	cm	**inches**	**cm**	**inches**	**cm**	**inches**	**cm**	**inches**	**cm**	**inches**	**cm**	**inches**
90	**6.7**	**2.6**	**12.2**	**4.8**	**18.7**	**7.4**	**25.2**	**9.9**	**38.2**	**15.0**	**51.2**	**20.2**
80	**8.7**	**3.4**	**16.2**	**6.4**	**24.7**	**9.7**	**34.2**	**13.5**	**51.2**	**20.2**	**69.2**	**27.2**
70	**10.7**	**4.2**	**19.2**	**7.6**	**28.7**	**11.3**	**40.2**	**15.8**	**61.2**	**24.1**	**83.2**	**32.8**
60	**11.7**	**4.6**	**21.2**	**8.3**	**32.7**	**12.9**	**44.2**	**17.4**	**70.2**	**27.6**	**97.2**	**38.3**
50	**12.7**	**5.0**	**23.2**	**9.1**	**35.7**	**14.1**	**49.2**	**19.4**	**78.2**	**30.8**	**110.2**	**43.4**
40	**13.7**	**5.4**	**26.2**	**10.3**	**39.7**	**15.6**	**54.2**	**21.3**	**88.2**	**34.7**	**124.2**	**48.9**
30	**15.7**	**6.2**	**28.2**	**11.1**	**42.7**	**16.8**	**60.2**	**23.7**	**100.2**	**39.4**	**144.2**	**56.8**
20	**16.7**	**6.6**	**31.2**	**12.3**	**47.7**	**18.8**	**68.2**	**26.9**	**115.2**	**45.4**	**171.2**	**67.4**
10	**19.7**	**7.8**	**36.2**	**14.3**	**55.7**	**21.9**	**79.2**	**31.2**	**141.2**	**55.6**	**220.2**	**86.7**
5	**21.7**	**8.5**	**40.2**	**15.8**	**61.7**	**24.3**	**90.2**	**35.5**	**169.2**	**66.6**	**277.2**	**109.1**
2.5	**24.7**	**9.7**	**44.2**	**17.4**	**68.7**	**27.0**	**102.2**	**40.2**	**202.2**	**79.6**	**342.2**	**134.7**
1	**26.7**	**10.5**	**48.2**	**19.0**	**75.7**	**29.8**	**116.2**	**45.7**	**245.2**	**96.5**	**448.2**	**176.5**
Mean	**12.7**	**5.0**	**24.2**	**9.5**	**36.7**	**14.4**	**51.2**	**20.2**	**86.2**	**33.9**	**127.2**	**50.1**

*****The results of this table are based on using Tables 9-1 and 9-2 of the EPA report "The Probability of Sea Level Rise".[15] Basically, the formula is multiplying the historic sea level rise (2.2 mm/yr) in East Central Florida (closest point used is Mayport, Fl., Table 9-2) by the future number of years from 1990 plus the Normalized Sea Level Projections in Table 9-1. In summary, the EPA report relied on various scientific opinions regarding sea level changes affected by factors such as radiative forcing caused by both greenhouse gases and sulfate aerosols, global warming and thermal expansion, polar temperatures and precipitation, and the contributions to sea level from Greenland, Antarctica, and small glaciers.

Ocean levels have been monitored by stations around the world. According to most of these monitoring stations, mean sea level has increased steadily over the past century.[16] The two graphs in Figures 6 and 7 illustrate data from the two closest NOAA sea level monitoring stations to the study area, Mayport to the north and Miami Beach to the south. As both graphs illustrate, sea level along the east coast of Florida has been increasing for at least the past 70 years.



Figures 6 and 7: Monthly sea level variations at the Miami Beach and Mayport monitoring stations over the past 70 years.

Miami Beach monitoring station shows a mean sea level trend of 2.39 mm/year based on data from 1931 to 1981. Mayport exhibits a mean sea level trend of 2.43 mm/year (0.80 feet/century) based on data from 1928 to 1999.[17]

Global vs. Relative Sea Level Rise

Global sea level rise is a result of increasing global ocean volume. The measurements of global sea level rise are the same regardless of the location on Earth. Relative sea level rise is the measure of the increase or decrease of sea level relative to land in specific locations. Relative sea level measurements will vary from location to location as a result of the primary contributors to the rise.[8] Local trends in subsidence or emergence can cause local variances in ocean levels.[9] For example, subsidence of the coastal region can be caused by extensive development. Land, under the weight of development, sinks below its original elevation. Increased development also means increased use of resources. The overpumping of wells, both oil and water, also leads to land subsidence. Since the magnitude of possible causes of sea level rise varies from site to site, relative sea level rise is important because it measures the cumulative effects of all the causes of sea level on a local basis.[14] Therefore, focusing on relative sea level rise rather than global sea level rise is important in local planning to protect shorelines.

In a study by the Oak Ridge National Laboratory, three sea level rise scenarios were calculated for Daytona Beach with its current local subsidence rate of 0.513 mm/year using a sea level rise trend for Daytona Beach of 2.013 mm/year.[13] Table 3 illustrates the sea level rise scenarios, without including land subsidence, of the Daniel's study based on the International Panel on Climate Change Business as Usual for 2100.

Table 3: Sea Level Rise Scenarios (cm) for Daytona Beach, Florida, used in Daniels et al. Study.

Scenario	Year				
	2000	2025	2050	2075	2100
A. Low Scenario	2	6.5	14	22	31
B. Moderate Scenario	5	7	32	48	66
C. High Scenario	8	27	50	78	110

The sea level rise scenarios in the Daniels et al. study were then calculated using the subsidence rate of Daytona Beach, resulting in Table 4. Local subsidence, as evident from the data, creates relative sea level rise of 5.6 cm by 2100 along the Volusia coastline, in addition to global sea level rise. When increased ocean volume is combined with local subsidence, relative sea level may be even higher along the coastline, as evident from the data in Table 4. Depending upon the scenario, subsidence can account for 5 percent – 18 percent of the rise in sea level 2100.

Table 4. Relative sea level rise (cm) for Daytona Beach, Florida. Present subsidence rate for Daytona Beach is 0.513 mm/year. The current sea level rise scenario represents local subsidence only [13].

	Year		
	1988	2050	2100
Current (as of 1988)*	0	3.1	5.6
A. Low		17.1	36.6
B. Moderate		35.1	71.6
C. High		53.1	115.6

Effects Related to Sea Level Rise
General

Coastlines could be affected by simple sea level rise with the "retreat" of the shoreline. Natural occurrences such as storm surges and waves may reach beyond current levels, and floodplains may be subjected to more effects as well. As a result, the total area affected by sea level rise and storm events could be larger than the land area projected to be covered with water.[2] Issues of sea level rise reach far beyond inundation and flooding. As sea level rises, salt water intrusion thatcan contaminate private and public wells, increased erosion, a loss of infrastructure and wetlands, and effects on the National Flood

Insurance Program may occur.[8] Sea level rise would force wetland migration that, with continued development, may be impeded if no open land exists to where the wetland may migrate.[9] With wetland, beach, and spoil island loss from no protection against sea level rise, the coastline can expect to have a decline in critical habitats and productivity.[1] Also, the larger, more powerful waves resulting from increasing sea level accelerate beach erosion.[16]

Although sea level rise contributes to or exacerbates these effects, it is not the lone culprit. Increasing development along the coast creates a greater withdrawal from the aquifer. This, in turn, enables the salt water wedge to move farther inland, contaminating the groundwater. Surface waters and wetlands may also be affected by saltwater intrusion. Shoreline erosion can be caused by both boat traffic and inlet stabilization.[1] Major hurricanes and Nor'easters are culprits of massive beach erosion and destruction, such as the 1984 Thanksgiving Day Nor'easter. A storm of this magnitude has a return period of 10–20 years. Currents, such as the powerful Florida Gulf Stream, are active transporters of beach sediment.[16] All aspects of shore erosion, however, must be considered in our study because shoreline protection or natural wetland migration is not dependent on the cause of erosion. Also, areas already experiencing erosion may indicate how similar areas may respond to sea level rise.[1]

Local Issues

The Florida Department of Environmental Protection, Bureau of Beaches and Coastal Systems updated the "Critical Erosion" List in 2003. Erosion is considered critical when there is a threat of loss of one of the following four interests: recreation, wildlife habitat, upland development, or important cultural resources. If a certain area has substantial erosion, but no public or private interests are threatened, the area is considered a "noncritical erosion area" and close monitoring is required. Approximately 41.7 miles of coastline in the study area are listed as "critical erosion" and 13.4 miles are "noncritical," making up almost half of the beaches/coastline in the study area.[18]

According to the Volusia County comprehensive plan, most of the county coastline accreted over that past 115 years, although erosion was experienced in the 1970s. This erosion then slowed in the 1980s.[19] More than 16 miles of beach in Volusia County, however, are classified as critical. The erosion threatens the area's tourism, development, and recreational interests. Although the entire county is not experiencing major erosion issues, more than an 8 mile stretch of beach between Ormond Beach, Daytona Beach, and Daytona Beach Shores is critically eroded. Although Bethune Beach is armored by a rock revetment and New Smyrna Beach is to receive sand from Ponce Inlet, just under 8.5 miles of the beaches are critically eroding in these areas. North of Ponce de Leon Inlet is a small stretch of beach, less than 1 mile long, that is critically eroding and threatening the State Park's recreational well-being. Finally, a 1 mile stretch of the Canaveral National Seashore is listed as noncritical erosion.[18]

Brevard County has 25 miles of critically eroding beaches, including a 24.6 mile stretch of beach southward from Canaveral Inlet. Because of Brevard County's beach restoration program, beaches in Canaveral, Indialantic, and Melbourne have been renourished, along with proposals for Melbourne Beach, Indialantic, and Cocoa Beach. These areas consist of high density development with major tourist recreation interests. In south Brevard, a 0.4 mile stretch of beach is critically eroding. Although two areas north of Cape Canaveral are considered noncritical, no monitoring is taking place.[18]

With almost half of the beaches in the study area considered critically eroding or eroding substantially, it is apparent that some action has taken place to protect the area from the destruction associated with erosion. It is extremely important to protect the beaches in these counties because of the dependence of the local economy on the beach tourist industry. Although the steps taken by the jurisdictions to protect the beaches, development, and infrastructure are for erosion purposes, these actions can be used to prepare and protect the coast from expected sea level rise as well.

Using data from a NOAA study in 1980 and 2004 Volusia County data and analyzing them in ArcView, more than 5,000 parcels in the study area are protected through armoring. By 2003, Volusia County increased their armoring from under 1,800 parcels to almost 2,500 parcels. (Current data for Brevard County are unavailable.) As seen in Figure 8, beach armoring through seawalls is common in northern Volusia County.

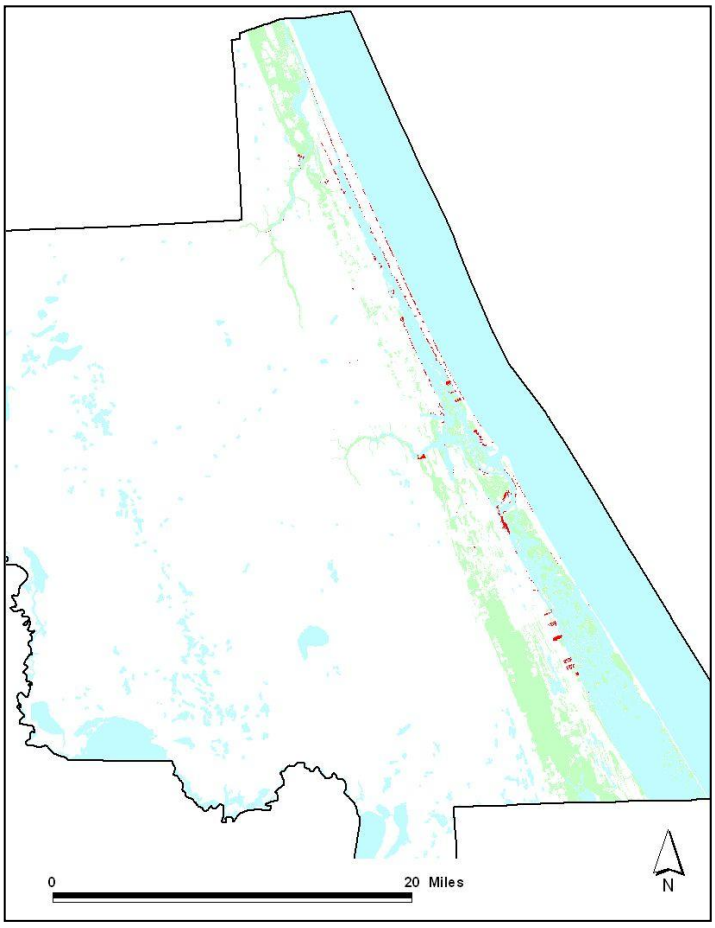


Figure 8: Seawalls along the Volusia County Coastline, represented in red.

Volusia County does not have an active beach nourishment program. A beach erosion feasibility study completed in December 2003, however, examiined the need for renourishment of the southern beaches. The report analyzed the main causes of erosion in the area, including storms, currents, and sea level rise. Brevard County has been actively renourishing the coastline for years. More than 500 parcels in Brevard County front renourished beach, comprising almost 12 miles of renourished beach, and a half-mile of natural accretion due to Cape Canaveral. Figure 9 illustrates the areas of Brevard County with beach renourishment.

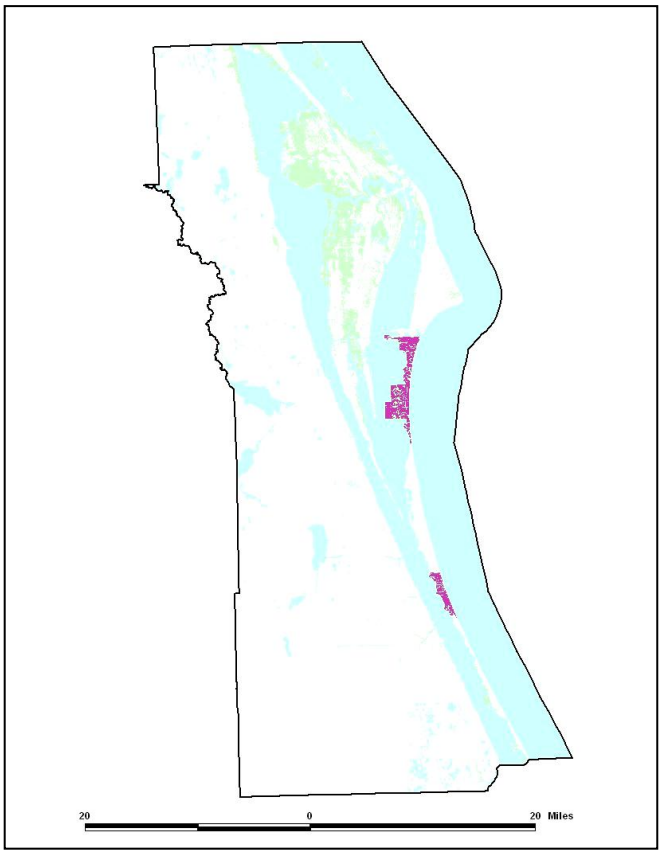


Figure 9: Areas of Brevard County with Beach Renourishment

SEA LEVEL RISE POLICIES

Although policies for sea level rise are not explicit on the local level or even the state level, current policies for coastal management can be used for protection against sea level rise. Land use, development, and economic growth may also influence how the certain areas would respond to sea level rise.

Federal Policies

Policies in the federal government concerning the protection of the shore from erosion, inundation, and sea level rise, whether directly or indirectly stated, influence the protection scenario of the coastline from sea level rise. Federally owned undeveloped coastal land most likely would not be protected from sea level rise, even without a direct policy. Conservation agencies generally follow the National Park Service policy of allowing nature to take its course, thus allowing the shoreline to naturally erode, wetlands to migrate, or land to become inundated. National Wildlife Refuges generally allow wetland migration.[36] Because the northern barrier island of Brevard County, the Cape, is federally owned, shore protection is unlikely for much of this barrier. With the Kennedy Space Center in the area, however, the protection of areas in the Cape is more likely.

Although the federal government does not directly regulate privately owned dry lands, it does require landowners to obtain permits to fill wetlands under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Although bulkheads and stone revetments are allowed, they are considered fill when constructed in areas flooded by the tides and hence require a permit.[8] As sea level rises and the shore erodes, even if the armoring is built inland of mean high water, eventually they will sit within the tides and a permit will be required for repair or replacement.[36]

The Clean Water Act and federal estuary programs are motivators for local governments to create setbacks for septic tanks and runoff. These setbacks will allow for retreat of a period of time while sea level rises. With continued erosion and sea level rise, however, the setback buffer eventually will be eliminated.[36]

The Coastal Barrier Resources Act (CoBRA), administered through the U.S. Fish and Wildlife Service, was enacted during the Reagan Administration by a coalition of environmental organizations and fiscal conservatives. The environmental objectives were to protect ecologically sensitive land, geologically vulnerable land, and the aesthetic and recreational values of barrier islands. The fiscal objective was to stop federal subsidies of coastal development. The law prohibits the expenditure of federal money on new structures in these CoBRA areas. (Federal funding can be used for repair of bridges, utilities, or structures built before October 1983 and for removal of debris after a disaster.[20]) The statute also precludes federal flood insurance, beach nourishment, and federally backed mortgages. Although CoBRA does not prohibit development, the law tends to discourage development in these areas.[36]

[8]Although state ownership of tidelands extends up to the mean high water mark, federal jurisdiction includes all "waters of the United States." Although the precise meaning of US waters must occasionally be litigated in the courts (especially with respect to inland wetlands that are only connected to navigable waters), there is no doubt that it includes all tidal wetlands as well as nontidal wetlands immediately adjacent to tidal wetlands.

East Central Florida includes nine CoBRA areas: five in Canaveral and one each in Ponce Inlet, Ormond by the Sea, Spessard Holland Park, and Coconut Point. In this region, the CoBRA areas generally are undeveloped, except for the southern CoBRA areas of Brevard County. The majority of the CoBRA areas are in the Cape Canaveral National Seashore, which is primarily wetlands. As a result, the area is likely to be left to allow wetland migration. In the northern area of the region, the CoBRA areas are mostly wetlands or sparsely developed dry land. Some areas have no bridge access or are undeveloped islands in the middle of wetlands. Beach nourishment and other forms of shore protection may not be cost-effective in these areas.

In the southern portion of the region, however, the CoBRA areas are more developed, because of island access and lack of wetlands in the immediate area. Although federal funding for beach nourishment, flood insurance, and other programs is unavailable in this area, the level of development in the area appears to be great enough for property owners to protect their land through other funds. For example, property owners might vote to create a special taxing district to fund beach nourishment. Another possibility would be to petition for the reversal of the CoBRA designation. In short, in the region of Volusia and Brevard counties, land with CoBRA designations mostly likely would be left to retreat naturally as sea level rises, with the possible exception of southern Brevard County.

Subsidies for stabilizing harbor entrances through jetties and beach nourishment for highly developed shores have been provided by the federal government. Although many areas of the shoreline are armored with seawalls, a major storm may destroy the wall and result in beach erosion of 50–100 feet.[36] The federal subsidy for beach nourishment enables the shore to be protected, which in this beach tourist region is critical. Brevard County, the southern portion of the region, has continued beach renourishment for many years. Some federal policies, such as the federal flood insurance, indirectly encourage and allow dense development in the coastal area because of the lower risk of coastal construction. As a result of flood regulations, improvements have been made that allow homes to withstand greater damage and remain standing although the beach has eroded. The federal government wetland program allows for wetland armoring, which is addressed in the section on state policies.[36]

The Coastal Zone Management Act specifically addresses sea level rise and the need for the study and development of plans for addressing land subsidence and sea level rise. The act states that coastal states must anticipate and plan for sea level rise to prevent or reduce the threats to property and life along the coast (and other hazard areas). Although specific policies and procedures are not discussed, the CZMA declares that coastal development must be managed to minimize the loss of property and life due to sea level rise, salt water intrusion, and the destruction of natural protective features.[21]

State Policies

Florida has no specific policy on sea level rise. However, as on the federal level, coastal management policies address consequences of sea level rise (e.g., coastal erosion, flooding, and wetland loss) as well as factors that will tend to help determine how the state ultimately responds to sea level rises (e.g., beach nourishment, seawall construction, conservation lands, coastal development).

In 1965, the Department of Environmental Protection began the coastal construction regulatory program. In 1970, a setback from the mean high water line was established at 50 feet. In 1978, however, when the setback line was renamed coastal construction control line (CCCL), it was stated that the CCCL should be representative of the 100 year storm surge. Any structure seaward of the CCCL should be able to withstand the wind and waves of the 100 year storm, and 110 mph winds.[22]

The purpose of the CCCL is to protect the beach and dune system and therefore allow for public access to the beaches, decrease erosion attributed to development, and protect upland structures. Within the CCCL zone, a 30 year erosion setback exists, which is determined on a site by site basis by evaluating historical measurements by Department of Environmental Protection. This erosion setback does not, however, factor in sea level rise. Permits for major structures seaward of the erosion setback are prohibited except for piers, coastal or shore protection structures, and single family dwellings meeting specific requirements.[22]

The National Flood Insurance Program, established in 1968, encouraged local governments to adopt regulations to decrease the costs associated with flooding. If the local government adopted such regulations, homeowners in the jurisdiction would be able to collect money from the program. If the city did not adopt such regulations, however, homeowners would be ineligible for the funding. This would include federally insured lenders.[22]

The Coastal Protection Act, which encompasses land from the seasonal high water line to 1500 feet landward of the CCCL, was enacted in 1985 by the Florida State Legislature. For barrier islands, however, the coastal building zone is the land from the seasonal high water line to 5,000 feet landward of the established CCCL or the entire island, whichever is less. Its aim is to protect private property and the natural environment from damage through construction standards. The elevation and foundation requirements are based on NFIP regulations, and the standard wind code applies. CCCL construction standards are stricter than those regulated by the local governments in the Coastal Building Zone.[22]

Seeing the need to protect and restore the beaches throughout Florida, the Florida Legislature adopted a comprehensive beach management program. Implementing beach management planning is essentially performed through the Beach Erosion Control Program. The program works with local, state, and federal entities to preserve and restore beaches. To receive funding, the activities slated for the beach must include restoration and nourishment activities, environmental studies and monitoring, dune restoration and protection activities, inlet sand transfer, inlet management planning, project design and engineering studies, and other activities designed to protect the beach from erosion.[22] Although this program is associated with erosion, the activities funded through the program are important planning solutions to sea level rise and its associated erosion.

A Strategic Beach Management Plan has been developed for the Cape Canaveral and Indian River Coast areas as well as the coast of Volusia County. The Brevard County Shore Protection Project, a federal project authorized in 1968, restored the shoreline south from Port Canaveral Inlet to Indialantic-Melbourne beach. In 1996, the project was reauthorized with nourishment of the beach from South Jetty to Patrick Air Force Base, and north of Indialantic to Spessard Holland Park. The Indian River County Shore Protection Project was authorized in 1986 for Sebastian Inlet Park and the city of Vero Beach. In

Volusia County, Ponce de Leon Inlet is dredged every three years, with the shoreline north of the inlet receiving the dredged sand. There are no beach nourishment programs currently in place in Volusia County, however, although feasibility studies are being conducted.[23]

Florida is aware of the importance of its beaches and the protection of private structures and infrastructure, as well as the extensive beach erosion problem along the beaches. Therefore, no one can install rigid shoreline armoring without first obtaining a permit from the Department of Environmental Protection. If DEP determines that these structures are unnecessary or will impede beach restoration projects, DEP may require removal even of structures that had been previously permitted.

Along estuarine shores, Florida statutes discourage the construction of vertical sea walls, which may threaten wetlands. The State prefers that property owners and local governments employ riprap or other and gently sloping artificial shorelines, with wetland vegetation. To obtain a permit for a new vertical wall in wetlands, one of the following conditions must be present: the construction would be located in a port, the construction is necessary to build a marina or public facilities, the construction is in a canal which is currently occupied by vertical seawalls, or the construction is by a public utility serving the public.[24]

Florida has programs to help acquire land for conservation purposes. Coastal land may be acquired if it is necessary to protect, manage, conserve, or restore important ecosystems to enhance or protect coastal, recreational, fish, or wildlife resources. Florida has enacted the Florida Preservation Act 2000, Florida Forever Act, Florida Forever Act Trust Fund, Conservation and Recreation Lands Trust Fund, and the Florida Communities Trust program to promote and enable acquisition of public land. Through the Department of Environmental Protection, a certain amount of funds is used expressly for the acquisition of coastal lands.[22] Acquiring public land now along the coast will help to create a setback or a buffer for the developed areas as sea level rises. This will allow the shoreline to naturally erode without endangering development.

Local Policies

Currently, no specific sea level rise policies exist on the local level. The Volusia County comprehensive plan in section 11.4.1.21 states, "Volusia County should continue to monitor sea level rise science to determine when and if a sea level rise event will affect the County. Based on pertinent data, the county will act accordingly."[19] The Brevard County comprehensive plan Policy 4.9 states, "Brevard County shall continue to collect and make available to the public, information related to sea level rise changes."[25] Current policies dealing with erosion, development, shore protection, and flood hazard mitigation together, however, form an implicit response to sea level rise.

As evident from county and city comprehensive plans, local entities have the common goal to reduce the impact of damage from a storm on property, life, public facilities, and natural resources. This goal is achieved by discouraging new development in coastal high hazard areas through limiting new public expenditures in those areas, limiting housing densities, and not financing new local transportation

corridors unless there is no other cost-feasible alternative.[9] Also, as the coastline changes, Brevard County will reevaluate the Brevard Coastal Setback Line and the Brevard Coastal Construction Line.[19,25] In unprotected areas, adjusting the setback will aid in the reduction of property and infrastructure loss as sea level rises.

According to local comprehensive plans, seawall construction on the local level must be consistent with the standards set by the state. In Volusia County, new vertical seawalls may be built only where there is serious threat to health, safety, principal buildings, or public infrastructure. A dune system with vegetation must be established over the sea wall to prevent the wall from being exposed. However, Volusia County prefers to use sloping stabilization with vegetation in lieu of vertical seawalls. Development adjacent to estuarine and riverine shorelines must maintain a buffer zone to conserve the vegetation and wetlands. Volusia County takes priority in preserving coastal and riverine wetlands. Therefore, activities around wetlands should enhance them and natural buffer zones or setbacks should be incorporated landward of all protected wetlands.[19]

In Volusia County, the CCCL line varies depending on protection already in place. For open ocean coasts without seawalls, the CCCL is located behind the landward base of the foredune ridge. The ridge should be allowed to expand landward by having a buffer between the ridge and building construction.[19]

Brevard County prohibits new shoreline hardening structures along the Atlantic Ocean north of Patrick Air Force Base. South of the base, no new hardening structures are allowed along the Atlantic Ocean unless they are for emergency provisions as noted in Florida Statues Chapter 163.3187 (1) (a). If no other alternative is feasible, the County will allow vertical wood, rock, or concrete walls that may also require dune restoration or revegetation. If more than 50 percent of a seawall is in need of repair, it is considered new construction; therefore, a permit is needed. In areas of wetlands, natural buffer aones or setbacks are required landward of all protected wetlands. Hardening of an estuarine shoreline in Brevard County is only allowed when a serious threat is posed to life and property. Like Volusia County, vegetation and other stabilization methods are encouraged. To help ensure no net loss of wetlands, Brevard County requires a 15 foot natural buffer around isolated wetlands and a 50 foot natural buffer around all others.[25]

Oceanfront development in Brevard County must maintain 50 percent of its native dune vegetation and no vegetation can be removed seaward of the CCCL. The county also requires a 200 foot shoreline protection buffer from the ordinary or mean high waterline. Only passive uses may be used seaward of the buffer.[25]

In Volusia County, the Environmental Management Services Group supports and sponsors shoreline habitat reclamation. Activities include dune restoration, shoreline stabilization, and regulation of urban shoreline redevelopment.[19] Also, beach nourishment efforts in the southern region of the study area (Brevard County) are extensive.

[9]Coastal High Hazard Areas include all areas that would be inundated with storm surge from a Category 1 Hurricane. It is part of Hurricane Vulnerability Zone, which is the portion of the unincorporated county that is evacuated during a Category 3 hurricane (111–130 mph wind and storm surge of 9–12 feet).

Both Volusia and Brevard encourage the acquisition of public land for conservation and enhancement of coastal resources. Efforts such as these may be used to protect the shoreline from sea level rise. Each county has programs to help conserve important land in the county. The Friends of the Scrub is an organization found in Brevard County aimed at protecting the scrub jay habitat.[27] Brevard County's Environmentally Endangered Lands Program (EEL) has acquired 18,000 acres of endangered land mostly through assistance from the state and the Saint Johns River Water Management District.[28] Both Volusia County and Brevard County share the Regional Land Trust for the Indian River Lagoon to create conservation easements.

In 1987, the Volusia County Land Acquisition Program came into effect to acquire land that meets resource conservation goals and objectives. Approximately 2,320 acres of recreation and environmentally endangered lands have been purchased in the coastal area through the program. An additional 47,000 acres of coastal zone land are federally, state, and county owned resource and park lands. These lands are undevelopeable.[19] Volusia County property owners can also donate or sell land to the Volusia County Land Trust and the Volusia County Greenways and Parks Program/Land Acquisition and Management. The Greenways and Parks Program works to protect open spaces that are managed for conservation or recreation purposes by creating corridors to link major parks and communities. In 2000, Volusia Forever was created. It is anticipated that over the life to the program, $100 million will be raised to finance the acquisition, improvement, and management of environmentally sensitive lands, water resources, and recreational lands.[27]

By continuing land acquisition on the local, county, state, and federal level, a buffer can be created along areas of the coast, also allowing land for wetland migration or development movement.

Private

Development in the study area includes single family, multifamily which includes apartments, town homes, and condos, and a number of resorts, hotels, and motels. Some cities such as Indian Harbour Beach have a high concentration of luxury homes, while other cities are geared toward the tourism industry, such as Daytona Beach. Daytona Beach Shores is the fastest growing city in Volusia County and consists of a 5.5 mile stretch of high rise condominiums, hotels, motels, townhouses, and single family dwelling.[26, 35] In the study area, various types of housing are protected by seawalls and beach renourishment: single family and multifamily housing as well as commercial due to the resorts and dependence of the study area on its beaches and tourists.

The development trend in the study area is that of buildout in all upland areas, except that which is owned by the federal government. This is evident in that the study area consists of more than 31,000 acres of undeveloped uplands. The majority of this undeveloped upland is situated in wetland areas, between wetlands and development, or scattered in other developed areas. There currently exist little or no large tracts to use for retreat purposes in the study areas, especially on the barrier island. In the southern portion of the study area, where development is less intense, there exists more undeveloped land. This part of the barrier island, however, is very narrow and has wetlands bordering areas. Therefore, because of lack of open space for development, the continued use of beach restoration and seawalls will be of great importance in protecting this part of the study area from sea level rise.

Private land owners have several options for conserving their land. Programs on the federal, state, and local levels as well as private organizations allow private land owners to donate, sell, or create conservation easements with some associated financial and tax benefits . Private land owners may opt to create a conservation easement on their property. This easement is a legal agreement that limits the amount of development on the property. The agreement between the government, land trust, or other agency and the property owner protects the conservation or agricultural interests. Benefits to the private land owner include not only ensuring that the land is managed to their intent, but they may receive income tax savings through a charitable tax deduction, decrease in real property taxes due to the reduced market value of the land by creating the conservation easement, no federal gift and estate taxes, and the exclusion of the easement property from the federal estate tax.[27]

Property owners also have the option to donate land or a portion of their land to a land trust, public agency, or nonprofit organization. As with creating an easement, the ecological or agricultural values of the land will be maintained. Also, the owner may experience a decrease in income tax and federal estate taxes. A third option is for a Bargain Sale or Charitable Sale of the land. In this option, a portion of the value of the land is sold while a portion is donated. This will result in charitable income tax deductions as well as savings on capital gains taxes.[27]

Land donations, easements, and sales can be made to a number of public and private organizations. On the national level, the Natural Resources Conservation Service administers the Farmland Protection Program and the Wetlands Reserve Program. The USFWS Partners for Fish and Wildlife program works to restore wildlife habitat on private land. The Nature Conservancy has a number of programs for the public land owner such as the Immediate Land Donation Program and the Charitable Remainder Unitrust Program. Other national organizations include the Sustainable Forests Alliance, The Conservation Fund, the Land Trust Alliance, The Trust for Public Land, the Wildlife Land Trust, The Farmland Stewardship Program, and the Stewardship America.[27]

On the state level, Florida offers the Florida Forever Program, which replaced the Preservation 2000 Program. This program works toward the restoration of damaged environmental systems, increased public access, increased protection through conservation easements, and public lands management. The Florida Division of Forestry oversees the Rural and Family Lands Act, conserving agricultural land. Finally, the Conservation Trust for Florida helps protect vital rural land.[27]

By acquiring easements or land along the coast, a natural buffer can be created to protect development from the effects of sea level rise as well as avoid development in critical hazard areas.

SEA LEVEL RISE PROTECTION SCENARIO MAP METHODS

The current trends and policies provide a basis for developing maps depicting the region's likely responses to sea level rise. Those responses will depend on the development in the area, current and future policies, and the state of shore protection along the coastline. Land uses may change; therefore, we must analyze the future land use as well as the current densities in the study area. The majority of dry land within the study area has been developed and portions of the barrier island have high density. In East Central Florida, as with other coastal areas in this state, planners are unable to foresee circumstances that would lead residential areas near the coast to revert to agriculture or forest. Therefore, this area may not see dramatic changes in densities or development of areas of currently open space. Nevertheless, the likelihood of future shore protection depends on the status of the land when it becomes threatened by erosion or inundation, so preparing maps that depict future shore protection must consider both future land use plans and existing land use.

Study Area

As with all the sea level rise planning studies in Florida, this study considers all land below the 10-foot (NGVD) contour.[10] The selection of this study area does not imply that we are predicting—or even analyzing the consequences of—a 10-foot rise in sea level. Because tidal influence can extend almost to the 5-foot contour, the 10-foot contour is approximately the highest elevation that might be inundated by tides were sea level to rise 5 feet over the next few hundred years—but that is not the primary reason we used the 10-foot contour to delineate the study area. In addition, current Category 3 Hurricane storm surge reaches at least 9 feet. Even with a 5 foot rise in sea level, a storm surge will reach beyond the current 10-foot contour to the 15-foot contour. Therefore, the 10-foot contour study area does not include all areas that would be effected by major hurricane as seen in 2004.

During the original design of this study, EPA and SWFRPC sought to identify a study area that could be implemented throughout Florida and that would include all land that might be significantly affected by sea level rise during the next century. If possible, they also sought to include land that might be affected over a longer period of time, but that goal had to be balanced against the extra cost of studying a larger study area. All things being equal, it is better to make the study area over-inclusive rather than under-inclusive: If someone later needs a map depicting only land below the 8-foot contour, then it would be very easy to subdivide our data and only show shore protection for land below the 8-foot contour. By contrast, if someone needs a map that includes some areas inland of our original study area, they will have to repeat our study for these higher areas.

The quality of topographic information varies throughout Florida. Some counties have LIDAR, and some water management districts have 2-foot contours. Nevertheless, the best topographic maps for

[10] 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

some portions of Florida have 5-foot contour intervals. Therefore, the only realistic choices for a statewide study area were the 5-, 10-, 15- and 20-foot contours.

Considering the criteria, EPA and SWFRPC decided that a 10-foot contour would probably be the most appropriate study area for Florida. Although the land below 5 feet is the most vulnerable, limiting the study area to such low land would exclude many areas that are potentially vulnerable to sea level rise during the next century. Statewide, most of the land between 5 and 10 feet is already below the base flood elevation for a 100-year storm, and hence will experience greater flooding as sea level rises. In East Central Florida, land with a 5 foot elevation is generally within the coastal high hazard zone; thus a 5 foot rise in sea level would bring all land below the 10-foot contour within the coastal high hazard zone. Finally, topographic contours are only estimates. Under the National Mapping Standards, up to 10 percent of the land can be higher or lower than the map indicates, by more than one-quarter of the contour interval. Thus a substantial amount of land depicted as between 5 and 10 feet may in reality be between 3 and 4 feet; using the 10-foot contour to delineate the study area helps to ensure that this very low land is considered.

The study area also includes all land within 1,000 feet of the shore, even if it is above the 10-foot contour. Rising sea level and other coastal processes can cause beaches, dunes, bluffs, and other land to erode even though it may have sufficient elevation to avoid direct inundation by rising water levels. The 1,000-foot extension is somewhat arbitrary; we chose that distance primarily to be consistent with similar studies in other states.[11] Extending the study area 1,000 feet inland also ensures that the study area is large enough to be seen along the entire shore on the county-scale maps produced by this study.

Data Collection and Compilation

Future land use shapefiles or hard copy maps were obtained by contacting each jurisdiction and county in the study area.[12] The Existing Land Use and Five Foot Topography Polygon shapefiles were downloaded from the St. Johns River Water Management District Website.

Topographic

Five foot interval topographic polygons were downloaded from the St. Johns River Water Management District website. The file was digitized from USGS 24k scale maps. Each quadrant of Volusia and Brevard County was downloaded and then merged into one shapefile for each county. A field named "Elevation" was added to the attribute table and elevations were categorized as "0–5 ft," 5–10 ft," and "Above 10 ft."[13]

[11]Maryland's land-use rules to protect Chesapeake and other coastal bays apply to land within 1000 feet of the shore.
[12]The jurisdictions in the study area include Brevard County, Cape Canaveral, Cocoa, Cocoa Beach, Indialantic, Indian Harbour Beach, Malabar, Melbourne, Melbourne Beach, Palm Bay, Palm Shores, Rockledge, Satellite Beach, and Titusville. Also, Volusia County, Daytona Beach, Daytona Beach Shores, Edgewater, Holly Hill, New Smyrna Beach, Oak Hill, Ormond Beach, Ponce Inlet, Port Orange, and South Daytona.
[13]We are uncertain whether these data are just their rendering of the well-known USGS 1:24,000 scale maps, measured relative to NGVD29.

Existing Land Use

Using the Florida Land Use Cover Classification Code System (FLUCCS), all land uses were classified as water, wetlands, and uplands. Changes applied to the shapefile were as follows: "canals and locks," "slough waters," and "embayments not opening" were classified as water; "beaches other than swimming beaches" were classified as uplands. The Existing Land Use Map was unioned with the topographic data to determine the study area of the 10 foot elevation and below.[14]

Future Land Use

Shapefile maps sent from the jurisdictions were reviewed for inconsistencies, corrections, and missing areas. Areas marked as "Unknown" on city FLU shape files were compared to the county FLU files and were categorized accordingly. If no FLU category existed, if possible, the unknown areas were classified as the surrounding land uses indicated or as noted by the city planner. Maps of cities currently not using GIS were digitized using Arc View GIS. By incorporating aerial photographs from Florida Geographic Data Library, street shape files, and city municipality files, city FLU maps were digitized and compared for accuracy. Areas within the cities maintaining the county FLU classifications were checked against county FLU maps and the correct classifications were recorded. Future land use categories were also reclassified into the categories in Table 5. The original and reclassified maps were sent to each city for review and to ensure the maps and reclassifications were consistent with the cities' Future Land Use Categories. After collaborating with individual cities, the maps were revised if necessary. All changes suggested by the jurisdictions were made to the shape file.

Table 5: Categories of Future Land Use Used in Project

Estate (1 un/4.9 ac – 1 un/ 0.9ac)[15]	Industrial
Single Family Residential (1 un/ 1 ac – 5.9 un/ac)	Mining
Multi Family Residential (>= 6 un/ac)	Military
Agriculture	Wetlands
Preserve	Water
Commercial	

When the shape files were merged using ArcView 3.2, many of the boundaries were inconsistent and overlapping. This was possibly due to the various original projections used by the different cities, as well as the base maps used to create the files. Therefore, a new Future Land Use file was created for the study area using the existing land use file and city boundaries. A new field called "Future Land Use" was added to the Existing Land Use shape file and the "Uplands" were populated according to the data received from each jurisdiction. Wetlands were classified according to the existing land use codes assuming current wetlands will remain intact. Because we used the SJRWMD Existing Land Use as the

[14]As discussed later in the text, our final maps also include all land within 1,000 feet of the shore, to account for possible shore erosion and to ensure that in areas where the ground near the water is relatively high, the study area is still large enough to sow up on county-scale maps.

[15]The residential land use criteria were taken from the SWFRPC Sea Level Rise Project to maintain consistency.

base map, however, some issues were encountered when classifying beaches because most jurisdictions do not classify beaches on their future land use. Therefore, any known beach or undeveloped upland without a future land use classification from the previous maps were given the classification "Preserve." By doing this, we can easily recognize and change any areas that are in fact beaches or undeveloped land but not conservation. Changes to these areas were made during the protection classification step. Therefore, in the shape file itself, some coastal areas with the attribute "Preserve" may not actually be conservation areas.

Critical Facilities

Critical facility lists, which include municipal, county, federal, and private facilities, were obtained from Volusia and Brevard counties. Volusia County critical facilities were determined using the county guidelines that any facility labeled with a 2 or 3 on the facility assessment list is considered a critical facility. Facilities without a number but within the surge zone were added to the critical facility list. According to Volusia County, a critical facility is "any facility that cannot go more than 24 hours without operational capability."[29] Addresses for each critical facility in Volusia County were researched through the reports provided by Volusia County, from internet resources, and by contacting individual cities or departments. A shape-file was created and addresses were geocoded using ArcView 3.2. Facilities with no street address were mapped by the closest cross streets or were given middle address numbers for the appropriate street. The Brevard County critical facility list was provided by the Emergency Management Division in an Access database. Therefore, the database was brought into ArcView 3.2 and the points were mapped according to the GPS coordinates provided in the database.

Critical facilities outside the study area were deleted from the file. Other facilities not included due to type included any facility deemed not necessary such as nongovernmental facilities, churches, businesses, nursing homes, etc.[16] The remaining critical facilities were included on the map as a point of interest for the jurisdictions, to indicate the number and types of critical facilities that would be affected by sea level rise. Critical facilities were represented by black points. Critical facilities included in this study are as follows:

NASA
Water Treatment Plant
Police Department
Fire Department
School
Air Force Base
Water towers
Sewer Pump Stations
Stormwater Pumping Station
Evac
Emergency Operations Centers
Wastewater Treatment Plant
Utility Plant
Hospital
Lift Stations
Central Services
Wells
Armory
Industrial Park

[16] Performed per methods sent by SWFRPC. A list of other critical facilities in the study area not included on the map is found in the Appendices

Protection Scenario Classifications

General Classifications

Our primary objective was to divide land within the study area into one of four categories: protection almost certain (brown), protection likely (red), protection unlikely (blue), and no protection (light green). Current trends, policies, and development are the most important factors used to determine protection scenario classifications. Table 6 illustrates the initial general scenarios classifications for the various land uses that all of the Florida studies are following. By using Future and Existing Land Use densities and categories, the majority of the study area was initially classified as directed in the state-wide classification Table 6. All polygons labeled "water" and "wetlands" based on the existing land use field were selected and copied to the new "Scenario" field. All "Uplands" polygons were then classified initially according to Table 6. To aid in initial classification, various shape files were used. A CoBRA shape file was downloaded from the Florida Geographic Data Library and a shape file available on the ECFRPC's network was used for District Owned Land, land currently or potentially public owned. The Volusia County GIS department provided the planning council with a sea wall shape file and Brevard County was the source for a beach renourishment shape file. As the study progressed on site by site basis, however, some areas were changed because of surrounding areas or other considerations.

Our maps generally followed those categories because they are appropriate for East Central Florida.[31] There is relatively little doubt that developed areas will be protected, with the possible exception of low-density areas without water and sewer, and CoBRA areas along the Atlantic Ocean, where the absence of federal subsidies might conceivably make sure protection unlikely if beach nourishment costs escalate in the future. Aside from those exceptions, the demand for a home near the coast is so great that property values can easily justify shore protection costs. Even though we recognize that tastes can change, we have been unable to identify any plausible reason to expect an inland migration of coastal residents comparable to the coastal migration that took place during the last 50 years. At the other extreme, there is relatively little doubt that within conservation areas, dry lands will gradually be flooded by as sea level rises, with the possible exception of those adjacent to key federal installations such as the Kennedy Space Center.

Undeveloped areas where growth is expected will almost certainly be protected if they are developed, but until they become development, it is still possible for conservation organizations to make arrangements that would allow wetlands to migrate inland in some of these areas. Therefore, most undeveloped lands where development is expected is likely to be protected. In some areas, even undeveloped areas are almost certain to be protected because the development is imminent or the land is already surrounded by developed areas that are certain to be protected.

Outside of the public lands, only about 2 percent of the coastal lowlands in our area are unlikely to become developed. Those lands include remote areas where development is impractical, and some privately owned agricultural and forest preservation areas. Shore protection is unlikely in these areas, either because shore protection costs are likely to be greater than the value of the land lost from allowing the shore to retreat or—in the case of lands with conservation easements—because allowing natural

processes to proceed is more consistent with the conservation ethic. Nevertheless, no policies would prevent owners from protecting their lands, so protection unlikely is a reasonable designation.

The approach does not always have a perfect one-to-one correspondence with the available data. For example, some land use categories (e.g., parks) could be certain, likely, or unlikely to be protected, depending on the fates of surrounding lands and specific purposes to which property is put. Moreover, although the Florida land use categories are all mutually exclusive, we also considered other data. Since some areas did not fall into one category, other determining factors may have been used to classify the area, including site specific review.

Table 6.

STATEWIDE APPROACH FOR IDENTIFYING LIKELIHOOD OF LAND USE PROTECTION[1]

Likelihood of Protection[2]	Land-Use Category	Source Used to Identify Land Area
Protection Almost Certain (brown)	Existing developed land (FLUCCS Level 1-100 Urban and Built-up) within extensively developed areas and/or designated growth areas.	Developed lands identified from water management districts (WMDs) existing Florida Land Use, Cover and Forms Classification System (FLUCCS) as defined by Florida Department of Transportation Handbook (January 1999); growth areas identified from planner input and local comprehensive plans.
	Future development within extensively developed areas and/or designated growth areas (residential/office/commercial/industrial).	Generalized Future Land Use Maps from local comprehensive plans, local planner input, and WMD.
	Extensively-used parks operated for purposes other than conservation and have current protection [3] or are surrounded by brown colored land uses.	County-owned, state-owned, and federally owned lands (based on local knowledge) or lands defined as 180 Recreational on the Level 1 FLUCCS, local planner input and Florida Marine Research Info System (FMRIS) for current protection measures.
Protection Likely (red)	Existing development within less densely developed areas, outside of growth areas, mobile home development not anticipated to gentrify, not on central water and sewer, and within a coastal high hazard area.[4]	Developed lands identified from WMD existing FLUCCS; growth areas identified from local planner input, local comprehensive plans and current regional hurricane evacuation studies.
	Projected future development outside of growth areas could be estate land use on Future Land Use Map.	Local planner input
	Moderately-used parks operated for purposes other than conservation and have no current protection or are surrounded by red land uses.	County-owned, state-owned, and federally owned lands (based on local knowledge) or lands defined as 180 Recreational on the Level 1 FLUCCS, local planner input, and FMRIS.
	Coastal areas that are extensively developed but are ineligible for beach nourishment funding due to CoBRA (or possibly private beaches unless case can be made that they will convert to public)	Flood Insurance Rate Maps for CoBRA, local knowledge for beach nourishment.
	Undeveloped areas where most of the land will be developed, but a park or refuge is also planned, and the boundaries have not yet been defined so we are unable to designate which areas are brown and which are green; so red is a compromise between	Local planner input.
	Agricultural areas where development is not expected, but where there is a history of erecting shore protection structures to protect farmland.	Local planner input.
	Military Lands in areas where protection is not certain.	FLUCCS Level 173.
Protection Unlikely (blue)	Undeveloped privately owned that are in areas expected to remain sparsely developed (i.e., not in a designated growth area and not expected to be developed) and there is no history of erecting shore protection structures to protect farms and forests.	Undeveloped lands identified from WMD existing FLUCCS Level 1-160 mining, 200 Agriculture, 300 Rangeland, 400 Upland Forest, 700 barren land ; Nongrowth areas identified from planner input, local comprehensive plans, Flood Insurance Rate Maps for CoBRA and current regional hurricane evacuation studies.
	Unbridged barrier island and CoBRA areas or within a coastal high hazard area that are not likely to become developed enough to justify private beach nourishment.	Flood Insurance Rate Maps for CoBRA, local knowledge for beach nourishment and local planner input.

Table 6.

STATEWIDE APPROACH FOR IDENTIFYING LIKELIHOOD OF LAND USE PROTECTION[1]

Likelihood of Protection[2]	Land-Use Category	Source Used to Identify Land Area
	Minimally used parks operated partly for conservation, have no current protection or are surrounded by blue colored land uses, but for which we can articulate a reason for expecting that the shore might be protected.	County-owned, state-owned, and federally owned lands (based on local knowledge) or lands defined as preserve on Future Land Use Map, local planner input, and FMRIS.
	Undeveloped areas where most of the land will be part of a wildlife reserve, but where some of it will probably be developed; and the boundaries have not yet been defined so we are unable to designate which areas are brown and which are green; so blue is a compromise between red and green.	Local planner input
	Conservation easements (unless they preclude shore protection)	Local planner input.
No Protection (light green)	Private lands owned by conservation groups (when data available)	Private conservation lands.
	Conservation rasements that preclude shore protection	Local planner input.
	Wildlife Refuges, portions of parks operated for conservation by agencies with a policy preference for allowing natural processes (e.g., National Park Service)	Local planner input.
	Publicly owned natural lands or parks with little or no prospect for access for public use.	County-owned, state-owned, and federally owned lands (based on local knowledge) defined as preserve on the Future Land Use Map and local planner input.

Notes: [Christine, please change to letters]

1. These generalized land use categories describe typical decisions applied in the county studies. County-specific differences in these decisions and site-specific departures from this approach are discussed in the county-specific sections of this report.

2. Colored line file should be used in areas where less than 10 foot elevations exist within 1,000 feet of the rising sea or color cannot be seen on ledger paper map.

3. Current protection may include sea walls, rock revetments, beach renourishment, levees, spreader swales, or dikes.

4. Coastal High Hazard Area defined in Rule 9J-5 FAC as the Category 1 hurricane evacuation zone and/or storm surge zone.

Site Specific Classifications

After classifying land areas according to Table 6, changes were performed based on site by site analysis. Arial photographs were used to observe current density, and/or surrounding density if the land was currently undeveloped, and types of development (i.e., expensive housing, apartments, hotels, resorts, open space, recreation area with development, etc). Also taken into account were the future land use and location of property relative to wetlands. Let us examine these exceptions from the initial classifications in detail.

Environmental aspects as well as social and economic aspects must be considered when classifying sea level rise protection scenarios. Undeveloped land around wetlands could be used to allow wetland

migration and preserve habitat and functions. Therefore, large areas of currently open/undeveloped land behind wetlands or between wetlands were classified as protection likely based on the statewide approach, although the future land use category is developed. Current low density development areas near wetlands or water bodies planning for greater development were also classified as protection likely. By limiting the development in these areas to its current density, less money would need to be expended to protect the property and infrastructure, and the property owners may be able to relocate their homes. If development were to build out in these areas, the cost to the public or jurisdiction may be greater and there would be no room for wetland migration.

An example of such a situation is located on the middle barrier island in Brevard County, just past the military and government land and north of SR A1A. This section of upland includes sporadic high and low density development between large areas of undeveloped land. The uplands are within and surrounded by wetlands with a preserve to the east. Because of the current low development in the area as well as the surrounding wetlands and preserve, our maps classify most of this area as protection likely. Four areas have high-density development, and hence we classified them as protection almost certain." Therefore, our maps recognize that the undeveloped areas probably will be developed and protected, but that they might remain undeveloped to allow for a buffer to protect the developed portions of the island and to allow for wetland migration. The maps also recognize that residents of areas with light development could relocate to the existing highly developed areas. This could reduce the cost of protecting infrastructure such as roads and wells as well as create open space to act as a buffer for the more developed areas.

