Sea Level Rise Project Final Report

South Florida Regional Planning Council

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through a cooperative agreement from the U.S. Environmental Protection Agency

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1. INTRODUCTION

This document presents the results of a study conducted by the South Florida Regional Planning Council (SFRPC) to distinguish the areas that are likely to be protected from erosion, inundation and flooding due to the effects of a rising sea level. The premise of the study was the assumption that sea level would rise five feet within 200 years. Such an effect, plus the potential of several more feet due to astronomical high tides and storms such as hurricanes, will severely impact coastal counties along their shorelines and other low lying areas.

Funding for this project was provided by the South West Florida Regional Planning Council (SWFRPC) through a cooperative agreement from the United States Environmental Protection Agency (USEPA).

Using a set of statewide general guidelines provided by the SWFRPC, variations on the general approach based on the SFRPC's familiarity with the region, and input from the 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 included the three counties in the SFRPC's Region: Miami-Dade, Broward and Monroe.[1]

[1] In a separate study, the SFRPC is preparing maps for the Treasure Coast Regional Planning Council (TCRPC) which includes Palm Beach, Martin, St. Lucie and Indian River Counties. This report contains information pertinent to the South Florida region only. Under separate cover, the TCRPC will provide a report for its region. The SWFRPC will combine the reports of all participating RPCs into a single, statewide study, with each RPC represented as one chapter. Issues included in the statewide report, such as scientific evidence supporting a rise in sea level, the rationale behind the categories chosen, federal and state policies, etc., are only briefly discussed here.

2. SEA LEVEL RISE PREDICTION IN SOUTHEAST FLORIDA

The Scope of Work for this project included the assumption that sea levels would rise five feet in 200 years. Calculations based on our reference information put the probability of that happening at roughly 30%. The mean probability is closer to 3 ¾ feet.

For reference, we used Tables 9-1 and 9-2 from the USEPA report *The Probability of Sea Level Rise* (see Appendix I and II). Using information from those tables, SWFRPC derived Table 1 of 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 III).

3. MAP DEVELOPMENT METHODOLOGY

Datasets used in the Study

The following tables list the digital datasets used in this Study, which are briefly described in the following section. Every effort was taken to obtain the "best available digital data" at the start of the Study. The use of multiple datasets from a single source helps to maintain consistency across county lines and better polygon registration.

Table 1 - 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 2 - 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 3 - 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 (Brief Description of the General Criteria)

Creation of the draft project maps followed closely the criteria laid-out in the *Statewide Approach for Identifying the Likelihood of Land Use Protection* Table (see Appendix IV). 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. County planning staff reviewed the draft maps and suggested changes where appropriate, and the maps have been revised accordingly.

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 V). The Future Land Use dataset provided polygons coded with the appropriate Future Land Use Map (FLUM) designation (see Appendix VI).

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.

<u>Study Area</u>

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, USEPA has to use the 20-foot contour to be certain that it included all the land that might be vulnerable. USEPA includes 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, USEPA wanted to ensure that the maps depict whether the shore is likely to be protected, even in areas where the land directly threatened is too small to show up in a county-scale map.

Due to the large amount of land below the 10-foot contour in Florida, the initial cooperative agreement between SWFRPC and USEPA reduced the Study Area to only consider 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 Southwest Florida is below the 10-foot contour anyway.

In some parts of Southeast Florida, the 10-foot contour is very close to the shoreline. To comply with the revised cooperative agreement, this study includes all lands within 1,000 feet of the shore. In order to determine which of the upland polygons initially determined to be "Outside the Study Area" (because elevation was 10+ feet) were located within 1,000 feet of the shoreline, we constructed a coastline buffer. The buffer started at the coastline and extended 1,000 feet inland. All polygons 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. However, a 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 ten feet or higher, were designated to be "Outside the Study Area" and received the color White.

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 the color 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 assigned the color Dark Green.

The likelihood of landuse protection against sea level rise was determined, as specified in the study's Scope of Work, using the general criteria table for Florida provided by SWFRPC (see Appendix IV).

Protection Almost Certain (Brown)

Coastal lands in South Florida have very high property values, compared with the costs of shore protection. Along the beaches, renourishment projects protect development and support the tourist economy. Along other navigable waters, armoring of the shoreline prevents erosion that can lead to the loss of waterfront property, much of which has been filled to the present elevation. In the aftermath of storm damages, homes are rebuilt. Most areas that have been developed, as well as undeveloped land in designated growth areas is almost certain to be protected.

The existence of shore protection is, by definition, a compelling reason to expect increased and continuous efforts to achieve protection from a rising sea. Land that has experienced coastal armoring or beach renourishment in the past generally implies that shore protection is almost certain An exception might be where land has been armored to protect support facilities in a park managed for conservation purposes, in which a policy to allow natural processes is followed. By contrast, 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. Land use data utilized in the production of the maps do not make this distinction between parks. Local knowledge was required