Our maps show the area just north of the NASA Causeway on the mainland in Brevard County as protection almost certain (brown) because the area is currently developed. The area south of the NASA Causeway is also developed and certain to be protected. Between these two areas is a large area of undeveloped property bordered by a large wetland and the causeway. If the future land use map and Table 6 together were used to classify this area, the area would be classified as protection likely because of the anticipated development. Nevertheless, it is realistic to assume that this area is also certain to be protected, because an inlet between the developed communities would not be desirable. Because a road already exists in this corridor, it would provide the best area for development. The entire area would be protected by raising the infrastructure or building seawalls. From an environmental perspective, however, it may be preferable if property owners in this undeveloped area traded rights of development for rights to develop within other undeveloped areas surrounded by development. This would allow the area to be used for wetland migration and environmental buffers. Regardless of whether the area is protection almost certain or protection likely, US 1 would need to be raised to either keep the connectivity of the two developed areas or the entire area would be raised because of evelopment (more would need to be done to protect the entire area than only raising US 1). Therefore, because of the current lack of development, it is currently classified as protection likely to acknowledge the opportunity for either development or wetland migration. If the area was classified as protection almost certain, one might conclude that we are saying that there would be no opportunity for the land to be used for wetland or habitat migration; the land would be protected as the surrounding developed land. By classifying this area as protection likely, the option is left open to use the land in an environmental capacity or to develop the land and protect it.

The blue lands within this area are agricultural lands classified according to Table 6. One might have expected that we would change them to red given the surrounding land classifications. Nevertheless, they border wetlands, will not be developed, and are likely to provide an opportunity for wetland and habitat migration or serve as a buffer if the surrounded area is indeed protected. We do not mean to suggest that an inlet will form. When these maps are produced at a small scale, one should see a narrow (e.g., 300 foot) area that probably will be protected to prevent an inlet from forming; but otherwise, wetland migration is likely.

Other small undeveloped lands surrounded by areas with a certain classifications were classified according to the surrounding scenarios. If protection is almost certain, it is not foreseeable that the open land would be left to give way to the ocean if the surrounding areas are to be protected. The land may also be protected to allow for future development for areas that may need to retreat.

Following EPA's national approach as well as the statewide approach, all military and NASA property in undeveloped areas were colored red. This designation is meant to convey our uncertainty rather than a specific expectation that shore protection is likely.[17] According to the "Supremacy Clause" of the U.S. Constitution, federal governmental land is exempt from local and state regulations. Also, because the area is in an undeveloped area, one cannot be certain as to how the government will address this issue and future land uses.[30] Most of this area is located on the Cape and situated in wetlands and preserve areas. In northern Brevard, however, a few sporadic military uplands were located within a CoBRA area. We decided not to follow the national and statewide approaches in these areas because they are small isolated areas outside the major military instillations. These "developments" areas would most likely be moved to other more densely developed areas. Therefore, we classified these areas as protection unlikely and colored them blue.[18]

As mentioned previously, some issues were encountered when classifying beach areas and undeveloped land along the beach in which jurisdictions did not include in future land use maps. Therefore, the easternmost sections (beaches and adjacent undeveloped land) of the barrier islands of both Brevard and Volusia counties were classified on a site by site basis.

Some beaches were classified as "Preserve" on the recommendation of jurisdictions during the course of the study. For example, in Brevard County, New Smyrna Beach identified a beach area classified as conservation, and thus classified as no protection, while the beach on the north side of this area is a recreational beach. Beaches experiencing beach renourishment, based on the shape file from Brevard

[17]EPA's project manager, Jim Titus, advised all contractors and grantees on this project that in his personal opinion, it is not appropriate for EPA to speculate on what the Department of Defense will choose to do with its coastal lands. He also points out that the Department of Defense is exempt from state and local regulations. EPA studies represent military bases as red to highlight the uncertainty, not to indicate that shore protection is likely. EPA hopes to eventually obtain an opinion from the Department of Defense regarding the most reasonable assumption for sea level rise studies, once all of the state-specific studies are complete. Nevertheless, the EPA studies classify military bases in urban areas as shore protection almost certain, because doing so does not require speculation regarding military intention—in such areas, even if the base were to close, it would require shore protection given its location in an area being protected in its entirety.

[18]The shapefiles we make available to SWFRPC and EPA designate military lands, so our departure from the general approach will not prevent others from modifying the maps if better information regarding DOD or NASA intentions becomes available.

County, were classified as protection almost certain. All land areas in Brevard County that are behind renourished beaches were classified as protection almost certain because of current protection already in place. Otherwise, beaches were given the same classification as the surrounding area, unless otherwise suggested by the local governments or are located in a CoBRA area, in which they were classified as no protection. For example, in Brevard County, a CoBRA area exists along the southern end of the barrier island. The beach in this area has been classified as no protection while the undeveloped uplands have been classified as protection unlikely, and the small areas of developed uplands are classified as protection likely.

Seawalls are an important form of protection for sea level rise, whether they are built to protect property from erosion or flooding. A shape-file of all current seawall armoring was obtained from Volusia County GIS Department. All property behind a seawall, including the adjacent beach, was classified as protection almost certain because of the existing protection. Current data for seawalls were unavailable for Brevard County. A shape-file downloaded from the NOAA website provided seawall data up to 1980. These data were used in the same capacity as the Volusia County file. Much of the property in the region, however, was already classified as protection almost certain because of beach renourishment or existing development.

Agricultural areas were classified according to Table 6. Review of the map, however, revealed that small agricultural areas exist in Brevard County and are surrounded by areas of reasonable or almost certain protection. In these cases, the farms will probably be rezoned for residential as development occurs around them. Therefore, these small plots, surrounded by current development or planned development, where the plan still contemplates agriculture, were classified according to the surrounding protection scenario. Areas such as these are found along the mainland of Brevard County and north of A1A in the middle barrier island.

Only Brevard County has a future land use of mining, and the area is inland and surrounded by undeveloped land, wetlands, and single family (low density) development. Therefore, the mining future land use was classified as protection likely, as is the surrounding area.

Local Stakeholder Review

Finally, local review of the maps was important in classifying land areas. Initially, during the first few months of 2004, we provided draft maps that focused exclusively on the role of elevation in the classification process. Volusia County and cities were sent draft maps to review in which areas below 5 feet were classified as protection unlikely and areas between 5 and 10 feet were classified as protection likely.[19] Each jurisdiction was asked to review and change the protection scenarios based on the

[19]These initial draft maps and guidelines were created and sent to Volusia County before we had fully considered the feasibility of shore protection and the infeasibility of a large-scale abandonment of the coast. The more in-depth classification guidelines and Table 6, later provided to the ECFRPC by SWFRPC and EPA, helped us and the localities realize that shore protection is feasible—and often already occurring—in low-lying developed areas.

protection scenario guidelines (see Table 6[20]). Responses from Volusia County and the cities did not result in significant changes. Volusia County stated the 200 year time frame exceeded their 20 year planning policy and therefore they had no suggested changes to the initial maps.[21] Daytona Beach Shores emailed a response of "no suggested changes" to the map. As the study progressed, however, the city was classified almost entirely as protection almost certain because of density and sea walls around the city. The City of New Smyrna Beach recommended the entire city to be classified as protection almost certain. Some discussion took place with Ormond Beach concerning the purpose and process of the study and the process of local review. No changes, however, were suggested by city staff. Finally, the City of Daytona Beach questioned the underlying assumptions of the study and had no comments to make about the map. After the local reviews, and with further discussion with the EPA and SWFRPC and follow-up analysis of the coastal areas using aerials and both the existing and future land use maps, the Volusia County map was modified based on the methodology previously described.

After the issues and lack of responses from Volusia County, we took a different approach with Brevard County. Rather than providing a map that considered only elevations and asking for comments and changes based on the general guidelines, we prepared a map based on those guidelines.[22] The maps were then sent to the appropriate jurisdictions. In Brevard County, the cities of Cocoa, Cocoa Beach, Palm Bay, Indian Harbour Beach, Cape Canaveral, Satellite Beach, Malabar, and Palm Shores responded with suggestions to the maps.

- *The City of Cocoa* suggested the marina be classified as protection almost certain because of residences and offices in the marina. Also, it was suggested that Lee Wenner and MacFarland parks be classified as protection almost certain because of the location, use of, and walls at the parks.
- *The City of Cocoa Beach* informed the ECFRPC that the parks are protected by beach renourishment and should be classified as protection almost certain.
- *Palm Bay* reviewed the maps and stated they had no additional comments or suggestions for the study area.
- *The City of Indian Harbour Beach* stated the entire city should be classified as protection almost certain. The northeast island of the city was originally classified as protection likely because of density; however, the city stated the area is newly developed and the most expensive housing in the city. The parks along the coast are hardened as well.
- *The City of Cape Canaveral's* planner suggested the entire city be classified as protection almost certain because of development patterns.
- *The City of Satellite Beach* pointed out a park that is used for conservation purposes as well as another park used as recreation. These areas are represented on the map as protection

[20]The current version of Table 6 was developed after this round of reviews, but the overall guidance was very similar. The key difference between Volusia and Brevard is that we asked Volusia to use guidance based on land use to revise maps that were based on elevations. We asked Brevard, by contrast, to review maps based on land use.

[21]The original draft report left many readers with the impression that the study is primarily focused on events 200 years hence, because of our explanation of the study area. We tried to revise the report so that it is more clear that shore protection may be required in the next few decades along most shores, and that the study is meant to inform planners about the long-term consequences of the decisions they make during the next comprehensive plan revision.

[22]We prepared the initial map for Brevard based on the more specific guidelines in Table 6. Instead of relying on the jurisdictions to make the classifications as with Volusia County, the ECFRPC classified the study area initially based on the above guidelines. These initial maps were then sent to the jurisdictions for more site by site review.

unlikely and protection likely, respectively. Otherwise, the city's protection scenario appeared accurate.

- *The City of Malabar* had no additional comments for the map.
- *The Town of Palm Shores* informed the ECFRPC that Palm Shores is built on a 20 foot bluff and is not in a flood zone. The Future Land Use category of low density has recently been changed to medium density and since roads have been widened, lands once inaccessible are now accessible. Therefore, the entire town should be classified as protection almost certain.

All suggestions offered by jurisdictions were documented and the maps were changed accordingly. Given the experience from jurisdictions within Brevard County, we concluded that providing localities with a first-cut sea level rise planning map based on familiar land use classifications and established policies is a more effective way to engage local government than simply providing a map with elevations and asking the localities to develop the classifications from scratch.

Although it was not practical to engage in a second round of interactions with each of the localities in Volusia County, we provided the County Emergency Management Department with the revised map and explained the revisions and logic over the phone. Since the first submittal, East Central Florida had experienced three hurricanes in rapid succession. Of the three, Hurricanes Charley and Frances inflicted the most damage, which included severe erosion along the barrier islands. In Volusia County, most beaches lost their primary dunes and the buildings behind them suffered varying levels of damage. Volusia County Emergency Management expressed interest in the study, recognizing the additional damage that could be caused by a 5 foot increase in water levels. They requested the RPC to explore the possibility of updating the Regional Hurricane Evacuation Study and the potential for incorporating the results of the study into the storm surge models.

Further analysis and changes of the maps continued during the project as new information, directions, and comments were made available. Additionally, in November 2003, SWFRPC informed us that the study area should include all land within 1,000 feet of the shore to account for possible erosion and ensure that the protection classification is visible in county-scale maps.[23] As a result, we added the 1,000-foot buffer to the mainland of Brevard County and assigned protection classifications. SWRPC further suggested that the areas above 10 feet on the barrier islands of Brevard and Volusia counties be assigned a protection classification. This was also completed. The above changes, however, were not reviewed by the appropriate jurisdictions because of time constraints.[24]

[23]This issue had not come up in the original study done by SWFRPC, because all land in that region within 1,000 feet of the shore is below the 10-foot contour anyway. Although EPA had provided drafts of reports from other states at the outset of this project, EPA, SWFRPC, and the other RPCs did not discuss the need for this buffer until SWFRPC has a conference call with the various RPCs during a visit by the EPA's project manager in November 2003.

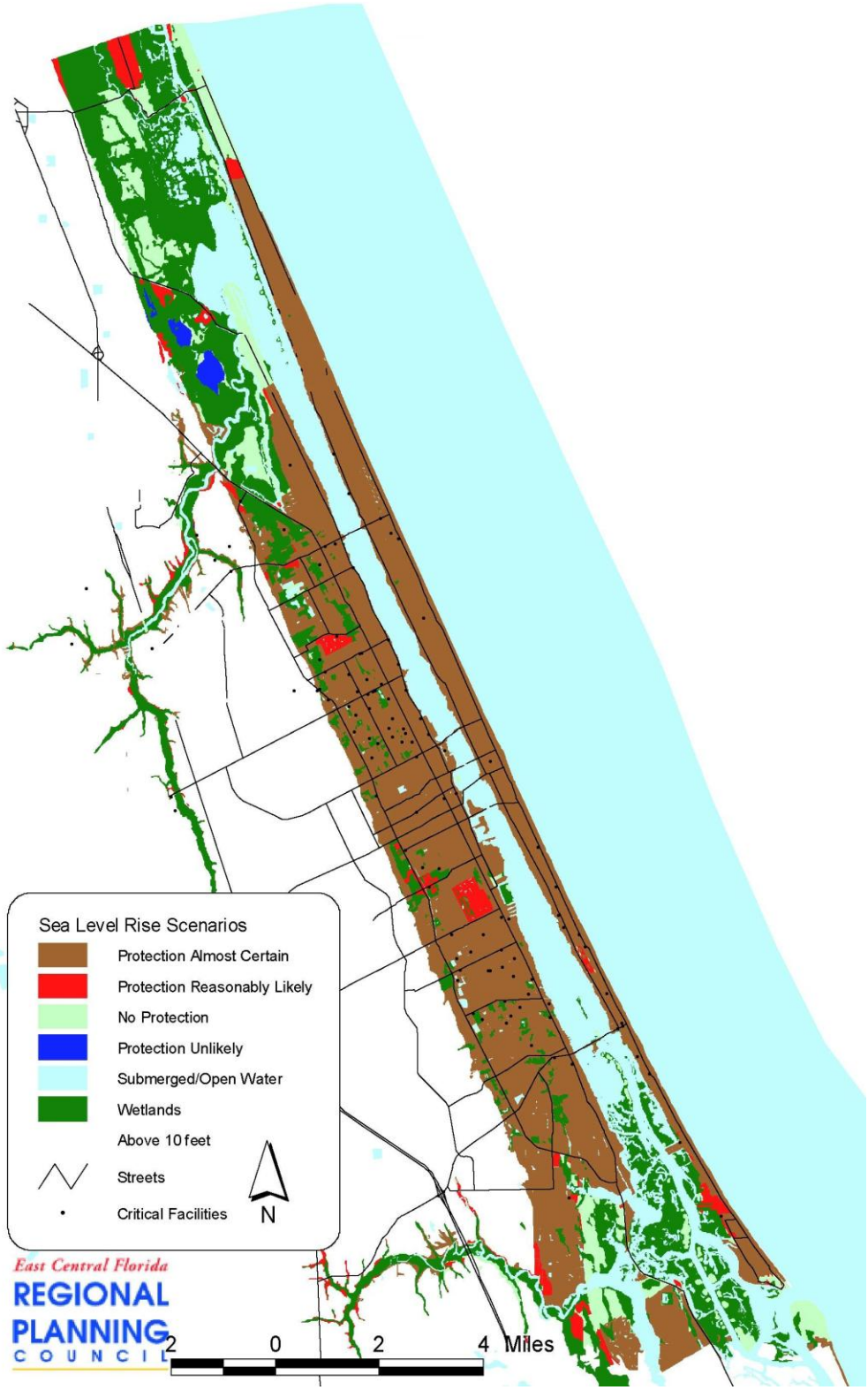
[24]The lack of review is probably not problematic. Including entire barrier islands within the study area makes the maps less confusing, but we know of no reason why the portion of a barrier island above 10 feet in elevation would have any different fate than surrounding portions, given that erosion—not—inundation is the primary impact on both the beach and the high ground immediately inland of the beach. Similarly, inclusion of land within 1,000 feet of the shore simply makes the maps easier to read, but we know of no areas where the land between 500 and 1,000 feet from the shore would have a different classification than land 0 to 500 feet from the shore. The only exception would be some CoBRA areas where we had already dealt with that issue.

Finally, the protection scenarios were colored according to the project guidelines. Table 7 describes each protection scenario and the corresponding color.

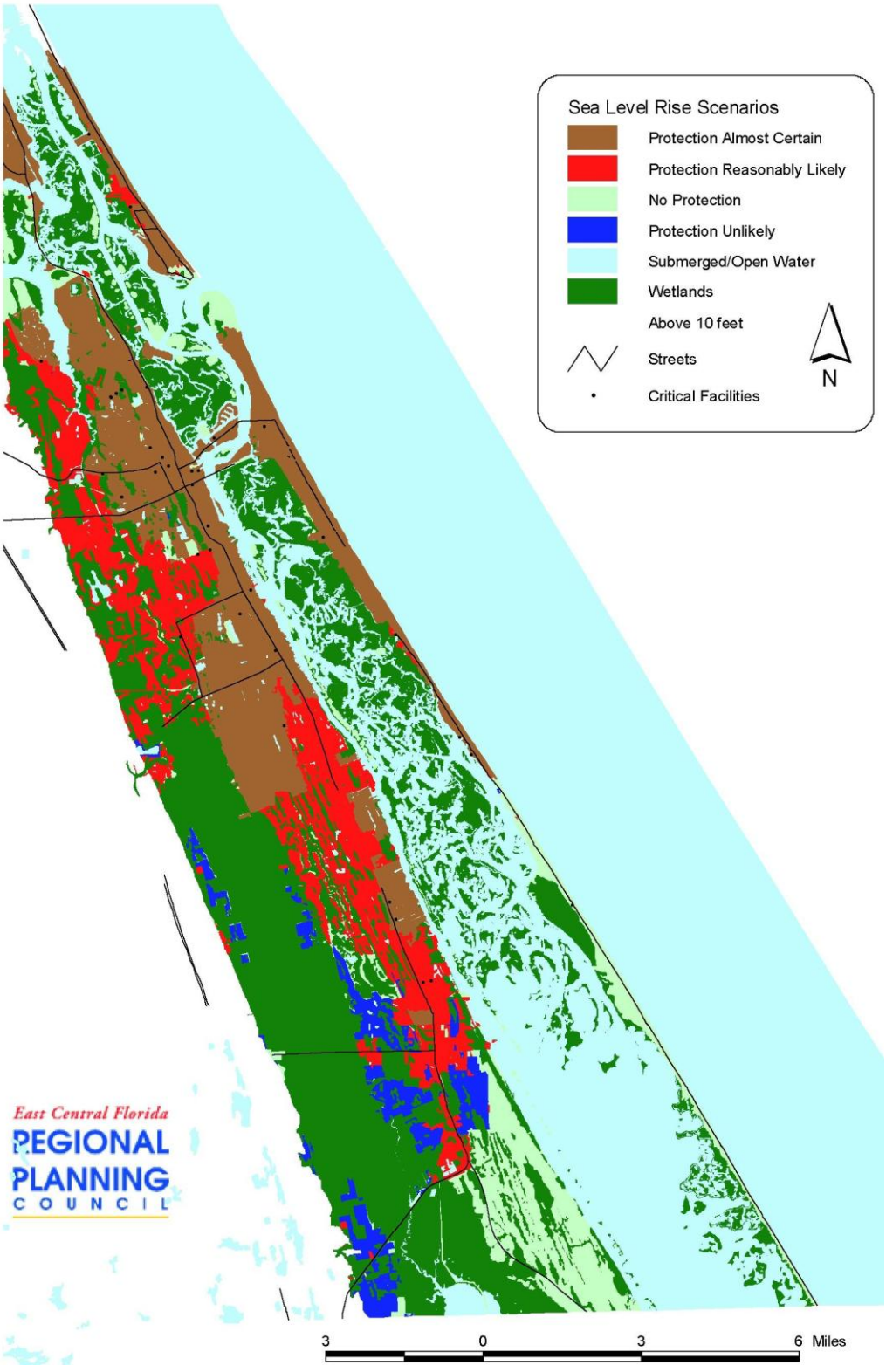
Table 7: Categories on final map and corresponding colors.

Conservation	No Protection	Light Green
Wetlands	Wetlands	Dark Green
Water	Water	Light Blue
Uplands	Protection Unlikely	Blue
Uplands	Protection Likely	Red
Uplands	Protection Almost Certain	Brown
Critical Facilities	Reference	Black

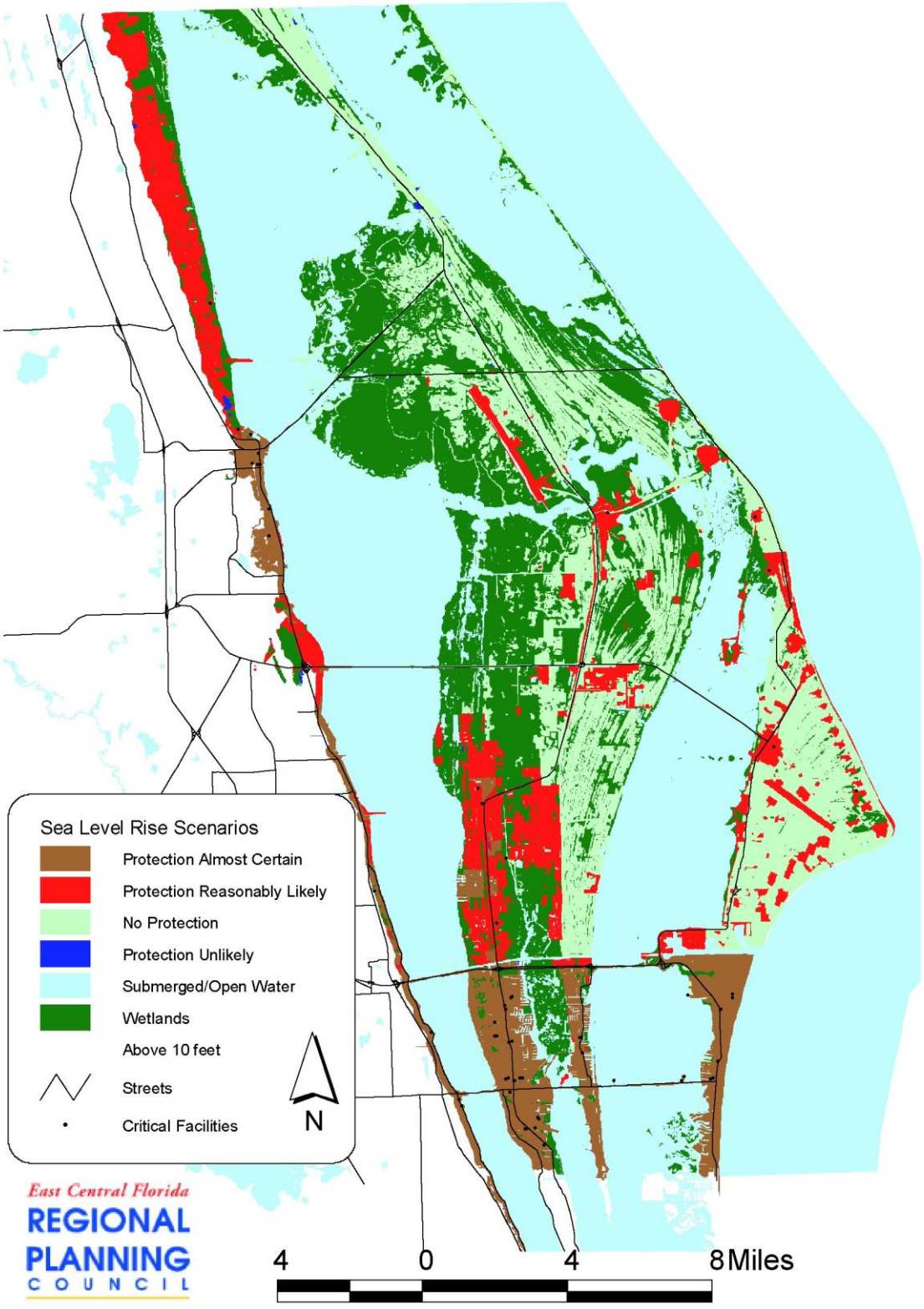
Adobe Files of each map were created, which allows for easy distribution via the Internet and display on the East Central Florida Regional Planning Council website. Map 2 shows the likelihood of shore protection for Volusia County, and Map 3 shows the likelihood of shore protection for Brevard County.



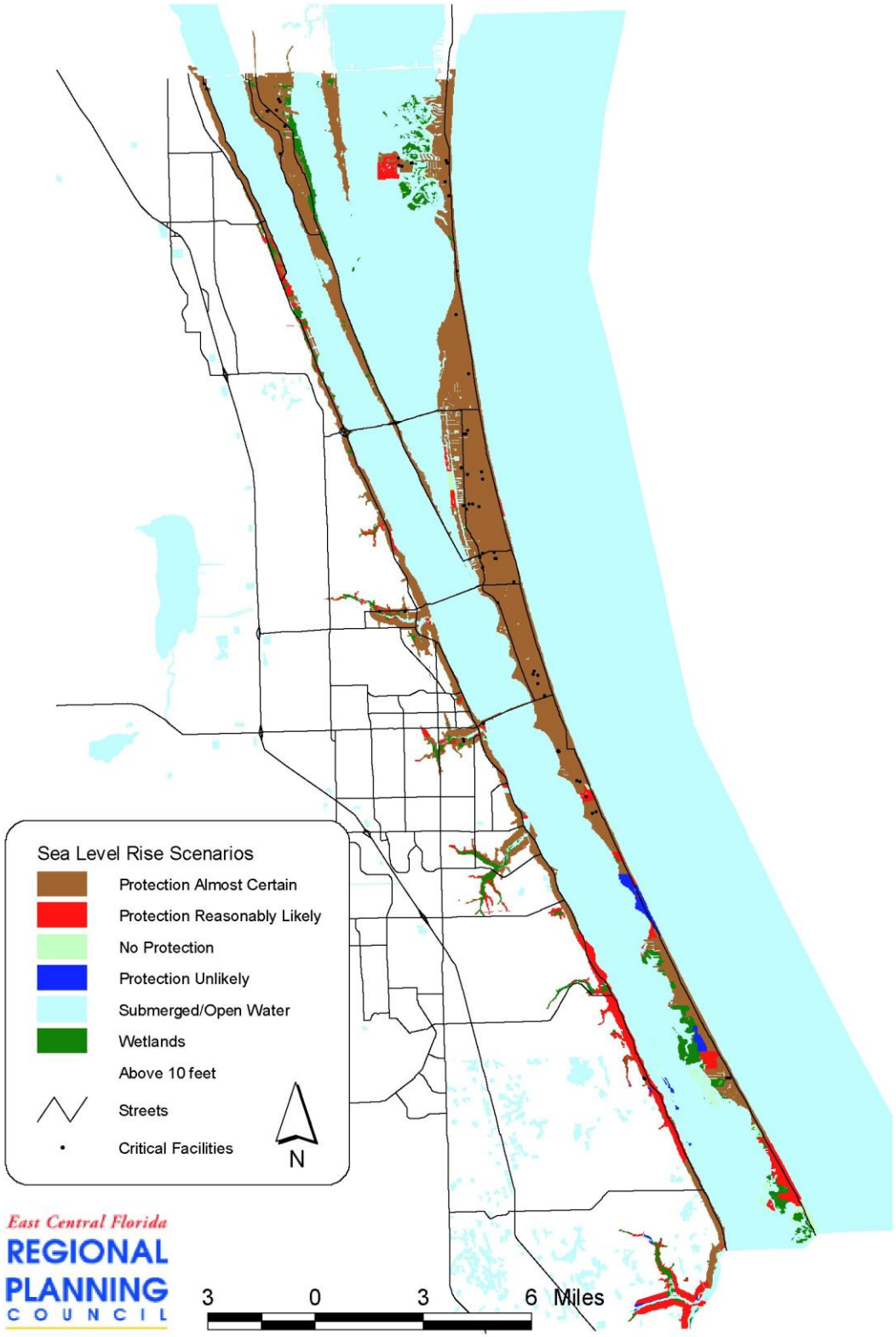
Map 2a: Northern Volusia County: Likelihood of Shore Protection



Map 2b: Southern Volusia County: Likelihood of Shore Protection



Map 3a: Northern Brevard County: Likelihood of Shore Protection



Map 3b: Southern Brevard County: Likelihood of Shore Protection

Recommended Scale

The scale for the maps of Volusia County and Brevard County were 1:100,000 and 1:150000, respectively. This scale was used to provide the maps at the largest scale possible with the counties cut into two 11 ×17 maps each. The Adobe files were then created to allow users to zoom in to specific areas.

ANALYSIS

The study area of Volusia and Brevard counties consists of 153,464 acres (240 square miles) of uplands and 95,950 acres (150 square miles) of wetlands. Therefore, a 5 foot rise in sea level would affect more than 250,000 acres (390 square miles) of the coastline, excluding water bodies. This accounts for approximately 18 percent of the land within Brevard and Volusia counties. According to the 2000 census, the current population in the coastal census tracts found completely or partially within the study area was approximately 503,000 in 260,000 dwelling units.[25] Coastal Volusia is expected to have a population of 350,000 in 183,000 dwelling units by 2020 and Brevard's 2020 coastal population is expected to be 199,000 in 104,000 dwelling units. Therefore, the entire study area is expected to have fewer than 550, 000 residents in 287,000 dwelling units by 2020.

Table 8 illustrates the breakdown of the various land uses in the study area that are subject to sea level rise. Wetlands and preserves make up the largest percentage of the study area while the most developed and developable land use subject to sea level rise is single family residential at 46,000 acres.

Table 8: Breakdown of acreage in East Central Florida subject to sea level rise.

Future Land Use	Brevard	Volusia	Total	Square Miles	% of Study Area
Agriculture	246	2674	2920	5	0.653
Commercial	16002	9211	25213	39	5.637
Industrial	1616	2690	4306	7	0.963
Estate	2029	3773	5802	9	1.297
Multi Family	8035	6423	14458	23	3.233
Single Family	23471	22815	46286	72	10.349
Preserve	41194	10809	52003	81	11.627
Military	1908	0	1908	3	0.427
Mining	12	0	12	0	0.003
Wetlands	53613	42395	96008	150	21.466
Unknown	447	51	498	1	0.111
Water	165933	31903	197836	309	44.234
Total Acreage	314506	132744	447250	699	100.000%

The protection scenarios assigned in the region break down as shown in Table 9. For example, the land where shore protection is almost certain accounts for 65,000 acres (102 square miles), which is 15 percent of the study area. Wetlands and water comprise 65 percent of the study area.

[25] Census tracts were used because the analysis was performed through GIS and the available data were census tracts. The analysis consists of all the tracts that are entirely or partly in the study area. Therefore, the population analysis includes a population projection for the entire study area and immediate surrounding areas. As a result, the projection numbers are a high end estimate.

Table 9: Acreage by Likelihood of Shore Protection – East Central Florida Region

Protection Scenarios	Brevard	Volusia	Total	Square Miles	% of Study Area
No Protection	40976	10287	51263	80	11.46
Protection Unlikely	618	2990	3608	6	0.81
Protection Likely	21620	11358	32978	52	7.37
Protection Almost Certain	31740	33812	65552	102	14.66
Wetlands	53613	42395	96008	150	21.47
Submerged/Open Water	165933	31902	197835	309	44.23
Total Acreage	314500	132744	447244	699	100.00

Table 10 presents the same results expressed as a percentage of the dry land within the study area. For all practical purposes, past and planned development has already made it inevitable that property will be protected and the inland migration of wetlands will be blocked along 30 percent of Brevard and 60 percent of Volusia County shores. Existing conservation lands, however, ensure that wetlands will be able to adjust to rising sea level along the shores of about 45 percent and 15 percent of the two counties coastal areas, respectively. Perhaps most important, we still have a realistic opportunity to choose between wetland migration or the type of coastal development that causes a gradual loss of wetlands for approximately 25 percent of the land in each county. Given current trends, a substantial portion of that land (5 percent) in Volusia County probably will not be protected, enabling wetlands to migrate.

Table 10: Percentage of Dry Land by Likelihood of Shore Protection

Protection Likelihood	Brevard	Volusia	Region
No Protection	43.2	17.6	33.4
Protection Unlikely	0.7	5.1	2.4
Protection Likely	22.8	19.4	21.5
Protection Almost Certain	33.4	57.9	42.7

Sea Level Rise Planning Solutions

Beaches erode 100 to 200 feet with every 1 foot rise in sea level. With a 50 percent chance of the sea level rising 4 feet by 2200, the beaches could erode 200 to 800 feet. Therefore, because most of the waterfront homes are located within 100 to 200 feet of the high water mark, these homes may be largely affected by sea level rise.[32] This can be very costly when protecting high density areas. "Land use is a state and local responsibility."[32] Therefore, it is important for decisions be made concerning the protection of developed and undeveloped land before it becomes too expensive or impossible to protect the shoreline and property. To determine the areas needing protection, coastal managers should look for relative sea level rise in specific areas. Each regional area has specific forces determining the extent of sea level rise, sea level decline, and inundation. These forces include vertical land movement, coastal erosion, saltwater intrusion, and high water tables.[8]

In the United States, a 1 meter rise in sea level may result in the loss of 50 to 82 percent of coastal wetlands provided all shores are protected. A 2 meter rise could result in a loss of 60 to 90 percent of the wetlands.[33] It is estimated, however, by protecting only developed areas, less wetlands would be lost because they would have the ability to migrate with the rising sea. Through protecting only developed areas, a 1 meter rise may inundate only 29 to 69 percent of wetlands, 20 percent less than by protecting the entire coastline. A 2 meter rise could result in a 61 to 80 percent loss, not a significant difference from protecting the entire coastline. Since the Southeast contains 85 percent of the coastal wetlands, 90 to 95 percent of the wetland loss would take place in this region.[33] This may become a large area of concern for Florida when the time comes to decide how to protect property owners, the natural shoreline, and natural resources.

To prevent or prepare for the negative impacts associated with sea level rise, it is important to begin planning for both the short and long term. Every problem has a number of solutions, and the best solution may vary from site to site. The study area of the Brevard and Volusia coastline is an important ecological and economical resource for the region and the state. Therefore, the best solutions should be planned well enough in advance to protect the resources and property of the region. Some solutions may require immediate action while others may take place over the course of 200 years; yet the best solutions may be a mix of techniques, structures, and planning.

Regulating Land Use

Comprehensive Planning

The Florida State Legislature enacted the Comprehensive Planning program to address development activity in Florida. The comprehensive plan process addresses the future in a realistic effort by implementing various environmental, social, and economic policies. Comprehensive plans address issues such as location and type of land development, allowable infrastructure in various areas, and coastal and environmental management.

Local comprehensive plans and zoning could be used to limit building in critical areas and provide policies to regulate the type of building and communities desired. These plans are currently used not only to regulate building but also to protect natural areas to ensure the natural migration and change of natural habitats along the coast.[1]

Future land use plans, found in the comprehensive plan, may be an important regulatory tool to protect infrastructure and property from the effects of sea level rise. It can provide specific goals and objectives concerning development, especially in critical areas. Future land use plans also address areas needed for conservation. Analysis of areas along the coast that should be preserved to aid in protection of the coastline should be performed and identified in the land use plans.[1] The plans and regulations can be adjusted to regulate critical areas, thus minimizing the negative effects of sea level rise, economically, physically, and socially.

Future land use plans can be used to limit the density and type of development allowed in critical areas. This would be most effective, however, only in undeveloped areas or locations that have not been built out yet. Although most of the developable land in the study area has already been developed, there are still areas currently undeveloped or with low density development. By limiting or discouraging development in these areas, sea level rise may have less impact on infrastructure, the economy, and private property. Future building in critical areas could also be aimed toward activities related to the ocean and therefore continue to be used as sea level rises.[1] This would keep the property value and allow the local government to use the areas to create local revenue. Although amending the future land use section of the comprehensive plan may be a short-term task and the development that may occur may also be short to long term, the effects of these changes will provide long-term planning for protection from sea level rise. Without proper planning for the future and poor land use goals and objectives, the effects of sea level rise can be more costly over time.[1]

Other changes to comprehensive plans concerning future development in areas in danger of sea level rise can include making new structures in critical areas be temporary and portable. For example, Maine developed the Coastal Sand Dune Rules, which require structures interfering with the landward migration of the natural dune system or migration of a sea level rise of up to 3 feet to be mobile and move with the migrating dunes.[3] Placing regulations on new infrastructure (or rebuilding after destruction), such as limiting it to areas outside the critical zones, would be an important change to comprehensive plans. This would encourage development in these areas and limit development in areas likely to be affected by sea level rise. The Volusia and Brevard County comprehensive plans discuss the above. Therefore, this is a step in protection against sea level rise. It is important to make certain the suggestions in the comprehensive plan are stringent and followed.

Zoning Regulations

Zoning is the legal aspect of development that regulates a variety of parameters that must be followed by the developer to ensure the safety and welfare of the jurisdiction's citizens. Zoning regulations include where a structure is to be placed on the property, maximum allowable structure height, amount of site coverage, and allowable densities.[1]. As with the comprehensive plan, regulating zoning regulations in critical areas can be an important tool in protecting property, resources, infrastructure, and the economy from sea level rise.

For site-specific development, zoning regulations can be amended to regulate where a structure can be placed on a lot, the size or height of the structure, and the densities of a development.[1] The placement of a structure on a lot may be of critical importance on beachfront property. The placement could allow for the beach to naturally migrate. Setbacks can be issued and purchased by the government to ensure public beach access.[3]

Planned Unit Development

Planned Unit Development regulations take zoning to another level. The plans address issues that are unique to a specific parcel of land and the zoning regulations on a PUD may be changed to best fit the land to be developed. Just as changing zoning regulations can protect critical areas, changing regulations in PUDs can help limit development, create natural buffers to allow environmental processes to continue naturally, and allow more open space to ensure areas for mitigation. Also, placing restrictions on development, such as writing building regulations to withstand sea level rise or requiring structures to be mobile so that they may be relocated as sea level rises, is important to protect private property and investments. Mitigation for off site areas can be increased so that it may be used if the land's future land use must be eliminated.[1]

Developments of Regional Impact

Florida enacted the Development of Regional Impact programto assess development proposals that may have multijurisdictional impact. This process is important if one jurisdiction's DRI will affect the sea level rise regulations, mitigations, or policies of another jurisdiction. However, because DRI requires jurisdictions to work together, and then have the approval of the State and Planning Council, many recommendations can be made to ensure the DRI considers local comprehensive plans in regard to sea level rise.[1] It may also allow for more cooperation and awareness throughout the region to ensure the best policies and regulations are in effect to protect investments and resources in the coastal communities.

Public and Critical Facilities Location

The development of a region is based generally on the location of certain public facilities and infrastructure. Development of schools, hospitals, and major roadways encourages development and growth in the surrounding areas. To limit development in critical areas, a public policy change to place future public facilities and infrastructure outside these critical areas could reduce the impacts of sea level rise on property and resource loss and the cost of protection.[1]

Regulations can also be placed on the locations of critical facilities. Structures on the coast may need to be rebuilt or modified to deal with sea level rise and/or the policies the communities may create for beach structures. Any future critical facility construction or reconstruction could be recommended to be placed away from any area vulnerable to sea level rise. More coastal communities may implement such policies for future land use and modeling simulations could be performed. Modifications of structure design, especially emergency buildings, will prepare for the future estimated rise in sea level and associated storm surge.

Critical facilities in vulnerable areas could be relocated by moving the entire structure with its contents or moving the contents only to a new location. The decision would depend on the type of facility, availability of developable property, and cost analysis of relocation. If only the contents of the facility are relocated, the vulnerable building could be either demolished or used in a capacity coinciding with sea level rise.[1]

Public Acquisition and Preservation

Open Space Controls

Open space can be classified as public or private. Private lands are owned by a private land owner and may include yards, commercial buffer areas, golf course, agricultural fields, forests, or even private conservation areas. Public lands include right of ways, parks, and conservation and preservation areas. As sea level rises, open space acting as shoreline buffers or outside wetlands will help allow the shore to naturally retreat and wetlands to migrate, as well as shore habitats. Having an appropriate amount of open space could limit the amount of development in critical areas and therefore decrease the loss of expenditure to protect the area and decrease the loss of property.[1] Open space could also be mitigated to provide areas for structures to move if necessary when sea level rises. These areas of open space could be used in a method that is compatible with sea level rise while providing an income to the region.

To protect natural habitat such as wetlands or estuaries, public land acquisition may be a feasible solution. This land acquisition could take place through donations, purchase, or expropriation. Leasebacks, the acquisition of land by a public agency which then sells the land to third parties with the stipulation of open space requirements, and sale backs, similar to the above but the land is acquired by the government and sold to private developers with open space regulations, could also be used to ensure open space in critical areas.[1]

Rolling Easements

The best scenario for low density mainland areas may be a rolling easement as the sea rises. Rolling easements are an attractive option because if the sea level does not rise to expected levels, money would not be spent. If the sea level does rise, the provisions will have been well planned and established before the easements would be in effect. Protecting low value property below the expected rise in sea level would not be realistic because the land would have to be raised at least 5 feet to keep it from becoming inundated. In this scenario, the property would continue to be used beneficially until it must give way to the ocean. Primarily, rolling easements are a warning for the property owner that, eventually, the property may be useless.[32]

Public Acquisition and Preservation Programs

Besides obtaining land to limit development to decrease funds spent on protection, acquiring critical areas for habitat migration and reestablishment ensures natural shorelines and resources for the future. Finding funding to acquire such land, however, may not be feasible at one time. Spanning land acquisitions over time, acquiring the most important areas first, could be more economical. Placing tax exemptions on undeveloped land may encourage private owners to keep the land open.[1]

Public land could be acquired through full fee title or through the acquisition of land use easements. The transfer of private land to public is full fee title acquisition and its use can be compatible with changes in sea level. For example, using land acquired by this method as a public park would decrease the cost of damage if there were few or no buildings. The use of a park may be able to change as sea level rises, especially if land is acquired with buildings on it. As needed the buildings could be moved or demolished and the land's use could change as needed. Private ownership still remains when land easements are acquired. Restrictions on the easement, However, can limit the possible damage of sea level rise to structures.[1] These easements may provide enough buffer on the property to protect the structures. This could reduce the property owner's protection cost because building a seawall, renourishing a beach, or relocating may not be necessary.

Areas of Critical State Concern

Areas of Critical State Concern is a state program that designates critical areas based on the qualities of the land. A critical area must be of environmental, historical, natural, or archaeological importance to the region or state, have major public investment, or present major development potential. This program can be used to control development in areas subjected to sea level rise. The regulations set forth in a critical area are the responsibility of the local government. The state is empowered to regulate land development in a critical area if the local government fails to properly regulate the development and administer its responsibilities.[1] Designating areas subjected to sea level rise as critical may be an important step in controlling development and reducing the economic impact of protecting or moving a number of structures.

Transfer of Development Rights

When one area is considered less desirable for development, rights may be transferred between property owners. The development rights that were on the parcel of land are moved to a parcel where development is more desirable. The property can then be used in a less intensive manner or one compatible with sea level rise.[1]

Density development rights can be used to keep development in areas subjected to sea level rise to a minimum and transfer the density rights outside the critical areas. Owners outside the area could develop at higher densities than originally allowed if they purchase density development rights from land owners in areas to be affected by sea level rise. If the property owner then chooses to develop the land, it could be used in a less intense capacity.[1]

For the transfer of development/density rights to work, the property owner outside the critical area must be zoned for densities lower than that which is desirable by the developer. If the densities are already acceptable, the developer may not purchase the development rights. Other restrictions on the land that may limit the densities could include environmental and political ones. It is also important to determine if the growth that would then occur in the area would be acceptable and committed in terms of infrastructure and public facilities.[1]

Engineered Solutions

Beach Renourishment

An effective possibility for resort communities would be to raise the island, or even mainland area, in place by pumping in sand from offshore. To raise the island in place, sand is used to raise lots, roads, and houses. Sand would also be added underwater to maintain the beach slope. Sand would not be needed to raise the entire area. Lots containing buildings could potentially be raised with cheaper materials than sand.[1] To deal with small levels of sea level rise, sand would need to be added only to the beach profile. As sea level rises, more sand may be needed to be added further in land to compensate for the continued beach nourishment. Consequently, pumping sand onto the island may result in bays becoming deeper and wider from the sand extraction, thus resulting in increased wetland erosion.[9]

Beach renourishment projects are generally expensive, time consuming, and large scale. The study area, however, depends on the beach for tourism and the economy. Therefore, protecting the beaches in Brevard and Volusia counties is of great importance now and in the future. Brevard County does have an active beach renourishment program; Volusia County, however, does not.

Seawalls

Seawalls are found in the study area and may continue to be an important protection option for property owners along the coastline. To keep the walls from cutting under because of increased erosion associated with sea level rise and greater wave energy, beach renourishment, especially in front of seawalls, may be a critical element. This would decrease the chances of the wall crumbling. Engineering a seawall is an option that could be done now depending on the view of the property owner, the erosion experienced on the property, and whether a form of beach renourishment is active in the area. A seawall could, however, be built further in the future as sea level rises.

The Army Corps of Engineers has the authority to issue permits to build erosion control features such as bulkheads as long as no vegetated wetlands are filled.[32] If the property owner is able to fill wetlands to protect their property or compensate for the beachfront loss, they must obtain a permit issued by the Corps. By receiving this permit, the property owner must create new wetlands or enhance degraded wetlands.[32] Building hard structures to protect property, however, does not allow wetlands to migrate. It is recommended that wetlands be allowed to migrate in response to rise in sea level to continue to serve as habitat, water filtration system, and mainland protection. If wetland loss of an armored shoreline is compared to wetland loss of unarmored shoreline, 38 to 61 percent of wetlands will be lost if the shore is protected, while only 17 to 43 percent will be lost if the shore is unprotected.[32]

Public Awareness

Public awareness and response plays a critical role in preparing for sea level rise. Through hearings, seminars, and workshops, the public can be informed of where sea level rise is expected to impact property and the choices they have as property owners if their property is located in such an area. It is important to make the public aware of the short-term and long-term responses, policies, and actions available to deal with sea level rise. Specialized media and journals oriented toward various workforce communities are valuable mediums to reach audiences such as engineers, planners, architects, and the like. Public involvement in creating policies and regulations to deal with sea level rise can influence the passage of legislation. Legislation passed could affect the way a community responds to sea level rise.

CONCLUSION

Rule 9J-5 of the Florida Administrative Code does not indicate that local governments are required to address planning for future sea level rise.[34] Currently, there are no known regulations in effect in Brevard or Volusia County to deal with sea level rise. In the Volusia County comprehensive plan, Policy 11.4.1.21 states that the county will monitor sea level rise to determine when the rise will affect the county and will then act accordingly. Brevard County Policy 4.9 states, "Brevard County shall continue to collect and make available to the public, information related to sea level rise changes." If statewide and local decisions and efforts are not made to implement ways to protect the shorelines from sea level rise, property owners may take a step in the wrong direction, both economically and environmentally, to protect their property. Issuing statewide regulations could ensure that the most economically and environmentally sound efforts are made to ensure the future of the region's coastline.

As is evident from this study, a considerable number of acres of the Brevard and Volusia county coast may be affected from a potential 5 foot rise in sea level. The areas affected include barrier islands as well as the mainland. Because of the importance of the beach community to the economic well-being of the region, important decisions to protect the natural and developed coastline of the counties could eventually be inevitable. Depending on the area affected, the solution to sea level rise and the implementation costs may vary. Also, the timing to implement the solution may be a critical factor. Should local governments decide through this study and other studies performed in the county that sea level rise evidence does exist and could potentially affect the county, the local government and property owners may begin the initial steps to decide on the constraints, areas, solutions, policies, and costs of protecting the region. By beginning initial steps to plan for future sea level rise, the financial and environmental burdens may be eased on the future citizens of the county.

Policies such as redefining zoning, land use, and density regulations could take effect in the near future and prevent more development in critical areas. Other solutions such as retreating or building seawalls may not be necessary until protection is absolutely crucial. It may be beneficial, however, for the decision and planning for such a project to be made in advance to ensure the best research, engineering, costs, and funding. Solutions phased over time (i.e., beach renourishment and land acquisition) researched, and analyzed now could maximize benefits and cut costs associated with damage and inundation.

This study documents the possible impacts of sea level rise on the coast of Brevard and Volusia counties. Therefore, in keeping with county policy, if the county and local governments determine that this study, combined with other sea level rise studies, provides enough evidence to begin discussion and more studies on how to protect the coastline from the projected sea level rise, the solutions presented in this study may be a stepping stone. The county and cities are presented, through this study, with options for decision making on land use and protection of common infrastructure and the economic base of the community. Many changes in policies and probable solutions to sea level rise will need to be researched for specific local costs and effects. Each area needing protection may benefit differently from various solutions. In developing areas, the EPA recommends impact assessments of sea level rise on manmade and natural coastal features. Land use planning processes are recommended to coincide with the impact assessment.[3] By performing research now and making proactive changes to the infrastructure and management of the coastlines, the problems associated with future sea level rise may be limited and less costly.[8]

The future is always hard to predict with precision. Changes made in the present may influence the predictions made for the future. Tegardless of the predictions for the future, however, local governments, county government, and property owners are presented with possible solutions for protecting the valuable coastline of the region as well as the impacts a possible 5 foot rise of sea level may cause. If the sea level does not rise to the predicted levels, at least society was prepared and perhaps changes were made to lower losses in floods and reduce beach erosion. If sea level rises to the predicted levels and preparations have been implemented, there may be less loss of natural habitat, property, infrastructure, and money.

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Appendix A

EAST CENTRAL FLORIDA REGIONAL PLANNING COUNCIL

SCOPE OF WORK AND METHODOLOGY

SEA LEVEL RISE MAPPING AND LOCAL GOVERNMENT REVIEW AND APPROVAL

A. Mapping Requirements (Completion Date 12/31/03 or sooner)

1. A five-foot rise in sea level within 200 years will be analyzed by the East Central Florida Regional Planning Council (ECFRPC) for the counties of Brevard and Volusia Counties. The estimated rate of sea level rise over the next 200 years and the probability of that rise for the Southeast Florida region will be provided in a table by the Southwest Florida Regional Planning Council (SWFRPC) based on an Environmental Protection Agency (EPA) report Title "The Probability of Sea Level Rise".

2. Based on the five-foot rise in 200 years, the new mean sea level shoreline will be at the current five-foot contour line. Furthermore, when adding a few feet for an astronomical high tide the sea level will be at the seven or eight-foot contour line. However, because seven or eight-foot contour lines are not readily available the ten foot contour line must be used. Therefore, the ECFRPC study area for a five-foot rise will be everything below the ten-foot contour line.

3. The maps for each county will include the following:

   A. Water features shown light cyan
   B. Wetlands shown as dark green
   C. 0' to 10' Uplands, not protected from sea level rise shown as light green
   D. 0' to 10' Uplands, protection likely but wetland migration possible shown as dark red
   E. 0' to 5, 0' to 10' or 5' to 10' Uplands, protection not likely shown as blue
   F. 0' to 5, 0' to 10' or 5' to 10' Uplands, protection definite shown as brown
   G. Above 10' shown as white
   H. Critical Facilities 0' to 5' Protection not recommended shown as dark blue
   I. Critical Facilities 5' to 10' Protection definite shown as brown
   J. Roads shown as thin black lines
   K. Above 10' shown as white
   L. North arrow symbol and scale.

4. To complete the maps features discussed above the ECFRPC will use the best

Appendix B

Volusia County Comprehensive Plan
(Sea Level Rise Section)

GOALS, OBJECTIVES, AND POLICIES

GOAL:
11.4 Protect, enhance and restore the functioning of the beach and dune systems and prohibit development activities that would damage or destroy such systems.

OBJECTIVE:
11.4.1 Maintain standards to minimize the impacts of structures and development on beach and dune systems and where necessary initiate dune restoration programs.

POLICIES:
11.4.1.21 Volusia County should continue to monitor sea level rise science to determine when and if a sea level rise event will affect the County. Based on pertinent data, the County will act accordingly.

Appendix C

Brevard County Comprehensive Plan
(Sea Level Rise Section)

Objective 4
Brevard County shall implement and improve as necessary a comprehensive beach and dune management program which protects, enhances and restores a naturally functioning beach system as funding is available.

Policy 4.9
Brevard County shall continue to collect and make available to the public information related to sea level changes.

Appendix D

Coastal Zone Management Act
(Sea Level Rise Sections)

§ 1451. Congressional findings (Section 302)

(l) Because global warming may result in a substantial sea level rise with serious adverse effects in the coastal zone, coastal states must anticipate and plan for such an occurrence.

§ 1452. Congressional declaration of policy (Section 303)

The Congress finds and declares that it is the national policy—

2) to encourage and assist the states to exercise effectively their responsibilities in the coastal zone through the development and implementation of management programs to achieve wise use of the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and esthetic values as well as the needs for compatible economic development, which programs should at least provide for—

B) the management of coastal development to minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard, and erosion-prone areas and in areas likely to be affected by or vulnerable to sea level rise, land subsidence, and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands,
and barrier islands,

(K) the study and development, in any case in which the Secretary considers it to be appropriate, of plans for addressing the adverse effects upon the coastal zone of land subsidence and of sea level rise; and

(3) to encourage the preparation of special area management plans which provide for increased specificity in protecting significant natural resources, reasonable coastal-dependent economic growth, improved protection of life and property in hazardous areas, including those areas likely to be affected by land subsidence, sea level rise, or fluctuating water levels of the Great Lakes, and improved predictability in governmental decision making;

§ 1453. Definitions (Section 304)

For the purposes of this title--

(1) The term "coastal zone" means the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each other and in proximity to the shorelines of the several coastal states, and includes islands, transitional and intertidal areas, salt marshes, wetlands, and beaches. The zone extends, in Great Lakes waters, to the international boundary between

the United States and Canada and, in other areas, seaward to the outer limit of State title and ownership under the Submerged Lands Act (43 U.S.C. 1301 et seq.), the Act of March 2, 1917 (48 U.S.C. 749), the Covenant to Establish a Commonwealth of the Northern Mariana Islands in Political Union with the United States of America, as approved by the Act of March 24, 1976 (48 U.S.C. 1681 note), or section 1 of the Act of November 20, 1963 (48 U.S.C. 1705), as applicable. The zone extends inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on the coastal waters, and to control those geographical areas which are likely to be affected by or vulnerable to sea level rise. Excluded from the coastal zone are lands the use of which is by law subject solely to the discretion of or which is held in trust by the Federal Government, its officers or agents.

1456b. Coastal Zone Enhancement Grants (Section 309)

(a) For purposes of this section, the term "coastal zone enhancement objective" means any of the following objectives:

(1) Protection, restoration, or enhancement of the existing coastal wetlands base, or creation of new coastal wetlands.

(2) Preventing or significantly reducing threats to life and destruction of property by eliminating development and redevelopment in high-hazard areas, managing development in other hazard areas, and anticipating and managing the effects of potential sea level rise and Great Lakes level rise.

Appendix E

Brevard County Critical Facilities							
FACILITY NAME	**ADDRESS**	**CITY**	**STATE**	**ZIP**	**FACILITY NUMBER**	**LATITUDE**	**LONGITUDE**
MELBOURNE BEACH FIRE STATION	505 OCEAN AVE	MELBOURNE BEACH	FL	32951000	12009440000002	28.067780	-80.564440
MELBOURNE BEACH PUBLIC WORKS DEPT	507 OCEAN AVE	MELBOURNE BEACH	FL	32951000	12009440000003	28.067780	-80.564440
MELBOURNE BEACH TOWN HALL	507 OCEAN AVE	MELBOURNE BEACH	FL	32951000	12009440000004	28.067780	-80.564440
MELBOURNE FIRE STATION #1	865 EAU GALLIE BLVD.	MELBOURNE	FL	32935000	12009439750010	28.128330	-80.635560
MELBOURNE WWTP-GRANT ST	2300 GRANT STREET	MELBOURNE	FL	32901000	12009439750021	28.073610	-80.609720
SATELLITE BEACH FIRE DEPARTMENT	1390 S. PATRICK DRIVE	SATELLITE BEACH	FL	32937000	12009644000001	28.188330	-80.606940
SATELLITE BEACH POLICE DEPARTMENT	510 CINNAMON DRIVE	SATELLITE BEACH	FL	32937000	12009644000002	28.109170	-80.580280
SATELLITE BEACH PUBLIC WORKS	530 CINNAMON DRIVE	SATELLITE BEACH	FL	32937000	12009644000003	28.172220	-80.610280
SCHOOL BOARD, AUDUBON ELEMENTARY	1201 N. BANANA RIVER DRIVE	MERRITT ISLAND	FL	32927800	12009442750004	28.376940	-80.668610
SCHOOL BOARD, CAPE VIEW ELEMENTARY	8440 NORTH ROSALIND	CAPE CANAVERAL	FL	32920219	12009102500004	28.391670	-80.599440
SCHOOL BOARD, EDGEWOOD JUNIOR HIGH	180 E. MERRITT AVENUE	MERRITT ISLAND	FL	32953349	12009442750006	28.361670	-80.696940
SCHOOL BOARD, FAIRGLEN ELEMENTARY	201 INDIAN TRAIL	COCOA	FL	32927590	12009131500025	28.438060	-80.760280
SCHOOL BOARD, GARDENDALE ELEMENTARY	301 GROVE BLVD.	MERRITT ISLAND	FL	32953449	12009442750007	28.378890	-80.707780
SCHOOL BOARD, GEMINI ELEMENTARY	2100 OAK STREET	MELBOURNE BEACH	FL	32951279	12009440000005	28.054440	-80.554440
SCHOOL BOARD, HOOVER JUNIOR HIGH SCHO	1 HAWK HAVEN DRIVE	INDIALANTIC	FL	32903299	12009333750003	28.100280	-80.575560
SCHOOL BOARD, INDIALANTIC ELEMENTARY	1050 NORTH PALM AVE	INDIALANTIC	FL	32903309	12009333750004	28.099720	-80.573330
SCHOOL BOARD, JEFFERSON JUNIOR HIGH	1275 S. COURTENAY PARKWAY	MERRITT ISLAND	FL	32952389	12009442750008	28.334720	-80.686940
SCHOOL BOARD, MERRITT ISLAND HIGH SCH	100 EAST MUSTANG WAY	MERRITT ISLAND	FL	32953319	12009442750009	28.376390	-80.700280
SCHOOL BOARD, MILA ELEMENTARY	288 W. MERRITT AVE	MERRITT ISLAND	FL	32953472	12009442750010	28.361670	-80.702220
SCHOOL BOARD, OCEAN BREEZE ELEMENTARY	1101 CHEYENNE DRIVE	INDIAN HARBOUR BEAC	FL	32937369	12009334500002	28.149440	-80.591940
SCHOOL BOARD, ROOSEVELT K-8 SCHOOL	1400 MINUTEMEN CAUSEWAY	COCOA	FL	32931209	12009131500027	28.316670	-80.631390
SCHOOL BOARD, SEA PARK ELEMENTARY	300 SEA PARK BOULEVARD	SATELLITE BEACH	FL	32937219	12009644000004	28.202500	-80.605560
SCHOOL BOARD, TITUSVILLE HIGH SCHOOL	150 TERRIER TRAIL	TITUSVILLE	FL	32780473	12009719000018	28.594720	-80.806110
SCHOOL BOARD, TROPICAL ELEMENTARY	885 S. COURTENAY PARKWAY	MERRITT ISLAND	FL	32952499	12009442750011	28.341110	-80.694720
TITUSVILLE POLICE DEPT. SUB-STATION	1026 PALMETTO	TITUSVILLE	FL	32796000	12009719000020	28.609440	-80.808610

Brevard County Critical Facilities							
FACILITY NAME	**ADDRESS**	**CITY**	**STATE**	**ZIP**	**FACILITY NUMBER**	**LATITUDE**	**LONGITUDE**
TITUSVILLE, CITY HALL ANNEX	445 S. WASHINGTON AVE.	TITUSVILLE	FL	32796000	12009719000023	28.609440	-80.807220
TITUSVILLE, MUNICIPAL MARINA	451 MARINA ROAD	TITUSVILLE	FL	32796000	12009719000024	28.621390	-80.811390
SATELLITE BEACH POLICE DEPT	565 CASSIA BLVD	SATELLITE BEACH	FL	0	12009644000005	28.170870	-80.604810
INDIAN HARBOUR BCH	40 CHEYENNE CT	INDIAN HARBOUR BEAC	FL	0	12009334500003	28.146110	-80.598060
COCOA BCH POLICE DEPT	20 S ORLANDO AVE	COCOA	FL	32932	12009131500030	28.309200	-80.610850
INDIALANTIC POLICE DEPT	220 FIFTH AVE	INDIALANTIC	FL	32903	12009333750005	28.090890	-80.570130
MELBOURNE BEACH POLICE DEPT	505 CINNAMON DR	MELBOURNE BEACH	FL	32951	12009440000006	28.067430	-80.564700
LEWIS CARROLL ELEMENTARY	1 SKYLINE BLVD	MERRITT ISLAND	FL	32953		28.393850	-80.699900
CAPE VIEW ELEMENTARY	8440 N ROSALIND AV	CAPE CANAVERAL	FL	0	12009102500005	28.392800	-80.599380
DEVINE MERCY CATHOLIC SCHOOL	1940 N COURTENAY PKWY	MERRITT ISLAND	FL	32953		28.390830	-80.702980
PALM CHAPEL CHRISTIAN SCHOOL	1890 N COURTENAY PKWY	MERRITT ISLAND	FL	32953		28.389260	-80.702750
GARDENDALE ELEMENTARY	GROVE BLVD	MERRITT ISLAND	FL	32953		28.378720	-80.706800
AUDUBON ELEMENTARY	1201 N BANANA RIVER DR	MERRITT ISLAND	FL	32953		28.377040	-80.669280
MERRITT ISLAND HIGH	100 E MUSTAND WAY	MERRITT ISLAND	FL	32953		28.376250	-80.701400
CHURCH OF OUR SAVIOUR	5301 N ATLANTIC AV	COCOA	FL	0	12009131500037	28.366240	-80.607230
EDGEWOOD JUNIOR HIGH	180 E MERRITT AV	MERRITT ISLAND	FL	32953		28.361750	-80.695550
MILA ELEMENTARY	288 W MERRITT AV	MERRITT ISLAND	FL	32953		28.361650	-80.703280
BARRY UNIVERSITY	41 E MERRITT AV	MERRITT ISLAND	FL	32953		28.360630	-80.699360
MERRITT ISLAND CHRISTIAN SCHOO	140 MAGNOLIA AV		FL	0		28.356050	-80.701700
ST MARKS ACADEMY	4 CHURCH ST	COCOA	FL	0	12009131500039	28.353650	-80.724900
TROPICAL ELEMENTARY	885 S COURTENAY PKY	MERRITT ISLAND	FL	32953		28.341340	-80.695080
THOMAS JEFFERSON JR HIGH	1275 S COURTENAY PKWY	MERRITT ISLAND	FL	32953		28.334560	-80.686970
MICHAEL BIEBINK SCHOOL	1900 S TROPICAL TR	MERRITT ISLAND	FL	32953		28.323070	-80.689350
COCOA BEACH HIGH	1500 MINUTEMEN CSWY	COCOA	FL	0	12009131500041	28.317550	-80.626830
THEODORE ROOSEVELT K-8	1400 MINUTEMEN CSWY	COCOA	FL	0	12009131500042	28.317540	-80.626300
COCOA BEACH CHRISTIAN SCHOOL	830 S ATLANTIC AV	COCOA	FL	0	12009131500044	28.303290	-80.609400
EMBRY RIDDLE AERONAUTICAL UNIV	1140 SCHOOL AV		FL	0		28.228120	-80.602380

Brevard County Critical Facilities							
FACILITY NAME	**ADDRESS**	**CITY**	**STATE**	**ZIP**	**FACILITY NUMBER**	**LATITUDE**	**LONGITUDE**
SEA PARK ELEMENTARY	300 SEA PARK BLVD	SATELLITE BEACH	FL	0	12009644000006	28.202500	-80.604360
SATELLITE HIGH	300 SCORPION CT	SATELLITE BEACH	FL	0	12009644000007	28.186360	-80.597400
SPESSARD L HOLLAND ELEMENTARY	50 HOLLAND CT	SATELLITE BEACH	FL	0	12009644000008	28.185400	-80.604000
DELAURA JUNIOR HIGH	300 JACKSON AV	SATELLITE BEACH	FL	0	12009644000009	28.183450	-80.597000
SURFSIDE ELEMENTARY	401 CASSIA BLVD	SATELLITE BEACH	FL	0	12009644000010	28.171450	-80.598800
ESPECIALLY FOR CHILDREN	1230 BANANA RIVER DR	INDIAN HARBOUR BEAC	FL	0	12009334500004	28.152100	-80.597990
OCEAN BREEZE ELEMENTARY	1101 CHEYENNE DR	INDIAN HARBOUR BEAC	FL	0	12009334500005	28.149570	-80.591760
BREVARD CO PUBLIC SAFETY - STA #83	5455 OLD DIXIE HIGHWAY	GRANT	FL	32949000		27.928330	-80.528060
BREVARD CO ROAD & BRIDGE-CENTRAL AREA	555 CONE ROAD	MERRITT ISLAND	FL	32952000	12009442750002	28.345830	-80.689440
BREVARD CO ROAD AND BRIDGE-TRAFFIC OP	580 MANOR DRIVE	MERRITT ISLAND	FL	32952000	12009442750003	28.345000	-80.688890
BREVARD CO WWTP-SO BEACHES REGIONAL	2800-S. HIGHWAY A1A	MELBOURNE BEACH	FL	32951000	12009440000001	28.041670	-80.547220
CAPE CANAVERAL WWTP	600 TOWER BOULEVARD	CAPE CANAVERAL	FL	32920000	12009102500003	28.393060	-80.619440
COCOA BEACH POLICE DEPT	2 SOUTH ORLANDO AVENUE	COCOA	FL	32931000	12009131500008	28.325000	-80.645830
COCOA BEACH WATER RECLAMATION	1600 WESTEND MINUTEMEN CAUSEWAY	COCOA	FL	32931000	12009131500011	28.325000	-80.645830
COCOA BEACH, FIRE STATION #1	25 SOUTH ORLANDO AVENUE	COCOA	FL	32931000	12009131500013	28.325000	-80.645830
COCOA BEACH, FIRE STATION #2	151 WEST VOLUSIA LANE	COCOA	FL	32931000	12009131500014	28.325000	-80.645830
HOSPITAL, CAPE CANAVERAL	P.O. BOX 320069 (STATE ROAD #520)	COCOA	FL	32932006	12009131500016	28.361110	-80.622220
INDIALANTIC FIRE STATION	216 FOURTH AVE	INDIALANTIC	FL	32903000	12009333750001	28.090830	-80.570280
INDIAN HARBOUR BEACH POLICE DEPT	2055 S. PATRICK DRIVE 40 CHEYENNE COUR	INDIAN HARBOUR BEAC	FL	32937000	12009334500001	28.146110	-80.598000
SCHOOL BOARD, CARROLL ELEMENTARY	1 SKYLINE BLVD.	MERRITT ISLAND	FL	32953309	12009442750005	28.394440	-80.699720
SCHOOL BOARD, COCOA BEACH HIGH SCHOOL	1500 MINUTEMAN CAUSEWAY	COCOA	FL	32931209	12009131500021	28.316670	-80.631390
RIVERSIDE CHRISTIAN ACADEMY	3333 N RIVERSIDE DR	INDIALANTIC	FL	0	12009333750006	28.130720	-80.591230
EAU GALLIE HIGH	1400 COMMODORE BLVD	MELBOURNE	FL	0	12009439750046	28.128360	-80.647680
HERBERT C HOOVER JUNIOR HIGH	1 HAWK HAVEN DR	INDIALANTIC	FL	0	12009333750007	28.101550	-80.575040
INDIALANTIC ELEMENTARY	1050 N PALM AV	INDIALANTIC	FL	0	12009333750008	28.096430	-80.573360
GEMINI ELEMENTARY	2100 OAK ST	MELBOURNE BEACH	FL	0	12009440000007	28.054730	-80.556130

Brevard County Critical Facilities							
FACILITY NAME	**ADDRESS**	**CITY**	**STATE**	**ZIP**	**FACILITY NUMBER**	**LATITUDE**	**LONGITUDE**
TITUSVILLE HIGH	150 TERRIER TRAIL	TITUSVILLE	FL	0	12009719000036	28.592330	-80.804240
ST TERESA CATHOLIC SCHOOL	207 OJIBWAY AV	TITUSVILLE	FL	0	12009719000041	28.580950	-80.803880
FAIRGLEN ELEMENTARY	201 INDIAN TRAIL	COCOA	FL	0	12009131500047	28.438050	-80.760470
CAPE CANAVERAL HOSPITAL	701 W COCOA BEACH CAUSEWAY	COCOA	FL	0	12009131500051	28.358820	-80.623370
FIRE STATION	113 HOPKINS AV S	TITUSVILLE	FL	32796	12009719000048	28.613630	-80.808070
FIRE STATION	6400 TROPICAL TRL N	MERRITT ISLAND N	FL	0		28.471710	-80.710810
FIRE STATION	300 ALMA BLVD	MERRITT ISLAND	FL	32953	12009442750012	28.384130	-80.707780
FIRE STATION	840 BANANA RIVER DR N	MERRITT ISLAND NE	FL	0		28.371070	-80.668090
FIRE STATION	151 VOLUSIA LA W	COCOA	FL	32931	12009131500053	28.359170	-80.610440
FIRE STATION	902 AIRPORT RD	MERRITT ISLAND	FL	32952	12009442750013	28.341560	-80.690660
FIRE STATION	25 ORLANDO AV S	COCOA	FL	32931	12009131500056	28.317340	-80.609920
FIRE STATION	299 SEA PARK BLVD	SATELLITE BEACH	FL	0	12009644000012	28.204050	-80.603700
FIRE STATION	216 FOURTH AV	INDIALANTIC	FL	32903	12009333750010	28.090890	-80.570260
FIRE STATION	2550 A1A HWY S	MELBOURNE BEACH	FL	31951	12009440000008	28.047800	-80.551680
FIRE STATION	5455 OLD DIXIE HWY	GRANT	FL	32949		27.928230	-80.527540
FIRE STATION	7400 A1A HWY	SUNNYLAND BEACH	FL	32951		27.927300	-80.486910
FIRE STATION	190 JACKSON AV	CAPE CANAVERAL	FL	32920	12009102500007	28.386930	-80.604730
FIRE STATION	1390 PATRICK DR S	SATELLITE BEACH	FL	0	12009644000013	28.172390	-80.606750
FIRE STATION	505 OCEAN AV.	MELBOURNE BEACH	FL	32951	12009440000009	28.067460	-80.564230
FIRE STATION	600 WALLACE AV	INDIAN HARBOUR BEAC	FL	0	12009334500012	28.139750	-80.583490
FIRE STATION	505 1/2 OCEAN AV.	MELBOURNE BEACH	FL	0	12009440000010	28.067290	-80.564230
FIRE STATION	418 PINE ST	TITUSVILLE	FL	0	12009719000053	28.610060	-80.810910
FIRE STATION		INDIAN HARBOUR BEAC	FL	0	12009334500013	28.150510	-80.599370
FIRE STATION		PAFB	FL	0		28.271290	-80.606580
BCU - SYKES CREEK REGIONAL WWTP			FL	0		28.423890	-80.705670
SOUTH BREVARD WATER CO-OP			FL	0		27.927320	-80.488580
SOUTH BREVARD WATER CO-OP			FL	0		27.927320	-80.488580
CITY OF COCOA - BANANA RIVER PUMP STA			FL	0		28.359490	-80.654480
CITY OF MELBOURNE - GRANT STREET WRF		MELBOURNE	FL	0	12009439750090	28.073070	-80.609480

Brevard County Critical Facilities							
FACILITY NAME	ADDRESS	CITY	STATE	ZIP	FACILITY NUMBER	LATITUDE	LONGITUDE
CITY OF MELBOURNE - GRANT STREET WRF		MELBOURNE	FL	0	12009439750091	28.073070	-80.609480
CITY OF TITUSVILLE - SAND POINT WRF		TITUSVILLE	FL	0	12009719000065	28.623660	-80.816940
CITY OF TITUSVILLE - SAND POINT WRF		TITUSVILLE	FL	0	12009719000066	28.623660	-80.816940
CITY OF TITUSVILLE - SAND POINT WRF		TITUSVILLE	FL	0	12009719000067	28.623660	-80.816940
BCU - SOUTH BEACHES REGIONAL WWTP			FL	0		28.040750	-80.548760
BCU - SOUTH BEACHES REGIONAL WWTP			FL	0		28.040750	-80.548760
CITY OF COCOA BEACH - WATER RECLAM. F		COCOA	FL	0	12009131500068	28.317120	-80.632630
COLONY PARK UTILITIES - WWTP			FL	0		28.478030	-80.712420
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
PATRICK AIR FORCE BASE			FL	0		28.253240	-80.607630
CAPE CANAVERAL 36 A&B			FL	0		28.472710	-80.540790
CAPE CANAVERAL #40			FL	0		28.561680	-80.577350
CAPE CANAVERAL #40			FL	0		28.561680	-80.577350
CAPE CANAVERAL #40			FL	0		28.561680	-80.577350
CAPE CANAVERAL #41			FL	0		28.583180	-80.583090
CAPE CANAVERAL #41			FL	0		28.583180	-80.583090
CAPE CANAVERAL #41			FL	0		28.583180	-80.583090
CAPE CANAVERAL AIR FORCE STATION			FL	0		28.490980	-80.577390
CAPE CANAVERAL AIR FORCE STATION			FL	0		28.490980	-80.577390
CAPE CANAVERAL AIR FORCE STATION			FL	0		28.490980	-80.577390
SEWER LIFT STATION # 45	DIXON/INDIAN RIVER DR.	COCOA	FL	0	12009131500089	28.391360	-80.738890
SEWER LIFT STATION # 1	100 RIVERSIDE DR.	COCOA	FL	0	12009131500132	28.360470	-80.727030
BCU - SYKES CREEK REGIONAL WWTP			FL	0		28.423890	-80.705670
SOUTH BREVARD WATER CO-OP			FL	0		27.927320	-80.488580
SOUTH BREVARD WATER CO-OP			FL	0		27.927320	-80.488580

Brevard County Critical Facilities							
FACILITY NAME	ADDRESS	CITY	STATE	ZIP	FACILITY NUMBER	LATITUDE	LONGITUDE
CITY OF COCOA - BANANA RIVER PUMP STA			FL	0		28.359490	-80.654480
CITY OF MELBOURNE - GRANT STREET WRF			FL	0		28.073070	-80.609480
CITY OF MELBOURNE - GRANT STREET WRF			FL	0		28.073070	-80.609480
CITY OF TITUSVILLE - SAND POINT WRF			FL	0		28.623660	-80.816940
CITY OF TITUSVILLE - SAND POINT WRF			FL	0		28.623660	-80.816940
CITY OF TITUSVILLE - SAND POINT WRF			FL	0		28.623660	-80.816940
BCU - SOUTH BEACHES REGIONAL WWTP			FL	0		28.040750	-80.548760
BCU - SOUTH BEACHES REGIONAL WWTP			FL	0		28.040750	-80.548760
CITY OF COCOA BEACH - WATER RECLAM. F			FL	0		28.317120	-80.632630
AT&T - CELLULAR ONE MERRITT ISLAND			FL	0		28.449850	-80.700180
COLONY PARK UTILITIES - WWTP			FL	0		28.478030	-80.712420
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
NASA - JOHN F. KENNEDY SPACE CENTER (			FL	0		28.586670	-80.650360
PATRICK AIR FORCE BASE			FL	0		28.253240	-80.607630
CAPE CANAVERAL AIR FORCE STATION			FL	0		28.490980	-80.577390
CAPE CANAVERAL AIR FORCE STATION			FL	0		28.490980	-80.577390
CAPE CANAVERAL AIR FORCE STATION			FL	0		28.490980	-80.577390
BCU - SYKES CREEK REGIONAL WWTP			FL	0		28.423890	-80.705670
SOUTH BREVARD WATER CO-OP			FL	0		27.927320	-80.488580
SOUTH BREVARD WATER CO-OP			FL	0		27.927320	-80.488580
CITY OF COCOA - BANANA RIVER PUMP STA			FL	0		28.359490	-80.654480
CITY OF MELBOURNE - GRANT STREET WRF			FL	0		28.073070	-80.609480
CITY OF MELBOURNE - GRANT STREET WRF			FL	0		28.073070	-80.609480

Brevard County Critical Facilities							
FACILITY NAME	**ADDRESS**	**CITY**	**STATE**	**ZIP**	**FACILITY NUMBER**	**LATITUDE**	**LONGITUDE**
CITY OF MELBOURNE - FRONT ST. BOOSTER			FL	0		28.080040	-80.599780
PRAXAIR - LINDE DIV. AIR SEPERATION P			FL	0		28.674300	-80.827990
CITY OF TITUSVILLE - SAND POINT WRF			FL	0		28.623660	-80.816940
CITY OF TITUSVILLE - SAND POINT WRF			FL	0		28.623660	-80.816940
CITY OF TITUSVILLE - SAND POINT WRF			FL	0		28.623660	-80.816940
BCU - SOUTH BEACHES REGIONAL WWTP			FL	0		28.040750	-80.548760
BCU - SOUTH BEACHES REGIONAL WWTP			FL	0		28.040750	-80.548760
CITY OF COCOA BEACH - WATER RECLAM. F			FL	0		28.317120	-80.632630
COLONY PARK UTILITIES - WWTP			FL	0		28.478030	-80.712420
PATRICK AIR FORCE BASE			FL	0		28.253240	-80.607630
NORTHGATE PROPERTIES - WTP & WWTP			FL	0		28.586670	-80.650360
FIRE STATION	1116 PINETREE DR	INDIAN HARBOUR BEAC	FL	32937000	12009334500008	0.000000	0.000000

APPENDIX G

VOLUSIA COUNTY CRITICAL FACILITIES			
FACILITY	**ADDRESS**	**CITY**	**ADDRESS**

South Beach Fire Station	4840 S. Atlantic Ave	County	4840 S. ATLANTIC AVE
Police Department	170 West Granada Blvd	Ormond Beach	170 WEST GRANADA BLVD
Fire Station	160 E. Granada Blvd	Ormond Beach	160 E. GRANADA BLVD
Fire Station	170 W. Granada Blvd	Ormond Beach	170 W. GRANADA BLVD
BT Utility Plant	35 Breakaway Trail	Ormond Beach	35 BREAKAWAY TRAIL
Halifax Onc. L/S	W. Granada Blvd	Ormond Beach	0 W. GRANADA BLVD
Lift Station 11 M	Timberline Tr & Main Tr	Ormond Beach	TIMBERLINE TR. & MAIN TR.
Lift Station 5 M	Misner's Branch & SR 40	Ormond Beach	MISNERS TR & GRANADA BLVD
Lift Station 8 M	N. Nova Rd & Florida East Coast Railroad	Ormond Beach	N. NOVA RD & FLORIDA EAST COAST RAI
Lift Station 8 M 3	River Bluff Dr & La Costa CT	Ormond Beach	RIVER BLUFF DR & LA COSTA CT
Lift Station 6 P	Neptune & John Anderson	Ormond Beach	NEPTUNE & JOHN ANDERSON
Lift Station 9 M	Main Tr & Shady Branch Tr	Ormond Beach	MAIN TR & SHADY BRANCH TR
Standish Ground Tank	Standish Dr. & John Anderson Dr.	Ormond Beach	STANDISH DR. & JOHN ANDERSON DR.
Water Plant	301 Jefferson St	Ormond Beach	301 JEFFERSON St
Water Tower	Airport Rd. & Leeway Tr.	Ormond Beach	AIRPORT RD. & LEEWAY TR.
WWTP	N. Orchard & Wilmette Ave	Ormond Beach	N. ORCHARD & WILMETTE AVE
Civil - Daytona	250 N. Beach Street	Daytona Beach	250 N. BEACH STREET
Fire Station #1	301 S. Beach St.	Daytona Beach	301 S. BEACH ST.
Fire Station #5	627 Nova Rd.	Daytona Beach	627 NOVA RD.
Central Services	950 Bellevue	Daytona Beach	948 BELLEVUE
Lift Station 97	2500 LPGA Blvd	Daytona Beach	2500 LPGA BLVD
Lift Station 100	100 Tournament Dr.	Daytona Beach	100 TOURNAMENT DR
Criminal Justice Center	251 North Ridgewood Ave	Daytona Beach	251 NORTH RIDGEWOOD AVE
Daytona Beach Police Dept.	990 Orange Ave	Daytona Beach	990 ORANGE AVE
Daytona Beach Police Dept.	510 Harvey Ave	Daytona Beach	510 HARVEY Ave
Master Pump Station	117 Seaway Ave	Daytona Beach Shores	117 SEAWAY AVE
River Point Sewer Station	3400 S. Peninsula	Daytona Beach Shores	3500 S. PENINSULA
Sewer Pump Station #1	3751 Cardinal Blvd	Daytona Beach Shores	3751 CARDINAL BLVD
Sewer Pump Station #2	113 Dunlawton Blvd	Daytona Beach Shores	113 DUNLAWTON BLVD
Sewer Pump Station #3	133 Atares Ave	Daytona Beach Shores	133 ATARES AVE
Sewer Pump Station #4	2800 S. Atlantic Ave	Daytona Beach Shores	2800 S. ATLANTIC AVE
Sewer Pump Station #5	2422 S. Atlantic Ave	Daytona Beach Shores	2422 S. ATLANTIC AVE

VOLUSIA COUNTY CRITICAL FACILITIES

FACILITY	ADDRESS	CITY	ADDRESS
Sewer Pump Station #7	Florida Shores Blvd & S. Peninsula	Daytona Beach Shores	FLORIDA SHORES BLVD & S. PENINSULA
Sewer Pump Station #9	2900 S. Atlantic Ave	Daytona Beach Shores	2900 S. ATLANTIC AVE
Fire Station	2628 Hibiscus Dr.	Edgewater	2628 HIBISUCS DR
Fire Station	1651 S. Ridgewood	Edgewater	1651 S. RIDGEWOOD
Police Department	135 E. Park Ave	Edgewater	135 E. PARK AVE
Elevated water tank	Jarecki Ave.	Holly Hill	JARECKI AVE & LPGA BLVD

Lift Station #1	475 Carswell Ave	Holly Hill	475 CARSWELL AVE
Lift Station #10	410 Dorothy Ave	Holly Hill	410 DOROTHY AVE
Lift Station #2	231 Riverside Dr.	Holly Hill	231 RIVERSIDE DR.
Lift Station #3	504 Riverside Dr.	Holly Hill	504 RIVERSIDE DR.
Lift Station #4	345 10th St.	Holly Hill	345 10TH ST.
Lift Station #5	946 Riverside Dr.	Holly Hill	946 RIVERSIDE DR.
Lift Station #6	1136 State Ave	Holly Hill	1136 STATE AVE
Lift Station #7	1300 Riverside Dr.	Holly Hill	1300 RIVERSIDE DR.
Lift Station #9	1601 Riverside Dr	Holly Hill	1601 RIVERSIDE DR
Lift Station #10-A	429 3rd St	Holly Hill	429 3RD ST
Lift Station #11	440 Magnolia Ave	Holly Hill	440 MAGNOLIA AVE
Lift Station #11-A	702 Commercial Ave	Holly Hill	702 COMMERCIAL AVE
Lift Station #12	620 Center Ln.	Holly Hill	620 CENTER LN
Lift Station #13	397 Dubs Dr.	Holly Hill	397 DUBS DR.
Lift Station #14	660 6th St.	Holly Hill	660 6TH ST.
Lift Station #16	834 8th St.	Holly Hill	834 8TH ST.
Lift Station #17	566 10th St.	Holly Hill	566 10TH ST.
Lift Station #17-A	1017 Chippewa Tr.	Holly Hill	1017 CHIPPEWA TR.
Lift Station 17-B	Great Oaks Circle	Holly Hill	GREAT OAKS & CHEROKEE
Lift Station 18	460 Walker St.	Holly Hill	460 WALKER ST.
Lift Station 18-A	1000 15th St.	Holly Hill	1000 15TH ST.
Lift Station 19	407 Flomich St.	Holly Hill	407 FLOMICH ST.
Lift Station 20	926 Flomich St.	Holly Hill	926 FLOMICH ST.
Lift Station 21	1000 Walker St.	Holly Hill	1000 WALKER ST.
Lift Station 24	944 Alabama Ave	Holly Hill	944 ALABAMA AVE
Lift Station 25	500 Calle Grande St	Ormond Beach	500 CALLE GRANDE
Well #6	455 LPGA Blvd	Holly Hill	455 LPGA BLVD
Well #11	Jarecki St. & LPGA BLVD	Holly Hill	JARECKI ST. & LPGA BLVD.
Well #12	1200 Center Ave	Holly Hill	1200 CENTER Ave
VOLUSIA COUNTY CRITICAL FACILITIES			
FACILITY	**ADDRESS**	**CITY**	**ADDRESS**
Well #12 C	15th St. & Center Ave	Holly Hill	15TH ST. & CENTER AVE
District 5/ Law Enforcement Services	101 E. Canal St.	New Smyrna Beach	101 E. CANAL ST.
Fire Station 51	103 Faulkner St.	New Smyrna Beach	103 FAULKNER ST.
Fire Station 52	309 Columbus Ave.	New Smyrna Beach	309 COLUMBUS AVE.
Fire Station 53	1400 N. Dixie Freeway	New Smyrna Beach	1400 N. DIXIE FREEWAY
Fire Station 54	813 Mary Ave	New Smyrna Beach	813 MARY AVE
Lift Station 08 - Submersible	Gorman Ct. & 10th St.	New Smyrna Beach	GORMAN CT. & 10TH ST.
Lift Station 14 - Can	Wayne Av & Lynn St	New Smyrna Beach	WAYNE AVE & LYNN ST.
Lift Station 58 - Submersible	Saxon Dr.	New Smyrna Beach	SAXON DR & CEDAR DUNES
Lift Station 59 - ABG	2051 Pioneer Rd	New Smyrna Beach	2051 PIONEER RD
Lift Station 63	2600 Turnbull Estates	New Smyrna Beach	2600 TURNBULL ESTATES

Lift Station 68 - Submersible	Engram Rd. & Ladyfish Rd.	New Smyrna Beach	ENGRAM RD. & LADYFISH RD.
Lift Station 69 - Submersible	Engram Rd. & Redfish Rd.	New Smyrna Beach	ENGRAM RD. & REDFISH RD.
Lift Station 70 - Submersible	Turtlemound Rd. and Starfish Rd.	New Smyrna Beach	TURTLEMOUND RD. & STARFISH RD.
Police Department	4680 S. Peninsula Dr.	Ponce Inlet	4680 S. PENINSULA DR.
Fire Station	46800 S. Peninsula Dr.	Ponce Inlet	4680 S. PENINSULA DR.
Fire Station #2	5839 Trailwood Dr.	Port Orange	5839 TRAILWOOD DR.
Lift Station - Emerald Isle Pl #1	4332 S. Peninsula Dr.	Port Orange	4332 S. PENINSULA DR.
Police Station	1672 S. Ridgewood Ave	South Daytona	1672 S. RIDGEWOOD AVE
Fire Station	1672 S. Ridgewood Ave	South Daytona	1672 S. RIDGEWOOD AVE
Fire Station	2107 Brian Ave	South Daytona	2107 BRIAN AVE
Aspen Lake Stormwater Pumping Station	922 Aspen Dr.	South Daytona	922 ASPEN DR.
Lift Station #01	1690 S. Palmetto Ave	South Daytona	1690 S. PALMETTO AVE
Lift Station #02	501 Big Tree Rd.	South Daytona	503 BIG TREE RD.
Lift Station #04	2323 Anastasia Dr.	South Daytona	2323 ANASTASIA DR.
Lift Station #05	635 Violet St.	South Daytona	635 VIOLET ST.
Lift Station #06	808 Valencia Rd,	South Daytona	808 VALENCIA RD,
Lift Station #08	2451 S. Ridgewood Ave	South Daytona	2451 S. RIDGEWOOD AVE
Lift Station #09	29 Sandusky Circle	South Daytona	29 SANDUSKY CIRCLE
Lift Station #10	918 Reed Canal Rd.	South Daytona	918 REED CANAL RD.
Lift Station #11	8 1/2 Spinnaker	South Daytona	8 1/2 SPINNAKER
Lift Station #12	2025 Hickorywood Dr.	South Daytona	2025 HICKORYWOOD DR.
Lift Station #13	2938 Lantern Dr.	South Daytona	2938 LANTERN DR.
Lift Station #14	794 Aspen Dr.	South Daytona	794 ASPEN DR.
VOLUSIA COUNTY CRITICAL FACILITIES			
FACILITY	**ADDRESS**	**CITY**	**ADDRESS**
Lift Station #17	1610 Magnolia Ave	South Daytona	1610 MAGNOLIA AVE
Lift Station #18	115 Bryan Cave Rd.	South Daytona	115 BRYAN CAVE RD.
Reed Canal Stormwater Control	740 Reed Canal Rd.	South Daytona	740 REED CANAL RD.
Sherwood Dr. Stormwater Pumping St.	2165 Sherwood Dr.	South Daytona	2165 SHERWOOD DR.
Law Enforcement Services	101 E. Canal St.	New Smyrna Beach	101 E. CANAL ST.
VOTRAN	950 Big Tree Rd.	New Smyrna Beach	950 BIG TREE RD.
EVAC	112 Carswell Ave	Daytona Beach	112 CARSWELL AVE
Armory	725 Ballough Rd	Daytona Beach	725 BALLOUGH RD
Chisolm Head Start Center	531 Mary Ave	New Smyrna Beach	531 MARY AVE
Ormond Beach Middle School	151 Domicilio Ave	Ormond Beach	151 DOMICILIO AVE
Ormond Beach Element. School	100 Corbin Ave	Ormond Beach	100 CORBIN AVE
Osceola Elementary School	100 Osceola Ave	Ormond Beach	100 OSCEOLA AVE
Holly Hill Middle School	1200 Center Ave	Holly Hill	1200 CENTER AVE.
Holly Hill Elementary School	1500 Center Ave.	Holly Hill	1500 CENTER AVE
Seabreeze High School	2700 N. Oleander Ave	Daytona Beach	2700 N. OLEANDER AVE
Bethune Cookman College	640 Dr Mary McLeod Bethune Blvd	Daytona Beach	640 DR MARY MCLEOD BETHUNE BLVD
Turie T Small Elem. School	800 South St.	Daytona Beach	800 SOUTH ST

Campbell Middle School	601 S. Keech St.	Daytona Beach	601 S. KEECH ST.
South Daytona Elem. School	600 Elizabeth Pl	South Daytona	600 ELIZABETH PL
Sugar Mill Elementary School	1101 Charles St.	Port Orange	1101 CHARLES ST.
Port Orange Elementary School	402 Dunlawton Ave	Port Orange	402 DUNLAWTON AVE
Longstreet Elementary School	2724 S. Peninsula Dr.	Daytona Beach	2724 S. PENINSULA DR.
New Smyrna Beach High School	100 Barracuda Blvd	New Smyrna Beach	100 BARRACUDA BLVD
Chisholm Elementary School	557 Ronnoc Ln.	New Smyrna Beach	557 RONNOC LN
Read-Pattillo Elementary School	400 Sixth St.	New Smyrna Beach	400 SIXTH ST.
New Smyrna Beach Middle School	1200 S. Myrtle Ave	New Smyrna Beach	1200 S. MYRTLE AVE
Edgewater Elementary School	500 S. Old County Rd.	Edgewater	500 S. OLD COUNTY RD.
Halifax County Fire Station	1580 Derbyshire Rd.	County	1580 DERBYSHIRE RD.
Port Orange County Fire Station	4200 S. Ridgewood Ave	County	4200 RIDGEWOOD AVE
Turnbull County Fire Station	1850 Pioneer Tr.	County	1850 PIONEER TR.
Massey Industrial Park	635 Airpark Rd.	County	635 AIRPARK RD.
New Smyrna Beach Brannon Memorial	105 S. Riverside Dr.	New Smyrna Beach	105 S. RIVERSIDE DR.
South Waterfront Park WTP	4632 Nellie St.	Edgewater	4632 NELLIE ST.
Holly Hill Industrial Area	Flomich St. and Railroad	Holly Hill	FLOMICH ST & RAILROAD
City of Holly Hill/07164 - WTPA	453 11 ST.	Holly Hill	453 LPGA BLVD
VOLUSIA COUNTY CRITICAL FACILITIES			
FACILITY	**ADDRESS**	**CITY**	**ADDRESS**
Golden Bay WWTP	200 Golden Bay Blvd	Oak Hill	GOLDEN BAY BLVD & CHEROKEE DR
New Smyrna Beach Airport Ind. Park	1504 Industrial Drive	New Smyrna Beach	1499 INDUSTRIAL DRIVE
Bert Fish Medical Center	401 Palmetto St.	New Smyrna Beach	401 PALMETTO ST.
Memorial Hospital-Ormond Beach	246 S. Atlantic Ave	Ormond Beach	246 S. ATLANTIC AVE
New Smyrna Airport Ind. Park	1500 Airway Circle	New Smyrna Beach	1500 AIRWAY CIRCLE
New Smyrna Airport Ind. Park	404 United Dr.	New Smyrna Beach	404 UNITED DR.
New Smyrna Airport Industrial Park	1486 Turnbull Bay Rd	New Smyrna Beach	1486 TURNBULL BAY RD
Holly Hill Industrial Area	LPGA Blvd & Enterprise Ct.	Holly Hill	LPGA BLVD & ENTERPRISE CT.
A T & T /21146	400 Carswell Ave	Daytona Beach	400 CARSWELL AVE

Appendix F
Responses from Jurisdictions Concerning Draft Protection Scenario Maps

I highlighted emails that add insight. However, the emails need to be divided into two groups:

Volusia County: Reactions to Draft Maps based on Elevations
Brevard County Reaction to Draft Maps based on the general guidelines.

I think that dates and a map should make this a reasonably easy task.

Message From: Danielle McCain [dmccain@malabartown.org]
Sent: Wednesday, March 17, 2004 9:06 AM
To: 'tara'
Subject: Malabar

Tara, I received the color map and decriptive text. Mr. Booth said what he could see looked fine but the area picture doesn't show all of Malabar. It only shows the very southern part of Malabar. I didn't know if you knew that. Thanks for allowing us this input.

From: Planning4u2@aol.com
Sent: Tuesday, March 02, 2004 2:08 PM
To: tara@ecfrpc.org
Subject: Re: Sea Level Rise Map Comments
Tara,

All the area in Red should be the Brown color. There probably shouldn't be any red on the map based on the development patterns. Also the area in green that runs along the northern portion of the City should be brown east of A1A.

That large red area shown is almost entirely under construction most of which are 45 foot condos.

If you have any questions, please call me 407-249-1503.

Sincerely,

Todd Peetz, AICP
City Planner
Cape Canaveral

From: Planning4u2@aol.com
Sent: Tuesday, March 02, 2004 3:58 PM
To: tara@ecfrpc.org

Subject: Re: Sea Level Rise Map Comments
Tara,

The beaches have under gone multiple renourishment efforts and my understanding is they will in the future as well. As the Port channel fills with sand they pump it out to get to the Cape Canaveral side.

My understanding is they brought in sand from some other part of the County and it was not consistent with what is on the beach and that is why the beach surf isn't all that clear. Anyway, as sea levels rise, life will get interesting for those living in Cape Canaveral.

If you have any other questions, let me know.

From: tara [tara@ecfrpc.org]
Sent: Thursday, February 19, 2004 10:35 AM
To: 'Nelson T. Lau'
Subject: responses to sea level rise

Mr. Lau,
Thank you for your response and I will make the changes you suggest.
As for your comments:

1. Since this park is a recreational park and surrounded by almost certain protection, I can change the park to “Reasonably Likely” or “Almost Certain”. If the park is capacity constrained by the amount of land (i.e. Ballfield, intensely used park, or boatyard – examples given by EPA) then it may be best to assign it “Almost Certain protection”. (It appears to me that it would be considered the above). However, if the natural shore is a key feature and there is plenty of land to allow for erosion, then the “Reasonably Likely” classification may be more appropriate. I will await your response on what classification to assign this park.
2. I will classify Whitley Marina as “Protection Almost Certain”
3. I will classify the area as “Protection Almost Certain”
4. See number 1. I will await your response on what classification to assign this park.

Responses to other comments:

1. Since the areas with the drainage ditches and canals are well behind areas that are greater than 10 feet in elevation and are not directly feeding/connected to the Indian River, we are going to take them off the map. Also, these areas would almost certainly not be reached or affected by the estimated 5 foot rise of sea level. Therefore, the areas focused on in Cocoa will be east of US 1.

2. I only focused on the area of the city which had land elevations 10 feet and under so that the necessary areas were more visible. This is why the western areas are not included on the map I emailed you.

-----Original Message-----
From: Nelson T. Lau [mailto:nlau@cocoafl.org]
Sent: Wednesday, February 18, 2004 8:23 AM
To: tara
Subject: RE: Cocoa Scenario Review

Hi Tara,

I reviewed the map, which contains the protection scenarios. I drew black arrows on the image where I think that the classification should be changed from "Protection Reasonably Likely" to "Protection Almost Certain". The map is attached in the original format you submitted to me. Here are my comments by arrow number:

1. McFarland Park: This park is a personal watercraft launching facility, which is a City of Cocoa park. To the north and south are single-family homes. Are parks not considered for protection?
2. The Whitley marina area contains a residential and professional office condominium. It should warrant as much protection as similar structures to the south, which are classified as "Protection Almost Certain".
3. This narrow strip is the edge of the westbound lanes of State Road 520 and the bridge which leads to and from Merritt Island (to the east). The absence of protection here would undermine road infrastructure.
4. Lee Wenner Park: This is another personal watercraft launching facility, and is a joint Brevard County/City of Cocoa Park. It is improved with parking facilities, playground equipment, boardwalks, docks, etc. Are parks not considered for protection?

Here are my other comments, which are separate from the four (4) arrows…

- On the left part of the map, there are many narrow strips of red. These are drainage ditches and canals. What is the policy regarding these?
- The City of Cocoa limits extends westward to Adamson Road. I have included the current city limits maps, which is in PDF format.

Thanks!
Nelson.

Hi Tara,

I concur with the information you sent to me.

I reviewed the map again and I noticed that by numbers 2, 3, and 4, there are still two small doughnut hole areas that are classified as "Protection Unlikely". They should be reclassified because everything around them is "Protection Almost Certain".

With all these changes, it appears that the entire shoreline along Cocoa will now be classified as "Protection Almost Certain".

Thank you,
Nelson Lau.

-----Original Message-----
From: tara [mailto:tara@ecfrpc.org]
Sent: Monday, March 01, 2004 4:31 PM
To: Nelson T. Lau
Subject: Cocoa Parks

Mr. Lau,
In response to the picture you sent concerning Lee Wenner and MacFarland Parks

1) Lee Wenner : I would suggest classifying as "Protection Almost Certain" as it is in close proximity to a major bridge, there appears to be "sea walls" already in place which would indicate protection practices already in effect. Also, it appears as though it is an intensely used park.

2) MacFarland park: I would suggest to classify as "Protection almost certain" as well just for the fact that it is surrounded by single family homes that would most likely be protected and this land would also be protected as to 1) aid in the protection of the surrounding houses. Or 2) this land could be protected to allow for natural erosion of the shore of the park. (I personally would assume scenario #1).

Therefore, I would suggest the parks be classified as "Protection Almost Certain". If you agree with this or would rather change either park to "Protection Reasonably Likely", let me know so that I may make the changes to the map.

Thank you.

Tara M. McCue
East Central Florida Regional Planning Council
407.623.1075

From: Tony Caravella [tcaravella@cityofcocoabeach.com]
Sent: Friday, February 13, 2004 11:52 AM
To: tara
Subject: RE:
Tara – I've reviewed the map and have some questions: Some areas identified as white has finished floor elevations lower that 10 feet, but most probably protected by a seawall (from canal). It appears light green are parks regardless of their location relative to the ocean, which these land areas would be protected by beach renourishment. I'm confused with the different shades of green identified on the island areas. Although these lands are identified as conservation on the City's future land use map I do not have knowledge that they may be classified as wetlands.

As to protection from flooding and hurricanes, the City implements the Florida Building Code and does have flood protection regulations for construction.

Anthony Caravella, AICP
Development Services Director
City of Cocoa Beach
321-868-3297 - Phone
321-868-3378 – Fax

From: Dave Watkins [watkid@palmbayflorida.org]
Sent: Tuesday, March 09, 2004 4:31 PM
To: tara
Subject: RE: Palm Bay sea level rise map
Ms. McCue:

Thanks for looking at our comments. I don't believe the City desires to change any of the proposed classifications at this time.

David Watkins
Planning Manager

From: Bruce Cooper [bcooper@satellitebeach.org]
Sent: Thursday, March 04, 2004 10:31 AM
To: 'tara'
Subject: RE: Sea Level Rise Map Comments

Dear Tara,
Appreciate your time today going over the map. Attached is a couple of notes that I have discussed with you. Let me know if you need anything else.
Based on your comments and the intent of the map, I believe that the map represents the City as intended.

Have a great day.
Bruce Cooper
Planning Director

-----Original Message-----
From: Collins, Belinda [mailto:CollinsB@CODB.US]
Sent: Tuesday, January 13, 2004 3:46 PM
To: tara
Subject: Review of Daytona Beach

Tara,

I forwarded your request to our Engineering Department and the following concerns were raised:

1. What is the purpose of the map ? If it is to establish another set of limits on land use the department is opposed to the effort does not endorse it nor does it wish to be subject to any restrictions that the development of such a map might be used to "legitimize" such restrictions.

2. When is the five-foot sea level rise projected to occur ? The department feels that there are many more issues of immediate and vital concern to which both the EPA and the Regional Planning Council could more beneficially direct their resources.

3. It was also suggested that this effort may need to be reconsidered before it goes any further.

I would appreciate a response to these concerns so that they may be properly addressed. Thank you for your help.

Belinda Collins, AICP

Principal Planner

City of Daytona Beach

From: Mark Rakowski [mrakowski@cityofnsb.com]
Sent: Thursday, January 29, 2004 9:08 AM
To: 'tara'
Subject: RE: sea level rise map

Tara,

I must say I am having a very difficult time understanding what you are driving at with this map and so is everyone else in my office. I will try to explain my confusion below after each one of your sentences. I suspect if we are having difficulty with this other jurisdictions are or may not be responding to your request.

I wish I could help more. Sorry

Mark
-----Original Message-----
From: tara [mailto:tara@ecfrpc.org]
Sent: Monday, January 26, 2004 10:43 AM
To: mrakowski@cityofnsb.com

Subject: sea level rise map

Mr. Rakowski.

I received your letter today concerning the sea level rise map. The purpose of the map is to provide the EPA (and cities) with a tool that can be used to depict the areas of the coastline that may be affected by a potential five foot rise in sea level and the areas property owners would most likely protect and those areas which would not. [Rakowski, Mark] I don't understand why anybody would not try to protect every property within the City. The data from the map will also be analyzed. [Rakowski, Mark] Analyzed for what? What we present to you is a map created using the future land use maps sent by each jurisdiction. [Rakowski, Mark] How are the future land use designations represented at all with this map? We have classified the map into general categories and elevations of 0'-5; and 5'-10'. [Rakowski, Mark] The map reads 0' - 5' and 0' - 10' and not as you described. The red and blue currently represent developed/planned developed areas (red 5-10' and blue 0-5'). [Rakowski, Mark] I think I understand this. We understand that according the category definitions I had sent you, the color classifications of many areas would change. [Rakowski, Mark] How can you change the elevation on the ground? Do you mean change the description of the colors? We do not know your jurisdiction's property value and development as well as you and that is why we are asking you to change classifications as you see fit. [Rakowski, Mark] The entire beachside (barrier island) is high property value as well as the North Causeway and lands along the river. In fact much of the mainland is fairly high property value compared to neighboring communities. However, the definition of high property value is fairly subjective. Also, are we going to protect land only based on its value? The City often has high value land very close to not as high value land. If one parcel were to be protected then the other would be. We are asking you to review any blue areas. Any areas currently colored blue that fall under the red or brown definitions, indicate on the map and we will change them as you recommend. [Rakowski, Mark] The red definition does not apply to our City. It seems as that definition is the opposite of the definition of our City. The Brown definition more closely fits the City except the part about the protection. If sea level rises 5-feet the area will be flooded unless some large levee system is built. (We provided the definitions so that you may be able to review and reclassify the areas. We thought by originally classifying the developed areas into elevations, it may be easier for your review of the property.) [Rakowski, Mark] This doesn't make sense to me. You do not need to change any red to blue because the blue color is only for property below five feet in elevation. [Rakowski, Mark] According to your map most of the City is 0' -5' and I don't think that is correct if you are referring to elevation above sea level.

Light green includes agriculture and preserve areas. [Rakowski, Mark] On the map you provided the light green areas are golf courses, schools, spoil islands and parks, essentially. If there is a mistake and you feel some of these areas should be classified differently, please indicate as such and if possible include the future land use classification so we may change that as well.[Rakowski, Mark] I don't think I can begin to change the map since it does not seem appropriate at all for our City.

For the wetland migration/mitigation, it would constitute as both. Yes, it would include areas that could be acquired for future wetlands, but may also be areas left open for wetlands to migrate to as sea level rises.[Rakowski, Mark] This is about the only section that makes any sense for our City.

I hope this helps. [Rakowski, Mark] Sorry to say that it doesn't really. Perhaps this map is appropriate for a rural area but I don't think it makes any sense for an urban community.

If you have any further questions or concerns, please feel free to contact me at 407.623.1075[Rakowski, Mark] I don't mean to appear to be uncooperative but the map doesn't fit in with our community to the point that I don't think we can comment on it.

Thank you.
Tara M. McCue
East Central Florida Regional Planning Council
407.623.1075

From: Mark Rakowski [mrakowski@cityofnsb.com]
Sent: Thursday, January 29, 2004 9:15 AM
To: 'tara'
Subject: RE: sea level rise color classifications

The entire City needs to be brown except that there is no protection. Would you be available for a conference call some time so you can try to explain this to our City Engineer and perhaps we can together figure out what you are trying to get with this map?

Mark

From: Ben Dyer [BDyer@co.volusia.fl.us]
Sent: Tuesday, January 27, 2004 8:39 AM
To: tara@ecfrpc.org
Cc: John Thomson; Montye Beamer; Ron Paradise
Subject: Re: Sea level rise map

Tara

The County has no adopted policy or plan to address the issues contained in the "Sea Level Rise Map". Therefore we have not developed categories or classifications as mentioned in your transmission below. As such the categories "Right to protection, but protection unlikely" or "Protection reasonably likely" or "Protection Almost certain" have no relevance at this time for local planning initiatives in unincorporated Volusia County. The "Sea Level Rise Map" is a theoretical document covering a geologic span of time and we do not feel it should serve as a present basis to make local land use recommendations.

As most of the area shown in the "Sea Level Rise Map" affects incorporated areas of the County you would need to contact individual Coastal Cities to find out how they view the proposed Map and its categories and classifications.

I hope this clarifies the County staff position, please call me if you have any questions.

Chapter 7: TREASURE COAST

by

Peter Merritt

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ACRONYMS

BCEP	Beach Erosion Control Program
BEBR	Bureau of Economic and Business Research
CBRA	Coastal Barrier Resources Act
CBZ	Coastal Building Zone
CCCL	Coastal Construction Control Line
CERP	Comprehensive Everglades Restoration Plan
COE	U.S. Army Corps of Engineers
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
EAR	Evaluation and Appraisal Report
EPA	U.S. Environmental Protection Agency
ESI	Environmental Sensitive Index for Coastlines
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FEMA	Federal Emergency Management Agency
FLUCCS	Florida Land Use, Cover and Forms Classification System
FLUM	Future Land Use Map
FMRI	Florida Marine Research Institute
FPL	Florida Power and Light
FS	Florida Statutes
GIS	Geographic Information System
ICW	Intracoastal Waterway
IRC	Indian River County
LIDAR	Light Detection and Ranging
MC	Martin County
NFIP	National Flood Insurance Program
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
PBC	Palm Beach County
RHA	Rivers and Harbors Act
RPC	Regional Planning Council
SFRPC	South Florida Regional Planning Council
SFWMD	South Florida Water Management District
SJRWMD	St. Johns River Water Management District
SLC	St. Lucie County
SBMP	Strategic Beach Management Plan
SWFRPC	Southwest Florida Regional Planning Council
TCRPC	Treasure Coast Regional Planning Council
USGC	United States Geologic Survey
WMD	Water Management District

SUMMARY

As part of an ongoing program evaluating global climate change, the U.S. Environmental Protection Agency (EPA) initiated a nationwide project promoting planning for and awareness of sea level rise. In 2000, the EPA issued a grant to the Southwest Florida Regional Planning Council (SWFRPC) to participate in this program and coordinate the study of sea level rise throughout Florida. In 2002, the Treasure Coast Regional Planning Council (TCRPC) entered into a contract with SWFRPC to conduct a study of sea level rise within the Treasure Coast Region.

This report creates maps of the Treasure Coast Region that distinguish the shores that are likely to be protected from erosion, inundation, and flooding from those where natural shoreline retreat is likely to take place. This report supports the EPA's national effort encouraging the long-term thinking required to deal with the issues associated with sea level rise. The ultimate goal of this project is to diminish losses to life and property from coastal hazards such as erosion and inundation, and to ensure the long-term survival of coastal wetlands.

This study follows the general approach of other sea level rise planning studies sponsored by the EPA. We used decision rules defined by a statewide approach for identifying likelihood of land use protection to characterize all uplands from 0 to 10 feet in elevation and within 1,000 feet of shoreline into the following four general categories: shore protection almost certain; shore protection likely; shore protection unlikely; and no shore protection. We assigned colors to these categories to distinguish the protection scenarios on the draft sea level rise maps prepared for each county. We then provided the draft maps to local government planners to obtain comments.

Applying the state-wide approach for assessing the likelihood of land use protection in the Treasure Coast Region resulted in the identification of 118,905 acres (83.2 percent) of uplands and 23,927 acres (16.8 percent) of wetlands in the study area. Regionally, the protection almost certain category accounted for 65.7 percent of the uplands in the study area. This was followed by protection likely (15.8 percent), protection unlikely (14.0 percent), and no protection (4.4 percent). A clear regional trend exists, reflecting an increase in the number of acres in the protection almost certain category when moving north to south from Indian River County to Palm Beach County. A total of 34 municipalities in the four counties of the Treasure Coast Region are likely to be impacted by sea level rise in the future.

This report is intended to stimulate local government planners and citizens to think about the problem of sea level rise. The maps provided in this report depict the expected response to sea level rise based on the best currently available knowledge. Local planners may decide in the future that it will be wise to retreat from lands we currently expect will be protected lands because of costs and environmental considerations. This project represents the first step in planning for sea level rise in the Treasure Coast Region.

INTRODUCTION

The earth's ocean levels have risen and fallen throughout geologic history. Recent measurements from tidal gauges worldwide indicate that ocean levels are currently rising. During the past 100 years, the global mean sea level has risen an average of about 7 inches.[1] Measurements along the United States coast indicate that sea level is rising at a rate of 10 to 12 inches per century.[2] The rate of sea level rise, however, is influenced by many factors, making it difficult to predict the exact levels over time. Twilley et al.[3] reported that global projections for sea level rise range from 5 to 35 inches over the next 100 years. Clearly, there is concern that sea level may rise at an accelerated rate in the future.

The prospect of sea level rise is of particular concern to Florida because of its expansive coastline, low elevations and flat topography , economic dependence of the tourism industry on beaches and coastal resources, and significant public and private investment in coastal areas. The 2004 population estimates indicate that Florida has about 17.5 million residents[4] and the majority of these people live and work near coastal areas. The ramifications of sea level rise in Florida could be far reaching.[5] In areas with a gently sloping shoreline, the horizontal advance of the sea can be 150 to 200 times the vertical rise.[6] A rising sea can cause increased erosion, flooding, and raise the frequency and severity of storm surges. Additionally, rising sea levels can contaminate freshwater supplies by causing saltwater intrusion into river systems, canals, groundwater aquifers, and low-lying coastal wetlands such as the Everglades ecosystem.

As part of an ongoing program evaluating global climate change, the U.S. Environmental Protection Agency (EPA) initiated a nationwide project promoting planning for and awareness of sea level rise. In 2000, the EPA issued a grant to the Southwest Florida Regional Planning Council (SWFRPC) to participate in this program and coordinate the study of sea level rise throughout Florida. This nationwide project promotes planning for sea level rise by developing maps that illustrate how communities expect to address the most fundamental question about sea level rise: Where will we retreat and where will we hold back the sea?

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[1] Warrick, R.A., C.L. Provost, M.F. Meier, J. Oerlemans, and P.L. Woodworth. 1996. Changes in sea level. Pp. 359-405 *In* Climate change 1995: The science of climate change. (J.T. Houghton, L.G. Meira Filho, B.A. Callender, N. Harris, A. Kattenberg and K. Maskell, Eds.). Cambridge University Press, London.

[2] Titus, J.G. and V.K. Narayanan. 1995. The probability of sea level rise. U.S. Environmental Protection Agency. Office of Policy, Planning, and Evaluation. EPA-230-R-95-008.

[3] Twilley, R.R., E.J. Barron, H.L. Gholz, M.A. Harwell, R.L. Miller, D.J. Reed, J.B. Rose, E.H. Siemann, R.G. Wetzel, and R.J. Zimmerman. 2001. Confronting Climate Change in the Gulf Coast Region: Prospects for sustaining our ecological heritage. Union of Concerned Scientists, Cambridge, Massachusetts, and Ecological Society of America, Washington, D.C.

[4] Bureau of Economic and Business Research. 2005. Projections of Florida population by county, 2004 – 2030. University of Florida, Bureau of Economic and Business Research Bulletin No. 141, Volume 38, No.2.

[5] Fiedler, J., F. Mays, and J. Siry, Eds. 2001. Feeling the heat in Florida: Glogal warming on the local level. Natural Resources Defense Council and Florida Climate Alliance, New York and Orlando.

[6] Leatherman, S.P., K. Zhang, and B.C. Douglas. 2000. Sea level rise shown to drive coastal erosion. EOS Transactions 81: 55-57.

The cooperative agreement between the EPA and South Florida Regional Planning Council (SFRPC) represents the first attempt to examine the long-term response to sea level rise through land use planning in Florida. To comprehensively examine sea level rise issues throughout the state, the SWFRPC has established agreements between five other RPCs in Florida to assist in this statewide effort, and intends to coordinate with all of the coastal RPCs when funds become available. In 2002, the Treasure Coast Regional Planning Council (TCRPC) entered into a contract with SWFRPC to conduct a study of land use impacts and solutions to sea level rise within the Treasure Coast Region. TCRPC is acting as a subcontractor to SWFRPC in completing the project. At the same time, SWFRPC entered into an agreement with the SFRPC to conduct a similar project in the South Florida Region. As part of these agreements, SFRPC is responsible for preparing the GIS maps for the TCRPC portion of the project.

This report creates maps of the Treasure Coast Region that distinguish the shores that are likely to be protected from erosion, inundation, and flooding from those areas where natural shoreline retreat is likely to take place. This report, along with the sea level rise projects being implemented by other Florida RPCs, is designed to support the EPA's national effort encouraging the long-term thinking required to deal with the issues associated with sea level rise. The ultimate goal of this project and the other projects being conducted elsewhere in Florida and the Atlantic coastal states from Georgia to Massachusetts is to diminish losses to life and property from coastal hazards such as erosion and inundation, and to ensure the long-term survival of coastal wetlands.

The sea level rise planning maps provided in this document are intended for general planning purposes. They do not represent a comprehensive program to address sea level rise, but rather constitute a planning baseline that decision makers can use when evaluating land use, infrastructure, wetland permits, and other decisions whose outcomes may be sensitive to future sea level rise, flooding, and shoreline erosion. The maps are not the result of a cost-benefit analysis, but rather the best planning judgment of the local and regional authorities responsible for land use planning.

Given the broad planning context of this study, an analysis of specific parcels is beyond the scope of this study. The maps are detailed enough, however, to identify the jurisdictions where factoring sea level rise into near-term decision making is most important. This report is intended as a starting point to help local governments engage in a dialogue about sea level rise. Communities in the region should begin to develop goals, strategies, and policies for inclusion in local government comprehensive plans. Sea level rise planning issues should become part of the discussion of all future development proposals in the coastal areas of the region.

CHARACTERISTICS OF THE REGION

The Treasure Coast's four counties are along the southeastern coast of Florida. From north to south, the counties are Indian River, St. Lucie, Martin, and Palm Beach. The Atlantic coast and lagoon system is the most prominent physiographic feature of the region. The region has approximately 100 miles of Atlantic coast line. Except for the southern part of Palm Beach County, the region has a coastal barrier island system. The region's barrier island coastline consists entirely of a sandy beach, approximately 25 percent of which is in public ownership.

Photo 1. View across Lake Worth Lagoon showing the downtown area of the City of West Palm Beach in the distance and Peanut Island in the foreground. The city's downtown is the most densely developed metropolitan area in the Treasure Coast Region. Peanut Island is home to a Palm Beach County Park with newly constructed recreational facilities, restored and created fish and wildlife habitat, Palm Beach Maritime Museum, historic former U.S. Coast Guard Station, and dredged material management area used by the Florida Inland Navigation District and the Port of Palm Beach. It is likely that portions of the city will have to take adaptive measures such as constructing larger seawalls to avoid impacts of sea level rise in future years. Similarly, Palm Beach County may need to implement land elevation and beach nourishment options to protect Peanut Island from rising seas in the future. Both cases will require extraordinary financial and political commitments within the region.

The Indian River Lagoon lies west of the barrier island from the northern boundary of the region, south to Jupiter Inlet. This estuary is designated as an Estuary of National Significance. Lake Worth Lagoon is a 20-mile-long estuary located centrally along the east coast of Palm Beach County.(See Photo 1.) The Indian River and Lake Worth lagoons are connected by the Atlantic Intracoastal Waterway, an inland navigation channel that traverses the east coast of Florida. The region's estuaries are important because they contain highly productive natural communities and

ecosystems, including seagrass beds, algal beds, oyster beds, exposed sand and shell bottoms, mud flats, tidal marshes, and mangrove swamps. Mangrove communities are the most abundant type of wetlands, with exposed vegetation bordering the estuaries of the region. Mangrove communities provide a nutrient base that is critical in maintaining the region's commercial and sport fish populations. The estuaries are heavily used by recreational boaters and are important to the marine industries. The estuaries are prime locations for boat facilities, waterfront development, and other water-related activities.

Immediately west of the lagoon system is the Atlantic coastal ridge, which parallels the present mainland edge through the region. During the Pamlico period, approximately 100,000 years ago, the ridge was the dune line when sea level was approximately 30 feet higher than it is today. In certain areas the sand dunes of the Atlantic coastal ridge reach elevations of greater than 90 feet. The ridge has well-drained sandy soils favored by urban development. Inland, a vast eastern valley occupies much of the interior of the northern three counties. This valley is drained by the St. John's, St. Lucie, and Loxahatchee rivers. Much of southern and western Palm Beach County is part of the Everglades ecosystem.

The estimated population for the Treasure Coast Region as of April 2004 was more than 1.7 million.[7] Approximately 71.7 percent of the region's population is in Palm Beach County. The population is projected to grow by approximately 59 percent over the next 25 years, especially in the region's urbanized coastal communities. Of the region's four counties and 49 municipalities , 72 percent have jurisdiction over land that is directly adjacent to the Atlantic coast, lagoon system, or Intracoastal Waterway. This includes four of the five local governments in Indian River County, all four local governments in St. Lucie County, all five local governments in Martin County, and 24 of the 38 local governments in Palm Beach County.

Figure 1 shows the general topography of the three northern Treasure Coast counties within three meters (about ten feet) above spring high water (the Palm Beach map was unfortunately garbled). Table 1 quantifies the same area.

[7] Bureau of Economic and Business Research. 2005. Projections of Florida population by county, 2004 – 2030. University of Florida, Bureau of Economic and Business Research Bulletin No. 141, Volume 38, No.2.

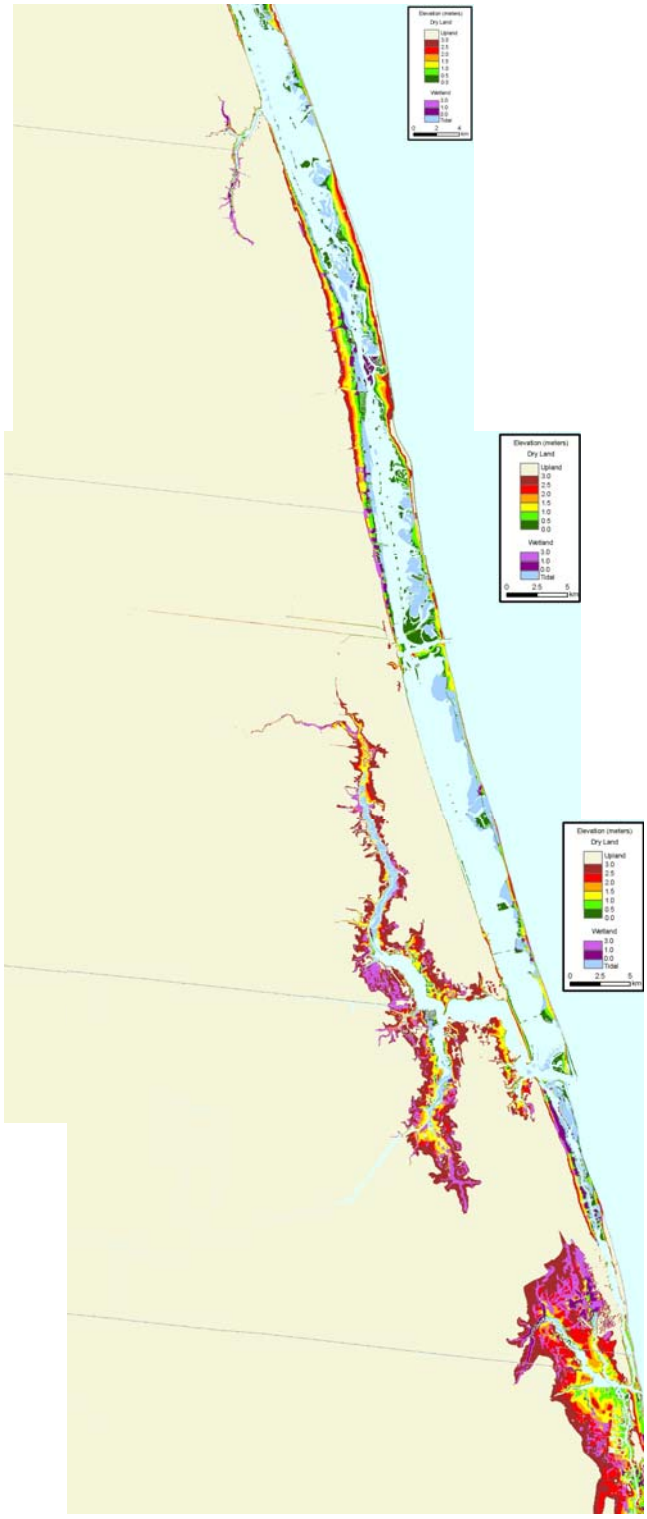


Figure 1. Coastal Elevations for Indian River, St. Lucie, and Martin Counties. Relative to Spring High Water. Source: See Table 1.

Table 1. Area of Land Close to Sea Level by County (square kilometers)											
	Elevations (m) above spring high water										
County		**0.50**	**1.00**	**1.50**	**2.00**	**2.50**	**3.00**	**3.50**	**4.00**	**4.50**	**5.00**
Indian River		8.2	16.5	26.9	34.5	41.3	49.3	54.5	59.4	67.2	77.6
St Lucie		4.1	9.2	18.3	22.1	27	50.8	66.7	81.1	182.5	212.1
Martin		4	12.1	27.3	37.8	59	109.4	135.6	162.5	324.1	363.1
Palm Beach		9.6	25.3	43.5	59.4	110.7	454.2	2058.3	3182.8	3611.5	3950.4
Total		26	63	116	154	238	664	2315	3486	4185	4603

Source: National Elevation Dataset and Titus J.G., 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. Section 1.1 in: *Background Documents Supporting Climate Change Science Program Synthesis and Assessment Product 4.1*, J.G. Titus and E.M. Strange (eds.). EPA 430R07004. U.S. EPA, Washington, DC.

SEA LEVEL RISE PREDICTIONS IN THE TREASURE COAST REGION

The global change in temperature is likely to have a number of consequences that will combine to cause sea levels to rise. The average surface temperature of the planet has risen by approximately 1°F (0.6°C) in the last 100 years. All of the warmest years on record have happened since 1980. Global warming is expected to raise surface temperatures by a few more degrees within the coming century.[8] EPA estimates suggest that there will be a 50 percent chance of a 1°C change in temperature by 2050, and a 90 percent probability of a 0.31°C rise in temperature. By 2100, there is a 90 percent chance of a change in temperature equal to last century's 0.6°C. As surface temperatures rise, added heat will penetrate the ocean and cause the layers of the ocean to warm and expand by 20 cm by 2100. These warmer temperatures may melt portions of the Greenland Ice Sheet and small glaciers as well as increase precipitation.

The SWFRPC used information in Titus and Narayanan to predict the amount of sea level rise in the Treasure Coast Region (Table 2). The projections rely on probabilities related to temperature increases and other factors. The projections in Table 2 indicate that by 2025 sea level is predicted to rise from 2.8 inches (90 percent probability) to 10.7 inches (1 percent probability) in the Treasure Coast Region. Predictions for 2200 are more dramatic, ranging from 21.0 inches (90 percent probability) to 177.3 inches (1 percent probability). These predictions underscore the importance of planning for sea level rise.

[8] Titus, J.G. and V.K. Narayanan. 1995. The probability of sea level rise. U.S. Environmental Protection Agency. Office of Policy, Planning, and Evaluation. EPA-230-R-95-008.

Table 2. Estimated Sea Level Rise for the Treasure Coast Region.

Sea Level Projection by Year[a]												
Probability (%)	**2025**		**2050**		**2075**		**2100**		**2150**		**2200**	
	cm	**inches**	**cm**	**inches**	**cm**	**inches**	**cm**	**inches**	**cm**	**inches**	**cm**	**inches**
90	**7**	**2.8**	**13**	**5.0**	**20**	**7.7**	**26**	**10.4**	**40**	**15.7**	**53**	**21.0**
80	**9**	**3.6**	**17**	**6.6**	**26**	**10.1**	**35**	**13.9**	**53**	**20.8**	**71**	**28.1**
70	**11**	**4.4**	**20**	**7.8**	**30**	**11.6**	**41**	**16.3**	**63**	**24.7**	**85**	**33.6**
60	**12**	**4.7**	**22**	**8.6**	**34**	**13.2**	**45**	**17.8**	**72**	**28.3**	**99**	**39.1**
50	**13**	**5.1**	**24**	**9.4**	**37**	**14.4**	**50**	**19.8**	**80**	**31.4**	**112**	**44.2**
40	**14**	**5.5**	**27**	**10.6**	**41**	**16.0**	**55**	**21.8**	**90**	**35.4**	**126**	**49.7**
30	**16**	**6.3**	**29**	**11.3**	**44**	**17.1**	**61**	**24.1**	**102**	**40.1**	**146**	**57.6**
20	**17**	**6.7**	**32**	**12.5**	**49**	**19.1**	**69**	**27.3**	**117**	**46.0**	**173**	**68.2**
10	**20**	**7.9**	**37**	**14.5**	**57**	**22.3**	**80**	**31.6**	**143**	**56.2**	**222**	**87.5**
5	**22**	**8.7**	**41**	**16.1**	**63**	**24.6**	**91**	**35.9**	**171**	**67.2**	**279**	**110.0**
2.5	**25**	**9.9**	**45**	**17.6**	**70**	**27.4**	**103**	**40.7**	**204**	**80.2**	**344**	**135.6**
1	**27**	**10.6**	**49**	**19.2**	**77**	**30.1**	**117**	**46.2**	**247**	**97.2**	**450**	**177.3**
Mean	**13**	**5.1**	**25**	**9.8**	**38**	**14.8**	**52**	**20.6**	**88**	**34.6**	**129**	**50.9**

[a]The results of this table are based on Tables 9-1 and 9-2 of the EPA Report "The Probability of Sea Level Rise" (Titus and Narayanan 1995). Basically, the formula is multiplying the historical sea level rise (2.3 mm/yr) in Southeast Florida (closest point used is Miami Beach, Fl., Table 9-2) by the future number of years from 1990 plus the Normalized Sea Level Projections in Table 9-1. In summary, the EPA Report relied on various scientific opinions regarding sea level changes affected by factors such as radiative forcing caused by both greenhouse gases and sulfate aerosols, global warming and thermal expansion, polar temperatures and precipitation, and the contributions to sea level from Greenland, Antarctica, and small glaciers.

MAPPING METHODOLOGY

General Approach

This study follows the general approach of the sea level rise planning studies that the EPA is sponsoring for other Atlantic Coast states. During the original design of this study, EPA and SWFRPC sought to identify a study area that could be implemented throughout Florida and that would include all land that might be significantly affected by sea level rise during the next century. If possible, they also sought to include land that might be affected over a longer period of time, but that goal had to be balanced against the extra cost of studying a larger study area.

Similar to other sea level rise planning studies in Florida, this study considers all land below the 10-foot (NGVD) contour.[9] We used the GIS data sets from the SFWMD and SJRWMD to define

[9] 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

the study area by identifying all locations that have an elevation of less than 10 feet. The rationale for the 10-foot elevation criterion is that 1) this detail of topographic information can be gathered statewide, and 2) tidal influences can extend almost to the 5-foot contour, which means the 10-foot contour is approximately the highest elevation that might be inundated by tides if sea level rises several feet over current levels. Although the land below 5 feet is the most vulnerable, limiting the study area to such low land would exclude many areas that are potentially vulnerable to sea level rise during the next century. Statewide, most of the land between 5 and 10 feet is already below the base flood elevation for a 100-year storm, and hence will experience greater flooding as sea level rises. Furthermore, topographic contours are only estimates. Under the National Mapping Standards, up to 10 percent of the land can be higher or lower than the map indicates by more than one-quarter of the contour interval. Thus a substantial amount of land depicted as between 5 and 10 feet may in reality be between 3 and 4 feet; using the 10-foot contour to delineate the study area helps ensure that this very low land is considered.

The study area also includes all land within 1000 feet of the shore, even if it is above the 10-foot contour, for two reasons. First, rising sea level and other coastal processes can cause beaches, dunes, bluffs, and other land to erode even though they may have sufficient elevation to avoid direct inundation by rising water levels. The 1000-foot extension is somewhat arbitrary; we chose that distance primarily to be consistent with similar studies in other states. Second, extending the study area 1000 feet inland also ensures that the study area is large enough to be seen along the entire shore on the county-scale maps produced by this study.

Protection Scenarios

Creation of the final project maps followed closely the criteria laid out in the statewide approach for identifying likelihood of land use protection (Table 3). This table represents a summary of the approaches taken by other states but adapted for use in Florida by SWFRPC and EPA with input from the other regional planning councils. We used this approach to characterize all uplands from 0 to 10 feet in elevation and within 1000 feet of shoreline into the following four general categories: Protection almost certain, Protection likely, Protection Unlikely, and No Protection. We assigned colors to these categories to distinguish the protection scenarios on the draft sea level rise maps prepared for each county. We then gave the draft maps to the local governments to obtain any general or site-specific corrections to the maps. The protection scenarios shown on the maps in this study illustrate the areas that planners within this region expect will be protected, or not protected, from erosion and inundation in the

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

Table 3. State-wide approach for identifying likelihood of land use protection.

Likelihood of Protection[2]	Land Use Category[1]	Source Used to Identify Land Area
Protection almost certain (brown)	Existing developed land (FLUCCS Level 1-100 Urban and Built-up) within extensively developed areas and/or designated growth areas.	Developed lands identified from water management districts (WMDs) existing Florida Land Use, Cover and Forms Classification System (FLUCCS) as defined by Florida Department of Transportation Handbook (January 1999); growth areas identified from planner input and local comprehensive plans.
	Future development within extensively developed areas and/or designated growth areas (residential/office/commercial/industrial).	Generalized future land use maps from local comprehensive plans, local planner input, and WMDs.
	Extensively used parks operated for purposes other than conservation and have current protection [3] or are surrounded by brown colored land uses.	County-owned, state-owned, and federally owned lands (based on local knowledge) or lands defined as 180 Recreational on the Level 1 FLUCCS, local planner input, and Florida Marine Research Info System (FMRIS) for current protection measures.
	Mobile home developments outside of coastal high hazard,[4] expected to gentrify, or connected to central sewer and water.	Local planner input and current regional hurricane evacuation studies.
Protection likely (red)	Existing development within less densely developed areas, outside of growth areas.	Developed lands identified from WMD existing FLUCCS; growth areas identified from local planner input, local comprehensive plans, and current regional hurricane evacuation studies.
	Mobile home development within a coastal high hazard area that is neither anticipated to gentrify nor on central water and sewer.	Local comprehensive plans and current regional hurricane evacuation studies.
	Projected future development outside of growth areas could be estate land use on future land use map.	Local planner input
	Moderately used parks operated for purposes other than conservation and have no current protection or are surrounded by red colored land uses.	County-owned, state-owned, and federally owned lands (based on local knowledge) or lands defined as 180 Recreational on the Level 1 FLUCCS, local planner input, and FMRIS.
	Coastal areas that are extensively developed but are ineligible for beach nourishment funding due to CBRA (or possibly private beaches unless case can be made that they will convert to public)	Flood Insurance Rate Maps for CBRA, local knowledge for beach nourishment.
	Undeveloped areas where most of the land will be developed, but a park or refuge is also planned, and the boundaries have not yet been defined so we are unable to designate which areas are brown and which are green; so red is a compromise between.	Local planner input
	Agricultural areas where development is not expected, but where there is a history of erecting shore protection structures to protect farmland.	Local planner input
	Dredge spoil areas likely to continue to receive spoils or be developed, and hence unlikely to convert to tidal wetland as sea level rises	Local planner input
	Military lands in areas where protection is not certain.	FLUCCS Level 173

Likelihood of Protection[2]	Land Use Category[1]	Source Used to Identify Land Area
Protection unlikely (blue)	Undeveloped privately owned lands that are in areas expected to remain sparsely developed (i.e., not in a designated growth area and not expected to be developed) and there is no history of erecting shore protection structures to protect farms and forests.	Undeveloped lands identified from WMD existing FLUCCS Level 1- 160 mining, 200 Agriculture, 300 Rangeland, 400 Upland Forest, 700 barren land ; Nongrowth areas identified from planner input, local comprehensive plans, Flood Insurance Rate Maps for CBRA, and current regional hurricane evacuation studies.
	Unbridged barrier island and CBRA areas or within a coastal high hazard area that are not likely to become developed enough to justify private beach nourishment.	Flood Insurance Rate Maps for CBRA, local knowledge for beach nourishment, and local planner input.
	Minimally used parks operated partly for conservation, have no current protection or are surrounded by blue colored land uses, but for which we can articulate a reason for expecting that the shore might be protected.	County-owned, state-owned, and federally owned lands (based on local knowledge) or lands defined as preserve on future land use map, local planner input, and FMRIS.
	Undeveloped areas where most of the land will be part of a wildlife reserve, but where some of it will probably be developed; and the boundaries have not yet been defined so we are unable to designate which areas are brown and which are green; so blue is a compromise between red and green.	Local planner input
	Dredge spoil areas unlikely to continue to receive spoils or be developed, and hence likely to convert to tidal wetland as sea level rises	Local planner input
	Conservation easements (unless they preclude shore protection)	Local planner input
No protection (light green)	Private lands owned by conservation groups (when data available)	Private conservation lands
	Conservation easements that preclude shore protection	Local planner input
	Wildlife refuges, portions of parks operated for conservation by agencies with a policy preference for allowing natural processes (e.g. National Park Service)	Local planner input
	Publicly owned natural lands or parks with little or no prospect for access for public use.	County-owned, state-owned, and federally owned lands (based on local knowledge) defined as preserve on the future land use map and local planner input.

Notes:
1. These generalized land use categories describe typical decisions applied in the county studies. County-specific differences in these decisions and site-specific departures from this approach are discussed in the county-specific sections of this report.
2. Colored line file should be used in areas where less than 10 feet elevations exist within 1,000 feet of the rising sea or color cannot be seen on ledger paper map.
3. Current protection may include sea walls, rock revetments, beach renourishment, levees, spreader swales, or dikes.
4. Coastal High Hazard Area defined in Rule 9J-5 FAC as the Category 1 hurricane evacuation zone and/or storm surge zone.

future. Those expectations incorporate state policies and regulations, local concerns, land use data, and general planning judgment.

Generally, the first step in assigning a protection scenario is to determine the general land use categories of the uplands within the study area in a particular county. Land use layers were obtained from GIS information gathered for the Treasure Coast Region by SFRPC. We used the best available data sets from federal, state, and county planning agencies. Counties within the Treasure Coast Region use different land use category classifications, but these categories can be summarized as including the following: agricultural, commercial, conservation, industrial, public/recreational, and residential. Typically, residential, commercial, recreational, and industrial lands were determined to be almost certain or likely to be protected. Undeveloped property, including privately owed property, agricultural land, minimally used parks, and dredge spoil areas were generally assigned the protection unlikely designation. Public and privately owned conservation areas were identified as no protection. We used colors to identify the protection categories on the sea level rise maps as follows: brown, protection almost certain; red, protection likely; dark blue, protection unlikely; light green, no protection; and dark green, wetlands. These categories are described in more detail below.

Protection almost certain (Brown). Coastal lands in the Treasure Coast Region have very high property values compared with the costs of shore protection. Therefore, most areas that have been developed, as well as undeveloped land in designated growth areas, are almost certain to be protected. The following describes how the maps captured this fundamental consideration.

Four land use categories are designated as protection almost certain. The first is existing developed land within extensively developed areas and/or designated growth areas. The second is future development within extensively developed areas and/or designated growth areas. The developed land and future growth areas include residential, office/commercial, and industrial uses. It is understood that every effort will be made to protect highly developed land from saltwater intrusion because of the economic value of these lands and the high population density in these areas. The third category is parks that are used extensively for purposes other than conservation and have current protection or are surrounded by protected lands. Examples of this type of land are parks with heavily used launching ramps located on-site. These parks are almost certain to be protected from sea level rise because they exist primarily for recreation and not exclusively for conservation purposes. Finally, mobile home developments outside of coastal high hazard areas connected to central sewer and water were included in this category.

Protection likely (Red). Although most coastal lands are almost certain to be protected, there are several areas where shore protection is likely, but not certain. Identifying these areas is important, for two reasons: First, if local elected officials were to decide that coastal wetland loss is likely to be too great, these areas would be better candidates for wetland migration than areas depicted in brown. Similarly, private conservancies might consider conservation easements in these areas to ensure the long-term survival of coastal wetlands. Second, if local elected officials concluded that shore protection costs were likely to be too great, these areas are less likely to receive funding for shore protection. These areas will probably be protected, but unlike the areas where shore protection is certain, there is at least a plausible reason why shores might not be protected.

The land uses within this scenario include less densely developed areas, future development outside of growth areas, extensively developed CBRA coastal areas, and private beaches. Moderately used parks used for purposes other than conservation, future development where a park or refuge is also planned, agricultural areas with historical shore protection, and military lands where protection is not certain are also included in this approach. As with the previous scenario, it is easy to assume that these mostly privately owned areas are too valuable to abandon. Because these areas are not, however, extensively developed yet, they have not reached the point where it would be inconceivable for policymakers and landowners to allow them to retreat.

Protection Unlikely (Dark Blue). Several areas exist in the region where shores seem unlikely to be protected. Identifying these areas is important for at least two reasons: First, the unlikelihood of long-term shore protection implies that people thinking about building structures in such an area must recognize that the land will probably be given up to the sea. Second, environmental planners can reasonably assume that wetlands or beaches will eventually migrate onto these lands. Because there is no expectation of shore protection, conservation easements that ensure long-term wetland migration should be relatively inexpensive.

Areas unlikely to be protected are places where lands are probably going to retreat, but where there is no absolute policy against shore protection. Generally, these are areas where land values are low compared with shore protection. In the case of privately owned nonconservation lands, shore protection would not be cost-effective compared to the value for the land. Land expected to become part of a nature reserve, but not guaranteed, is also in this category. “Protection unlikely” areas include undeveloped privately owned lands, unbridged barrier islands or lightly developed coastal high hazard areas, minimally used parks, undeveloped areas where most of the land will be part of wildlife refuge but where development is also planned, and conservation easements that preclude shore protection.

No Protection (Light Green). The final protection scenario includes lands that are certain not to be protected because they are conservation lands where shore protection is absolutely prohibited. Private lands owned by conservation groups, conservation easements that preclude shore protection, wildlife refuges and parks with a policy preference for natural occurring processes, and public lands/parks with little or nor prospect for public use fall within this category.

Wetlands (Dark Green). Wetlands were also mapped in this project. Most authors have concluded that wetlands could not keep pace with a significant acceleration in sea level rise and thus, that the area of wetlands converted to open water will be much greater than the area of dry land converted to wetlands. Moreover, in areas where dikes protect farmland or structures, all the wetlands could be lost.[10]

[10] Titus, J.G., R.A. Park, S.P. Leatherman, J.R. Weggel, M.S. Greene, P.W. Mausel, S. Brown, C. Gaunt, M. Trehan, and G. Yohe. 1991. Greenhouse effect and sea level rise: The cost of holding back the sea. Coastal Management 19:171–204.

The sea level rise maps produced in this study also show water areas in light blue. This category includes the open water of the Atlantic Ocean, coastal estuaries, rivers, lakes, and canals. All areas outside the study area are depicted in white. This category includes all areas that both are more than 1,000 feet from the shore and have an elevation of 10 feet or higher.

Data Sets

The SFRPC used its GIS mapping system to produce the sea level rise maps presented in this report. TCRPC helped SFRPC gather data used in the mapping and reviewed the accuracy of the maps. We used the latest digital data sets available at the time from the sources shown in Table 4. Every effort was taken to obtain the best available digital data suitable for the Study. The majority of the data sets for Indian River County were derived from the SJRWMD. Most of the data sets for the St. Lucie, Martin, and Palm Beach counties were derived from the SFWMD. The use of multiple datasets from a single source helps maintain consistency across county lines and better polygon registration.

We obtained terrain elevation from the Elevation Contours datasets. The Existing Land Use dataset provided polygons coded with the appropriate FLUCCS designations. The Future Land Use dataset provided polygons coded with the appropriate FLUM designation. The Environmental Sensitivity Index dataset maintained by the FMRI provided information on shoreline protection, including manmade features. CBRA Zones were obtained from NOAA.

Table 4. GIS data sets used to produce the sea level rise maps.

Description	Type	Scale	Source	Year
Indian River County				
Elevation Contours	Polygon	N/A	SJRWMD	N/A
Existing Land Use	Polygon	N/A	SJRWMD	2000
Future Land Use	Polygon	N/A	GeoPlan	N/A
Environmental Sensitivity Index	Line	N/A	FMRI	2001
Public Water Use Permits	Polygon	24,000	SJRWMD	2003
CBRA Zones	Polygon	N/A	NOAA	1998
St. Lucie, Martin, and Palm Beach counties				
Elevation Contours	Polygon	24,000	SFWMD	1994
Existing Land Use	Polygon	40,000	SFWMD	1995
Future Land Use	Polygon	40,000	SFWMD	1997
Environmental Sensitivity Index	Line	N/A	FMRI	2001
Public Water Use Permits	Polygon	N/A	SFWMD	2003
Public Lands	Polygon	N/A	SFWMD	2001
CBRA Zones	Polygon	N/A	NOAA	1998

Mapping Procedures

The SFRPC performed the following general procedures to create the sea level rise map for each of the counties in the region:

1. Combined the elevation, future, and existing land use polygon layers into a single layer containing the characteristics of all three.

2. Added two fields to the database: ACRES, which was calculated for each polygon, and SEARISE, which would eventually contain the sea level rise category.

3. Designated the study area by removing all polygons not in the study area. Using elevation data, we changed the color of all polygons 10 feet and higher to white and the SEARISE field was changed to outside study area. In addition, all polygons within 1,000 feet of the coastline were included in the study area, regardless of elevation. The remaining lands were less than 10 feet in elevation and represented the study area.

4. Removed wetlands from the study area by selecting polygons less than 10 feet in elevation based on FLUCS codes and FLUM designations. The color of these was changed to dark green and their SEARISE field to wetlands.

5. Removed water by selecting polygons less than 10 feet in elevation based on FLUCS codes and FLUM designations. The color of these was changed to light blue and SEARISE to water.

6. Used the appropriate FLUCS codes and FLUM designations to select the polygons representing uplands less than 10 feet in elevation that represented the following areas: protection almost certain (brown), protection likely (red), and protection unlikely (dark blue).

7. Defined additional protection almost certain (brown) areas based on coastline characteristics as depicted by the FMRI Environmentally Sensitive Shorelines database. We used the following criteria: any dark blue or red polygon completely surrounded by a) armored or renourished shore, b) another brown area, or c) an area 10 feet or higher in elevation was deemed to be protection almost certain by default and changed to brown.

8. Followed the procedures of the statewide approach to identify agriculture, conservation lands, preserves, parks, and recreation lands based on FLUCS codes and FLUM designations and labeled them no protection with light green.

9. Given the scale of the original datasets, and the regional scope of the study, prepared 11 ×17 inch maps for each county. The maps were then exported in Adobe Acrobat PDF format.

10. Used the GIS software to calculate acreage by sea level rise category for each county and exported the results to MS Excel files.

Local Government Review

The contract for this project required local government staff to review the draft sea level rise maps for each county. Local planners are the best authorities to identify whether specific areas of their regions will be protected against sea level rise. The statewide approach (Table 3) recognizes instances where existing land use data formats may not be complete enough to identify a protection scenario for a land area. Local planner input is particularly helpful in determining the

future status of currently undeveloped areas. Whether an undeveloped area outside of a growth area will be developed in the future is a determinant of the protection status of the locale. Local planner information is also invaluable in determining whether park areas or conservation lands should be protected against sea level rise.

TCRPC planning staff first met with the planning staff of the SFRPC on December 6, 2002, to discuss the data collection, mapping procedures, and analysis of the data. Upon receipt of the first round of draft maps for the project, TCRPC performed an internal review of the maps with regional planners on October 13, 2003. Upon receipt of revised maps, TCRPC arranged a series of individual meetings to solicit input from local government planners in each of the counties in the Treasure Coast Region. The first round of meetings took place in November 2003. Council staff met with planners in Palm Beach County on November 12, 2003; Martin County on November 13, 2003; Indian River County on November 14, 2003; and St. Lucie County on November 25, 2003. The planning directors and key county staff members participated in reviewing the draft sea level rise maps.

After the meetings to solicit input from local government planners in 2003, the SWFRPC and EPA modified the mapping procedures for the sea level rise project. This resulted in the creation of a new set of maps for the region. TCRPC received the first draft of the modified maps in 2004. After regional review, these maps were revised again in 2005. The latest revisions of the sea level rise maps were received by TCRPC in June 2005. TCRPC staff scheduled a second round of meetings to get additional input from local government planners. TCRPC staff met with planners in Martin County on August 31, 2005; St. Lucie County on September 1, 2005; Palm Beach County on September 1, 2005; and Indian River County on September 2, 2005. Local government planners provided comments on the statewide planning approach, draft sea level rise maps, and other coastal management issues. The individual planners that participated in these meetings are identified in the Acknowledgments section of this report. Comments from local government planners are summarized in the Map Analysis section of this report.

MAP ANALYSIS: REGIONAL RESULTS

Using the statewide approach for assessing the likelihood of land use protection in the Treasure Coast Region, we identified 118,905 acres (83.2 percent) of uplands and 23,927 acres (16.8 percent) of wetlands in the study area (Table 5). The study area includes the entire barrier island system throughout the region as well as properties directly adjacent to the lagoons, major river systems, and the ICW. Regionally, the protection almost certain category accounted for 65.7 percent of the uplands in the study area. This was followed by protection likely (15.8 percent), protection unlikely (14.0 percent), and no protection (4.4 percent). A clear regional trend exists, reflecting an increase in the number of acres in the protection almost certain category when moving north to south from Indian River County to Palm Beach County.

Table 5. Acres of each sea level rise category in the Treasure Coast Region.

Jurisdiction	Protection Almost Certain (Brown)	Protection Likely (Red)	Protection Unlikely (Dark Blue)	No Protection (Light Green)	Wetlands (Dark Green)
Indian River County	3,507	6,620	5,581	175	4,896
St Lucie County	10,589	5,317	371	1,376	7,556
Martin County	12,781	3,475	9,047	3,531	7,474
Palm Beach County	51,256	3,404	1,696	179	4,001
Regional Total	78,133	18,816	16,695	5,261	23,927

The entire study area has approximately five times the area of dry land as the area of tidal wetlands. Given that the tidal wetlands are generally below 3 feet in elevation and that dry land ranges from 3 to 10 feet, sea level rise would cause a net gain of wetlands if the area was undeveloped, even if wetlands were unable to vertically accrete as sea level rises. The area of potential wetland creation (protection unlikely and no protection), however, is only about 91.8 percent of the area of existing tidal wetlands. This suggests that a net loss of wetlands is likely. There is, however, substantial regional variation in that assessment. Perhaps more important, whether that loss is modest or near total appears to depend on land use decisions that have not yet been made. Most of the potential for wetland creation lies in lands classified as protection unlikely rather than no protection.

Throughout the region, the barrier island system and uplands east of the ICW are some of the most vulnerable lands subject to impacts of sea level rise. Yet, these areas have significant infrastructure resulting from public and private investment and are of local, regional, and state importance in terms of tourism, recreation, and marine industries. Given the importance of the barrier island system, we assume that actions will be taken to protect existing infrastructure and land uses where possible. If sea level continues to rise, a system of bridges and causeways may need to be constructed to provide access to development and facilities located on higher elevations. Such a system might be similar to the infrastructure that is already in place in the Florida Keys. The following sections describe how sea level rise impacts may affect each of the counties in the region.

INDIAN RIVER COUNTY

A total of 15,883 acres of uplands and 4,896 acres of wetlands were identified in the Indian River County portion of the study area (Map 1). Indian River County is the only county in the region where the protection almost certain category did not include the largest acreage. However, the combination of the protection almost certain and protection likely categories accounts for about 63.8 percent of the uplands in the study area in this county.

The upland areas most likely to be affected by sea level rise represent about 4.9 percent of the total county area. The main areas of impact are expected on the barrier island, on the shorelines of the Indian River Lagoon and Sebastian River, and within islands in the lagoon and river systems. The county and four of the five municipalities in the county have jurisdiction over land use planning in the study area. The affected municipalities are the City of Vero Beach, City of Sebastian, Town of Indian River Shores, and Town of Orchid.

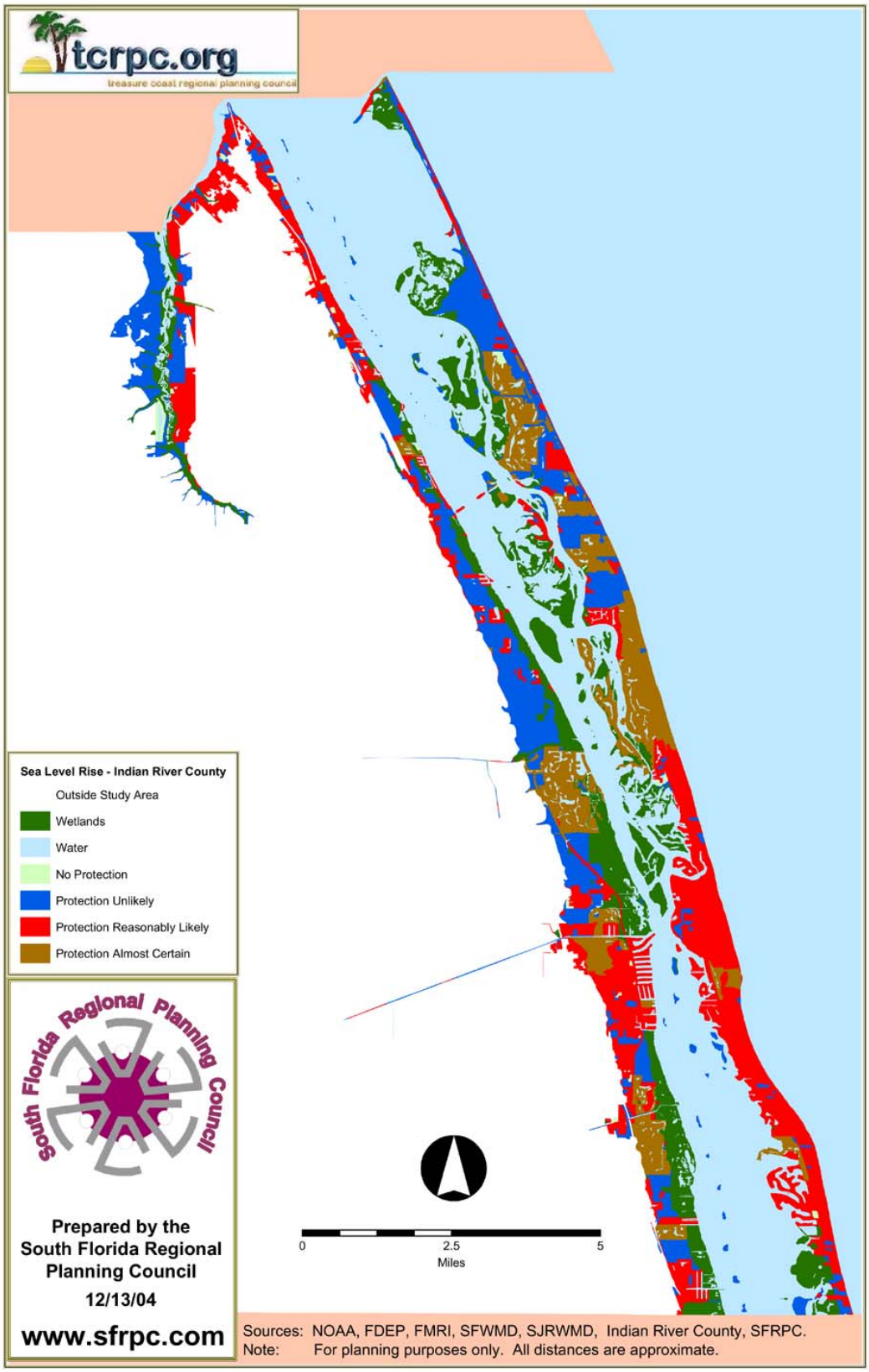
Barrier Island. The barrier island in Indian River County is known as Orchid Island. The northern end of Orchid Island is Sebastian Inlet State Park, which is dominated by wetlands. The narrowest part of the island is the stretch just south of the park. Because of its narrow width, this area is the portion of the island that is most susceptible to being breached by a hurricane. The creation of a new inlet in this area would interrupt State Road A1A. Local planners indicated that they generally expect the highway will be protected. This may be accomplished by closing any new inlet that forms and maintaining a sufficient buffer to protect the integrity of the road. Alternatively, the road could be maintained by a bridge over the new inlet. The narrow strip of land in this area is classified protection likely, indicating that the road is likely to be maintained in this area.

The largest dark blue area on the Orchid Island is part of Pelican Island National Wildlife Refuge. Local planners indicated that it would be more appropriate for this area to be light green, signifying no protection because much of it is in conservation. Planners, however, indicated that State Road A1A would be protected at all locations on the barrier island.

The brown area signifying protection almost certain south of Pelican Island National Wildlife Refuge is the Town of Orchid. The larger brown area to the south is the Town of Indian River Shores. Between Orchid and Indian River Shores, our maps show communities that are almost certain to be protected interspersed with areas where protection is less likely. The brown areas on the barrier island primarily represent residential areas with significant land value. Local planners have noted that the extensive red area on southern half of the barrier island should also be brown. This entire area is primarily residential and has water and sewer service by the City of Vero Beach.

Mainland along the Sebastian River. The western shore of the Sebastian River is primarily dark blue, signifying protection unlikely. This area is now part of the St. Sebastian River Preserve State Park. Local planners have indicated it would be more appropriate for this area to be light green, signifying no protection, because this is a conservation area. This is the largest area in the county where the inland migration of wetlands could take place as sea level rises.

Map 1. Indian River County: Likelihood of Shore Protection.



The eastern shore of the Sebastian River is primarily red, signifying protection likely. This area includes a number of low-lying residential communities. Local planners indicated that the red classification seems appropriate in this area.

Mainland along the Indian River Lagoon. The northern shore of the lagoon is primarily red, signifying protection likely for the areas surrounding and on the outskirts of the City of Sebastian. Local planners indicated that this classification seems appropriate. South of this area the shoreline of the Indian River Lagoon is primarily dark blue, signifying protection unlikely. Smaller areas of red signifying protection likely and numerous dark green areas signifying wetlands also exist in this area. Local planners indicated that most of the dark blue areas on the west shore of the Indian River Lagoon were previously in agriculture. Many of these areas were recently developed or are being developed. These new residential areas have well-designed drainage systems to help protect the lagoon. It would be more appropriate for this area to be brown, signifying protection almost certain.

The largest brown area east of the lagoon is the Grand Harbor development. The next largest brown area to the south is the downtown area of the City of Vero Beach. Local planners indicated that most of the dark blue areas north of the City of Vero Beach on the mainland have filled in with development. It would be more appropriate for these areas to be brown. South of the downtown area of the City of Vero Beach is primarily red. The areas west of Indian River Boulevard south to the county line should probably be brown. The areas east of Indian River Boulevard are very low-lying areas that should probably remain red.

Planner Review Summary. Indian River County planners had the following comments concerning the statewide approach for identifying likelihood of land use protection (Table 3) and the Indian River County shore protection map (Map 1):

- The land use in much of the study areas has changed very dramatically in the last 4–5 years. Many areas that were previously vacant are now developed. It would be desirable if the study could be based on more current land use data.
- The area where the barrier island is most likely to be breached is near the north end where it very narrow. If the island is breached it is almost certain that State Road A1A would be maintained through protection of the land or construction of a bridge.
- The extensive red area on the southern half of the barrier island should probably be brown. This entire area is primarily residential and has water and sewer service by the City of Vero Beach.
- The large dark blue area on the north end of the barrier island is part of Pelican Island National Wildlife Refuge. It would be more appropriate for this area to be light green.
- Another dark blue area south of Pelican Island National Wildlife Refuge on the barrier island is Captain Forster Hammock Preserve. It would be more appropriate for this area to be light green.
- The dark blue area on the west side of the South Prong of the Sebastian River is part of the Sebastian Creek State Preserve. It would be more appropriate for this area to be light green.

- The red areas along the east shore of the South Prong of the Sebastian River and along the west side of the Indian River Lagoon in the northern part of the county are primarily older residential areas. The classification of protection likely is appropriate in these areas.
- Most of the dark blue areas north of the Grand Harbor development on the west shore of the Indian River Lagoon are areas that were previously agriculture. Most of these areas were recently converted or being converted to residential. These new residential areas have well-designed drainage systems to help protect the lagoon. It would be more appropriate for this area to be brown.
- The area south of Grand Harbor to the downtown area of the City of Vero Beach is primarily dark blue and red. Because of recent development, it would be more appropriate for this area to be brown.
- The majority of the dark blue areas north of the City of Vero Beach on the mainland have filled in with development. It would be more appropriate for these areas to be brown.
- The area south of the downtown area of the City of Vero Beach along the west shore of the Indian River Lagoon is primarily red. The areas west of Indian River Boulevard south to the county line should probably be brown. The areas east of Indian River Boulevard are very low lying areas that should probably remain red.
- There are several upland areas designated as conservation along the west shore of the Indian River Lagoon in the south end of the county. These areas appear to be dark blue on the map. It would be more appropriate for this area to be light green.
- The county does not currently have policies specifically dealing with sea level rise.
- The county will be updating the comprehensive plan through the EAR process in 2008.
- County planners will consider adding new policies dealing with sea level rise in the next major update to the comprehensive plan.

ST. LUCIE COUNTY

A total of 17,653 acres of uplands and 7,556 acres of wetlands were identified in the St. Lucie County portion of the study area (Map 2). The Protection almost certain category accounts for the largest percentage (60 percent) of the uplands in the study area in St. Lucie County. The combination of the protection almost certain and protection likely categories accounts for 90.1 percent of the uplands in the study area in this county. St. Lucie County has almost no areas classified as protection unlikely because most of the agricultural land adjacent to the coastal waterways has already been developed or protected in conservation areas.

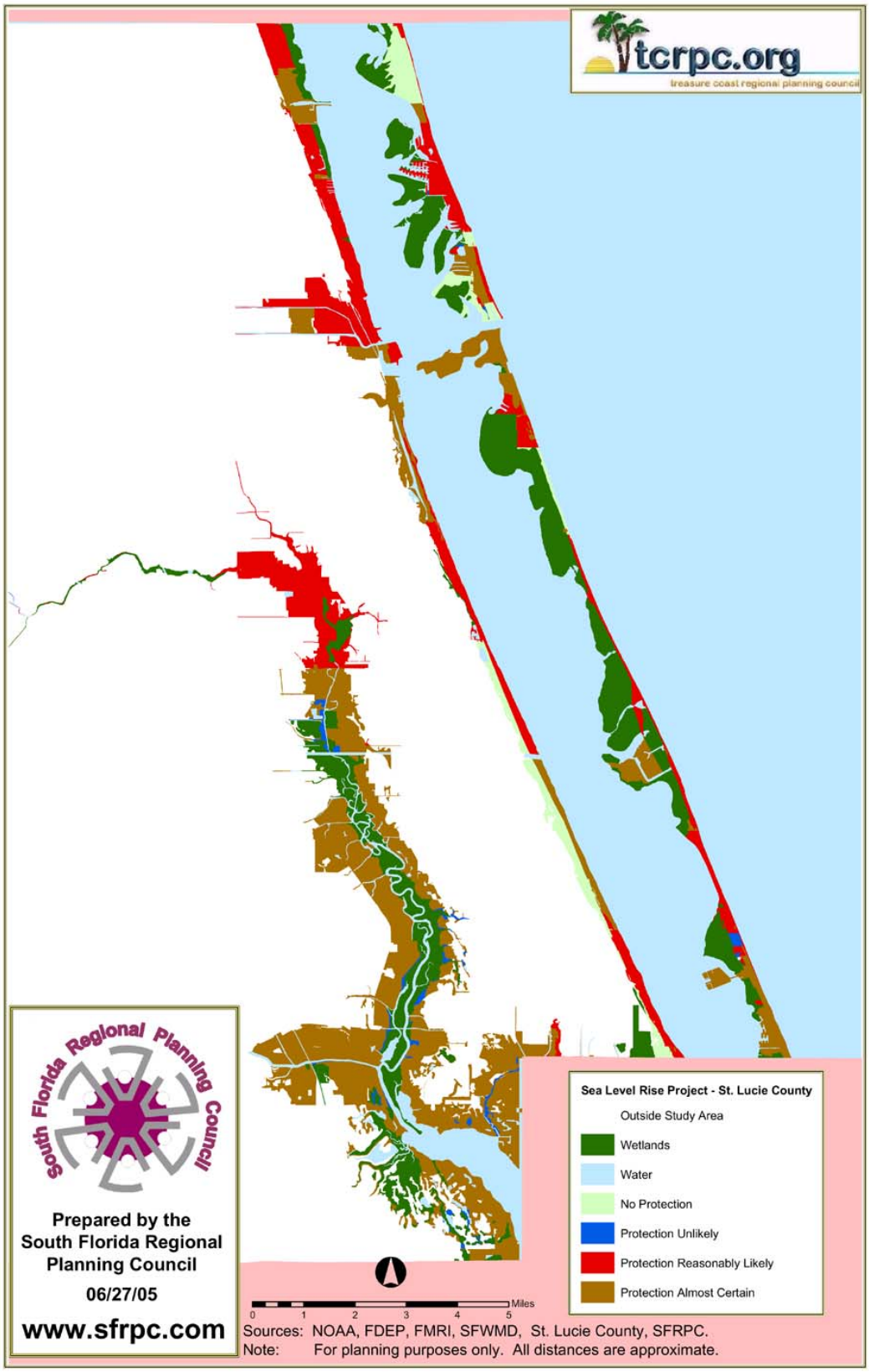
St. Lucie County has the greatest acreage of wetlands in the four counties examined. This wetland acreage accounts for 31.7 percent of the regional study area wetlands. The main areas classified as wetlands are located along the eastern shoreline of the Indian River Lagoon and in the North Fork of St. Lucie River. Most of these wetland areas have limited or no opportunity for the inland migration as the sea level rises because they are adjacent to developed areas.

The upland areas most likely to be affected by sea level rise represent about 4.8 percent of the total area of St. Lucie County. The main areas of impact are expected on the barrier island, on the shorelines of the Indian River Lagoon and North Fork of the St. Lucie River, and within islands in the lagoon and river systems. The county and all three of the municipalities in the county have jurisdiction over land use planning in the study area. The affected municipalities are the City of Port St. Lucie, City of Fort Pierce, and Town of St. Lucie Village.

Barrier Islands. The barrier islands in St. Lucie are known as North Hutchinson Island north of the Fort Pierce Inlet and South Hutchinson Island south of the inlet. Avalon Beach State Park is near the north end of North Hutchinson Island. This park includes the largest area of light green, signifying no protection, on the barrier island system in the county. Areas south of the park are primarily low- density residential and high-rise multifamily buildings. These areas are red, signifying protection likely, and brown, signifying protection almost certain. The area near the Inlet is Fort Pierce Inlet State Recreation Area, which also includes some areas of light green. Local government planners noted that the island has numerous narrow areas where it could be breached by a hurricane. If the island is breached at any location, it is almost certain that State Road A1A would be maintained through protection of the land or construction of a bridge. Maintenance of the road is important to provide access to recreational facilities and for emergency evacuations.

The north end of South Hutchinson Island is connected to a causeway on the south side of the Fort Pierce Inlet. The causeway includes the Smithsonian Institute, U.S. Coast Guard Station, historical museum, and a variety of other commercial and public uses. Local planners indicated that the use of brown is appropriate in this area. Residential areas in Fort Pierce extend south along the barrier Island from the inlet. These areas are red and brown. Local planners indicated that South Hutchinson Island has numerous narrow areas where it could be breached by a hurricane. If the island is breached at any location it is almost certain that State Road A1A would be maintained through protection of the land or construction of a bridge.

Map 2. St. Lucie County: Likelihood of Shore Protection.



The land lying east of A1A, however, on the barrier island is very vulnerable. These areas should be considered for relocation in the event of destruction by a hurricane.

The central portion of South Hutchinson Island contains the most significant critical facility in St. Lucie County, the FPL St. Lucie nuclear power plant. This area is brown, signifying Protection almost certain. Local planners indicated that it is critical that the road be maintained in this area through protection of the land or construction of a bridge. The road is necessary for hurricane evacuation and evacuation in the event of an emergency at the plant.

The areas to the south of the power plant on South Hutchinson Island are primarily multifamily residential on both sides of State Road A1A. Also, there are two mobile home areas along the lagoon, including Nettles Island, which extends into the lagoon. Nettles Island and the areas dominated by high rise developments are shown in brown. Local planners noted that Nettles Island is very low and seems very vulnerable to sea level rise. It is not clear how or if this area will be protected from sea level rise.

Mainland along the Indian River Lagoon. The upland areas of the northern shore of the lagoon are primarily red, signifying protection likely and brown, signifying protection almost certain. The northernmost brown area is the Harbor Branch Oceanographic Institution. The red areas north of this area are primarily residential. The red areas south of Harbor Branch south to Fort Pierce include a variety of commercial, industrial, and residential uses. This also includes the historic district of the Town of St. Lucie Village. Local planners indicated that because of the importance of this area it should be brown.

The most densely populated urban center in the county is the City of Fort Pierce. A portion of the city is classified as protection almost certain, but much of the downtown area is classified as protection likely. Critical facilities in the downtown Fort Pierce include the Fort Pierce municipal power plant and the Port of Fort Pierce. The power plant is an older facility that may be replaced in future years. The port is an under developed facility that is likely to be expanded in future years. Sea level rise issues should play an important role in the future planning of both of these facilities. Local planners indicated that it would be more appropriate for this area to be brown.

The western shoreline of the Indian River Lagoon south of Fort Pierce is classified protection almost certain and protection likely. The mapped categories in this area are narrow because the elevations are very steep along this stretch of the lagoon. In spite of relatively high elevation above sea level, the narrow road on the bluff in this area suffered from storm erosion during the hurricanes in 2004. The county is actively working to repair the storm damage and armor these areas to prevent erosion in the future. Local planners indicated that the red areas south of Fort Pierce on the west side of the Indian River Lagoon should be brown because the county has already made a commitment to protect the shoreline.

Mainland along the North Fork of the St. Lucie River. The largest area in the county classified as Protection almost certain is on both sides of the North Fork of the St. Lucie River. This area is primarily residential development in the City of Port St. Lucie. The area classified as Protection likely at the northern reaches of this river system represents more sparse development in this area. Local planners indicated that the red area at the upper reaches of the North Fork of

the St. Lucie River has some recent residential development. It would be more appropriate for these areas to be brown. Local planners indicated that sea level rise may convert some of the fresh water wetland systems along the North Fork of the St. Lucie River to estuarine systems. The wetland areas along the river north of about Midway Road are primarily fresh water systems that may be affected.

Planner Review Summary. St. Lucie County planners had the following comments concerning the statewide approach for identifying likelihood of land use protection (Table 3) and the St. Lucie County sea level rise map (Map 2):

- The barrier island has numerous narrow areas where it could be breached by a hurricane. If the island is breached at any location it is almost certain that State Road A1A would be maintained through protection of the land or construction of a bridge. The road is necessary for hurricane evacuation and evacuation in the event of an emergency at the FPL St. Lucie nuclear power plant.
- Nettles Island is very low and seems very vulnerable to sea level rise. It is not clear how or if this area will be protected from sea level rise.
- In general, the land east of A1A on the barrier island is very vulnerable. These areas should be considered for relocation in the event of destruction by a hurricane.
- The area in brown on the south side of the Fort Pierce inlet includes the Smithsonian Institute, U.S. Coast Guard Station, historical museum, and a variety of other commercial and public uses. The use of brown is appropriate in this area.
- The red area north of Fort Pierce is the historic district of St. Lucie Village. This area should be brown.
- The red areas south of Fort Pierce on the west side of the Indian River Lagoon should be brown. The county has already made a commitment to protect the shoreline after erosion from the hurricanes in 2004.
- The county has few places where wetlands will be able to migrate inland as sea level rises. Avalon Beach State Park is one of the largest areas where this could occur.
- Sea level rise may convert some of the fresh water wetland systems along the North Fork of the St. Lucie River to estuarine systems. The wetland areas along the river north of about Midway Road are primarily fresh water systems that may be affected.
- Many of the mangrove systems in the Indian River Lagoon could persist in place as the sea level rises. Management of the impounded mangrove systems for mosquito control may need to be adjusted to compensate for changes in sea level.
- The extensive brown area along the North Fork of the St. Lucie River is primarily residential development in the City of Port St. Lucie. The use of brown is appropriate in this area.
- The red area at the upper reaches of the North Fork of the St. Lucie River has had some recent residential development. It would be more appropriate for these areas to be brown.
- The county does not currently have policies specifically dealing with sea level rise.
- The county will be updating the comprehensive plan through the EAR process in 2007.
- County planners will consider adding new policies dealing with sea level rise in the next major update to the comprehensive plan.

MARTIN COUNTY

A total of 28,834 acres of uplands and 7,474 acres of wetlands were identified in the Martin County portion of the study area. The Protection almost certain category accounts for 44.3 percent of the uplands in the study area in Martin County (Map 3). The combination of the Protection almost certain and Protection likely categories accounts for 56.4 percent of the uplands in the study area in this county. Martin County contains the largest acreage of the Protection Unlikely category in the four counties examined.

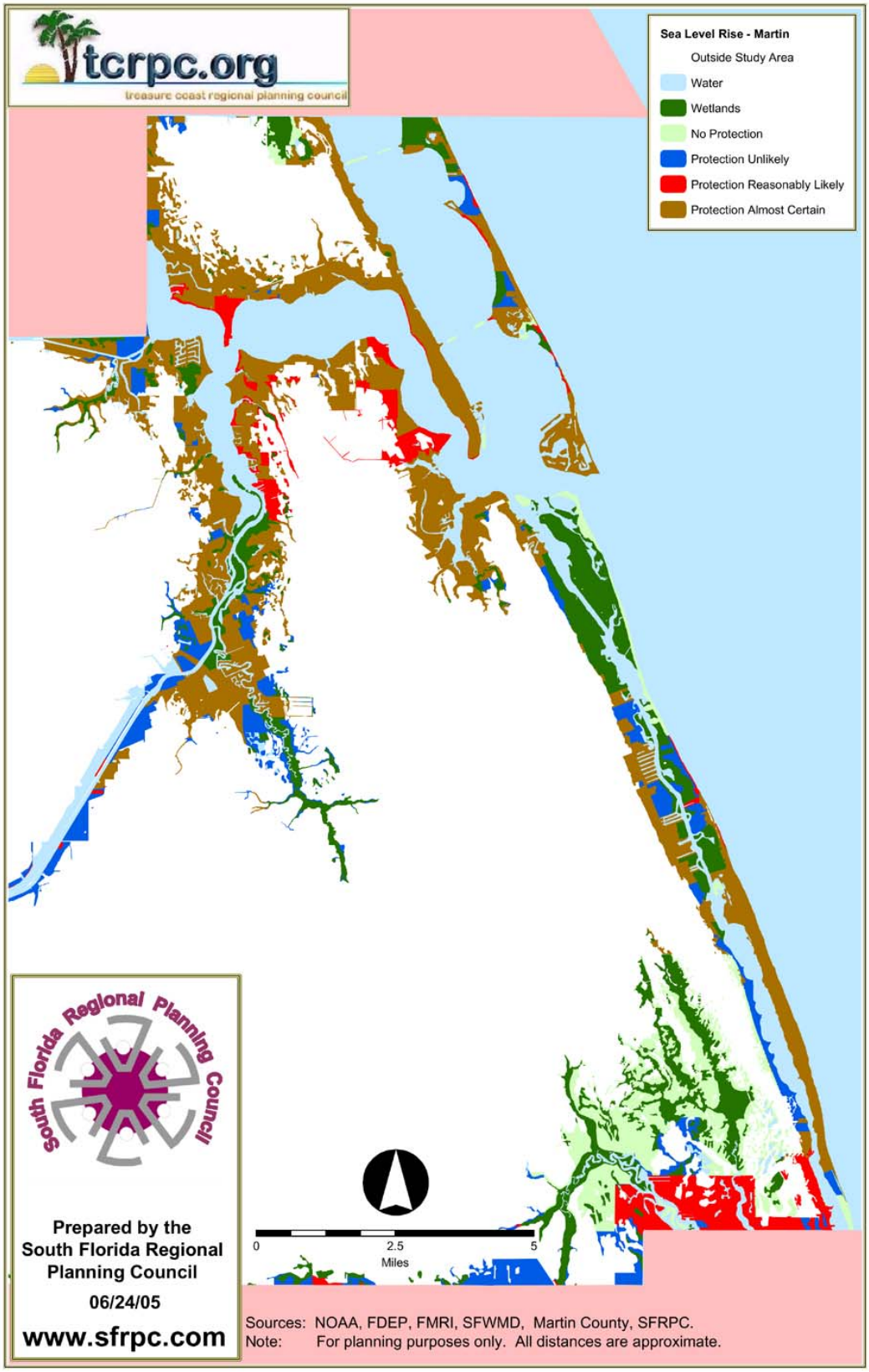
Relatively large areas classified as wetlands are located along the shoreline of the Indian River Lagoon. The wetlands in these areas are primarily mangrove forest. The other relatively large areas classified as wetlands are at the upper reaches of the South Fork of the St. Lucie River, North Fork of the Loxahatchee River, and Northwest Fork of the Loxahatchee River. These wetland systems currently transition from mangrove forests to freshwater forested systems.

The upland areas most likely to be affected by sea level rise represent about 7.2 percent of the total area of Martin County. The main areas of impact are expected on the barrier islands; along the shorelines of the Indian River Lagoon, St. Lucie, and Loxahatchee rivers; and within islands in the lagoon and river systems. The affected municipalities are the City of Stuart, Town of Sewall's Point, Town of Ocean Breeze Park, and Town of Jupiter Island.

Barrier Islands. The barrier islands in Martin County are Hutchinson Island north of the St. Lucie Inlet and Jupiter Island south of the inlet. State Road A1A extends south on Hutchinson Island into Martin County from St. Lucie County. This portion of Martin County is primarily brown, signifying protection almost certain, with dark green identifying wetlands. The developed areas are predominately residential. MacArthur Boulevard extends to a development known as Sailfish Point at the south end of Hutchinson Island. This is an extremely narrow portion of the Barrier Island, and the roadway was damaged during the 2004 hurricane season. The county has repaired the road and armored this area to protect it from future storms. Local planners indicated that the roads on the barrier islands are expected to be maintained in the event of breaching. The roads are important to reach recreational areas and for hurricane evacuation.

The entire north end of Jupiter Island consists of the St. Lucie Inlet Preserve State Park and Hobe Sound National Wildlife Refuge. These areas consist primarily of mangrove wetlands and sandy beaches and dunes. The uplands are identified in light green, signifying No Protection. The narrowest point of Jupiter Island is near Peck Lake. Local planners indicated that if Jupiter Island is breached near Peck Lake, it is likely that the new inlet would remain. This area is part of Hobe Sound National Wildlife Refuge and does not currently have a road. A breach in any other part of Jupiter Island with a road would be repaired and protected.

Map 3. Martin County: Likelihood of Shore Protection.



Most of the southern portion of Jupiter Island is brown, signifying protection almost certain. This area is primarily a residential area in the Town of Jupiter Island. The light green area at the south end of the island is The Nature Conservancy's Blowing Rocks Preserve. If this area were to be breached, local planners indicated that the main road through Jupiter Island would be protected.

Mainland along the Indian River Lagoon. The upland areas of the northern shore of the lagoon are primarily brown. North of the St. Lucie River these areas include the Town of Ocean Breeze Park and the Town of Sewall's Point. South of the St. Lucie River, the lagoon shoreline is brown where the area is dominated by residential development. A large expanse of wetlands occurs on the shore of the lagoon directly west of St. Lucie Inlet State Preserve. This area is part of Seabranch Preserve State Park. Most of the areas on the western shore of the lagoon south of this point are brown, signifying Protection, or dark blue, signifying Protection Unlikely. Most of the brown represents residential areas with significant infrastructure. Some of the dark blue areas appear to be uplands associated with county parks and the Hobe Sound National Wildlife Refuge. It would be more appropriate for these areas to be light green, signifying No Protection. The very southern segment of the western shore of the lagoon shows up as red, signifying Protection likely. This area is a mix of commercial and residential development. Local planners indicated that it would be more appropriate for these areas to be brown.

Mainland along the St. Lucie River. The upland areas of the shores of the St. Lucie River are primarily brown. This area includes a mix of residential, office, commercial, and marine uses in and near the City of Stuart. This is the most populated area in Martin County. Several of these areas are red; however, it would be more appropriate for these areas to be brown. The southern reaches of the South Fork of the St. Lucie River have extensive fresh water wetland systems. These areas are very susceptible to conversion to a salt water system, which would result in major ecological changes.

Mainland along the Loxahatchee River. The North and Northwest Forks of the Loxahatchee River enter Martin County in the extreme southeastern portion of the county. The major expanses of light green and dark green in this area occur in Jonathan Dickinson State Park. The red areas to the south of the park are primarily residential. Local planners indicated that parts of this area currently may be on wells and septic tanks, but much of this area is slated to be hooked up to public water and wastewater facilities. It would be more appropriate for these areas to be brown.

The Loxahatchee River has extensive freshwater wetlands that may be impacted by sea level rise. The Northwest Fork of the Loxahatchee River is designated as a National Wild and Scenic River.[11,12] The SFWMD and FDEP are currently preparing a restoration plan designed to reduce current levels of salt water intrusion up the river. The SFWMD and COE are also addressing this

[11] Treasure Coast Regional Planning Council. 1999. Loxahatchee River basin wetland planning project for Palm Beach County. Technical Summary Document, U.S. EPA Cooperative Agreement X994652-94-7, Treasure Coast Regional Planning Council, Stuart, Florida.

[12] Florida Department of Environmental Protection and South Florida Water Management District. 2000. Loxahatchee River National Wild and Scenic River management plan, plan update. South Florida Water Management District, West Palm Beach, Florida.

salt water intrusion issue through the CERP. Options for increasing freshwater flows down the river and placing salinity barriers at critical locations are being evaluated. Planning for sea level rise may be critical in these restoration efforts. Current restoration plans to protect the river from salt water intrusion may reduce the potential for wetland migration up the Northwest Fork of the Loxahatchee River.

Planner Review Summary. Martin County planners had the following comments concerning the state-wide approach for identifying likelihood of land use protection (Table 3) and the Martin County sea level rise map (Map 3):

- The red and brown areas seem similar enough that a distinction between them may be unwarranted. Both areas represent developed areas that are likely be protected. There is value in distinguishing between developed and undeveloped areas.
- The main focus should be identifying all land within the10-foot corridor so that planning issues can focus on concerns related to sea level rise.
- The red area at the south end of Jonathan Dickinson Sate Park is primarily single-family residential. Parts of this area currently may be on wells and septic tanks, but much of this area is slated to be hooked up to public water and wastewater facilities. It would be more appropriate for these areas to be brown.
- There are several areas where the barrier island is extremely narrow and could be breached by a hurricane. If the island is breached north of the inlet, State Road A1A and the road to Sailfish Point will be maintained. In fact, the road to Sailfish Point was repaired and armored after being damaged in the 2004 hurricane season.
- If Jupiter Island is breached near Peck Lake, it is likely that the new inlet would remain. This area is part of Hobe Sound National Wildlife Refuge and does not currently have a road. A breach in any other part of Jupiter Island with a road would be repaired and protected. The roads are important to reach recreational areas and for hurricane evacuation.
- Martin County already made a significant financial commitment to repair and armor Indian River Drive after it was damaged by erosion in the 2004 hurricane season.
- The Loxahatchee River and South Fork of the St. Lucie River have extensive fresh water wetland systems. These areas are very susceptible to conversion to a salt water system, which would result in major ecological changes.
- The county does not currently have policies specifically dealing with sea level rise.
- The county will be updating the comprehensive plan through the EAR process in 2008.
- County planners will consider adding new policies dealing with sea level rise in the next major update to the comprehensive plan.

PALM BEACH COUNTY

A total of 56,535 acres of uplands and 4,001 acres of wetlands were identified in the Palm Beach County portion of the study area (Map 4). The protection almost certain category in this county accounts for about 43.3 percent of the uplands in the study area within the region, and 90.7 percent of the uplands in the study area in Palm Beach County. The combination of the protection almost certain and protection likely categories accounts for 96.7 percent of the uplands mapped in this county. The wetlands remaining in the Palm Beach County portion of the study area account for only 16.8 percent of the wetlands identified in the region. The county has no significant concentrations of areas classified as wetlands, and there are little or no opportunities for the inland migration of wetlands in Palm Beach County.

The upland areas most likely to be affected by sea level rise represent about 4.3 percent of the total area of Palm Beach County. The main areas of impact are expected on the barrier islands and areas east of the ICW; shorelines of the Indian River Lagoon, Lake Worth Lagoon, and other estuaries; shorelines of the Loxahatchee River; shorelines of several inland waterways; and within islands in the lagoon and river systems. The municipalities that boarder the ICW or Atlantic Ocean have the greatest potential to be affected by sea level rise. These include the following 23 municipalities in Palm Beach County:

- City of Boca Raton
- City of Boynton Beach
- Town of Briny Breezes
- City of Delray Beach
- Town of Gulf Stream
- Town of Highland Beach
- Town of Hypoluxo
- Town of Juno Beach
- Town of Jupiter
- Town of Jupiter Inlet Colony
- Town of Lake Park
- City of Lake Worth
- Town of Lantana
- Town of Manalapan
- Village of North Palm Beach
- Town of Ocean Ridge
- Town of Palm Beach
- City of Palm Beach Gardens
- Town of Palm Beach Shores
- City of Riviera Beach
- Town of South Palm Beach
- Village of Tequesta
- City of West Palm Beach

Map 4. Palm Beach County: Likelihood of Shore Protection.

Barrier Islands. The barrier islands in Palm Beach County are Jupiter Island north of the Jupiter Inlet, Singer Island north of the Lake Worth Inlet, and Palm Beach Island south of the Lake Worth Inlet. The portion of Jupiter Island in Palm Beach County is red. This area includes single family residential in the Town of Jupiter Inlet Colony and several high-rise residential buildings in the Village of Tequesta. Local planners have indicated that this area should be brown.

Nearly the entire shoreline along the Atlantic Coast, lagoon systems, and inland waterways of Palm Beach County is developed and classified as protection almost certain. An exception just south of the Jupiter Inlet is Carlin Park, which is red. To the south is another red area, which is the largest area of red on the map. This area includes some developed areas in the Town of Juno Beach and the Juno Hills Natural Area, which is owned and managed by Palm Beach County for conservation. It would be more appropriate if the developed areas could be separated and classified protection almost certain and the Juno Hills Natural Area be shown as light green, signifying no protection.

The barrier island is light green at MacArthur Beach State Park. This is an area where the Barrier Island is very narrow. It would be possible for the island to be breached at this location without interrupting travel on State Road A1A, which runs on the west side of the island. If the island were breached in the park without affecting State Road A1A, it is likely that the breach would be allowed to remain. Local planners indicated however, that the road would be repaired and protected if it were damaged by a hurricane.

The red area on the south end of Singer Island is the Town of Palm Beach Shores. This area is primarily residential. Local planners have indicated that this area should be identified as brown. Similarly, the only sizable red area on Palm Beach Island is along the southeastern shore of the Town of South Palm Beach. This is a highly developed area that should be identified as brown.

Peanut Island. The only sizable dark blue area, signifying Protection Unlikely, in the county is Peanut Island, which is located adjacent to the Lake Worth Inlet. Peanut Island is home to a Palm Beach County Park, with newly constructed recreational facilities, restored and created fish and wildlife habitat, Palm Beach Maritime Museum, historic former U.S. Coast Guard Station, and dredged material management area used by the Florida Inland Navigation District and the Port of Palm Beach. Local planners indicated that the dark blue seems appropriate because much of it is used for recreation. The low-lying historic structures in the red area on the south side of the island would probably be protected.

Mainland along ICW and Lagoon Systems. Nearly the entire length of the county is classified as brown on the western shore of the ICW and lagoon systems. This includes a portion of the downtown area of the City of West Palm Beach, the most urbanized portion of the county. This area also includes two main critical facilities, the Port of Palm Beach and FPL Riviera power plant, which are both located on the western shore of Lake Worth Lagoon in the City of Riviera Beach. Sea level rise issues should play an important role in the future planning for these facilities.

Inland along the Canal Systems. The sea level rise map for Palm Beach County identifies the areas adjacent to several inland canal systems as brown. These freshwater canals are managed by

the SFWMD for flood control purposes. For example, the C-17 canal typically has a discharge elevation set from 8 to 9 feet above sea level; the C-51, C-16, and C-15 canals are typically controlled at from 8.5 to 9.5 feet; and the Hillsborough canal is typically controlled at an elevation from 7.5 to 8.5 feet. These areas were included in the mapping because the discharge elevations of these canals are below 10 feet above sea level. The land adjacent to these canal systems, however, is generally above 10 feet in elevation. The mapping procedure that caused these areas to be included in the study area should be evaluated. Similarly, the adequacy of the flood control structures in these canals should also be examined as part of long range planning for sea level rise.

Planner Review Summary. Palm Beach County planners had the following comments concerning the state-wide approach for identifying likelihood of land use protection (Table 3) and the Palm Beach County sea level rise map (Map 4):

- The maps would be more useful if one could zoom in to see more details on a computer.
- The maps would be improved if they contained the main roads and municipal boundaries.
- The barrier island is very narrow at several locations. If the island is breached it would likely be repaired and the road would be maintained. The road is very important for hurricane evacuation.
- The dark blue signifying protection unlikely on much of Peanut Island seems appropriate because much of it is used for recreation. The low-lying historic structures on the Peanut Island would probably be protected.
- The developed areas identified in red on the barrier island should be brown. Most of these areas have public water and sewer service. These areas include the Town of Palm Beach Shores and parts of the Town of Juno Beach shown in red. The Town of Jupiter Inlet Colony is still on septic tanks, but receives its water service from the Village of Tequesta.
- The county does not currently have policies specifically dealing with sea level rise.
- The county will be updating the comprehensive plan through the EAR process in 2009.
- County planners will consider adding new policies dealing with sea level rise in the next major update to the comprehensive plan.

DISCUSSION

Responses to Sea Level Rise

Many coastal management, construction, and planning and zoning guidelines can prepare citizens and governments for rising sea levels. The Coastal Zone Management Subgroup of Intergovernmental Panel on Climate Change Response Strategies Working Group[13] described the three basic pathways for responding to sea level rise. The strategies of retreat, accommodation, and protection are described below:

Retreat. This is the strategy of abandoning lands and structures in coastal zones and allowing marine ecosystems to move inland. In this response, there is no effort to protect the land from sea level rise. Governments exercising the retreat option generally prevent development in prone areas, allow development with conditions for abandonment (e.g., rolling easement), or withdraw subsidies for construction in danger zones. Governments can restrict development in coastal areas through a variety of policies. These approaches usually include land acquisitions, setbacks, low densities, planning and zoning restrictions on coastal land use, and bans on redevelopment of damaged structures.

Accommodation. This strategy allows for land use and occupancy of vulnerable areas to continue, but with no attempts to prevent flooding or inundation. It is a hybrid of retreat and protection, because structures are protected while floodplains and shorelines advance farther inland. Governments favoring accommodation can strengthen flood preparations, prohibit activities that may destroy protective coastal resources, or deny government flood insurance coverage of inhabitants of vulnerable areas. Strengthened flood preparations may include countering rising seas and high winds through building code requirements, improvement of drainage, and education. Like retreat, accommodation requires advance planning by local governments. Local governments must also accept that valuable land may be lost to rising seas. Although accommodation is a common short-term response, it may be less useful in the long run. Although it may be practical in some circumstances to maintain habitable homes as wetlands advance onto people's yards, eventually the wetlands would become inundated and homes would be standing in the water.

Protection. This strategy involves using structural, defensive measures to protect the land from the sea, so that land use can continue. Shores can be protected by hard structures such as seawalls, revetments, and dikes, or by soft structural techniques like beach nourishment and elevating land surfaces with fill. Unlike the first two options, protection has a dramatic impact on both the immediate environment and ecosystems beyond the immediate area. The costs to wetlands, unprotected uplands, and offshore fisheries must be assessed before protective measures are constructed.

Federal Policies and Programs

[13] Coastal Zone Management Subgroup. 1990. Strategies for adaptation to sea level rise. Intergovernmental Panel on Climate Change Response Strategies Working Group. Ministry of Transport and Public Works, The Hague, Netherlands.

Although a few federal policies specifically deal with the problems of sea level rise, several policies address the same effects of sea level rise, such as flooding, erosion, and wetland loss. These policies are included in the Coastal Zone Management Act, the Coastal Barrier Resources Act, the Clean Water Act, the Rivers and Harbors Act, and the National Flood Insurance Act.

The Coastal Zone Management Act of 1972 is the federal law that created and guides the United States' coastal management programs. Congress created the CZMA to deal with the threats to the country's coastal zone caused by increasing and competing demands on the land and water of the zone. The CZMA establishes the coastal management policy of the United States as preserving, protecting, developing, and, where possible, restoring or enhancing the resources of the nation's coastal zone by encouraging and assisting the states to exercise to develop and implement their own coastal management programs. Congress also specifically addressed the issue of sea level rise in the act:

> Because global warming may result in a substantial sea level rise with serious adverse effects in the coastal zone, coastal states must anticipate and plan for such an occurrence.
>
> The Congress finds and declares that it is the national policy . . . the management of coastal development to minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard, and erosion-prone areas and in areas likely to be affected by or vulnerable to sea level rise, land subsidence, and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands.

The provisions of the CZMA are realized through the Coastal Zone Management Program (CZMP), which is administered by NOAA. The CZMP is a voluntary federal-state partnership that provides cost-sharing grants to states to develop and implement their own coastal zone management plans. The CZMP bases eligibility for federal approval of state plans on several factors. Each state's plan is required to define boundaries of the state's coastal zone and identify uses within the area to be regulated by the state plan, the criteria for regulations such uses and the guidelines for priorities of uses within the coastal zone. After NOAA approves the plan, grants are awarded for implementation of the state's coastal management plan. In addition to providing financial assistance, the CZMP also supports states by offering mediation, technical services and information, and participation in priority state, regional, and local forums. Thirty-four states and territories with federally approved coastal management programs are participants in the CZMP. almost all of the nation's shoreline (99.9 percent) is currently managed by the CZMP. The main effect of the CZMA on the issue of sea level rise is to make state policymakers aware of the matter when they create their own coastal management plans.

Another piece of federal legislation that has a bearing on coastal management policies is the Coastal Barrier Resources Act (CBRA), which was enacted in 1982. CBRA was designed to protect barrier islands along the nation's coast. Coastal barrier islands are located off of the mainland coast and protect the mainland by receiving the majority of the ocean's energy contained in winds, waves, and tides. Coastal barriers also protect and maintain productive ecosystems that exist within this protective zone. In drafting the law, Congress found that certain actions and programs of the federal government have subsidized and permitted development on coastal barriers and the result has been the loss of barrier resources, threats to human life, health, and property, and the expenditure of millions of tax dollars each year.

CBRA established a Coastal Barrier Resources System, which designated various undeveloped coastal barrier islands for inclusion in the system. The boundaries of the system are contained on maps kept on file by the Department of the Interior. CBRA prohibits various federal actions and policies on islands within the system. The act places several restrictions on federal government spending on expenditures that encourage development or modification of a coastal barrier. No new expenditures or federal assistance can be used on coastal barrier islands for the following projects:

1) The construction or purchase of any structure, appurtenance, facility, or related infrastructure.

2) The construction or purchase of any road, airport, boat landing facility, or other facility on, or bridge or causeway to, any system unit.

3) The carrying out of any project to prevent the erosion of, or to otherwise stabilize, any inlet, shoreline, or inshore area, except that such assistance and expenditures may be made available on (certain designated units) for purposes other than encouraging development and, in all units, in cases where an emergency threatens life, land, and property immediately adjacent to that unit.

Notwithstanding the previous restrictions, CBRA does provide exceptions to limitations on a variety of expenditures with the barrier system. These include military and Coast Guard activities; maintenance of federal navigation channels; maintenance of certain publicly owned roads, structures, and facilities; scientific research; and nonstructural projects for shoreline stabilization that mimics, enhances, or restores a natural stabilization system. Nonstructural shore erosion control projects usually use bioengineering to create protective vegetative buffers stabilizing stream banks and shorelines and creating near-shore habitats for aquatic species and waterfowl. Another feature of the act is the prohibition of national flood insurance or HUD assistance to any projects within the barrier system that facilitate an activity that is not consistent with CBRA's provisions. CBRA is a good start in the prevention of development in areas that will be most affected by the effects of sea level rise.

The National Flood Insurance Program (NFIP) is another important component of federal coastal management policy. The NFIP is administered by the Federal Emergency Management Agency (FEMA), with its primary goals being to save lives and reduce future property losses from flooding. The NFIP is a voluntary program based on a mutual agreement or partnership between the federal government and local communities. This partnership provides that the federal government will make federally backed flood insurance available to home and business owners in communities that agree to adopt and enforce comprehensive floodplain management standards designed to reduce flood damages. NFIP transfers most of the costs of private property flood losses from the taxpayers to people that choose to live within floodplains through insurance premiums and increased construction standards.

Community response to this requirement involves the adoption of land use, zoning, and building code standards that, at a minimum, include the design and construction standards of the NFIP.

The minimum NFIP design and construction standards are applicable to all new construction, substantial damages and substantial improvements to existing structures located in Special Flood Hazard Areas or in Special Flood Hazard Areas that have not yet been identified by FEMA. The Special Flood Hazard Areas represent the statistical chance of a 100-year flood occurring in any given year. The 100-year flood has a 1 percent chance of occurring in any given year.

NFIP imposes stricter requirements on communities in the V-Zones of Flood Insurance Rate Maps. These are locales in coastal high hazard areas located along coastlines that are subject to high water levels, wave action, and erosion from strong storms and hurricanes. The wind and resultant waves and tidal surges from these storms cause water moving at high velocities to sweep over nearby land. Generally, the V-Zone indicates the inland extent of a 3-foot breaking wave atop a storm surge. These areas are extremely hazardous to life and property.

The NFIP requires a number of building requirements for new construction or substantial improvements in coastal high hazard areas to be able to withstand wind and waves. New buildings and improvements must:

- Obtain and maintain the elevation of the bottom of the lowest horizontal structural member of the lowest floor;

- Be located landward of mean high tide and no new construction is allowed over water;

- Be elevated so that the bottom of the lowest horizontal structural member of the lowest floor is at or above the base flood elevation on a pile or column foundation;

- Allow the space below the lowest elevated floor to be free of obstruction or must be enclosed with nonsupporting breakaway walls, open lattice-work, or insect screening designing to collapse under wind and water loads without causing damage to structural supports or the elevated structure;

- Not use fill for structural support of buildings; and

- Prohibit manmade alteration of sand dunes and mangrove stands that would increase potential flood damage.

As previously noted, the CBRA prohibits new NFIP coverage for new or substantially improved structures in any coastal barrier in the CBRA system.

The Clean Water Act of 1972 is another federal law that has an impact on the health of our nation’s coastal areas and wetlands. Section 404 of the Clean Water Act sets national policy for the discharge of dredged or fill material into the nation’s navigable waters and adjacent wetlands. The act has even been interpreted to have authority over inland wetlands. Section 404 gives jurisdictional responsibility for issuing dredge permits to the COE. The EPA has responsibility for developing and interpreting the criteria used in permit issuances.

The Clean Water Act prohibits the discharge of dredged or fill material at a specific site if there is a practicable alternative to the proposed discharge that would have less adverse impact on the aquatic ecosystem or if the discharge will cause or contribute to significant degradation of U.S. waters. Practicable alternatives under the Clean Water Act include activities that do not include a discharge into U.S. waters or discharges into waters other than the specific site requested. Degradation caused to U.S. waters is deemed to be significant adverse effects to human health or welfare, aquatic life stages and ecosystems, ecosystem diversity and productivity, and recreational, aesthetic, and economic values. Discharges from established and ongoing farming, ranching, and forestry activities are exempt from Section 404 provisions.

To receive a permit to discharge dredge materials, the applicant must prove to the COE that they have taken steps to avoid wetland impacts where practicable, minimized potential impacts to wetlands, and provided compensation for any remaining, unavoidable impacts through activities to restore or create wetlands. States also have a role in Section 404 decisions, through state program general permits, water quality certification, or program assumption.

An additional federal law that gives the COE additional authority over construction in navigable waters and wetlands is the Rivers and Harbors Act (RHA). Sections 9 and 10 of the act authorize the COE to regulate the construction of any structure or work within navigable waters of the United States. The types of structures the RHA allows the COE to regulate include the following: wharves, breakwaters, or jetties; bank protection or stabilization projects; permanent mooring structures, vessels, or marinas; intake or outfall pipes; canals; boat ramps; aids to navigation; or other modifications affecting the course, location condition, or capacity of navigable waters.

When issuing permits for construction of the aforementioned structures, the COE must consider the following criteria: (1) the public and private need for the activity, (2) reasonable alternative locations and methods, and (3) the beneficial and detrimental effects on the public and private uses to which the area is suited. The COE is also required to consult with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service to protect and conserve wildlife resources.

State Policies and Programs

As with federal policies, few Florida policies specifically address the issue of sea level rise. However, state coastal guidelines that cover beach management policies can be used to respond to sea level rise concerns. These policies are included in the Coastal Construction Line Program, the Beach Erosion Control Program, and the Coastal Building Zone and Strategic Beach Management Plans.

The Florida Beach and Shore Preservation Act was enacted by the state legislature to preserve and protect Florida's beach and dune system. Beaches and dunes are the first line of defense against storms, acting as a buffer between the sea and coastal development. One of the programs authorized by the Beach and Shore Preservation Act to be an essential element in the protection effort is the Coastal Construction Control Line (CCCL) Program (Beach and Shore Preservation Act, Florida Statutes Chapter 161).

The CCCL Program was designed to protect Florida's beach and dune system from irresponsible construction that could weaken, damage, or destroy the health of the dune system. Structures that are built too close to the sea can inhibit the beach and dune system from its natural recovery processes and can cause localized erosion. Improperly constructed structures are a threat to other nearby coastal structures should they be destroyed by storms. The CCCL Program gives the State the jurisdiction to apply stringent siting and design criteria to construction projects within the control line. The CCCL is not a setback line, but is rather a demarcation line of the State's authority.

The CCCL is marked at the landward limit of coastal areas that are subject to the effects of a 100-year storm surge. Although wind and flooding may intrude farther inward than the 100-year storm surge area, effects landward of the CCCL are considerably less than within the CCCL. Within the CCCL, the State prohibits the construction or siting of structures that would cause a significant adverse impact to the beach and dune system, result in the destabilization of the system, or destroy marine turtle habitat. To meet these requirements, structures are required to be located a sufficient distance from the beach and frontal dune and must also be sited in a way that does not remove or destroy natural vegetation. The CCCL also requires all structures to be constructed to withstand the wind and water effects of a 100-year storm surge event. This involves creating structures that meet American Society Civil Engineering 7-88 Sect. 6 wind design standards for 110 mph winds and 115 mph for the Florida Keys. Water standards include a foundation design to withstand a 100-year storm event, including the effects of surge, waves, and scouring. There is no prohibition of rebuilding under the CCCL Program. Because of the effects of erosion, the CCCL Program discourages the construction of rigid coastal armoring (seawalls) and instead encourages property owners' use of other protection methods such as foundation modification, structure relocation, and dune restoration.

Another similar endeavor to regulate coastal construction is the Coastal Building Zone (CBZ). The CBZ was established as part of the Coastal Protection Act of 1985 to protect coastal areas and to protect life and property. The CBZ is similar to the CCCL Program in that it is a regulatory jurisdiction rather than a setback line. The CBZ envelops land from the seasonal high water line to 1,500 feet landward of the CCCL. In those areas fronting on the ocean but not included within an established CCCL, the CBZ includes the land area seaward of the most landward V-Zone line, as established by NFIP's flood maps. The V-Zone is an area likely to experience a wave greater than 3 feet high with storm surge or areas within the 100-year storm event used by the CCCL program. Local governments enforce the Coastal Building Zone, as a part of their building codes.

Within the CBZ, new construction is required to meet the Standard Building Code 1997 wind design standard of 110 mph and 115 mph for the Florida Keys. As for water standards, structures are required to meet National Flood Insurance Program requirements or local flood ordinance requirements, whichever are stricter. Foundations must also be designed to withstand a 100-year storm surge. CBZ construction standards are less stringent than CCCL standards because NFIP flood maps have lower base flood elevations for 100-year storm events than do CCCL studies.

Another state effort to protect Florida's beaches, authorized by the Beach and Shore Preservation Act, is the Beach Erosion Control Program (BCEP). The BECP is the primary program that

implements the Florida Department of Environmental Protection's beach management recommendations. The BCEP was created to coordinate the efforts of local, state, and federal governments in protecting, preserving, and restoring Florida's coastal resources. One of the activities of this program is the offering of financial assistance to counties, local governments, and other special districts for shore protection and preservation efforts. The BECP will provide up to 50 percent of project costs. The mix between federal, state, and local funds is different for each project.

Beach management activities eligible for funding from the BECP include beach restoration and nourishment activities, project design and engineering studies, environmental studies and monitoring, inlet management planning, inlet sand transfer, dune restoration and protection activities, and other beach erosion prevention related activities.

Another endeavor of the BECP is the development and maintenance of a Strategic Beach Management Plan (SMBP) for Florida. The SBMP is a multiyear repair and maintenance strategy to carry out the proper state responsibilities of a comprehensive, long-range, statewide program of beach erosion control; beach preservation, restoration, and nourishment; and storm and hurricane protection. The SBMP is divided into specific beach management plans for Florida's coastal regions.

Local Government Policies

All of the counties in the region have comprehensive plans that contain coastal management elements. None of the counties in the region has policies specifically dealing with sea level rise. Each of the counties, however, has goals, objectives, and policies that are related to sea level rise issues. Some of these objectives most relevant to sea level rise are summarized below.

Indian River County

Objective 4: *Beaches and Dunes*. By 1998, all natural functions of the beach and dune system in Indian River County shall be protected and no unmitigated human-related disturbance of the primary dune system shall occur.

Objective 5: *Limiting Public Expenditures in the Coastal High-Hazard Area*. Through 2004, there will be no expansion of infrastructure within the Coastal High Hazard Area other than that which is deemed necessary to maintain existing levels-of-service.

Objective 11: *Limit Densities in the Coastal High Hazard Area*. Through 2020, there will be no increase in the density of land use within the Coastal High Hazard Area.

St. Lucie County

Objective 7.1.1: *Future Development in the Coastal Area*. St. Lucie County shall continue to protect the natural resources of the coastal area from adverse impacts caused by future development through the implementation and strengthening of existing environmentally related laws and the assignment of appropriate Future Land Use designations.

Objective 7.1.5: *Beaches and Dunes*. St. Lucie County shall provide for the protection and restoration of beaches and dunes. A comprehensive beach and dune management program shall be adopted by 2003 which enhances the natural functioning of the beach-dune system while reducing unnatural disturbances of the primary dune.

Objective 7.2.1: The County shall address development and redevelopment in the coastal area in the County's Hurricane Evacuation Plan.

Martin County

Objective. *Beach and Dune and Off-Shore Systems*. To develop procedures and standards to protect, enhance and restore beach and dune systems and minimize construction-related impacts

Objective. *Hazard Mitigation and Coastal High Hazard Area*. To limit public expenditures in the designated coastal high hazard area to necessary public services in order not to subsidize new development in this area.

Objective. *Direct Population Away from Coast*. Encourage low density land uses within the coastal high hazard area in order to direct population concentrations away from this area.

Palm Beach County

Objective 1.2: *Shoreline Protection*. Palm Beach County shall protect, enhance and restore the beaches and dunes through implementation and maintenance of the Palm Beach County Shoreline Protection Plan.

Objective 2.2: *Public Subsidy of New Coastal Development*. Palm Beach County shall not subsidize new or expanded development in the coastal area.

Objective 2.3: *Development in High Hazard Area*. Palm Beach County shall direct population concentrations away from known or predicted coastal high-hazard areas and shall not approve increases in population densities n the coastal high hazard area.

Proposed Policies

Planners in each of the counties in the Treasure Coast Region indicated a willingness to consider the adoption of policies specifically related to sea level rise. The following policy statements are offered for consideration by local governments in coastal areas:

Policy 1: Consider the impact of sea level rise in all land use amendments in coastal areas less than 10 feet in elevation.

Policy 2: Obtain detailed topographic maps showing one foot contours in the coastal zone to assist in planning for sea level rise.

Policy 3: Develop a plan to protect or relocate all critical public facilities that are located in areas projected to be impacted by sea level rise in the next 50 years.

Policy 4: Closely monitor updates to sea level rise forecasts and predictions.

Policy 5: Develop a sea level rise response plan that specifically identifies the areas where retreat, accommodation and protection will be implemented.

CONCLUSIONS

This report is intended to stimulate local government planners and citizens to think about the problem of sea level rise. Although this project covers a timeframe of 200 years, planning for sea level rise should begin now. The sea is already rising and some shores are already eroding. Moreover, an effective response may require a lead time of many decades. If we develop areas where wetland migration is preferred in the long run, it might take a lead time of 50-100 years to relocate the development. Even in areas that we protect, shore protection measures can take decades to plan and implement.

The relevance of planning for sea level rise can also be seen by the events of 2004 hurricane season. The Treasure Coast Region suffered extensive damage from storm surges, wind and erosion. With strong hurricane seasons projected to continue into the future, because of warmer ocean waters, the events of the 2004 hurricane season are likely to reoccur.

The rate of development and increase in population in the Treasure Coast Region are other important factors in starting the preliminary stages of planning for sea level rise now. As sea levels continue to rise, much of the currently developed increasingly populated area can be expected to be flooded. Planners must begin to decide which land areas in their counties and municipalities will be protected against sea level rise, and what the cost will be to holding back the sea. Citizens living in these areas must also know the costs associated with protection against sea level rise.

The sea level rise maps provided in this report only depict the expected response scenarios to sea level rise based on the best currently available knowledge. Local planners may decide in the future that it will be wise to retreat from lands currently deemed to be protected lands, due to costs and environmental considerations. This project represents the first step in planning for sea level rise in the Treasure Coast Region.

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ACKNOWLEDGMENTS

TCRPC offers its gratitude to the other RPCs in Florida for sharing information and jointly developing language as a statewide report on sea level rise is developed. Appreciation is extended to Daniel L. Trescott of the SWFRPC and James G. Titus of the EPA for coordinating the statewide planning effort in Florida. Special thanks go to Manuel Cela of the SFRPC for producing the sea level rise maps for the Treasure Coast Region, and John E. Hulsey of the SFRPC for sharing planning ideas. This report benefited from discussions about sea level rise with local government planners, including Bob Keating, Roland DeBlois, Sasan Rohani, Ken Oristaglio, and Andy Sobczak with Indian River County; David Kelly, Diana Waite, Vanessa Bessey, and Donald B. West with St. Lucie County; Nicki van Vonno and Ross Wilcox with Martin County; and Lorenzo J. Aghemo, Isaac Hoyos, Michael R. Howe, Etim S. Udoh, and Erin Fitzhugh with Palm Beach County. The project manager for TCRPC and principal author of this document is Peter G. Merritt, Regional Ecologist with TCRPC.

Chapter 8: SOUTH FLORIDA

by

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INTRODUCTION

The Risk of Sea Level Rise

A significant portion of South Florida's 4,250 square miles are either wetlands or within a few meters above the level of the sea. Flooding has long been a reality with which both our infrastructure and much of the population must occasionally contend. Every decade, sea level rises another inch, slightly increasing the risk of flooding. Many climate scientists now believe that rising global temperatures may accelerate the rate at which the sea rises. What, if anything, should a low-lying region such as ours do to prepare?

This report presents a study conducted by the South Florida Regional Planning Council (SFRPC) to identify the areas in this region that are likely to require protection from erosion, inundation, and flooding as sea level rises.[1] The premise of the study was the assumption that eventually sea level will rise enough to threaten most low-lying areas in South Florida. When combine with astronomical high tides and storms such as hurricanes, rising sea level may have a severe impact on shorelines and other low-lying areas. Table 1 lists the area of land vulnerable to sea level rise in South Florida, and Figure 1 is a map of those lands.

Table 1. Area of Land Close to Sea Level by County (square kilometers)

	Elevations (m) above spring high water									
County	**0.50**	**1.00**	**1.50**	**2.00**	**2.50**	**3.00**	**3.50**	**4.00**	**4.50**	**5.00**
Broward	12	266	462	884	1752	2153	2817	2983	2994	3000
Miami-Dade	585	1320	2597	3502	4057	4201	4296	4335	4353	4358
Monroe	1631	1821	1952	2055	2074	2078	2080	2080	2080	2080
Total	2228	3408	5011	6441	7883	8433	9192	9398	9427	9438

Source: National Elevation Dataset and Titus J.G., 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. Section 1.1 in: *Background Documents Supporting Climate Change Science Program Synthesis and Assessment Product 4.1*, J.G. Titus and E.M. Strange (eds.). EPA 430R07004. U.S. EPA, Washington, DC.

[1]Funding for this project was provided by the South West Florida Regional Planning Council (SWFRPC) through a cooperative agreement from the U.S. Environmental Protection Agency (USEPA).

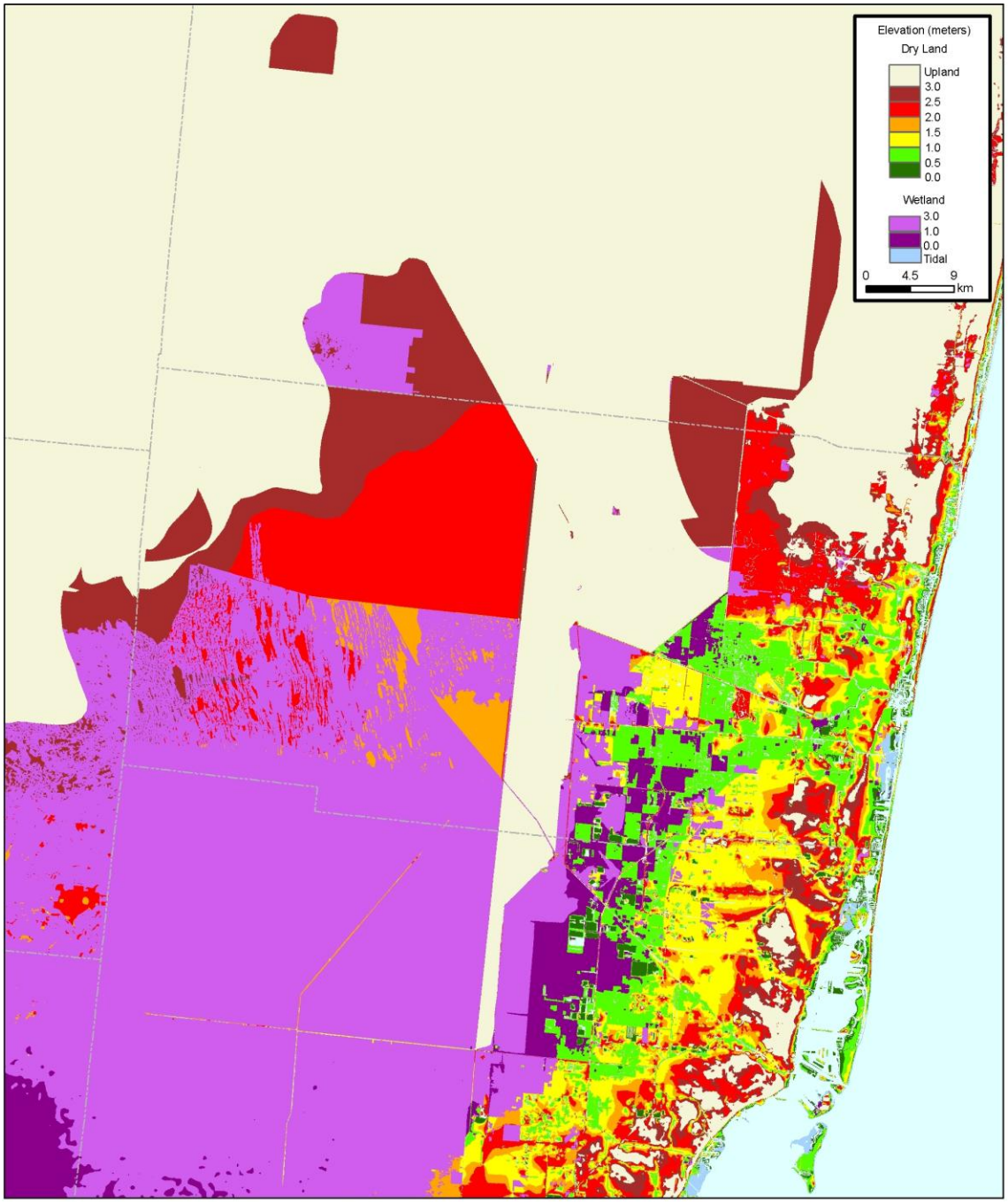


Figure 1a: Lands Vulnerable to Sea Level Rise in Broward County. Source: See Table 1.

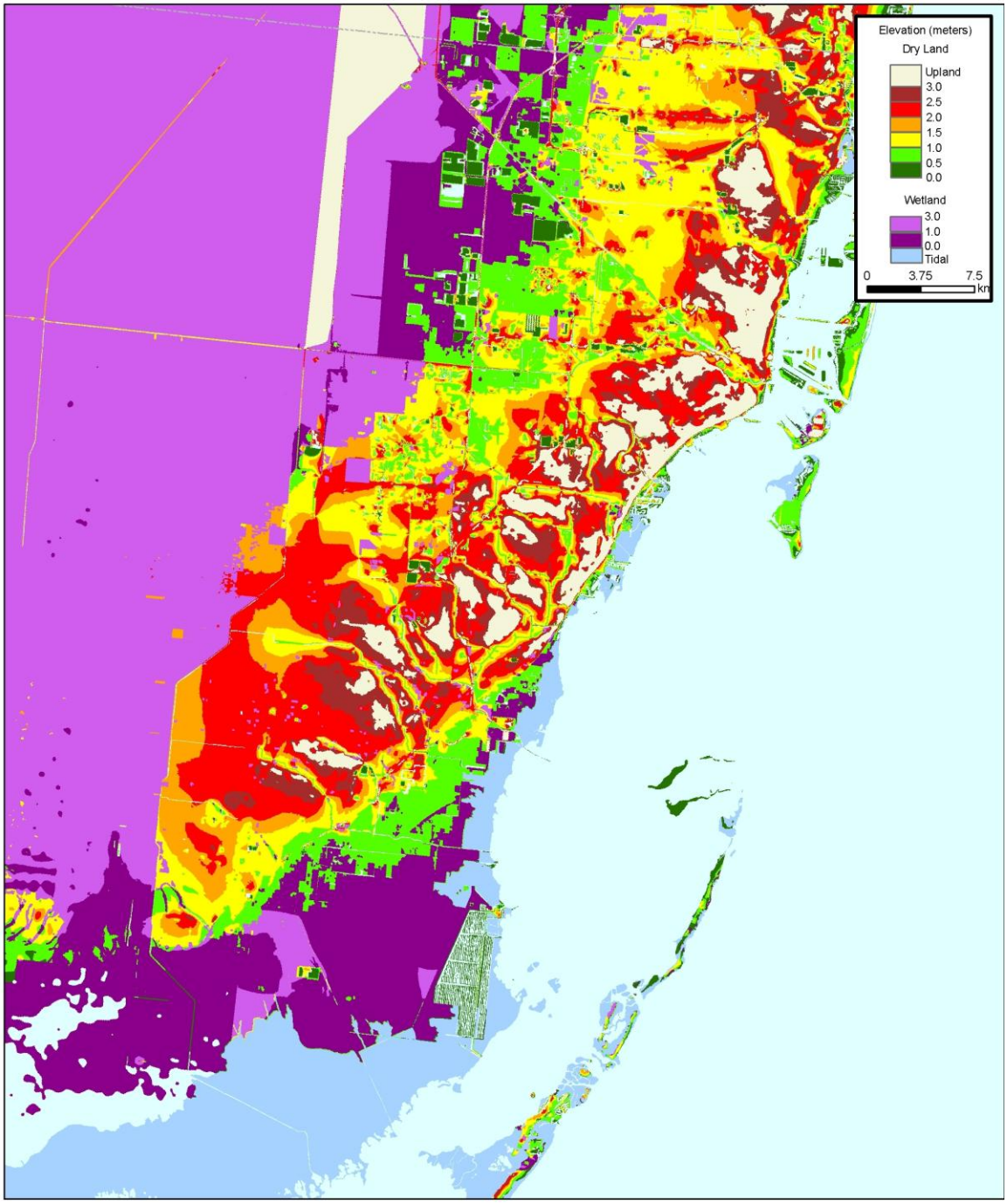


Figure 1b: Lands Vulnerable to Sea Level Rise in Miami-Dade County

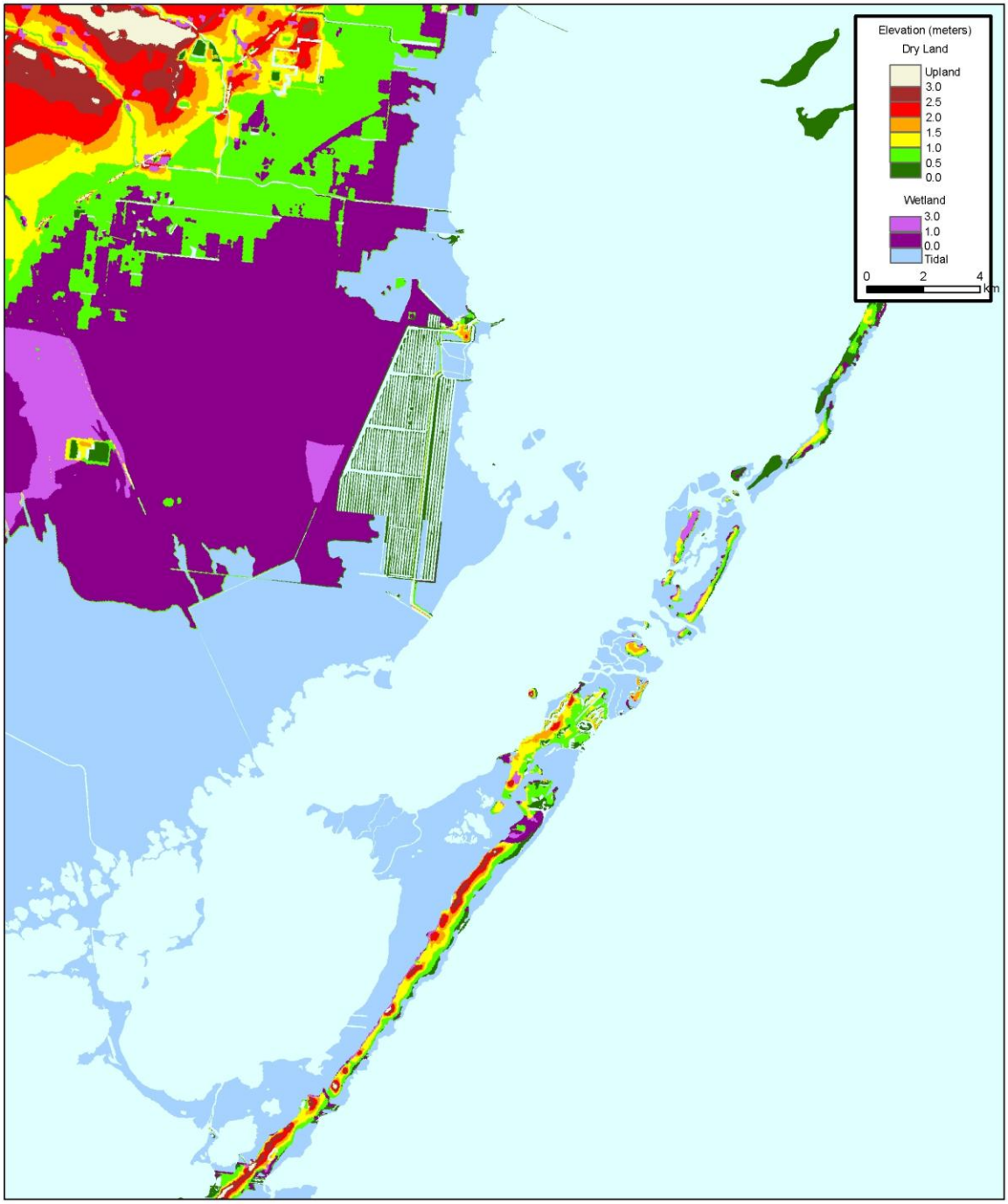


Figure 1c. Grayvik and Card Sound to Key Largo and Tarpon Basin

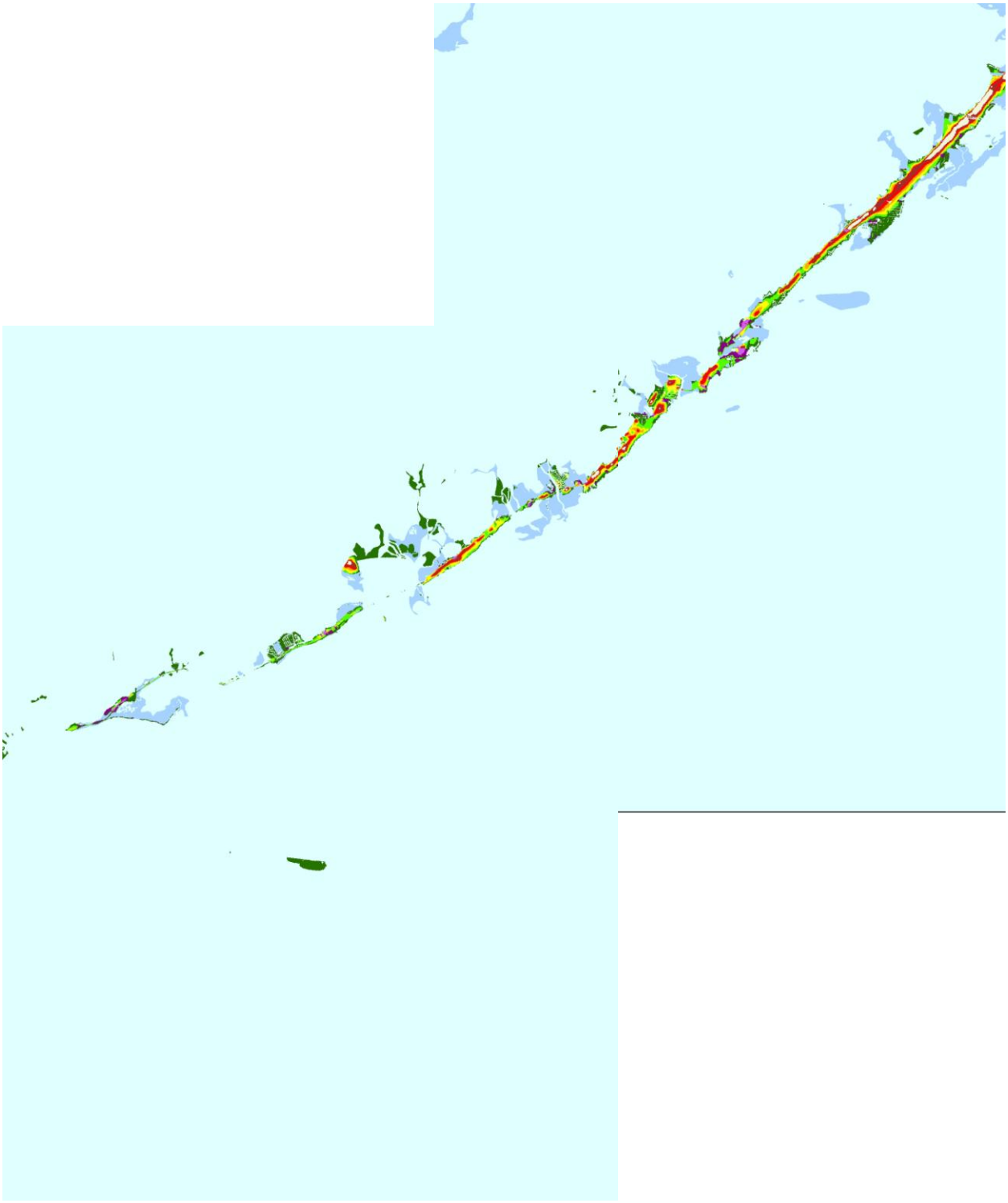


Figure 1d. Key Largo to Long Key

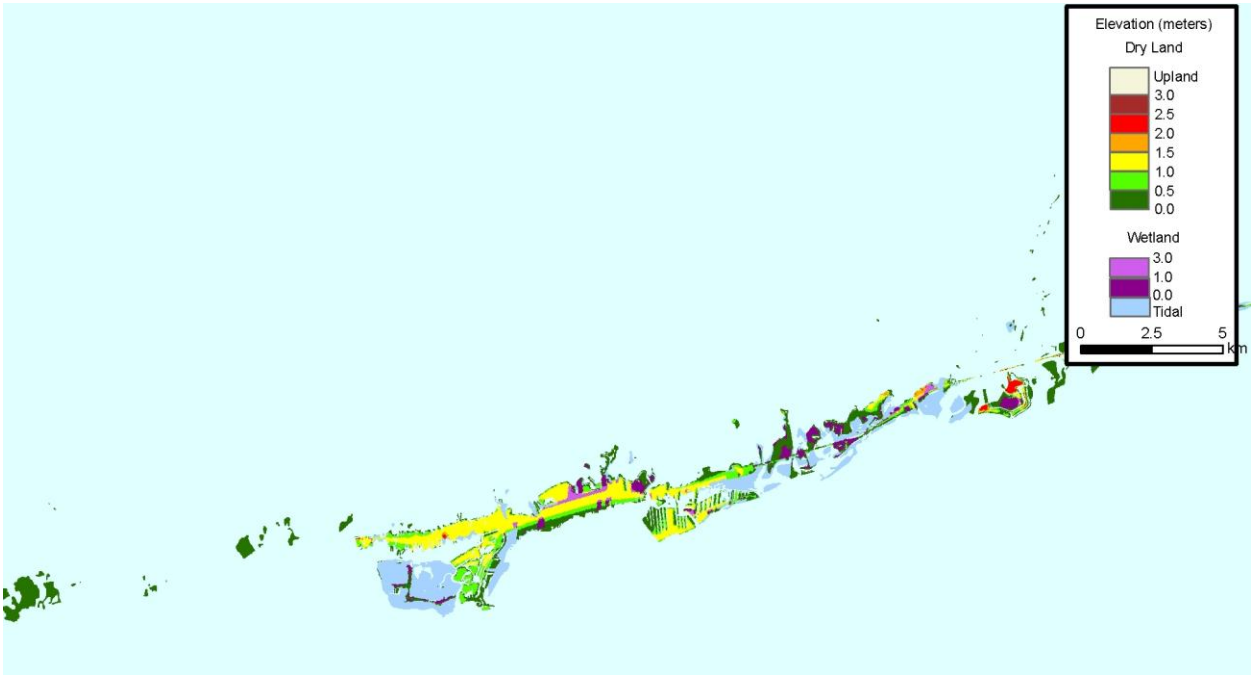


Figure 1e. Duck Key to Boot Key

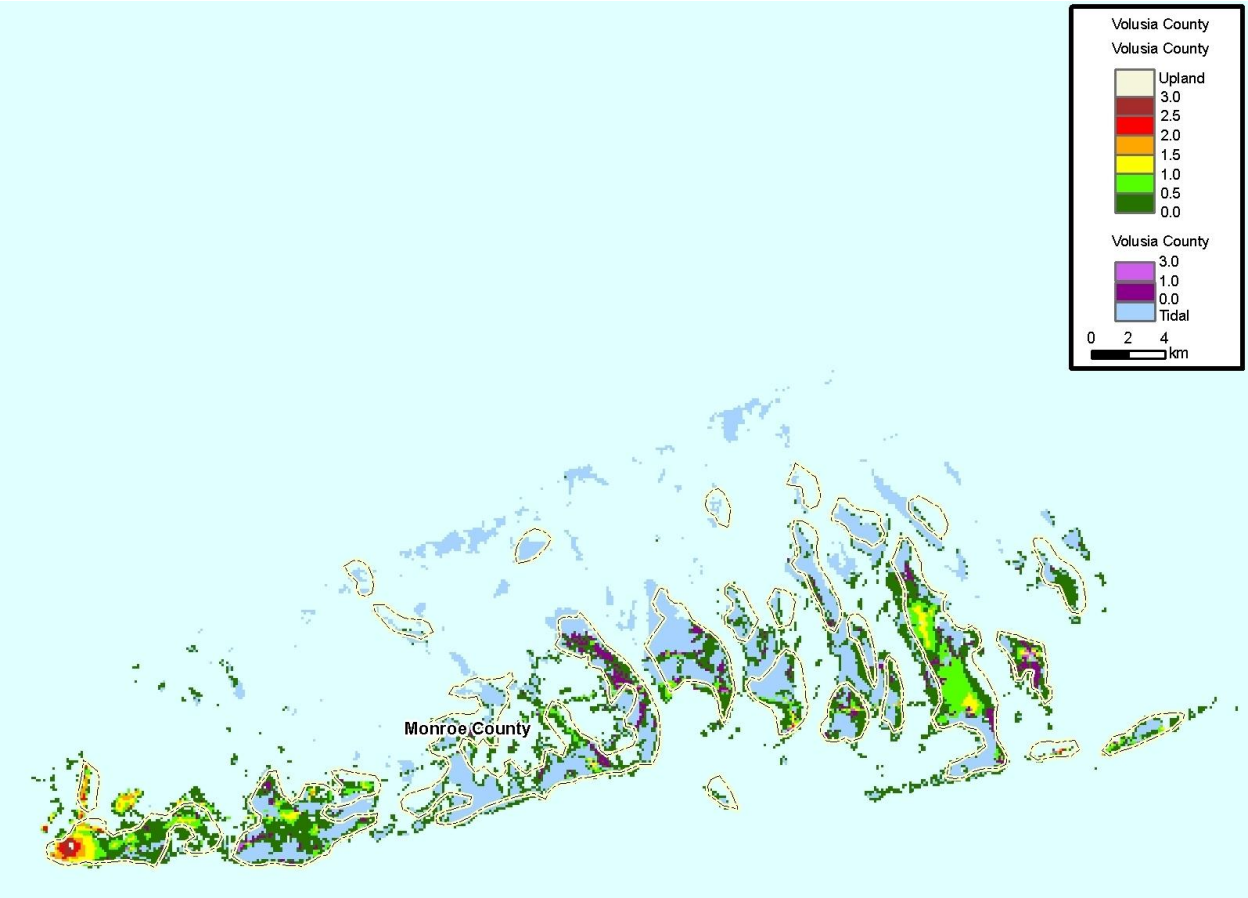


Figure 1e. Big Pine Key to Key West.

Purpose of this Study

This study develops maps that distinguish the areas likely to be protected from erosion and inundation as the sea rises from those areas that are likely to be left to retreat naturally. The natural retreat may occur either because the cost of holding back the sea is greater than the value of the land or because environmental policies favor natural shorelines over the structures and fill material required to hold back the sea. This report is part of a national effort by the US Environmental Protection Agency (EPA) to encourage the long-term thinking required to deal with the impacts of sea level rise. For each state, EPA is evaluating potential responses to sea level rise, with attention focused on developing maps that indicate the lands that would probably be protected from erosion and inundation as the sea rises.

Using a set of statewide general guidelines provided by the SWFRPC, variations on the general approach based on SFRPC's familiarity with the region, and input from county governments, the Council's Geographic Information System (GIS) was used to develop draft maps depicting the

likelihood of shoreline protection to combat the effects of the rise in sea level. The study area was the three counties within the SFRPC's jurisdiction: Miami-Dade, Broward, and Monroe. [2]

This study analyzes state and local coastal management and development patterns to the extent that they are foreseeable. The maps that accompany this study illustrate the areas that local planning officials expect to be protected from erosion and inundation by rising sea level. The maps are not meant to indicate whether people will hold back the sea forever, which would depend on cost factors and scientific uncertainties outside the scope of this analysis.[3] Instead, the maps are meant to define the initial response to sea level rise over the next several decades. Those judgments incorporate state policies and regulations, local concerns, land-use data, and general planning judgment. This analysis does not analyze whether hard structures, soft engineering, or some hybrid of the two approaches is most likely. Those decisions will depend on a variety of factors, including both economics and the evolution of shore protection methods in Florida.

This effort is not a land use plan or a precursor to land use regulations. Rather, it is an analysis of the implications of existing policies and trends.

Within the study area, our maps use the following colors:

- Brown—areas that will almost certainly be protected if and when the sea rises enough to threaten it.

- Red—areas that will probably be protected, but where it is still reasonably possible that shores might retreat naturally if development patterns change or scientists were to demonstrate an ecological imperative to allow wetlands and beaches to migrate inland.

- Blue—areas that probably will not be protected, generally because property values are unlikely to justify protection of private lands, but in some cases because managers of publicly owned lands are likely to choose not to hold back the sea.

- Light Green—areas where existing policies would preclude holding back the sea. These areas include both publicly and privately owned lands held for conservation purposes.

Outside the study area, we generally show both nontidal wetlands and tidal wetlands as dark green.

[2]SFRPC also prepared maps for the companion study of the Treasure Coast region..
[3] For example, the sea could rise 10–20 feet over a period of several centuries if one of the world's ice sheets were to melt. See, e.g., IPCC (2001).

METHODS

Sea Level Rise Prediction in South Florida

The Scope of Work provided by SWFRPC for this project included the assumption that sea levels would rise 5 feet in 200 years. Calculations based on our reference information put the probability of that happening at roughly 30 percent. The mean expected rise in sea level is about 3¾ feet.

We provided all participants with copies of two tables from the USEPA report *The Probability of Sea Level Rise* (see Appendices A and B). Using information from those tables, SWFRPC derived a table for local sea level rise in Florida for its report *Land Use Impacts and Solutions to Sea Level Rise in Southwest Florida*. This table was adapted for our report to reflect differences for Southeast Florida (see Appendix C).

Study Area

The purpose of the sea level scenario was to focus our conversations with local officials on the land that would be protected from a gradual rise in sea level, as distinct from an abrupt rise. For reasons we describe below, we examined all land below the 10-ft (NGVD) contour,[4] and we tried to ensure that no one got the idea that we were predicting a 10-foot rise in sea level any time soon. A rapid rise of 5-10 feet would probably require a very different response than the gradual rise this report considers. If the sea rises more slowly than we assume, (e.g.rising 5 feet over three or four centuries), by contrast, our study is still valid because in the context of a slow rise in sea level, shore protection depends primarily on land use, not the rate of sea level rise.

This study follows the general approach of the sea level rise planning studies that USEPA is sponsoring along other Atlantic Coast states. In those studies, the study area consists of dry lands that are either below the 20-foot (NGVD) elevation contour, or land within 1,000 feet of the shore. Because the United States Geological Survey (USGS) maps in many areas along the Atlantic Coast have contour intervals of 20 feet, EPA had to use the 20-foot contour to be certain that it included all the land that might be vulnerable. EPA included land within 1,000 feet of tidal wetlands or open water, even if it is above the 20-ft contour, for two reasons. First, even high ground can erode as sea level rises. Second, EPA wanted to ensure that the maps depict whether the shore is likely to be protected, even in places where the area directly threatened is too small to show up in a county-scale map.

[4] 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

Because of the large amount of land below the 10-foot contour in Florida, the initial cooperative agreement between SWFRPC and EPA reduced the study area to consider only the 10-foot contour. The matter of lands within 1,000 feet of the shore was not addressed in that original agreement, because all land within 1,000 feet of the shore in South*west* Florida is below the 10-foot contour anyway. But in some parts of South*east* Florida, the 10-foot contour is very close to the shoreline. As a result, this study includes all lands within 1,000 feet of the shore. Therefore, we hadTo determine which of the land above the 10-ft contour is within 1,000 feet of the shoreline. Therefore, we constructed a coastline buffer, which started at the coastline and extended 1,000 feet inland. All polygons from our data set with any land within this buffer were included in the study. Slight differences in polygon registration between the different datasets could result in a few very small polygons being incorrectly included or excluded.Buta visual inspection revealed none.

The first step was to determine the study area boundaries. Based on the project's Scope of Work, all areas that are both more than 1,000 feet from the shore and have an elevation of 10 feet or higher, were designated to be "Outside the Study Area" and shaded white in the final maps.

Datasets Used in the Study

Tables 2 through 4 list the digital datasets used in this study, and are briefly described in the following section. We tried to obtain the "best available digital data." The use of multiple datasets from a single source helps maintain consistency across county lines and better polygon registration.

Table 2 - Miami-Dade County Datasets

Description	Type	Scale	Source	Year
Elevation Contours	Polygon	24,000	SFWMD	1994
Existing Land Use	Polygon	40,000	SFWMD	1995
Future Land Use	Polygon	40,000	SFWMD	1997
Environmental Sensitivity Index	Line	N/A	FMRI	2001
Hurricane Evacuation Zones	Polygon	24,000	Miami-Dade	1997
Water & Sewer Service Areas	Polygon	3,600	Miami-Dade	1998
Canals and Levees	Line	24,000	SFWMD	1997
Urban Development Boundary	Polygon	N/A	Miami-Dade	2003
Public Lands	Polygon	N/A	SFWMD	2001
CoBRA Zones	Polygon	N/A	NOAA	1998

Table 3 - Broward County Datasets

Description	Type	Scale	Source	Year
Elevation Contours	Polygon	24,000	SFWMD	1994
Existing Land Use	Polygon	40,000	SFWMD	1995

Future Land Use	Polygon	40,000	SFWMD	1997
Environmental Sensitivity Index	Line	N/A	FMRI	2001
Hurricane Evacuation Zones	Polygon	24,000	Broward	1997
Water & Sewer Service Areas	Polygon	3,600	Broward	1998
Canals and Levees	Line	24,000	SFWMD	1997
Public Lands	Polygon	N/A	SFWMD	2001
CoBRA Zones	Polygon	N/A	NOAA	1998

Table 4 - Monroe County Datasets

Description	**Type**	**Scale**	**Source**	**Year**
Elevation Contours	Polygon	24,000	SFWMD	1994
Existing Land Use	Polygon	40,000	SFWMD	1995
Future Land Use	Polygon	40,000	SFWMD	1997
Environmental Sensitivity Index	Line	N/A	FMRI	2001
Hurricane Evacuation Zones	Polygon	24,000	Monroe	1997
Public Lands	Polygon	N/A	SFWMD	2001
CoBRA Zones	Polygon	N/A	NOAA	1998

METHODOLOGY OF MAP CREATION

Our approach for creating the draft maps followed the general statewide approach developed by Dan Trescott and Jim Titus (see Table 5). This table represents a summary of the approaches taken by other states but adapted for use in Florida by SWFRPC with input from the other regional planning councils. Applying those criteria in a mapping analysis requires some judgment regarding how one addresses conflicts in data or mapping rules, which we explain later in this section. Figures 2–4 illustrate the draft maps we produced using the data and mapping decision rules explained in this section.

Table 5
General Approach for Identifying the Likelihood of Protection from Sea Level Rise in Florida[1]

Likelihood of Protection[2]	Land Use Category	Source Used to Identify Land Area
Protection Almost Certain (brown)	Existing developed land (FLUCCS Level 1-100 Urban and Built-up) within extensively developed areas and/or designated growth areas.	Developed lands identified from Water Management Districts (WMD) existing Florida Land Use, Cover and Forms Classification System (FLUCCS) as defined by FDOT Handbook (January 1999); Growth areas identified from planner input and local comprehensive plans.
	Future development within extensively developed areas and/or designated growth areas (residential/office/commercial/industrial).	Generalized Future Land Use Maps from local comprehensive plans, local planner input and water management districts.
	Extensively used parks operated for purposes other than conservation and have current protection[3] or are surrounded by brown colored land uses.	County-owned, state-owned, and federally owned lands (based on local knowledge) or lands defined as 180 Recreational on the Level 1 FLUCCS, local planner input, and Florida Marine Research Institute (FMRI) for current protection measures.
Protection Likely (red)	Existing development within less densely developed areas or outside of growth areas or mobile home development not anticipated to gentrify or not on central water and sewer or within a coastal high hazard area.[4]	Developed lands identified from WMD existing FLUCCS; growth areas identified from local planner input, local comprehensive plans, and current regional hurricane evacuation studies.
	Projected future development outside of growth areas could be estate land.	Future Land Use Map and local planner input.
	Moderately used parks operated for purposes other than conservation and have no current protection or are surrounded by red colored land uses.	County-owned, state-owned, and federally owned lands (based on local knowledge) or lands defined as 180 Recreational on the Level 1 FLUCCS, local planner input, and FMRIS.
	Coastal areas that are extensively developed but are ineligible for beach nourishment funding due to COBRA (or possibly private beaches unless case can be made that they will convert to public)	Flood Insurance Rate Maps for COBRA, local knowledge for beach nourishment.
	Undeveloped areas where most of the land will be developed but a park or refuge is also planned & the boundaries have not yet been defined; so unable to designate which areas are brown or green; red is a compromise.	Local planner input.

	Agricultural areas where development is not expected, but where there is a history of erecting shore protection structures to protect farmland.	Local planner input.
	Military lands in areas where protection is not certain.	FLUCCS Level 173.
Protection Unlikely (blue)	Undeveloped privately owned that are in areas expected to remain sparsely developed (i.e., not in a designated growth area and not expected to be developed) and there is no history of erecting shore protection structures to protect farms and forests.	Undeveloped lands identified from WMD existing FLUCCS Level 1–160 mining, 200 Agriculture, 300 Rangeland, 400 Upland Forest, 700 barren land ; nongrowth areas identified from planner input, local comprehensive plans, Flood Insurance Rate Maps for COBRA and current regional hurricane evacuation studies.
	Unbridged barrier island and COBRA areas or within a coastal high hazard area not likely to become developed enough to justify private beach nourishment.	Flood Insurance Rate Maps for COBRA, local knowledge for beach nourishment, and local planner input.
	Minimally used parks operated partly for conservation, have no current protection or are surrounded by blue colored land uses, but for which we can articulate a reason for expecting that the shore might be protected.	County-owned, state-owned, and federally owned lands (based on local knowledge) or lands defined as preserve on Future Land Use Map, local planner input, and FMRIS.
	Undeveloped areas where most of the land will be part of a wildlife reserve, but where some of it will probably be developed and the boundaries have not yet been defined so we are unable to designate which areas are brown and which are green; so blue is a compromise between red and green.	Local planner input.
	Conservation easements (unless they preclude shore protection)	Local planner input.
No Protection (light green)	Private lands owned by conservation groups (when data available)	Private conservation lands.
	Conservation easements that preclude shore protection	Local planner input.
	Wildlife Refuges, portions of parks operated for conservation by agencies with a policy preference for allowing natural processes (e.g., National Park Service)	Local planner input.
	Publicly owned natural lands or parks with little or no prospect for access for public use.	County-owned, state-owned, and federally owned lands (based on local knowledge) defined as preserve on the Future Land Use Map and local planner input.

1. These generalized land use categories describe typical decisions applied in the county studies. County-specific differences and site-specific departures are discussed in the county-specific sections.
2. Colored line file should be used in areas where less than 10 foot elevations exist within 1,000 feet of the rising sea or color cannot be seen on ledger paper map.
3. Current protection may include sea walls, rock revetments, beach renourishment, levees, spreader swales, or dikes.
4. Coastal High Hazard Area defined in Rule 9J-5 FAC as the Category 1 hurricane evacuation zone and/or storm surge zone.

Terrain elevation was obtained from the Elevation Contours datasets. The Existing Land Use dataset provided polygons coded with the appropriate Florida Land Use, Cover and Forms Classification System (FLUCCS) designations (see Appendix IV). The Future Land Use dataset provided polygons coded with the appropriate Future Land Use Map (FLUM) designation (see Appendix E).

The Environmental Sensitivity Index dataset, maintained by the Florida Marine Research Institute (FMRI), provides information on shoreline protection, including man-made features. Several other datasets were used, including Hurricane Evacuation Zones, Water and Sewer Service Areas, Public Lands, and, for Miami-Dade County, the Urban Development Boundary.

Water Areas (Light Blue)

Water areas were determined using FLUCCS codes. All study area polygons with a Level 1 of 500–Water or a Level 3 of 816–Canals and Locks were assigned a "Water" value and shaded light blue.

Wetlands (Dark Green)

Wetlands were also determined using FLUCCS codes. Study Area polygons not already assigned a value and having a FLUCCS Level 1 code of 600–Wetlands were designated as "Wetlands" and shaded dark green.

Protection Almost Certain (Brown)

Coastal lands in South Florida have very high property values compared with the costs of shore protection. Along the ocean, sand replenishment protects development, supports the tourist economy, and keeps the beaches wide enough for recreation. (See Photos 1 and 2). Along other navigable waters, shoreline armoring prevents the loss of waterfront land and property, much of which was created by filling wetlands. Fill can also be brought in to elevate yards currently prone to flooding. In the aftermath of storm damages, homes are rebuilt. Homes are not abandoned to the sea, except occasionally in the most lightly developed, flood-prone areas near the western development boundaries. Therefore, it is reasonable for planners to assume that most areas that have been developed and undeveloped land in designated growth areas are almost certain to be protected.

The existence of shore protection is, by definition, a compelling reason to expect land to be protected from a rising sea. Therefore, existing shoreline armoring and past beach renourishment generally imply that shore protection is almost certain, at least in areas where shore erosion (as opposed to tidal inundation) is the likely mechanism by which land might be threatened. Similarly, the existence of beach nourishment implies that shore protection *is* almost certain. Nevertheless, shore protection might not automatically imply that *future* protection is certain if—

for example—existing protection is designed to prevent rainwater flooding or land has been armored to protect support facilities in a park managed for conservation.

Parks are a special case. South Florida has many seaside parks with the primary purpose of recreation and tourism, which would be deemed too important to the local economy and quality of life to leave unprotected. Our general approach was to assume that shore protection is certain for extensively used parks operated for purposes other than conservation, including parks that already have shore protection, while assuming that shore protection is likely but not certain for moderately used parks or parks surrounded by other areas where shore protection is likely. In some parts of Florida, a waterfront recreational park may represent the one relatively natural area in an otherwise developed community. As sea level rises and waterfront backyards are protected with shoreline armoring, those parks may continue to have natural shores—at least if shore erosion does not threaten the overall use. Land use data, however, generally do not indicate the types of park use that would allow us to readily make that distinction. Some types of parks are considered "developed" by land use data, while other parks show have an undeveloped land use code. Local knowledge was required to make that distinction.

Photo 1. Beach Nourishment in Miami-Dade County. Looking south from Bal Harbor, during the early stages of the 1998 Surfside beach renourishment project. Sheridan Bal Harbor is the large, curved building in the foreground.

Application

Given these justifications, let us now examine how the maps captured these considerations.

In general, land with existing development within developed areas or designated growth areas were determined from the unassigned polygons in the Study Area by using the FLUCCS Level 1 code of 100 (Urban and Built-Up). These polygons were assigned a value of protection almost certain and were shaded brown.

Similarly, future development within extensively developed areas and/or designated growth areas was also shaded brown. These areas were determined using land use codes from the Future Land Use Map (FLUM).

Finally, extensively used parks not operated for conservation, areas with current protection, and areas already surrounded by protected areas were shaded brown. These areas were chosen from the remaining unassigned study area polygons having a FLUCCS Level 1 code of 180 (Recreational) or a current designation of man-made protection on the Florida Marine Research Institute (FMRI) Environmental Sensitive Index dataset.

Protection Likely (Red)

Approach

Although most coastal lands are almost certain to be protected, there are a number of areas where shore protection is likely, but not certain (red). Identifying these areas is important, for two reasons: First, if local officials and residents were to decide that coastal wetland loss is likely to be too great in South Florida, these areas would be better candidates for wetland migration than areas depicted in brown. Similarly, private conservancies might purchase conservation easements in these areas to ensure the long-term survival of coastal wetlands. Second, if local officials concluded that shore protection costs were likely to be too great, these areas are less likely to receive government funding for shore protection. These areas will probably be protected, but unlike the areas where shore protection is certain, there is at least a plausible reason why shores *might* not be protected.

The general approach to identifying lands where shore protection is likely, but not certain, focuses on three broad categories of lands: (1) Developed areas where one can articulate a reason for being less than certain about future shore protection, (2) undeveloped areas where development is likely, and (3) undeveloped areas that might be protected for some reason even if they are not developed.

South Florida has many types of land where one can articulate a reason for being less than certain about shore protection. Because of the rapidly rising costs of land in South Florida, however, planners are certain that nearly all developed and developable land would be protected if the sea level was to rise incrementally, such as 1 foot every 40 years. The cost of elevating land is a small fraction of property values, and other forms of shore protection, such as enhancement of the existing levee system, may be more cost-effective.

Still, one cannot be certain that all developed areas will be protected. Homes on estate-sized lots, particularly in agricultural areas, may be worth protecting, but, if wetland migration became a priority, it may be advisable to purchase conservation easements from property owners to allow mangroves to establish themselves on portions of the properties. Properties not connected to water and sewer often have a sufficiently low investment in infrastructure that buyouts might be feasible if land owners are faced with increasing floods or if purchases for other public purposes

prevail. Lands covered by the Coastal Barrier Resources Act are ineligible for federal subsidies of flood insurance, mortgages, and beach nourishment. Therefore, if flood risks or beach nourishment costs increase, those lands might follow natural processes In all of these areas, shore protection is likely—perhaps very likely—but not as certain as it would be in most developed areas.

In areas where future development is expected, shore protection is often not certain, because, until development occurs, it is possible for a policy decision or a private transaction to development. This is particularly true adjacent to environmentally sensitive lands, where public land purchases are common. Statewide, the intensively used parks are the most widespreadundeveloped land use that is likely to be protected Nevertheless, in South Florida, especially Miami-Dade County, perhaps 60,000 acres of agricultural land may be protected because of its location within the existing levee system, whether it is eventually developed or not.

Military lands (outside of urban areas) are a final category where the general approach is to depict the land as red. This does not reflect a determination that the military is likely to protect the land so much as it reflects a study-wide convention that local planners need not speculate on the intentions of the military. Thus, red reflects uncertainty. In the case of urban lands, even if a base was closed, the shores would almost certainly be protected to allow conversion to other urban uses. Outside of urban areas, however, military bases often have environmental programs to preserve wetlands in portions of the base that are held as a security buffer. Moreover, closed coastal military bases in rural areas are sometimes transferred to environmental agencies.

Application

Existing development within less densely developed areas or outside designated growth areas or not on central water and sewer or within coastal high hazard areas were assigned the value protection likely and shaded red. The absence of water and sewer generally implies a relatively light density and modest public infrastructure, making it at least plausible that the land could be abandoned to the sea if shore protection costs escalate or if conservation organizations were to purchase lands for wetland migration. These areas were chosen from unassigned study area polygons using FLUCCS codes, Central Water and Sewer Service Areas, Urban Development Boundaries, and Hurricane Evacuation Zones.

Coastal areas that are extensively developed but fall within CoBRA Zones (i.e., not eligible for flood insurance or beach nourishment funding) and have no current protection were determined to be protection likely and shaded red.

Also chosen and assigned the same value were estate lands from the FLUM, moderately used parks operated not for conservation (based on FLUCCS Level 1 of 180–Recreational), and military lands where protection is not certain (based on FLUCCS Level 3 of 173–Military).

Agricultural areas with a history of erecting water intrusion protection structures to protect farmland from freshwater flooding also fit in this category.

Protection Unlikely (Blue)

A few areas exist in South Florida where shores seem unlikely to be protected. Identifying these areas is important for at least two reasons: First, the unlikelihood of long-term shore protection implies that people thinking about building structures in such an area must recognize that the land will probably be given up to the sea. Second, environmental planners can reasonably assume that wetlands or beaches will eventually migrate onto these lands. Because there is no expectation of shore protection, conservation easements that ensure long-term wetland migration should be relatively inexpensive.

The general approach designates several types of lands where shore protection is unlikely, but in most coastal counties, relatively little land falls into those categories. The most important category is privately held land that for some reason is very unlikely to be developed extensively enough to justify shore protection. Some agricultural areas are unlikely to be developed because they are located in the areas where development is strongly discouraged. In South Florida, this is particularly true of land outside the levees, because these lands are vulnerable to flooding during extreme rainfall and because the development these lands would negatively affect the Everglades and other conservation areas. In the Florida Keys, development is strongly discouraged in areas with habitat for rare and endangered species, which are expected to be purchased for conservation, and on privately owned unbridged barrier islands.

Application

Undeveloped lands not in designated growth areas with no history of erecting shore protection or water intrusion structures were designated as protection unlikely" and shaded blue. These areas were determined from the remaining unassigned study area polygons with FLUCCS Level 1 values of 160–Mining, 200–Agriculture, 300–Rangeland, 400–Upland Forest, or 700–Barren Lands.

Minimally used parks operated partly for conservation (FLUM designation of Preserve) with no current protection or surrounded by other blue areas were also determined to be protection unlikely and shaded blue.

No Protection (Light Green)

Although there are relatively few areas where shore protection is possible but unlikely, there is a large amount of land managed for conservation purposes, where natural shoreline processes will almost certainly allow nature, or whatever processes may be contributing to sea level rise, to take its course (no protection). Those areas were identified largely by a process of elimination. The remaining unassigned study area polygons included wildlife refuges and parks operated by the National Park Service (see section on " federal policies"). These areas were assigned a value of no protection and shaded light green.

Step-By-Step Map Procedure for Creating the Maps

Given the preceding approach, our maps were based on the following steps:

1. Exclude land above 10 foot contour.
2. Exclude wetlands.
3. Existing development is brown. Set all land with FLUCCS codes in the 100s and 800s to brown, except for military lands.
4. Future development is brown. Among remaining polygons, set all land where future land use data set indicates development to brown.
5. Agriculture lands between the levees are brown. Among remaining polygons, set all agricultural lands (FLUCCS codes in the 200s) east of the western levee and west of the Coastal Levee to brown.
6. Land with existing shore protection is brown. The MRI Environmental Sensitive Index dataset identifies manmade shores as a vector (line) feature. Any polygon for which that vector passes within 100 feet is changed to brown.
7. Development without water and sewer is red. We select Existing and Future Development polygons (brown). Within that selection, if there is no water and sewer, change from brown to red.
8. In Miami: Developed hurricane evacuation areas outside of the urban development boundary (UDB) are red. Select Existing and Future Development. Within that selection, in Miami, if land is outside UDB *and* in a hurricane evacuation area, change from brown to red.
9. Some parks are red. All lands with Code 180 that are outside of the UDB are assigned red.
10. Shore protection likely but not certain in developed CoBRA areas not already protected. Select Existing and Future Development. Within that selection, if the area is CoBRA *and* there is no manmade shore, change from brown to red.
11. Military lands outside urban areas are red. Among polygons not yet selected, change lands with military land uses to red.
12. Undeveloped lands not in Growth Areas are blue. Broward and Monroe: Among codes in the 200s, 300s, 400s, 700s, and 160s, unassigned polygons are blue. Miami-Dade, among codes in the 200s, 300s, 400s, 700s, and 160s, unassigned polygons outside the UDB are set to blue.
13. Agricultural lands outside the levees are blue. East of the coastal levee and west of the inland levee, among unassigned polygons: Lands that are agricultural either in FLUCCS (200s) or FLUM Agriculture are set to blue.
14. Remaining lands are light green. Those land are also identified as Natural Preserves in SFWMD public lands.
15. After county stakeholder review meetings, create stakeholder review layer and change the final maps accordingly, as explained in stakeholder review sections of this report.

BROWARD COUNTY

Broward County is located north of Miami-Dade, bordered by the Atlantic Ocean on the east and Everglades wetlands to the west. Although encompassing 1,250 square miles, a significant portion of the county's landmass is outside the urbanized area. Most of these areas are publicly owned wetlands used for water conservation and Everglades restoration. Broward County shares a similar development history to Miami-Dade, especially with regard to the system of levees. In 2002, the county had a population of more than 1.7 million people.

The southern two-thirds of the county are dominated by areas having elevations below 10 feet, with potential impacts due to sea level rise. The wetlands near the coast are West Lake County Park, a remnant mangrove forest at the confluence of the Dania Cut-off Canal, and the Intracoastal Waterway. As one continues north, the gradual rise of the Florida peninsula clearly shows as elevations are uniformly above 10 feet.

Discussion of Shore Protection Map

Figure 2 shows the map we created based on our initial data-gathering effort and conversations with county officials. Broward County is almost completely developed. Very high real estate prices almost guarantee that all urban upland areas will be protected.

In general, the eastern urban areas are separated from the western wetlands by a series of levees. The levees were constructed to keep the water stored in various water preserves from flooding agricultural and urban areas. Almost all study area lands within the urbanized portion of the county are today developed as urban, or within designated growth areas, and have central water and/or sewer service. These areas were designated protection almost certain, and shaded brown.

Clearly visible on the map are two red areas to the west and southwest of the urban portion of the county. These are agricultural lands within designated growth areas and east of the levees (on the "dry" side). They are, however, not on central water or sewer, and thus designated protection likely.

Most of the county's Atlantic coast is heavily developed, much of it already protected.
A few notable exceptions are within CoBRA zones and not eligible for beach nourishment funding. These isolated areas were also designated protection likely in the draft maps.

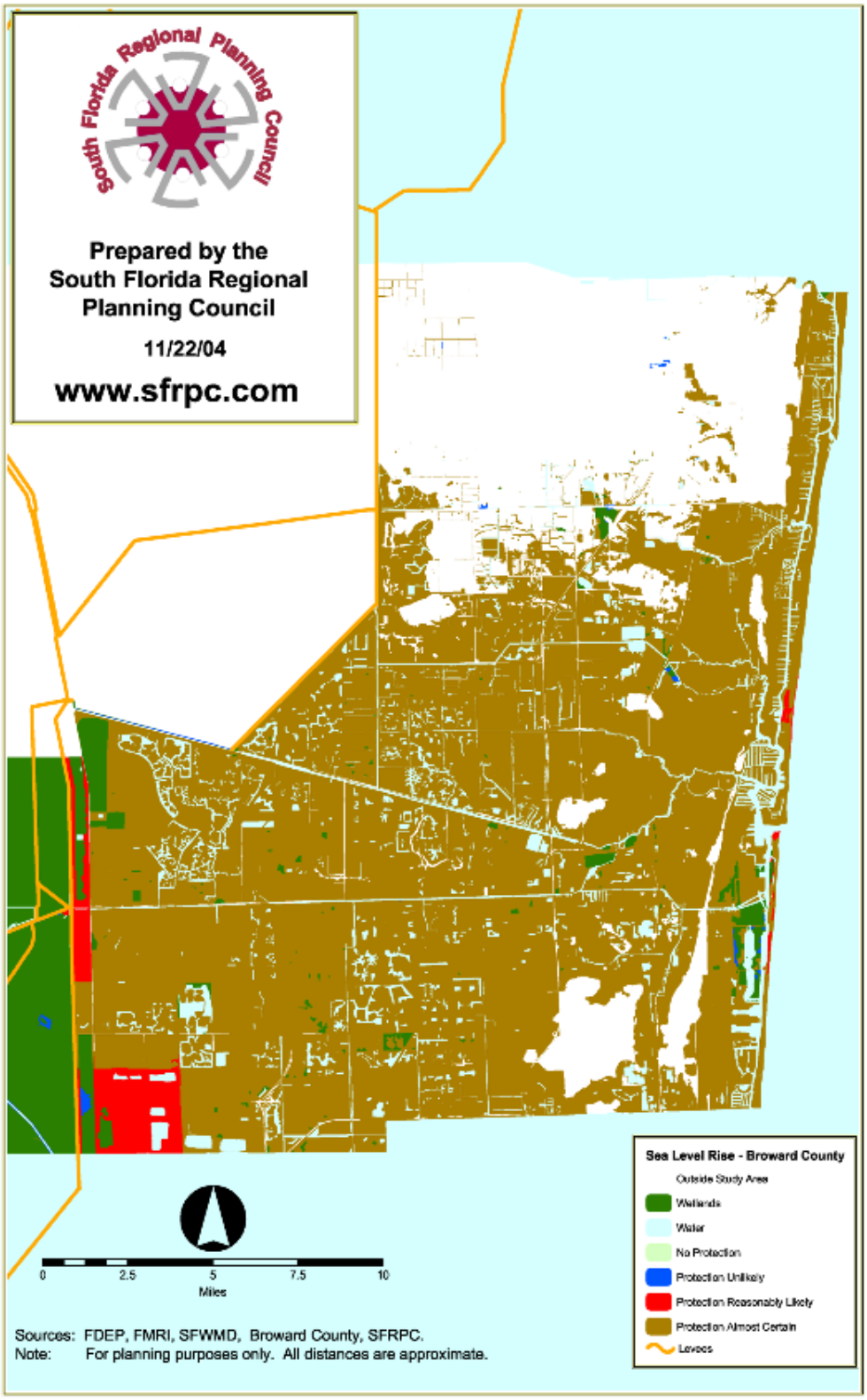


Figure 2. Likelihood of Shore Protection in Broward County: Stakeholder Review Draft Map

Stakeholder Collaboration

Preliminary Meeting with County Staff

Before attempting to determine the areas likely to be protected, Council staff presented maps showing the extent of the land that might be inundated as sea level rises to the Broward County Hazard Mitigation Task Force during its regularly scheduled meeting for June , 2003. The Task Force acts as the working group for Broward's Local Mitigation Strategy (LMS), and as a subcommittee of the County's Emergency Coordinating Council. The purpose of LMS groups is to anticipate future disasters and plan for activities today that will reduce vulnerability to lives and property from future disasters. Broward's focus regarding sea level rise is protection of its beachfront tourism industry (see Photos 2 and 3), and protection of its vulnerable residents during hurricanes. The County is committed to continueperiodic beach renourishment activities. Task Force participants noted the potential for damage to the potable water aquifer from sea level rise to the west. Council staff will continue to participate in LMS activities to keep the sea level rise issue in the consciousness of County staff.


Photos 2 and 3. Hollywood Beach. (June 2005).

Stakeholder Review of Shore Protection Maps

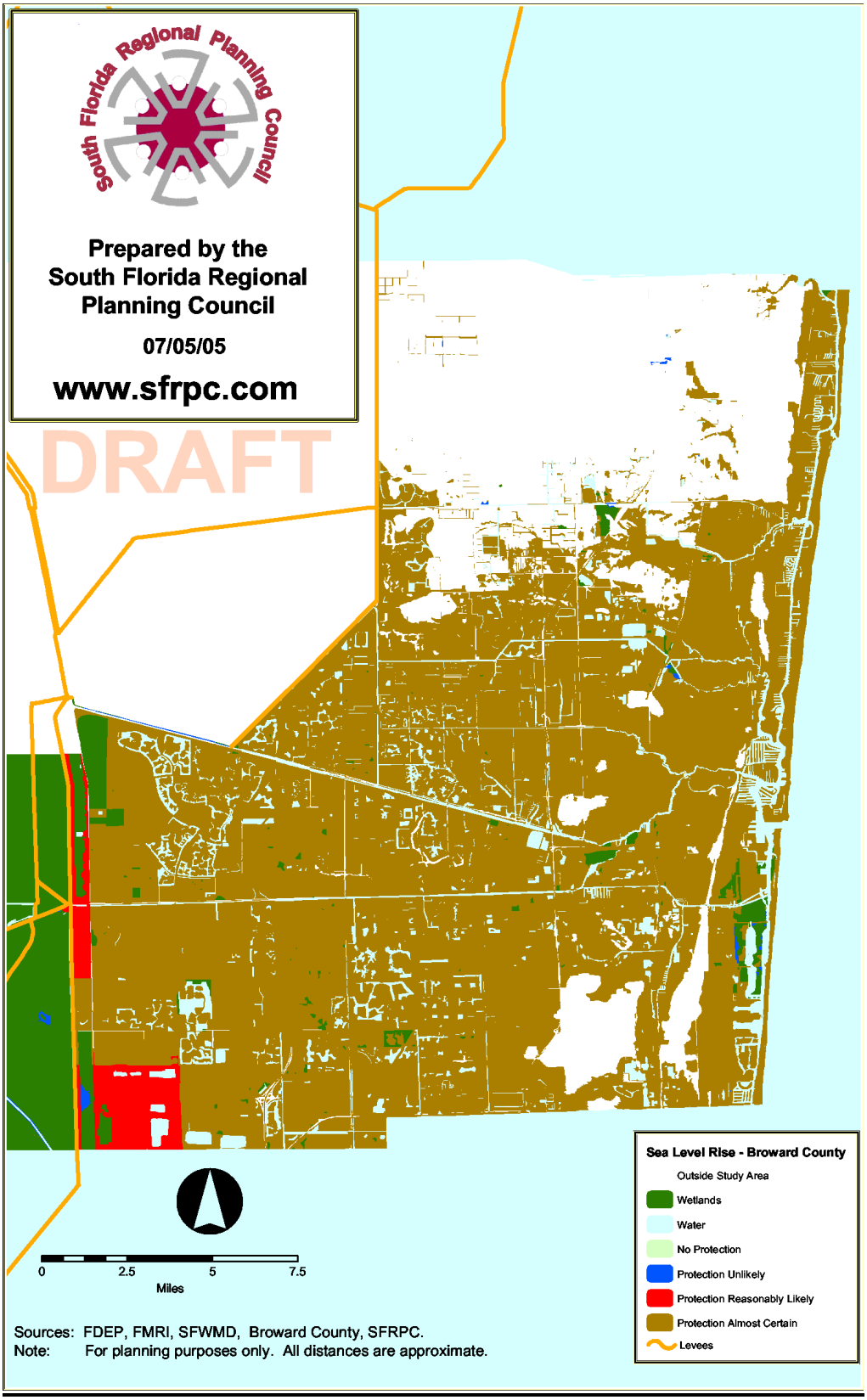
Peter Schwarz, Broward County Department of Urban Development Planning
Ryan Williams, Broward County Department of Emergency Management

SFRPC held a stakeholder review meeting at its offices in Hollywood on June 13, 2005, with staff from all three counties as well as Dan Trescott from the SWFRPC and Jim Titus from EPA.

After 20 minutes of general discussion and a 10 minute discussion of Broward County, the meeting subdivided into county-specific discussions, with John Hulsey of SFRPC joining the Broward discussion. Because almost all the dry land in Broward County is being developed and land values are high, the remaining discussion for Broward was fairly brief.

County staff agreed with all the brown designations in the draft maps. In addition, staff suggested that all the areas colored red on the barrier islands in the draft maps should be changed to brown, including Hugh Taylor Birch State Park, Fort Lauderdale Beach, John U. Lloyd State Park, and North Beach County Park. These areas receive millions of dollars in funding for current beach nourishment projects, are significant tourism assets for the local economy, and are almost certain to be protected as sea level rises in the decades ahead. With these changes, all of the dry land within the study area in Broward is depicted as brown except for some sparsely settled agricultural lands.

Map 1 shows our final map of Broward County. Table 6 quantifies the acreage of each protection category. More than 99 percent of the dry land in the county is likely or certain to be protected as sea level rises.



Map 1. Likelihood of Shore Protection in Broward County

Table 6 - Broward County Acreage by Sea Level Rise Category

Polygons	Acreage	% of Dry land in Study Area	Color	Category
59,892	797,942		N/A	County
21,159	521,667		White	Outside Study Area
815	63,885		Dark Green	Wetlands
9,897	21,869		Light Blue	Water
0	0	0	Light Green	No Protection
125	1,644	0.9	Dark Blue	Protection Unlikely
147	5,017	2.6	Red	Protection Likely
27,749	183,860	96.5	Brown	Protection Almost Certain

MIAMI-DADE COUNTY

Miami-Dade County is located on the Atlantic Coast of Southeast Florida, with Monroe County to the south (the Florida Keys) and west and Broward County to the north. Of the total area of almost 2,000 square miles, nearly 1,300 are covered by wetlands. Most of these wetlands are within Everglades National Park, Biscayne National Park, or Big Cypress National Preserve. Population exceeded 2.3 million people in 2002.

The county's landmass is characterized by a coastal ridge generally running north-south, giving way to the west and south to downward sloping uplands and very low elevations, often below the ordinary high water mark.. Beginning in 1950, levees were built west of the established agricultural areas to keep the fresh Everglades waters from inundating those areas and the urban areas to the east. (See Photo 4.) In a reversal of roles, these levees may one day keep salt water flowing north from the Gulf of Mexico and Florida Bay from intruding into the same urban areas. The levees, and their effect on local water levels, represent a significant county-specific deviation from the general criteria used throughout the state to identify the likelihood of protection.

Photo 4. Levee Along Krome Avenue (June 2005)

Discussion of Shore Protection Map

Figure 3 shows the map we created based on our initial data-gathering effort and conversations with county officials. The map is dominated on the south and west by vast areas of wetlands, shaded dark green. Interspersed among the wetlands are upland forests in National Park lands, which, by federal policy, will receive no protection and are shown as light green.

Starting in the northwest along Levees L-33 and L-30, the areas shaded red (protection likely) to the east are mostly agricultural lands, with some developed areas outside the county's growth area or not on central water and sewer. The areas east of the levee where shore protection is unlikely (shaded blue) include recreational and open spaces, forests, mining, barren lands, and other undeveloped areas. None of these lands are within designated growth areas.

The Lake Belt Area encompasses the many distinct square-shaped lakes found in this region, the result of rock mining operations. Once mining operations are finished, county policy will revert these areas to recreational use, hence our maps show them as blue..

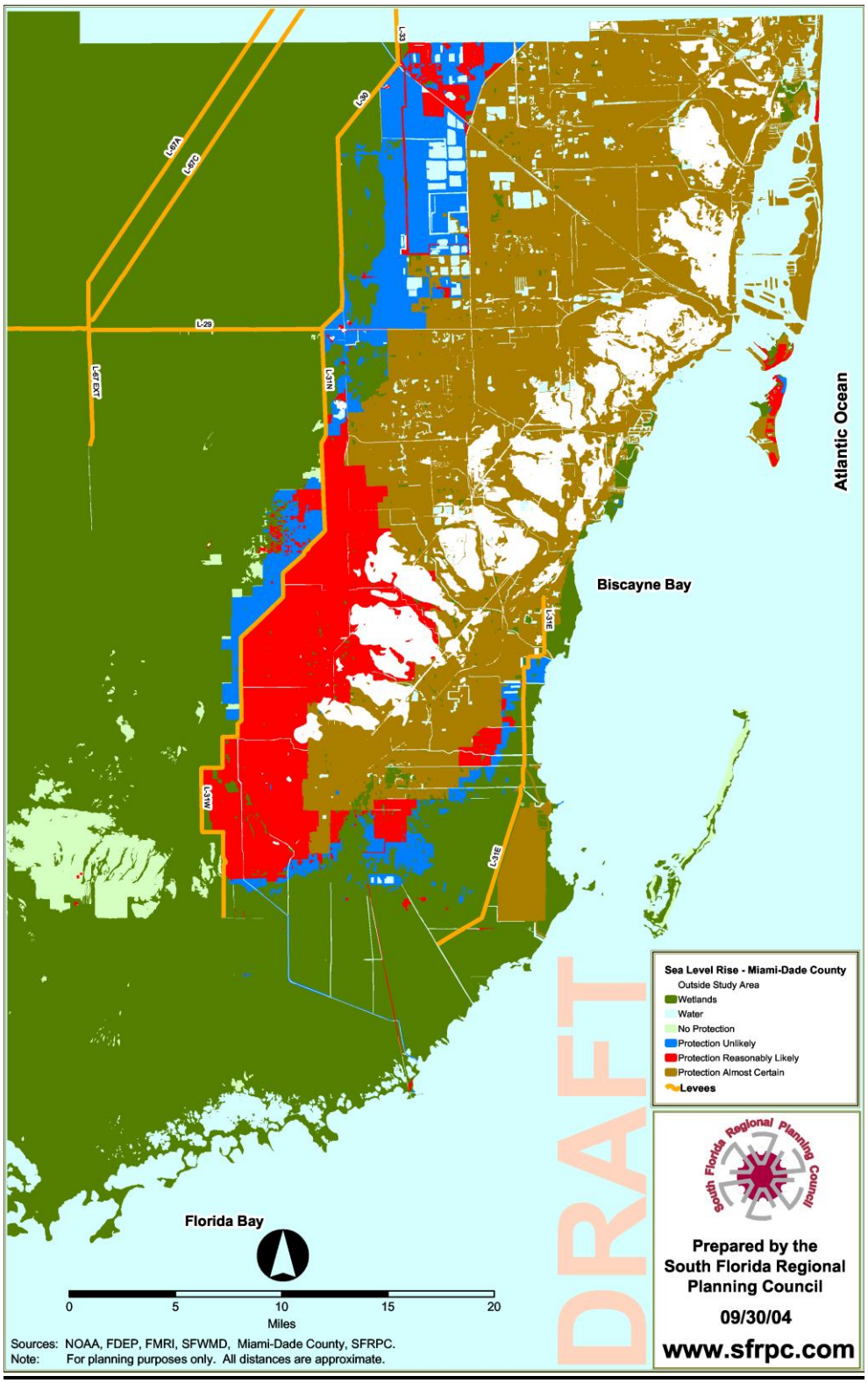


Figure 3. Likelihood of Shore Protection in Miami-Dade County: Stakeholder Review Draft Map

Running north and south on the west, Levees L-31N and L-31W serve as a hard boundary between wetlands and the generally urbanized areas to the east. Large tracts of land where shore protection is unlikely (blue) adjacent and immediately west of these levees are primarily agricultural lands. (See Photo 5.) As we developed these maps, however, negotiations were under way for the addition of a second levee in this area, which would make it reasonably possible to protect lands west of the levee (on the "wet" side).[5] On the northern edge of the area shaded blue is the "8 ½ Square Mile Area", which the draft maps designated as protection likely (red).

Adjacent to these levees on the east side are large red areas of mostly agricultural lands, which, by virtue of their location on the "dry" side of the levees, are likely to be protected. Also included on the eastern fringe of the areas shown in red, are developed lands not served by central water and sewer or outside the county's Urban Development Boundary.

The areas shown as red or blue along the southern border, between the urban area and the wetlands, are very similar in nature (i.e., agricultural lands, outside growth areas, etc.) to those already mentioned.

The former Homestead Air Force Base, also located along the southern urban border, is planned to be reused as an economic resource by Miami-Dade County, as well as continued use by the Department of Defense as the Homestead Air Reserve Base and thus designated protection almost certain, and shaded brown.

The large areas shaded brown on the east side of Levee L-31E and adjacent to the coast are the cooling canals from the Florida Power and Light Turkey Point Nuclear Power Plant. Under any scenario, this area will certainly be protected.

From the south, running north along the coast, are the most heavily developed areas of the county. With a few exceptions for patches of wetlands, these areas are almost certain the be protected. The coastal ridge shows up clearly in the map because its elevation being greater than 10 feet leaves it outside the study area, and hence depicted in white. Although near the coast, the ridge is within 1,000 feet in only two spots, both near Downtown Miami. The Coastal Ridge is urban and already has shore protection structures.
The barrier islands between the northern part of Biscayne Bay and the Atlantic Ocean include some of the most valuable real estate in the county. For the most part, they are extensively developed and their shores are already being protected by seawalls, rip rap, or beach renourishment programs. As such, our maps show them as "protection almost certain" (brown). .

The draft maps had several exceptions to the general mapping rules on Key Biscayne and Virginia Key (to the southeast of Miami) and one small section in the northern part of the county. These areas contain wetlands, have no shore protection, and are located within CoBRA Zones. These exceptions were mostly clarified in the stakeholder review, described below.

[5] During the stakeholder review meeting, all of the blue areas were changed to either red, shore protection likely, or dark green, wetland.

Photo 5. Canal and levee with agricultural lands to the west. This photo is near the Howard Drive crossing of the levee, into the largest agricultural area outside of the levee system. June 2005.

Stakeholder Collaboration

Preliminary Meeting with County Staff

Before attempting to determine the areas likely to be protected, Council staff presented maps showing the extent of the land below the 5- and 10-ft (NGVD) contours.to two groups: the Miami-Dade Local Mitigation Strategy (LMS) Working Group in July 2003; and the Miami-Dade Climate Change Adaptation Task Force in January 2004.

Miami-Dade County is the only county in South Florida to proactively explore the consequences of sea level rise in its planning. Miami-Dade County Planning and Zoning is sponsoring the South Miami-Dade Watershed Study and Plan, which will determine the impacts of future development to the year 2050 on the tributary area supplying freshwater to Biscayne National Park. As part of this study, the assumption is being made that sea level will rise 6 inches by 2050. The resulting plan will influence the location of future urban development to areas which are less environmentally sensitive and less vulnerable to natural hazards.

The Miami-Dade Climate Change Adaptation Task Force is charged with determining and mitigating ways in which Miami-Dade County contributes to climate change, as well as planning

for the negative impacts of climate change. Recommendations of this task force have led to changes in county policies and practices, including the purchase of a fleet of more than 400 hybrid gasoline/battery powered county cars to reduce carbon monoxide emissions. The County plans to purchase other hybrid vehicles such as vans and trucks as they become available.

Stakeholder Review of Shore Protection Maps

Paula Church, Miami-Dade County Department of Planning and Zoning
Frank Reddish, Miami-Dade County Department of Emergency Management
Jonathan Lord, Miami-Dade County Department of Emergency Management

SFRPC held a stakeholder review meeting at its offices in Hollywood on June 13, 2005, with staff from all three counties as well as Dan Trescott from the SWFRPC and Jim Titus from EPA. After 20 minutes of general discussion and a 10-minute discussion of BrowardCounty, the meeting subdivided into county-specific discussions, with Manny Cela and Dan Trescott discussing the project with the Miami-Dade representatives. John Hulsey joined the second half of the discussion, after Broward County officials departed. The discussion of Miami-Dade County lasted approximately 75 minutes..

At the beginning of the meeting, county officials were surprised that we would be consulting with land use planners on a sea level rise study rather than the water managers. Trescott explained that it is true that the Corps and SFWMD would be involved in deciding how best to protect developed areas—but that it is land use that ultimately drives whether lands require protection. County staff were initially uncomfortable with the notion that any portion of the county might ultimately be given up to the sea, but after discussing the reasoning for designating some areas outside the levees as unlikely to be protected, they agreed that for this first-cut effort, it is useful to identify the areas with the greatest chance of not being protected from rising sea level.

The county suggested the following changes to the maps

1. *Change the county and state parks on Key Biscayne from red to brown.* These parks are extensively used for recreation and not just conservation. They also have some degree of protection in the form of beach renourishment (Crandon Park) and seawalls (bayside of Bill Baggs Cape Florida State Park). Moreover, they border along other areas where shore protection is certain.
2. *Change the western half of the blue polygon on the north ocean side of Key Biscayne from blue to red.* The east part (ocean side) was correctly depicted as blue. The park land and road would need to be protected on the west side. On the east side fronting the ocean, environmental reasons will probably preclude shore protection due to the petrified coral reef, the only such reef in the United States.
3. *Change the red areas on Virginia Key to brown.* The County plans to create a more developed and extensively used park on this public land..
4. *Change Haulover Beach Park from red to brown.*

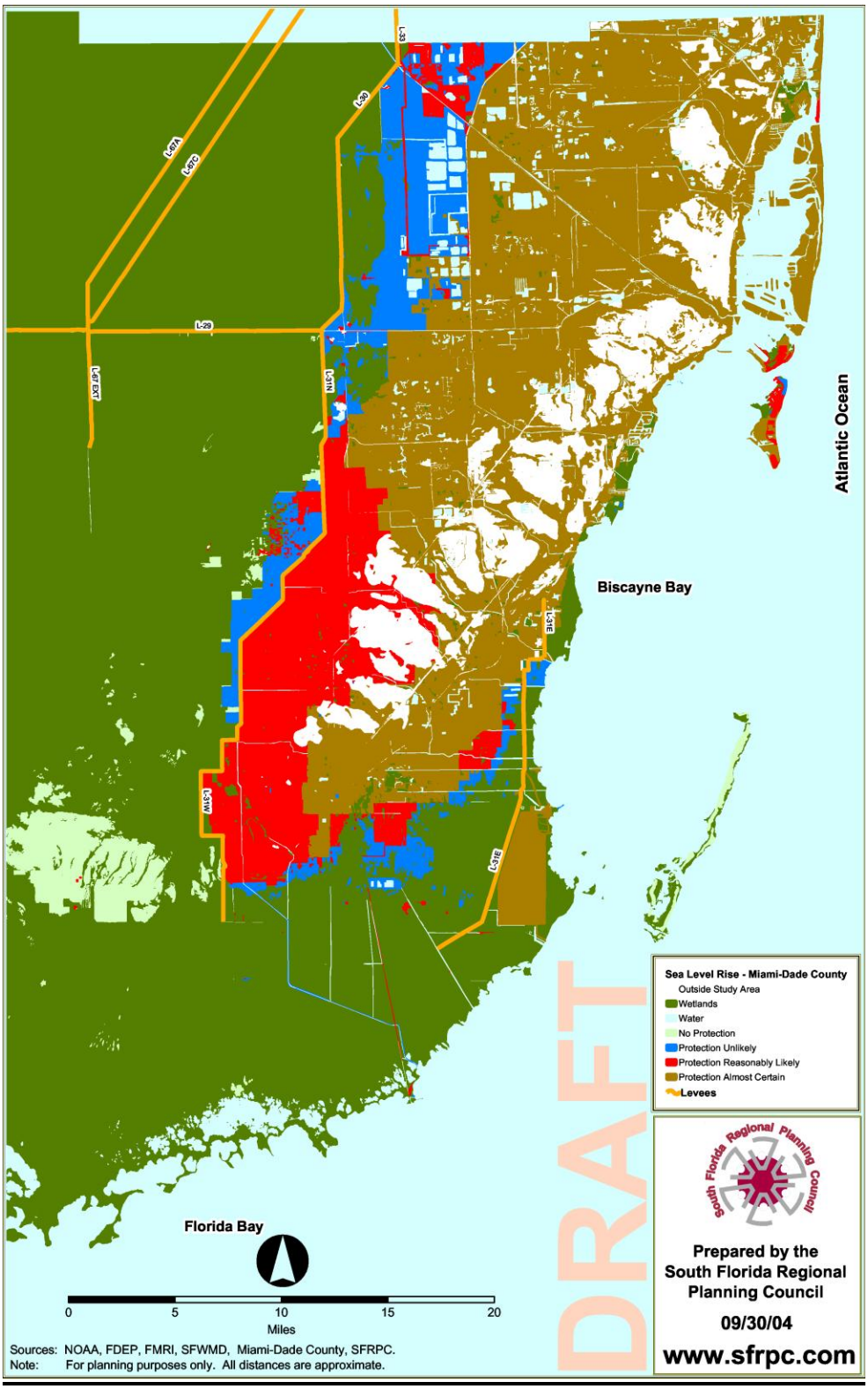
5. *From Miami Beach north, change all parks on the barrier island depicted as red to brown.*. These parks are extensively used, receive beach renourishment, and are next toor surrounded by—other lands that are certain to be protected.
6. *Change Frog Pond from red to purple or dark green, and the Rocky Glades area from blue to dark green.* The draft maps correctly reflected existing land uses, including both agriculture and low-density residential (1 unit/40 acres). These areas will be redesignated to an Environmental Protection category, which does not allow residential development and restricts other land uses as well. As part of the Comprehensive Everglades Restoration Plan, federal and state governments will purchase these areas and convert them to wetlands.[6]
7. *Change the "8 and ½ Square Mile Area" to reflect current restoration plans.* The draft map showed a combination of green, blue, and red. The western third of this area will be converted to wetlands as part of the Everglades restoration and should be changed to purple or dark green. The remaining two-thirds should be changed to red, to reflect plans to increase the allowable density and protect the area with a new levee.

Map 2 shows our final map of Miami-Dade County. Table 7 quantifies the acreage of the various shore protection categories. Approximately 80 percent of the dry land the County is likely or certain to be protected. Nevertheless, because the majority of the land in the county is nontidal wetland, mangroves may have the potential to migrate inland onto existing nontidal wetlands in as many areas as the protection of dry land blocks such a migration.

Table 7 - Miami-Dade County Acreage by Sea Level Rise Category

Polygons	Acreage	% of Dry Land in Study Area	Color	Category
70,191	1,268,450	N/A	N/A	County
14,883	65,401	N/A	White	Outside Study Area
11,797	829,991	N/A	Dark Green	Wetlands
9,241	39,313	N/A	Light Blue	Water
838	26,403	7.9	Light Green	No Protection
998	35,598	10.7	Dark Blue	Protection Unlikely
2,426	61,751	18.5	Red	Protection Likely
30,008	209,993	62.9	Brown	Protection Almost Certain

[6] The maps produced by SFRPC showed tidal and nontidal wetlands as dark green. Our final maps distinguish tidal and nontidal wetlands, showing the latter as purple. Because these wetlands are nontidal wetlands, they are shown in purple.



Map 2. Likelihood of Shore Protection in Miami-Dade County. To depict the largest possible scale of the developed areas, this map omits portions of the County within the Everglades.

In addition to the suggested map changes, County staff specifically confirmed the reasonableness of several map delineations:

8. According to Emergency Management staff, it was appropriate to depict the rock mining areas in the northwest portion of the county as protection unlikely (blue). These areas– some of which are leased for rock mining–will convert to park use once the mining is complete.
9. According to Emergency Management staff, the cooling canals of Turkey Point are almost certain to be protected, as shown in the draft maps. The infrastructure must be protected to serve the function as cooling canals for the power plant, to thermal pollution of Biscayne Bay. However, SFRPC staff should consult with Florida Power and Light.
10. According to Emergency Management staff, for hurricane storm surge protection and long-term sea level rise protection, connecting the south end of the L-31W levee and L-31E levee might be feasible.
11. The agricultural area in southwest Miami-Dade depicted in red is unlikely to be developed for residential purposes so that tropical fruit that can be grown there, and future development should not be allowed.
12. Planning staff agrees that the maps correctly depict the East Everglades Area as protection unlikely. The SFWMD wants to raise water level in that area.
13. The areas east of the levee (L-31W) in south Miami-Dade are correctly depicted as red. These areas will probably be protected. Most likely, either they will be developed or governments will decide to protect them for agriculture.
14. The maps correctly depict most of the dry land in the county as protection almost certain. Property values are too high for people to voluntarily abandon their homes to the sea.

MONROE COUNTY MAP ANALYSIS

Monroe County is located south and west of Miami-Dade, bordered by the Atlantic Ocean on the east and south and the Gulf of Mexico and Florida Bay to the west. In 2002, the county had a population of only 79,000 people, all of them residing in the Florida Keys, a string of islands which has 102 or the county's 1000 square miles of land. The rest of the county's land is on the mainland within Everglades National Park, and is mostly wetland.

Discussion of Shore Protection Map

Figure 4 shows the map we created based on our initial data-gathering effort and conversations with county officials. Virtually the entire landmass of Monroe County lies below 10 feet elevation, and much of it is below 5 feet. (See Photo 6). The few exceptions are either within 1,000 feet of the coast or completely surrounded by developed areas. Thus, we included the entire county in the study area.[7]

Photo 6. Big Coppitt Key. (June 2005)

Available vacant lands suitable for development in the Florida Keys are very scarce and extremely valuable. With a scant 250 building permits issued per year for the entire county, owners of developed lands are very likely to protect their investments.

[7] Excluding the small amount of land that is more than 1000 feet from the shore and above the 10-ft contour would have required more effort than including it in the study area.

Starting with the Lower Keys in the south, most upland areas in the City of Key West and Stock Island are already developed and/or protected. (See Photos 7 and 8.) This includes the military facilities in the Naval Air Station. These areas are designated protection almost certain (shaded brown). A few exceptions, notably those within CoBRA designated areas and turtle-nesting areas, were changed to protection likely (shaded red).

The areas designated "no protection" (light green) are portions of the many federal, state, and local parks, wildlife refuges, sanctuaries, etc. located in the Florida Keys.

Northward through the Middle Keys, most dry lands are developed and designated "Protection Almost Certain" (brown). The exceptions in this area are a few CoBRA areas (shore protection likely) and several conservation parcels designated protection unlikely (blue).

Similarly, the dry lands in the Upper Keys are mostly developed and/or already protected. These areas are also designated "protection almost certain".. A few CoBRA designated areas are shown as "shore protection likely" (red) , with conservation parcels designated as shore protection unlikely (blue).. Additional federal, stateand local parks, wildlife refuges and sanctuaries are designated as "no shore protection" (light green). .

Photos 7 and 8. Key West. The first photo shows Mallory Square with Sunset Key (formerly Tank Island) in the background. The second photo shows the public beach on the south side of Key West. June 2005.

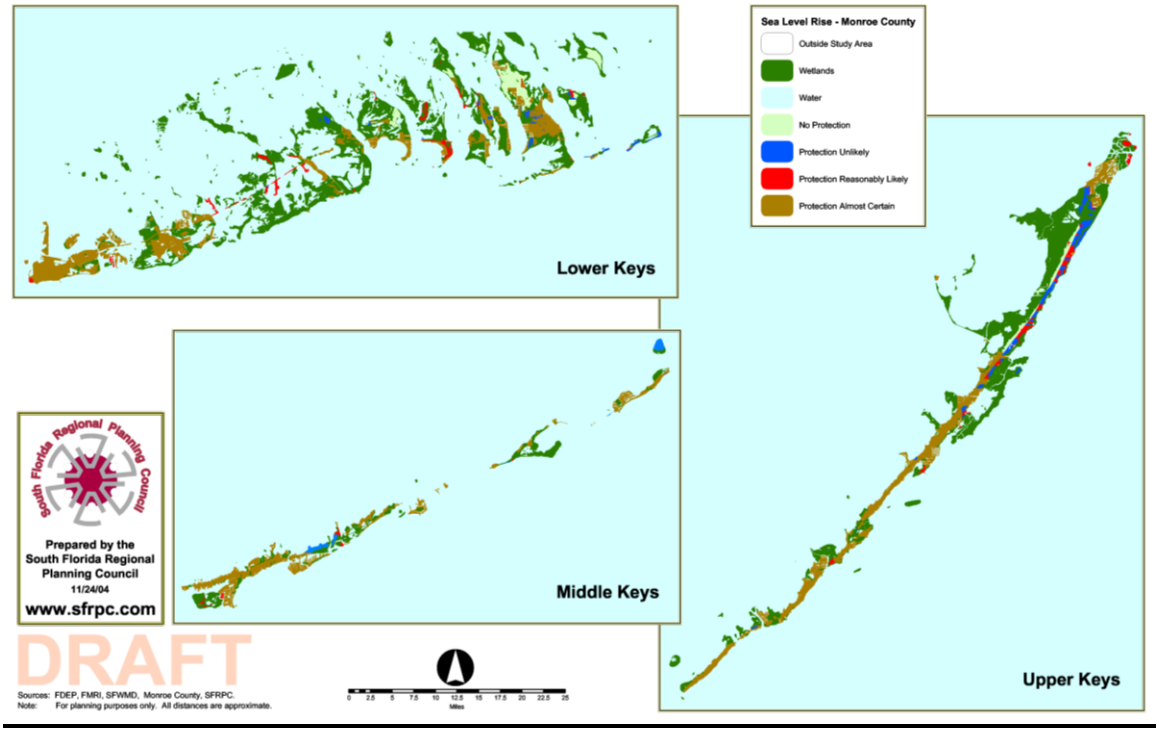


Figure 4. Likelihood of Shore Protection in the Florida Keys: Stakeholder Review Draft Map.

Stakeholder Collaboration

Preliminary Meeting with County Staff

Before attempting to determine the areas likely to be protected, Council staff presented the initial maps showing the extent of the lands below the 5- and 10-ft contours at a meeting of the Water Resources Advisory Council (WRAC) of the South Florida Ecosystem Restoration Task Force in Key Largo in July 2003. The meeting was attended by officials of Monroe County and its municipalities as well as water utilities, environmental agencies, and advocacy groups. Of particular concern was the impact on potable water supplies in south Miami-Dade, the source of drinking water for the Florida Keys. Monroe County is dedicated to the provision of centralized sewer systems throughout the Florida Keys to prevent degradation of nearshore water quality at considerable expense to preserve the opportunity for future growth. Monroe County is the first in south Florida to face an affordable housing crisis due to high real estate values. These factors increase the likelihood of further protection against the rising sea.

The South Florida Water Management District is a co-partner with the U.S. Army Corps of Engineers in the planning and implementation of the Comprehensive Everglades Restoration Plan (CERP). Planning for the CERP assumes a rise in sea level of 6 inches by 2050, the expected completion of plan implementation. With an estimated price tag of $8 billion in 2000 dollars, it was noted that many of the environmental benefits of Everglades restoration could be short-lived if the premise of this study is proven accurate.

Stakeholder Review of Shore Protection Maps

Jeff Stuncard, principal planner, Island Planning Team, Key Largo Office
Tim McGary, director of Growth Management
Jason King, Key Largo Office,
Beth LaFleur, Marathon Office
Andrew Trivette, Marathon Office

SFRPC organized a second meeting with Monroe County land use and emergency management planners at the SFRPC offices on June 13, 2005. Representing Monroe County were Irene Toner of Monroe County Department of Emergency Management and Jeff Stuncard of Monroe County Department of Growth Management. Also present were Jim Titus of the EPA and Dan Trescott of the SWFRPC, as well as officials from Miami-Dade and Broward counties. Jeff Stuncard invited Jim Titus to visit the planning staff in Monroe County to discuss the maps in greater detail on June 16. Titus visited Jeff Stuncard and Jason King at the Key Largo office, and Beth La Fleur, Andrew Trivette, and Tim McGarry at the Marathon Office.

The discussion included Monroe County's proposed plan to divide land in the Florida Keys into three tiers, in which development is either encouraged or discouraged, with Tier 1 being the most

environmentally sensitive and, therefore, the most likely to not be protected from the rising sea.[8] The Monroe County planners noted that the polygons used by the SFWMD were too general,[9] and that an area shown as brown on the draft maps may have a small portion having been developed, and likely to be protected, while other areas within that polygon are proposed to be in Tier 1, protection unlikely. In some areas, land has been purchased for conservation since the SFWMD land use data were produced, leading the County to suggest that we change such areas to no protection or wetland, depending on the characteristics of the property. Other coastal areas that the drafts showed as protection almost certain were identified as sea turtle nesting areas, within which armoring of the shore is prohibited, making shore protection of adjacent developed lands less than certain; so we changed those areas from brown to red. Finally, county staff asked us to designate almost all other Tier 3 areas (which are targeted for future development) to protection almost certain. In a few cases, the County provided aerial photographs to identify specific locations for future shore protection as sea level rises.

The SFRPC attempted to make all of the site-specific changes requested by local officials. However, because these comments came at the end of the study by which time most resources were expended, it was too late to incorporate the general mapping methodological suggestions. Therefore, the maps correctly reflect the County's thinking at the scale at which we made the corrections, but the underlying map data do not have the level of precision that they would have had if we had been able to completely follow all of the county's suggestions.

We now describe in more detail the comments that county staff provided during the three stakeholder review meetings. SFRPC does not necessarily agree with all the comments, but we include those comments to provide a complete record of the basis for the maps.

Meeting in Hollywood.

SFRPC held a stakeholder review meeting at its offices in Hollywood on June 13, 2005, with staff from all three counties, as well as Dan Trescott from the SWFRPC and Jim Titus from EPA. After 20 minutes of general discussion and a 10-minute discussion of Broward County, the meeting subdivided into county-specific discussions, with Jim Titus discussing the project with Jeffrey Stuncard of Monroe County for the next 100 minutes. Dan Trescott, John Hulsey, and Manny Cela joined the final 20 minutes of this meeting, after the representatives from Broward and Miami-Dade had left.

Jeffrey Stuncard stated that he understood the purposes and methods of the study, and that Monroe County would like to help SFRPC in this endeavor. The draft maps, however, were inconsistent with county environmental and land use policies, and would require several revisions. The primary concern, he suggested, was that the maps did not appear to recognize the ongoing and proposed restrictions on development in Tier 1. He indicated that he was unprepared to say precisely how the map should be revised, because this meeting was the first he

[8]The proposed tier system has not yet been accepted by the Florida Department of Community Affairs. Nevertheless, the County views it as the most accurate guide to how the county manages economic growth.
[9]As explained in previous sections, parcel level data were not available for all of the counties when we began this study. As a result, the used polygons from the SFWMD for future land use to maintain consistency throughout the study.

had ever heard of the sea level rise planning study. He would need to consult with colleagues and various data sources back at the office. When Jim Titus offered to visit Monroe County, he agreed to set up meetings three days later at his office in Key Largo, as well as the main office in Marathon.

Meetings in the Keys: General Issues.

At the Key Largo meeting, Mr. Stuncard and Jason King addressed the Upper Keys. Although our maps define the Upper Keys as all of the Florida Keys from Upper Matacumber Key north, county policies do not apply to the incorporated areas. Therefore, this meeting addressed only Key Largo and the small islands to the north. Both Stuncard and King reiterated that the distinction between Tier 1 and other lands provides the most important countywide indication as to whether lands will be developed and require shore protection. Accordingly, they offered to send a shapefile so that we could ensure that our sea level rise planning maps are consistent with the county policy.[10]

We then discussed each of the specific areas. Planning staff generally agreed with the protection almost certain (brown) designations and made several suggested changes for the protection likely (red) and unlikely (blue) areas.

In the afternoon, Titus first met with Tim McGary, director of Growth Management for Monroe County. He indicated that he recalled an EPA-sponsored meeting on sea level rise in Marathon in 1999, which had included Dr. Billy Causey, two council members, several scientific experts, and about 100 area citizens. he had not heard of this particular effort until the previous week, however, when he assigned Mr. Stuncard to attend the meeting. He encouraged the organizers of this study to try harder to keep Monroe County in the loop. The policies of Monroe County, he said, are very different from other Florida counties, so assumptions that may be appropriate in other counties do not apply to Monroe. In particular, the county's Rate of Growth Ordinance (ROGO) has largely curtailed development in Tier 1 areas—and a proposed rule is likely to restrict it further. After 20 minutes, he turned Titus over to Andrew Trivette. Ten minutes later, Beth LaFleur joined the meeting.

At the outset, both Mr. Trivette and Ms. LaFleur stressed that they had only learned about this study the previous day. Without time to prepare, Ms. LaFleur said that she would not be able to suggest specific changes to the maps, and also had to leave at 2 PM. Trivette said that he had read the report, understood the type of information that the Key Largo Office had provided, and could provide the information we needed after Ms. LaFleur departed. We therefore started with a general discussion.

[10] SFRPC declined the offer to revise the maps to incorporate these county data. The various data layers had already been combined before the stakeholder review maps were created. Therefore, using the county data would not merely require a simple replacement of an old data layer with a new data layer, but rather redoing all the GIS processing. Compare GIS decision rule tables for the companion studies of Maryland, Virginia, New Jersey, and Georgia (Chatham County), where the data "flattening" took place after the final review, making it easy to replace one data layer with another.

Trivette and LaFleur said that we should have met with Monroe County before undertaking the mapping effort. The maps should use county data and reflect county policies. In particular:

- The SFWMD wetlands data classify both developed and undeveloped dry land areas as wetlands. We should correct the wetland errors. We should use county data as a check.
- Monroe County also has data on developable wetlands. Those areas should be red or brown, not dark green.
- The maps should reflect county rules prohibiting shoreline armoring in turtle nesting areas.
- The SFWMD future land use data are inaccurate or obsolete.[11]
- Monroe County's Tier 1 and Tier 3 are the county's official vision of future land use, and should be used instead of the SFWMD data, which are based on pre-1992 policies.
- It would make more sense to use the county parcel data than the SFWMD land use land cover data. Doing so would obviate the need to make numerous polygon-specific edits resulting from our discussions.

Titus indicated that SFRPC had decided—at the outset—that it could not undertake the sea level rise analysis on a parcel-by-parcel basis, and that a lead author has to have some discretion in the method of conducting a study.[12] Otherwise, he said, it seemed to him that their suggestions were consistent with the types of comments that the overall study method was designed to solicit. Nevertheless, some additional discussion was required to determine the best way to make such improvements. We describe the map changes and underlying rationale suggested by the County comments.

In turtle-nesting areas, change brown to red. Shoreline armoring (e.g., bulkheads, stone revetments, seawalls) is prohibited in these areas. Trivette said that permits had not been issued for beach nourishment, bio-logs, or other "soft" forms of shore protection in these areas either. Moreover, the regulations prohibit construction of a home less than 100 feet from the shore in this area. Existing homes have not been moved out of this 100-foot buffer area to accommodate turtles, but if an existing home was destroyed by a storm, reconstruction efforts would be subject to the regulations. For all of these reasons, one cannot say that these developed lands are *certain* to be protected. On the other hand, county staff was unable to go so far as to say that shore protection was unlikely. Environmentally sensitive shore-protection measures are more expensive than shoreline armoring, but given the high land values along the Atlantic waterfront, they would be economically feasible.

We applied this change to land east of US-1 within 300 feet of the shore in turtle nesting areas that the County identified. If the County were to provide a data set, a future effort could more precisely incorporate this policy wherever it applies.

[11]The draft maps often have brown polygons that are several times as large as they ought to be. In some—perhaps all—of these cases, the brown polygons in the draft maps comprise an entire area that was originally platted for development—but only a small area has been developed; little or no development is anticipated, and some of the land may even be owned by the county for preservation purposes.

[12] Although SFRPC decided not to conduct a parcel-specific analysis, the data it used do contain numerous parcel-sized polygons.

Make sure that the maps can be easily revised as new wetlands data become available. Although a given map must use an available wetlands data set, a better digital wetlands data set will be available in the next few years. Therefore, the GIS dataset should be set up in a fashion that allows the map to be easily revised when new wetlands data become available.

This suggestion is consistent with the approach taken by most of the sea level rise studies outside of Florida, where protection categories are identified for all areas and a wetlands data set is placed "on top" of the protection layers to create the final set of maps. In those cases, a different wetlands data set can be easily incorporated. But all of the studies in Florida followed a different approach, in which all wetlands are excluded from the study at the outset. Therefore, all the GIS processing would have to be redone to use a different data set. Although reprocessing the GIS data layers so that wetlands data can be revised is a straightforward GIS task, it would be time consuming, and is best left for a future effort.

Use Monroe County Tier 3, rather than SFWMD future land use data, to identify those areas where expected future land use makes shore protection certain.. The tier system is the county's expected future land use; the older SFWMD future land use is obsolete. Tier 3 can simply be substituted for SFWMD's future development data, in the process followed for identifying brown polygons (including those that are later changed to red due to other factors such as COBRA). The net effect of this change is that undeveloped lands in Tier 1 are unlikely to be protected.

For the same reason that we cannot simply substitute one layer of wetlands data for another, we could not substitute one future development layer for another with the available resources. A future effort could do so. Meanwhile, as discussed below, we did make site-specific corrections to accomplish the same thing, albeit with less precision than if we used the county's data layer.

Developable wetlands should be depicted as red. These lands are likely—but not certain—to be developed.

Similarly, we could not make this general change. Nevertheless, we did make site-specific corrections for those cases identified by the County.

Make site-specific corrections as identified by county reviewers. We did make all of those changes, which we now examine in detail.

<u>Site-Specific comments and map changes</u>:

Maps 3-5 show our final maps of the Upper, Lower, and Middle Florida Keys, based on approximately 50 specific map changes suggested by Monroe County planning staff. We briefly describe each of those changes; Appendix VI shows the location of the suggested changes corresponding to each of the index letters in the following list of map changes.

Key Largo Office—Upper Keys.

A. *Change North Key Largo on the east side of FL-905, from US-1 to Card Sound Road from blue and red to light green, except for three lightly developed areas: Valois, Post Rod, and Cary's Fort.* This area is the primary Tier 1 area for the Upper Keys. These lands are being acquired by the County for conservation purposes. The draft map already showed light green on the west side of FL-905 because of the presence of Crocodile Lake National Wildlife Refuge. Construction in this area is strongly disfavored—with only one new home every 10–15 years. This area entirely falls under jurisdiction of CoBRA.

B. *Within the North Key Largo area, the community of Valois is an exception—it should be depicted as shore protection likely (red) as shown in the draft maps.* The area protected consists of the land between Charlemagne, Valois, and Marseilles streets, as well as plotted lots between Palm and Atlantic streets. The land between Marseilles and the plotted lots along Palm, however, should be depicted in light green. This area is only about 25 percent developed, but protecting the developed lots and streets leading to them would probably require protecting most of these neighborhoods, even if no additional lots are developed.[13] Given the Tier 1 status and light development, shore protection is not as certain as for the rest of Key Largo.

C. *Within the North Key Largo area, the developed lots in the Post and Carysfort subdivisions should be depicted as red, the rest of the land should be depicted in blue.* These 30-lot subdivisions have three and four homes, respectively, with little prospect for additional development. Although the individual homes are likely to be protected, such protection would probably not require shore protection for the entire neighborhoods. Therefore, the rest of the neighborhoods should be shown as blue rather than red. [14]

D. *Change "Road to Nowhere" from red to light green.* At one time development was planned, but this land is now a county conservation area.

E. *Change the small brown polygon northeast of Pennekamp State Park to blue.* The County doubted the accuracy of shoreline armoring data suggesting that this area was armored, given that the land behind it is undeveloped county-owned vacant land. Perhaps the data should have referred to the shores of Pennekamp State Park.

F. *The blue and red between Pennekamp State Park and the US-1/FL-905 intersection are correct.* The red polygons refer to planned condominiums, a school, and Pennekamp State Park. In this case, the state park should be depicted as red because the land is infrastructure, including docking facilities, parking lots, and glass-bottom boats to transport visitors to a mostly aquatic park. The blue areas are county-owned land that may be held for conservation purposes, but they might also be used for governmental purposes.

G. *In the Port Largo area, change part of the Kawama subdivision from red to brown and the rest from red to blue.* The developers got high density in the portion depicted in brown in return for not developing most of the area depicted in red—but a portion of the area in red is being developed and should stay red.[15]

H. Change the blue National Park Service lands near Pirate's Cove from blue to light green.

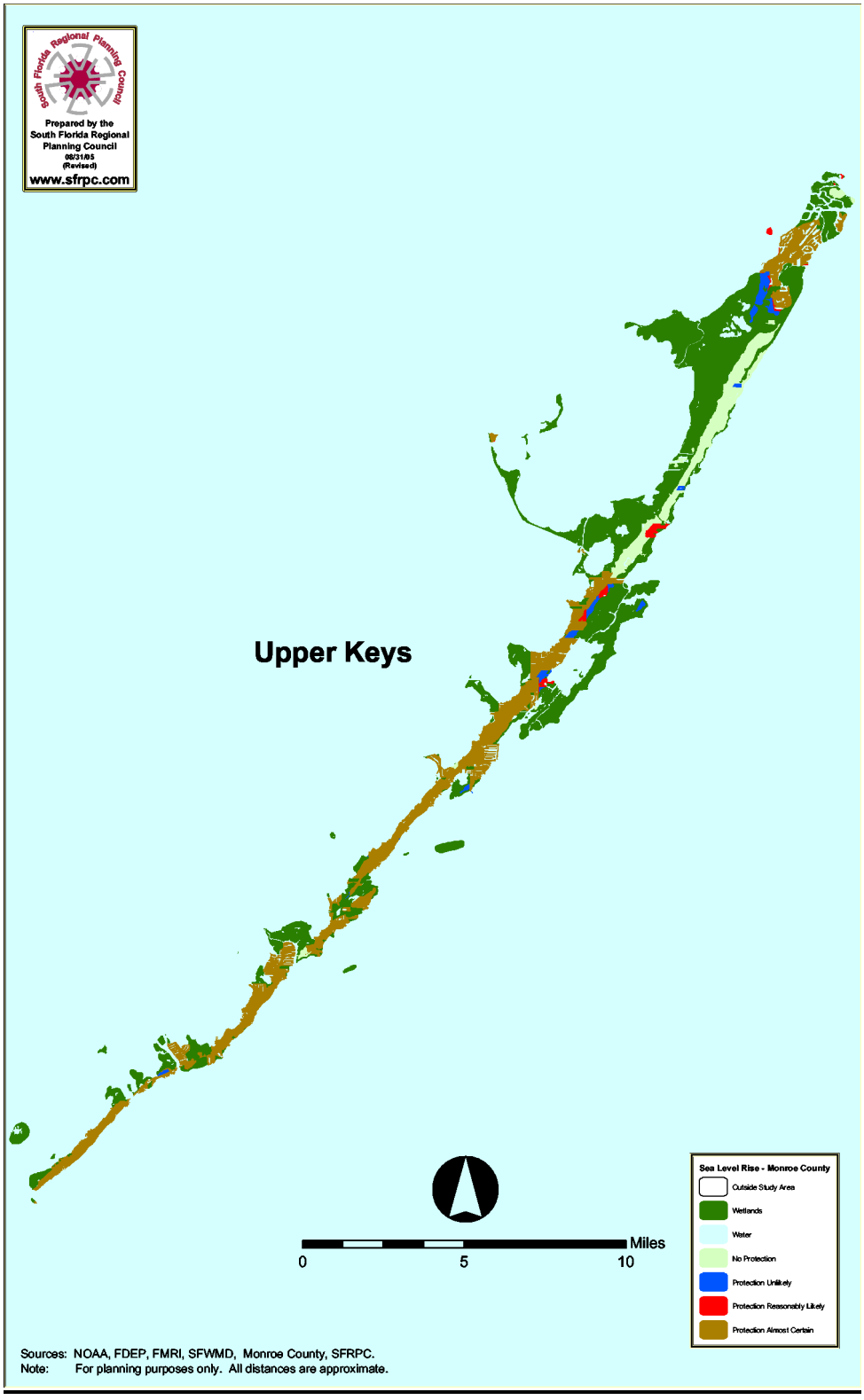
I. *Change the red polygon at the southern end of Key Largo to light green.* This land is zoned "natural area" and is owned by the county.

[13] Staff provided an aerial photo with road and parcel overlay depicting this area.
[14] Staff provided two aerial photos with road and parcel overlay depicting this area.
[15] Staff provided an aerial photo with road and parcel overlay depicting this area.

J. *Within the Ocean Reef area, change the bridged island from red to brown*. On this island, vacant lots have sold for $5–10 million.

K. Within the Ocean Reef area, the two islands owned by Ocean Reef Club are undevelopable and should be changed to light green. The two smaller islands each have at least one home and are correctly depicted as red.

L. The blue polygons in the northwest quadrant of the US-1/Card Sound Road intersection are correctly mapped.



Map 3. Likelihood of Shore Protection in the Upper Keys

Marathon Office—Lower and Middle Keys

A. *Change Stock Island from red to brown.*
B. *Look into why Shark Key is red*. It is Tier 3 and probably should be changed to brown.
C. *US-1 at mile 13. This area should be changed from red to light green*.
D. *The road just south of Bay Point on the east side of US-1 is developed and hence that polygon should be changed from red to brown*.
E. *Bay Point is totally built out and should be changed to brown*.
F. *Along Old Finds Bight, at the northern end of the Saddlebunch Keys, the red polygon is an area with old missile silos. If this is military land, then leave red. Otherwise, change to blue*.[16]
G. *Change to Sugarloaf Shores Airport landing strip from red to brown*. The landing strip is very important to the Sugarloaf Lodge.
H. *Change the peninsula on Sugarloaf Key just south of Sugarloaf Blvd. on the east side of US-1 from red to brown*. This area is totally built out.
I. *The two red polygons at the southeast end of Sugarloaf Key are*
J. *…owned by US Fish and Wildlife Service and should be changed from red to light green*.
K. The KOA campground at the eastern end of Sugarloaf Key is correctly mapped as brown.
L. No change.
M. *There is little development in the polygon at the west end of Sugarloaf Key, just to the north US-1. Change this polygon to red*.[17]
N. *Change the red polygon at the northern end of Cudjoe Key from red to light green*. (Note: because this land is military, and the study defined military lands as red or brown, we kept it as red.)
O. No change.
P. *Change polygon just south of US-1 near center of Cudjoe Key from brown to blue*. Development is very unlikely.
Q. *Change Little Knockemdown Key from red to blue*. The homes on this island were built illegally and will eventually be removed.
R. *Raccoon Key. Unless a specific justification can be provided for why this is brown, change to blue*.
S. *The small red polygon at the southern tip of a light green polygon near the north end of Summerland Key is an error—the red should be light green*.
T. *Change two polygons from red to blue at north end of Big Torch Key*. There are only three houses out there.

[16]This area is military and hence we left it as red.
[17]County staff pointed out that using county future land use designations instead of the SFWMD future land use would probably have resulted in a much smaller brown polygon, with the remainder blue. Such a mapping would also be satisfactory, perhaps preferable. This and similar observations led the County to emphasize that the single most important correction to the map would be to replace the obsolete future land use data with the county's future land use map.

U. *Change the brown to blue near the center of the western shore of Big Torch Key*. This area is undeveloped.

V. *Change the two red polygons to brown along the western shore of the southern portion of Big Torch Key*.

W. *Middle Torch Key has far too much brown*. Hopefully that will be corrected when county future land use data are used.

X. *Change polygon at Northwest end of Ramrod Key from brown to red*. There has been a moratorium on development here.

Y. *Big Pine Refuge: Change three brown polygons to light green*.

Z. Nevertheless, less development is anticipated in Big Pine than the map suggests. Little or no additional homes will be constructed on this island due to efforts to preserve key deer. (See Photo 9.) Look at the tier-based maps on our web page and change accordingly.

AA. *On Big Pine Key, most of the land South (Atlantic side) of US should be changed from brown to blue*, except for a few areas that have already been developed.

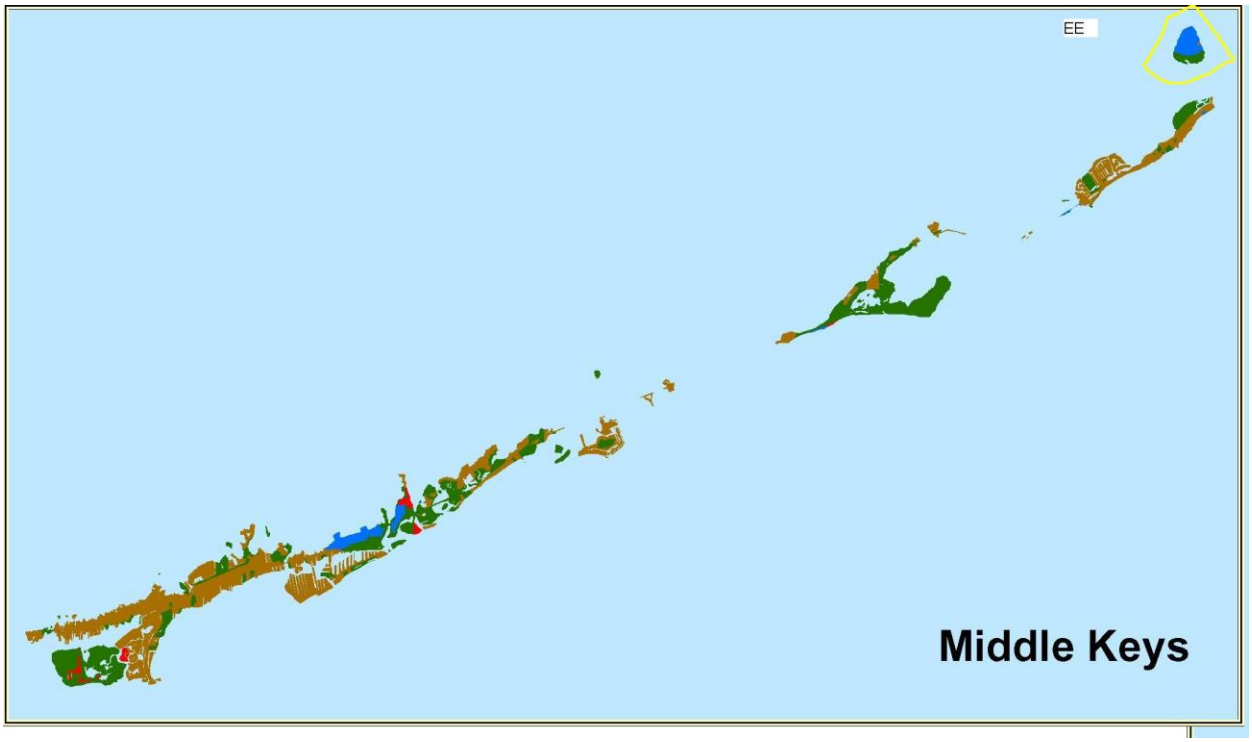
BB. *Change brown to blue*.

CC. *Change the Boy Scout Campground on West Summerland Kay from brown to red.*

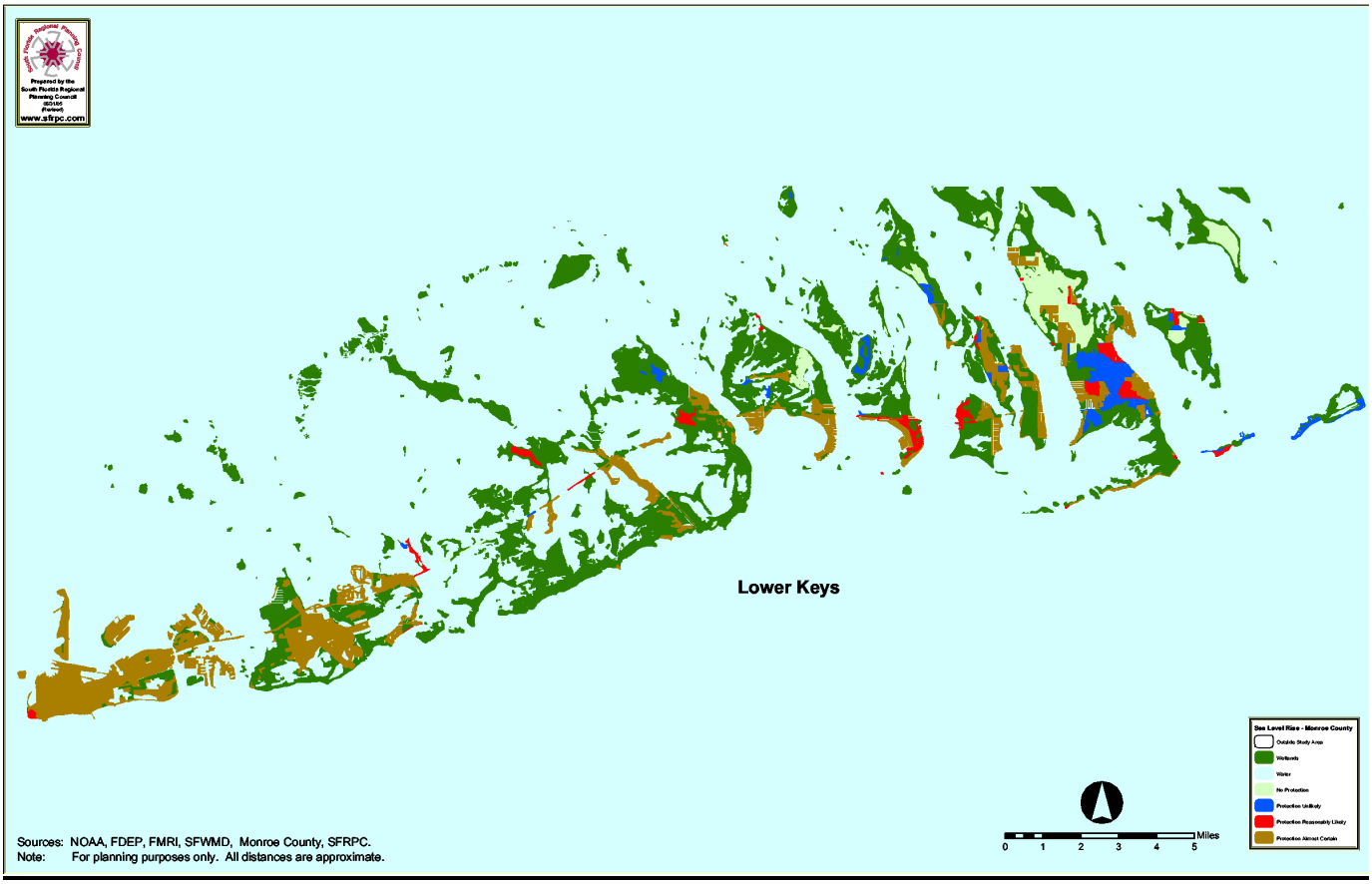
DD. *Change Bahia Honda State Park from red and brown to blue*

EE. *Change Lignumvitae Key from blue to light green*. This is conservation land.

FF. *Long Key has turtle beach protection areas. Change the brown southeast of US-1 to blue* (change made but not shown on Appendix Fmap).



Map 4. Likelihood of Shore Protection in the Middle Keys



Map 5. Likelihood of Shore Protection in the Lower Keys

Photo 9. **Key Deer on Big Pine Key.** The photo was taken through the open window of a compact car, which towered over these knee-high deer. (June 2005)

Table 8 quantifies the area of land within each of the shore protection categories. Approximately two thirds of the dry land in the county is likely or certain to be protected—much less than the other two counties. As the maps show, the likelihood of shore protection varies from key to key. Most of the larger keys will be mostly protected, with the exception of Big Pine and the northern portion of Key Largo. But shore protection is unlikely in many of the smaller keys. Shore protection is precluded by governmental policies in virtually all of the mainland, with the possible exception of Flamingo.

Table 8 - Monroe County Acreage by Sea Level Rise Category

Polygons	Acreage	% of Dry Land in Study Area	Color	Category
25,545	641,596	N/A	N/A	County
0	0	N/A	White	Outside Study Area
10,011	559,556	N/A	Dark Green	Wetlands
7,424	49,251	N/A	Light Blue	Water
778	8,649	26.4	Light Green	No Protection

620	3,121	9.5	Dark Blue	Protection Unlikely
477	1,591	4.9	Red	Protection Likely
6,235	19,428	59.3	Brown	Protection Almost Certain

Map 4. Likelihood of Shore Protection in the Upper Florida Keys
Map 5. Likelihood of Shore Protection in the Lower Florida Keys
Map 6. Likelihood of Shore Protection in the Middle Florida Keys

A NOTE ON THE EVERGLADES

The focus of this report is on the relationship between the evolution of land use development and the question of whether dry land will be protected from rising sea level, a question that has not been previously addressed in South Florida. How the South Florida Water Management District and others will manage the flow of the water from the Everglades to the sea is outside the scope of this study—but no less important.

Those concerned about the welfare of the Everglades may have to consider land use and water management. Whether the lands depicted in blue (and even red) along the western side of Miami-Dade County convert to wetlands would ultimately depend on how high a priority Everglades National Park and others attach to minimizing the net loss of wetlands, as well as shore protection costs. It may also depend on whether the sawgrass and other freshwater portions of the Everglade gradually convert to salinity-tolerant mangroves as sea level rises: Some scientists warn that saline waters seem to be inducing sulfate reduction of the soils, which may cause the land to subside and convert sawgrass to open water rather than mangroves. The low lands along the coastal ridge appear to be more suitable for mangroves as sea level rises. Currently, however, park managers are interested in the best way to manage the ongoing retreat of the park's seaward edge rather than acquisitions that would enable the system to migrate inland as sea level rises.[18]

Therefore, the possible interests of the park in wetland migration do not directly change shore protection prospects in the areas depicted by our maps of the three counties (which exclude much of the Everglades). Within the park boundaries, however, National Park Service staff indicated that shore protection is unlikely. Under most circumstances, National Parks allow nature to take its course, and the no shore protection designation is appropriate. But the Atlanta Office of the National Park Service has suggested that Flamingo be considered a historic site. The Park Superintendent has responded that such a designation would be ill-advised, and has also indicated that Flamingo would not be rebuilt if it were destroyed by a hurricane. Under these circumstances, park staff indicated that depicting Flamingo as shore protection unlikely is the most appropriate designation.[19]

Map 6 shows our final map of the likelihood of shore protection in and around Everglades National Park. [Waiting for IEc]

[18]For example, at the National Park's "Climate Friendly Parks" workshop, the consensus of staff was that the primary responses that the park should take in response to global climate change are (a) reduction of greenhouse gas emissions and other air pollutants on park property and (b) education of visitors about the implications of climate change, including the gradual loss of the Everglades. There was some sentiment to start planning for the gradual abandonment of coastal facilities, but doing so has a lower priority. There was no sentiment in favor of taking measures to ensure that the park continues to exist as sea level rises. Climate Friendly Parks Workshop, Homestead, Florida, June 15–16, 2005.

[19]Email from Julie Thomas, National Park Service, to Jim Titus, EPA, June 21, 2005 (recounting a conversation the previous week with Everglades Park Superintendent about whether Flamingo will be protected as sea level rises, at the Climate Friendly Parks workshop).

Map 6. The Likelihood of Shore Protection in and around Everglades National Park.

SEA LEVEL RISE AND LAND USE SOLUTIONS

Summary solutions to sea level rise impacts on land uses, include :

- Land use regulatory controls
- Community design strategies
- Local mitigation strategies (LMS)
- Public acquisitions, takings, and preservation (ACSC, conservation areas, public acquisition programs)
- Public programs (National Flood Insurance, beach renourishment)
- Public information (public awareness)

Time constraints on this project prevented us from elaborating further.

CURRENT FEDERAL AND REGIONAL PLANNING FOR SEA LEVEL RISE

Federal Policies Affecting the Likelihood of Shoreline Protection

The federal government has several major policies that directly and indirectly affect the likelihood that shores will be protected from erosion, inundation, and increased flooding as sea level rises. We first examine some policies that encourage retreat and then some policies that encourage shore protection.

Policies that Encourage a Retreat

The federal government influences shore protection as a landowner, a regulator, and a subsidizer.[20] As a coastal land owner, the federal government has made several very large parcels of land unavailable for development. Because undeveloped lands are much less likely to be protected than developed areas, federal ownership itself often makes shore protection unlikely, even where there is no specific policy on whether to protect the shore or retreat.

Several conservation-oriented landowning agencies consciously allow wetlands and beaches to migrate inland. Everglades National Park and Big Cypress National Preserve all follow the National Park Service general policy of allowing natural processes to work their will. The most noteworthy example of the National Park Service's commitment to allowing shores to retreat was the recent relocation of Hatteras Light in North Carolina, which was moved more than 1,000 feet inland on a special-purpose railroad track at a cost of more than $10 million. National Wildlife Refuges generally allow wetlands to migrate inland within their boundaries.

Even agencies that regularly protect some shores may foster shore retreat to some extent. Military bases armor shores to protect buildings and naval port facilities; but military bases often have substantial undeveloped buffer areas where natural shores are preserved.

The federal government does not generally regulate the use of privately owned dry lands; so itdoes not directly discourage development in the coastal zone. Nevertheless, Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act require landowners to obtain permits to fill wetlands. Regulations interpreting the requirements of these statutes often discourage or prohibit fill and other beach nourishment activities along bay shores. Although bulkheads and stone revetments are generally allowed in this region, they are technically fill and require a permit if below mean high water. Although these structures can be built inland of mean high water, eventually they sit within the ebb and flow of the tides as sea level rise and shores erode; therefore replacement or repair might require filling the "waters of the United States" and hence require a permit.

[20]For further details on federal policies that might allow wetlands to migrate inland, see J. G. Titus (2000) "Does the US Government Realize that the Sea Is Rising?" *Golden Gate University Law Review*, Vol. 30:4:717–778. The article also points out that federal research programs and state assistance programs can help save wetlands as sea level rises.

State and local efforts to protect water quality are often motivated by the federal estuary programs and the Clean Water Act.

The Coastal Barrier Resources Act (CoBRA) prohibits federal subsidies and flood insurance to specific designated portions of barrier islands, barrier spits, and other coastal areas.[21] In other parts of the state, CoBRA areas with easier access have been developed, but the unavailability of federal subsidies makes beach nourishment unlikely; in other areas, the lack of federal subsidies for sewerage treatment has limited the density. The unavailability of flood insurance and federally backed mortgages also discourages development.

Policies that Encourage Shore Protection

The federal government has long provided subsidies for jetties that stabilize harbor entrances, and beach nourishment along intensely developed shores. In areas like Miami Beach, seawalls did—and probably still would—protect development from eroding shores; so the subsidy for beach nourishment primarily alters the type of shore protection. Along more moderately developed shores in South Florida, , the absence of shore protection would probably result in seawalls designed for a modest storm; but a major storm would destroy the seawall, and permanently erode the shore 50–100 feet. In these areas, the availability of federal beach nourishment enables the shore to be protected.

Numerous federal policies appear to encourage or enable relatively dense development in the coastal zone. Federal flood insurance decreases the risk of coastal construction. Improved building codes resulting from flood insurance regulations enable homes to continue standing in the water after the Gulf of Mexico erodes during a storm, making retreat unnecessary provided that the beach returns (either naturally or from a beach nourishment project). Federal subsidies for sewerage treatment plans make it possible to more densely develop coastal areas where a proliferation of septic tanks would severely pollute coastal bays. The federal wetland program explicitly allows shoreline armoring, while having no explicit policies to prevent shoreline armoring.

South Florida Regional Planning Council

The Strategic Regional Policy Plan (SRPP) for South Florida is a guide for local governments in the development and implementation of their comprehensive plans. It also provides a framework for nongovernmental organizations seeking to enhance their activities within the region. The SRPP was adopted by the South Florida Regional Planning Council on June 7, 2004, and is applicable for all project reviews.

Included in the SRPP are two goals and several policies that address sea level rise in our region.

[21] Strictly speaking, the denial of subsidies does not discourage development, it simply removes an encouragement. The combination of providing subsidies to some areas while denying it to others, however, probably causes development to shift from the former to the latter.

SRPP Goal 9 – Energy
Develop clean, sustainable and energy-efficient power generation and transportation systems

Increased Global Climate Change Concerns

South Florida is especially vulnerable to the effects of global climate change, which are long-term changes in the value of temperature or precipitation over the course of a decade or longer having important economic, environmental, or social effects. Potential effects include sea level rise that could adversely impact communities located in low-lying areas. Adverse impacts to the low-lying areas could include loss of land and structures, wildlife habitat loss, accelerated coastal erosion, exacerbated flooding, increased vulnerability to storm damage, and increased salinity of rivers, bays, and aquifers, which would threaten supplies of fresh water.

Global Climate Change

Policy 9.7 Assess the impacts of global climate change and sea level rise on South Florida's resources and land uses.

Policy 9.8 Establish greenhouse gas emission reduction goals and implement renewable energy measures to minimize the risks posed by sea level rise and other effects of global climate change.

SRPP Goal 19 - Coastal High Hazard Area
Direct future development away from areas most vulnerable to storm surge

Policy 19.5 Incorporate buffer and conservation zones into site designs for new development and redevelopment in the storm surge areas to mitigate possible damage. Consider the inevitable rise in sea level in all decisions regarding the design, location, and replacement of coastal development or redevelopment.

Preliminary results of the sea level rise study were presented to the South Florida Regional Planning Council board at its September 2003 meeting. The presentation included draft maps of the region. The board accepted the findings without comment.

CONCLUSION

The South Florida Region presents a challenge to current and future planners addressing the issue of sea level rise and its impacts on low-lying areas. The region's current population of more than 4 million is expected to increase by nearly 2 million in the next 25 years.

A significant portion of the region's 4,250 square miles are already wetlands or very low-lying areas. Because of very high real estate prices, most developed areas in the three counties are already protected in one fashion or another. On the Atlantic Coast, man-made structures and beach renourishment are common and expected to continue in the future. Much of the land immediately adjacent to the coast is of technological origin, having been dredged and filled with benthic materials to form the canals and waterfront lots at great cost in a speculative market. The value of this land has become so great as to suggest the raising of seawalls and the importation of additional fill incrementally over the study period to protect property investments is very likely. The issue becomes the method by which property owners and local governments (dependent on the tax base provided by waterfront properties) cooperate and fund the necessary activities to prevent inundation, including the elevation or replacement of infrastructure to serve those properties.

To the south and west, the system of levees currently in place to keep freshwater from intruding into urban areas are likely to keep seawater from doing the same thing. Doubtless, as the sea would pound against these earthen dikes, they will require armoring to prevent erosion, and, perhaps, elevation to prevent overtopping by waves during storm events. This, too, will require advance planning and cooperation to implement. South Florida can use the recent experience of New Orleans in Hurricane Katrina as a cautionary tale regarding this potential solution.

If current trends of sea level rise continue, the majority of south Florida's vast freshwater wetlands will likely become saltwater marshes. Fortunately, opportunities exist for the retreat and migration of habitat types northward into the interior on government-owned land. The problem of saltwater intrusion to the sole-source Biscayne Aquifer will require greater investments in desalination technology to continue to provide south Florida with drinkable water. The real threat is to those rare and endangered habitats indigenous to the Florida Keys for which there exist no opportunities for inland migration. Aside from the logistics of protecting developed areas, this is the topic which will require the greatest study and dedication of resources.

APPENDICES

A. Estimating Sea Level Rise at a Specific Location

B. Historic Rate of Sea Level Rise at Various Locations in the United States

C. Estimated Sea Level Rise for Southeast Florida

D. Florida Land Use, Cover and Forms Classification System (FLUCCS)

E. SFWMD Future Land Use Map (FLUM) Attribute Definitions

F. Monroe County: Index maps for stakeholder review map changes.[I don't see this map anywhere? will it have the letters in the lists in the text to track the changes?]

Appendix I
Estimating Sea Level Rise at a Specific Location
Normalized Sea Level Projections, Compared with 1990 Levels (cm)

Cumulative Probability	Sea Level Projection by Year					
	2025	**2050**	**2075**	**2100**	**2150**	**2200**
1	–10	–16	–21	–24	–32	–40
5	–3	–4	–5	–6	–7	–8
10	–1	–1	0	1	3	5
20	1	3	6	10	16	23
30	3	6	10	16	26	37
40	4	8	14	20	35	51
50	5	10	17	25	43	64
60	6	13	21	30	53	78
70	8	15	24	36	65	98
80	9	18	29	44	80	125
90	12	23	37	55	106	174
95	14	27	43	66	134	231
97.5	17	31	50	78	167	296
99	19	35	57	92	210	402
Mean	5	11	18	27	51	81
σ	6	10	15	23	47	81

NOTE:
To estimate sea level at a particular location, add these estimates to the rise that would occur if current trends were to continue. See Table 9-2 (Appendix II in this report) for historic rates of sea level rise. For example, if sea level is currently rising 3 mm/yr, then under current trends, sea level will rise 26 cm between 1990 and 2075. Adding 26 cm to the normalized values in the table, the median estimate for 2075 is 43 cm, with a 1 percent chance of an 83 cm rise.

Source: Table 9-1 from "Probability of Sea Level Rise", U.S.E.P.A.

Appendix II
Historic Rate of Sea Level Rise
At Various Locations in the United States
(millimeters/year)

Atlantic Coast					
Eastport, ME	2.7	Sandy Hook, NJ	4.1	Portsmouth, VA	3.7
Portland, ME	2.2	Atlantic City, NJ	3.9	Wilmington, NC	1.8
Boston, MA	2.9	Philadelphia, PA	2.6	Charleston, SC	3.4
Woods Hole, MA	2.7	Lewes, DE	3.1	Ft. Pulaski, GA	3.0
Newport, RI	2.7	Annapolis, MD	3.6	Fernandina, FL	1.9
New London, CT	2.1	Solomons Is., MD	3.3	Mayport, FL	2.2
Montauk, NY	1.9	Washington, DC	3.2	**Miami Beach, FL**	**2.3**
New York, NY	2.7	Hampton Roads, VA	4.3		

Gulf Coast					
Key West	2.2	Grand Isle, LA	10.5	Galveston, TX	6.4
St. Petersburg, FL	2.3	Eugene Island, LA	9.7	Freeport, TX	14.0
Pensacola, FL	2.4	Sabine Pass, TX	13.2	Padre Island, TX	5.1

Pacific Coast					
Honolulu, HI	1.6	Los Angeles, CA	0.8	Astoria, OR	–0.3
Hilo, HI	3.6	Santa Monica, CA	1.8	Seattle, WA	2.0
San Diego, CA	2.1	San Francisco, CA	1.3	Neah Bay, WA	–1.1
La Jolla, CA	2.0	Alameda, CA	1.0	Sitka, AK	–2.2
Newport, CA	1.9	Crescent City, CA	–0.6	Juneau, AK	–12.4

Source: Table 9-2 from "Probability of Sea Level Rise", U.S.E.P.A.

Appendix III
Estimated Sea Level Rise for Southeast Florida

Sea Level Projection by Year

Probability (%)	2025		2050		2075		2100		2150		2200	
	cm	inches	cm	inches	cm	inches	cm	inches	cm	inches	cm	inches
90	7	2.8	13	5.0	20	7.7	26	10.4	40	15.7	53	21.0
80	9	3.6	17	6.6	26	10.1	35	13.9	53	20.8	71	28.1
70	11	4.4	20	7.8	30	11.6	41	16.3	63	24.7	85	33.6
60	12	4.7	22	8.6	34	13.2	45	17.8	72	28.3	99	39.1
50	13	5.1	24	9.4	37	14.4	50	19.8	80	31.4	112	44.2
40	14	5.5	27	10.6	41	16.0	55	21.8	90	35.4	126	49.7
30	16	6.3	29	11.3	44	17.1	61	24.1	102	40.1	146	57.6
20	17	6.7	32	12.5	49	19.1	69	27.3	117	46.0	173	68.2
10	20	7.9	37	14.5	57	22.3	80	31.6	143	56.2	222	87.5
5	22	8.7	41	16.1	63	24.6	91	35.9	171	67.2	279	110.0
2.5	25	9.9	45	17.6	70	27.4	103	40.7	204	80.2	344	135.6
1	27	10.6	49	19.2	77	30.1	117	46.2	247	97.2	450	177.3
Mean	13	5.1	25	9.8	38	14.8	52	20.6	88	34.6	129	50.9

The results of this table are based on Tables 9-1 and 9-2 of the EPA Report "The Probability of Sea Level Rise". Basically, the formula is multiplying the historic sea level rise (2.3 millimeters/year) in Southeast Florida (closest point used is Miami Beach from EPA Table 9-2) by the future number of years from 1990 plus the Normalized Sea Level Projections in EPA Table 9-1. In summary, the EPA Report has relied on various scientific opinions regarding sea level changes affected by factors such as radiative forcing caused by both, greenhouse gases and sulfate aerosols, global warming and thermal expansion, polar temperatures and precipitation and the contributions to sea level from Greenland, Antarctica and small glaciers.

Source: Table 1 from “Land Use Impacts and Solutions to Sea Level Rise in Southwest Florida,” Southwest Florida Regional Planning Council.

Appendix IV

Florida Land Use, Cover and Forms Classification System (FLUCCS)
January 1999
Department of Transportation
Surveying and Geographic Mapping Section

LAND USE AND COVER CLASSIFICATIONS LISTING OF LEVELS 1 – III

This classification listing (Levels I–III) reflects the detailed identification possible in depicting the land use, land cover and land forms. With the employment of color or false color infrared aerial photography, a higher degree of accuracy, precision and detail can be realized. The recommended scale is 1:12,000 to 1:10,000 or larger for both the aerial photography and the graphics product (i.e., the maps). Once again, the listing presented herein is not a fixed categorization but rather an open-end system which may be expanded as the need arises.

100 URBAN AND BUILT-UP

110 Residential, Low Density <2 DUs/acre
111 Fixed Single Family Units
112 Mobile Home Units
113 Mixed Units <Fixed & mobile home units>
116 Low Density with Golf Courses
119 Low Density Under Construction
120 Res, Medium Density (2-5DUs/acre)
121 Fixed Single Family Units
122 Mobile Home Units
123 Mixed Units <Fixed & mobile home units>
126 Medium Density with Golf Courses
129 Medium Density Under Construction
130 Residential, High Density
131 Fixed Single Family Units (6+DUs/acre)
132 Mobile Home Units (6+DUs/acre)
133 Multiple DUs, Low Rise (2 or less stories)
134 Multiple DUs, High Rise (3+stories)
135 Mixed Units <Fixed & mobile home units>
136 Multiple-High DUs (1,2,4 Stories, golf)
139 High Density Under Construction
140 Commercial and Services
141 Retail Sales and Services
142 Wholesale Sales and Services
143 Professional Services
144 Cultural and Entertainment
145 Tourist Services
146 Oil and Gas Storage
147 Mixed Commercial and Services
148 Cemeteries
149 Commercial & Services Under Constr
150 Industrial
151 Food Processing
152 Timber Processing
153 Mineral Processing
154 Oil and Gas Processing
155 Other Light Industrial
156 Other Heavy Industrial
159 Industrial Under Construction
160 Extractive
161 Strip Mines
162 Sand and Gravel Pits
163 Rock Quarries
164 Oil and Gas Fields
165 Reclaimed Land
166 Holding Ponds
170 Institutional
171 Educational Facilities
172 Religious
173 Military
174 Medical and Health Care
175 Governmental
176 Correctional
177 Other Institutional
178 Commercial Child Care
179 Institutional Under Construction

180 Recreational
181 Swimming Beach
182 Golf Courses
183 Race Tracks
184 Marinas and Fish Camps
185 Parks and Zoos
186 Community Recreational Facilities
187 Stadiums <not associated with schools>
188 Historical Sites
189 Other Recreational
190 Open Land
191 Undeveloped Land within Urban Areas
192 Inactive Land (strt pattern, no structures)
193 Urban Land in transition
194 Other Open Land

200 AGRICULTURE

210 Cropland and Pastureland
211 Improved Pastures
212 Unimproved Pastures
213 Woodland Pastures
214 Row Crops
215 Field Crops
220 Tree Crops
221 Citrus Groves
222 Fruit Orchards
223 Other Groves
224 Abandoned Groves
230 Feeding Operations
231 Cattle Feeding Operations
232 Poultry Feeding Operations
233 Swine Feeding Operations
240 Nurseries and Vineyards
241 Tree Nurseries
242 Sod Farms
243 Ornamentals
244 Vineyards
245 Floriculture
246 Timber Nurseries
250 Specialty Farms
251 Horse Farms
252 Dairies
253 Kennels
254 Aquaculture
259 Other
260 Other Open Lands <Rural>
261 Fallow Crop Land

300 RANGELAND

310 Herbaceous (Dry Prairie)
320 Shrub and Brushland
321 Palmetto Prairies
322 Coastal Scrub
329 Other Shrubs and Brush
330 Mixed Rangeland

400 UPLAND FORESTS

410 Upland Coniferous Forests
411 Pine Flatwoods
412 Longleaf Pine - Xeric Oak
413 Sand Pine
414 Pine - Mesic Oak
415 Mixed Pine
419 Other Pines
420 Upland Hardwood Forests
421 Xeric Oak
422 Brazilian Pepper
423 Oak - Pine - Hickory
424 Melaleuca
425 Temperate Hardwoods
426 Tropical Hardwoods
427 Live Oak
428 Cabbage Palm
429 Wax Myrtle - Willow
430 Upland Hardwood Forests, Continued
431 Beech - Magnolia
432 Sand Live Oak
433 Western Everglades Hardwoods
434 Hardwood - Coniferous Mixed
435 Dead Trees
436 Upland Scrub, Pine and Hardwoods
437 Australian Pines
438 Mixed Hardwoods
439 Other Hardwoods
440 Tree Plantations
441 Coniferous Plantations
442 Hardwood Plantations
443 Forest Regeneration Areas
444 Experimental Tree Plots

445 Seed Plantations

500 WATER

510 Streams and Waterways
520 Lakes
521 Lakes larger than 500 acres
522 Lakes larger than 100 acres
523 Lakes larger than 10 acres
524 Lakes less than 10 acres
530 Reservoirs
531 Reservoirs larger than 500 acres
532 Reservoirs larger than 100 acres (40 hectares) but less than 500 acres
533 Reservoirs larger than 10 acres (4 hectares) but less than 100 acres
534 Reservoirs less than 10 acres (4 hectares) which are dominant features
540 Bays and Estuaries
541 Embayments opening directly into the Gulf of Mexico or the Atlantic Ocean
542 Embayments not opening directly into the Gulf of Mexico or the Atlantic Ocean
550 Major Springs
560 Slough Waters
570 Major Bodies of Water
571 Atlantic Ocean
572 Gulf of Mexico

600 WETLANDS

610 Wetland Hardwood Forests
611 Bay Swamps
612 Mangrove Swamps
613 Gum Swamps
614 Titi Swamps
615 Streams and Lake Swamps (Bottomland)
616 Inland Ponds and Sloughs
617 Mixed Wetland Hardwoods
618 Willow and Elderberry
619 Exotic Wetland Hardwoods
620 Wetland Coniferous Forests
621 Cypress
622 Pond Pine
623 Atlantic White Cedar
624 Cypress - Pine - Cabbage Palm
625 Hydric Pine Flatwoods
626 Hydric Pine Savanna
627 Slash Pine Swamp Forest
630 Wetland Forested Mixed
631 Wetland Shrub
640 Vegetated Non-Forested Wetlands
641 Freshwater Marshes
642 Saltwater Marshes
643 Wet Prairies
644 Emergent Aquatic Vegetation
645 Submergent Aquatic Vegetation
646 Treeless Hydric Savanna
650 Non-Vegetated
651 Tidal Flats
652 Shorelines
653 Intermittent Ponds
654 Oyster Bars

700 BARREN LAND

710 Beaches Other Than Swimming Beaches
720 Sand Other Than Beaches
730 Exposed Rock
731 Exposed Rock with Marsh Grasses
740 Disturbed Land
741 Rural land in transition without positive indicators of intended activity
742 Borrow Areas
743 Spoil Areas
744 Fill Areas <Highways-Railways>
745 Burned Areas
746 Abandoned Railways
747 Dikes and Levees

800 TRANSPORTATION, COMMUNICATION AND UTILITIES

810 Transportation
811 Airports
812 Railroads
813 Bus and Truck Terminals
814 Roads and Highways
815 Port Facilities
816 Canals and Locks
817 Oil, Water or Gas Lng Dist Trans Lines
818 Auto Parking Facilities

819 Transportation Facilities Under Constr
820 Communications
821 Transmission Towers
822 Communication Facilities
829 Communication Facilities under Construction
830 Utilities
831 Electric Power Facilities
832 Electrical Power Transmission Lines
833 Water Supply Plants
834 Sewage Treatment
835 Solid Waste Disposal
839 Utilities Under Construction

900 SPECIAL CLASSIFICATIONS

910 Vegetation
911 Sea Grass

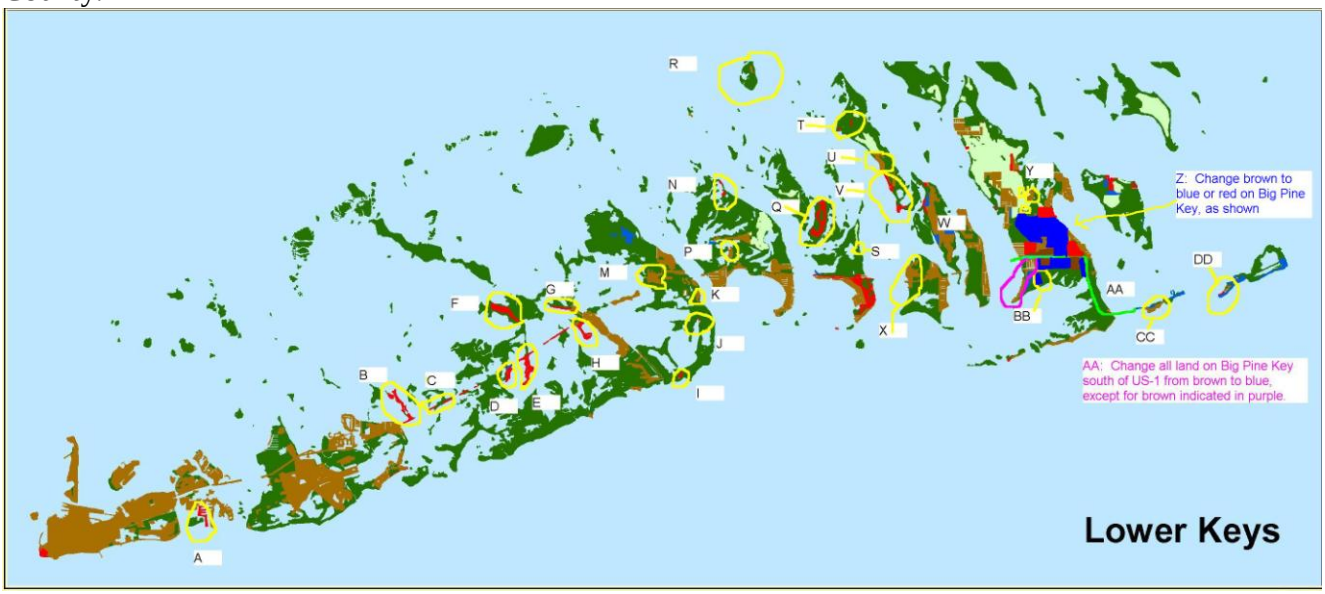
Appendix V

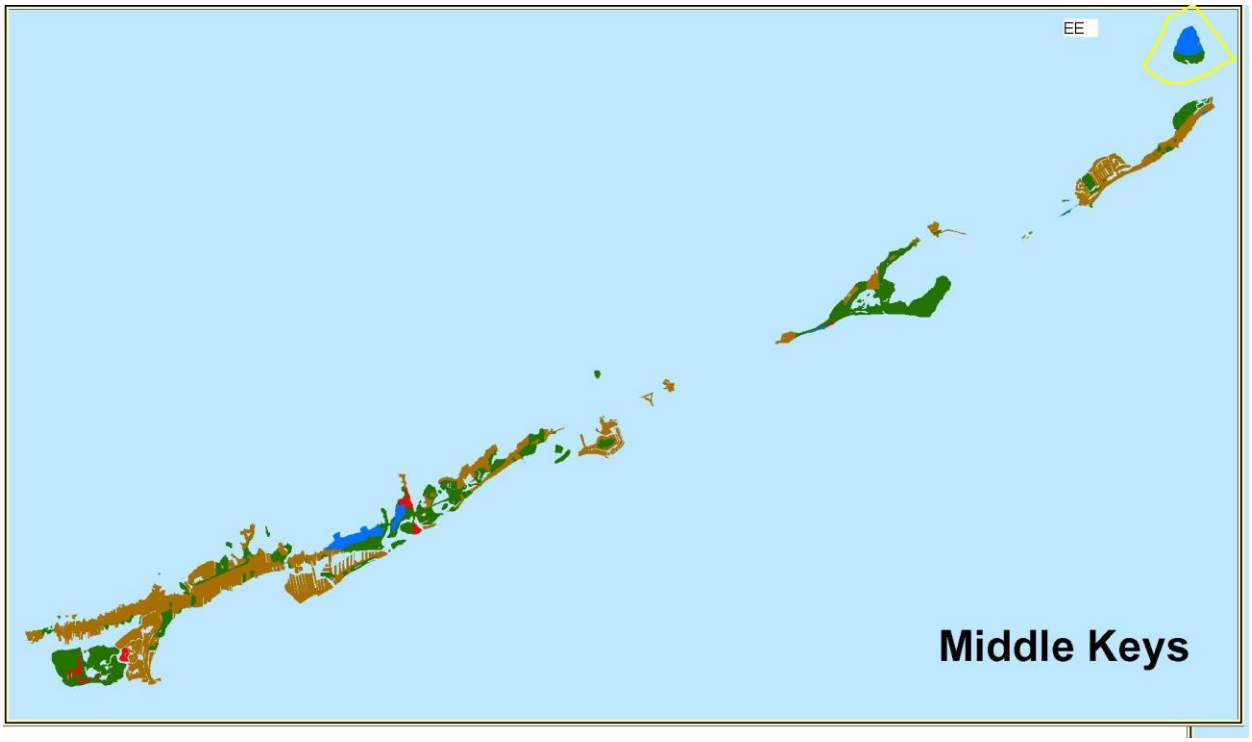
South Florida Water Management District (SFWMD)
Future Land Use Map (FLUM) Attribute Definitions

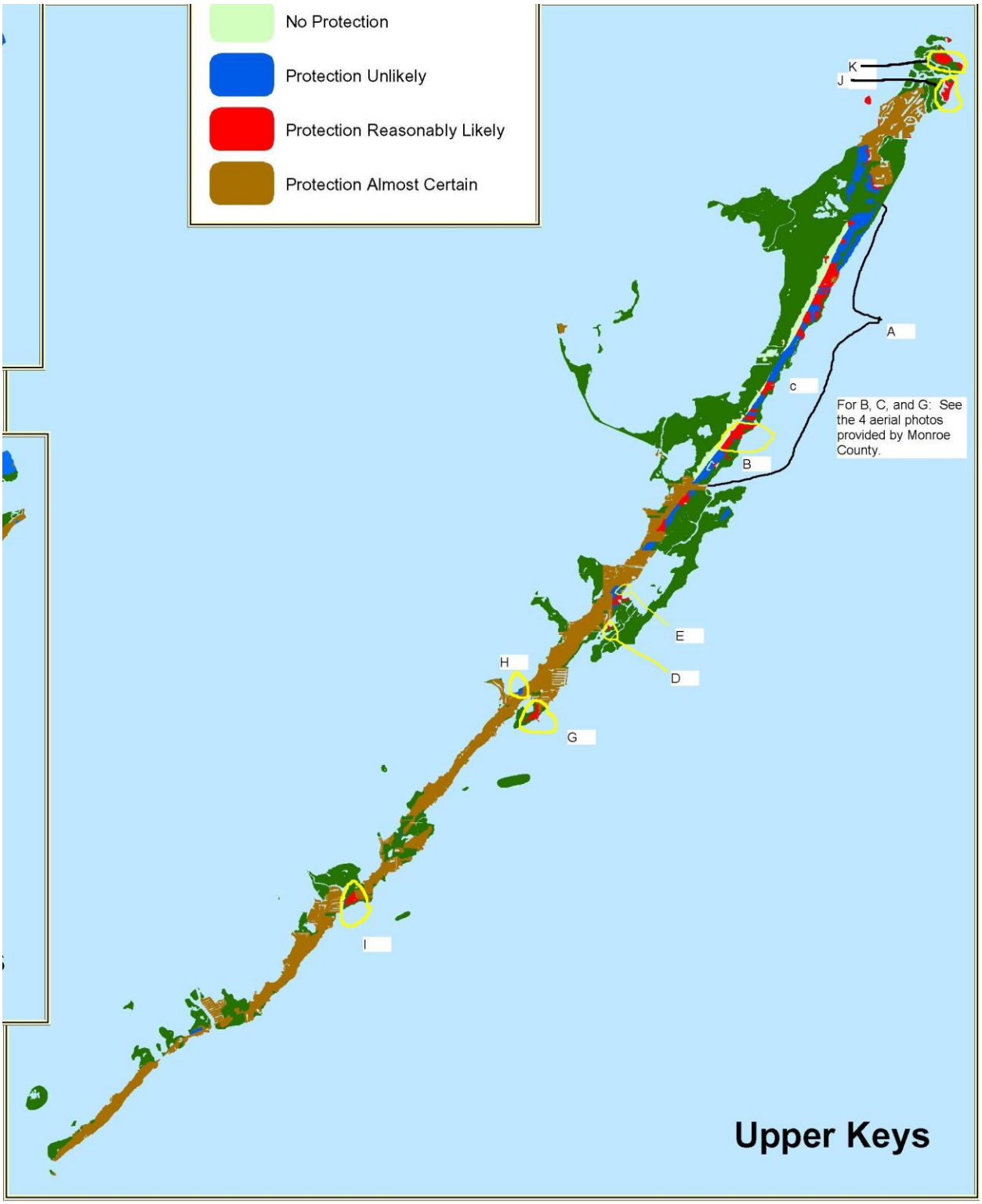
Code: AG =	Agriculture
Code: COF =	OFFICE & PROFESSIONAL SERVICES
Code: COM =	GENERAL COMMERCIAL
Code: CPD =	COMMERCIAL PLANNED DEVELOPMENT
Code: CR =	COMMERCIAL RECREATION
Code: CRS =	RETAIL SALES & SERVICES
Code: CW =	WHOLESALE SALES & SERVICES
Code: EXT =	EXTRACTIVE
Code: IND =	GENERAL INDUSTRIAL
Code: INH =	HEAVY INDUSTRIAL
Code: INL =	LIGHT INDUSTRIAL
Code: INP =	INDUSTRIAL PLANNED DEVELOPMENT
Code: ISE =	EDUCATIONAL & RELIGIOUS
Code: ISG =	GOVERNMENTAL OFFICES
Code: IST =	GENERAL INSTITUTIONAL
Code: NAC =	CONSERVATION
Code: NAP =	PRESERVATION (PUBLIC)
Code: PKC =	COMMUNITY RECREATIONAL FACILITIES
Code: PKG =	GOLF COURSES
Code: PKM =	MARINAS & FISH CAMPS
Code: PKN =	NEIGHBORHOOD PARK
Code: PKR =	GENERAL RECREATION
Code: RES =	NON-SPECIFIC RESIDENTIAL
Code: RSF =	SINGLE FAMILY NO SPECIFIC DENSITY
Code: RSF-2 =	SINGLE FAMILY DENSITY RANGE OF .2 TO 2.0 DU/AC
Code: RSF-5 =	SINGLE FAMILY DENSITY RANGE OF 2.1 TO 5.0 DU/AC
Code: RSF-10 =	SINGLE FAMILY DENSITY RANGE OF 5.1 TO 10 DU/AC
Code: RMF =	MULTI-FAMILY NO SPECIFIC DENSITY
Code: RMF-8 =	MULTI-FAMILY DENSITY RANGE OF 5.0 TO 8.0 DU/AC
Code: RMF-20 =	MULTI-FAMILY DENSITY RANGE OF 8.1 TO 20 DU/AC
Code: RMF-40 =	MULTI-FAMILY DENSITY RANGE OF 20.1 TO 40 DU/AC
Code: RMF-60PL =	MULTI-FAMILY DENSITY RANGE OF 40.1 AND ABOVE
Code: RMH =	NON-SPECIFIC MOBILE HOME CLASSIFICATION
Code: R-PUD =	NON-SPECIFIC RESIDENTIAL PUD
Code: TA =	AIRPORTS & PORTS
Code: TR =	ROADS & RAILROADS
Code: TU =	OTHER UTILITIES & COMMUNICATIONS FACILITIES
Code: TW =	WATER SEWAGE & SOLID WASTE FACILITIES
Code: WB =	BAYS & ESTUARIES
Code: WL =	LAKES & RESERVOIRS

CoBRA	Coastal Barrier Resources Act
ESI	Environmental Sensitive Index for Coastlines
FLUCCS	Florida Land Use, Cover and Forms Classification System
FLUM	Future Land Use Map
FMRI	Florida Marine Research Institute
SFRPC	South Florida Regional Planning Council
SFWMD	South Florida Water Management District
SWFRPC	South West Florida Regional Planning Council
TCRPC	Treasure Coast Regional Planning Council
USGS	United States Geological Survey

Appendix VI. Index Map Illustrating the Locations of Corrections Suggested by Monroe County.






No Protection
Protection Unlikely
Protection Reasonably Likely
Protection Almost Certain
K
J
A
c
For B, C, and G: See the 4 aerial photos provided by Monroe County.
B
E
D
H
G
I
Upper Keys

ACKNOWLEDGMENTS

This report was prepared under the overall direction of Daniel Trescott of the Southwest Florida Regional Planning Council. His enthusiasm and continual source of insights made this project an enjoyable experience. By providing a statewide approach and coordinating with the sponsoring agency, he made it possible for us to focus on the issues that directly concern South Florida.

Manny Cela undertook all data gathering, GIS, and mapping involved in this project. He also prepared the first draft of this report, and drafted the sections on predicting sea level rise, datasets, general criteria for map creation, discussion of shore protection maps, and the report's Conclusion. He also prepared all maps (other than the annotated maps) and all tables except for Table 5.

James G. Titus of the U.S. Environmental Protection Agency obtained the map changes sought by Monroe County during meetings at Hollywood, Key Largo, and Marathon. He also drafted the subsections on purpose, study area, shore protection categories, stakeholder collaboration, the Everglades, and federal policies. Trescott and Titus prepared Table 5.

John Hulsey organized all of the initial meetings with county officials, as well as the stakeholder review meeting with all three counties held at the SFRPC offices. With the assistance of Trescott, he obtained the suggested map revisions for Broward and Miami-Dade Counties. He also drafted the sections on Land Use solutions and the Region's Response.

We also wish to thank the many staff members of Broward, Miami-Dade, and Monroe counties individuals who provided corrections to the maps and text.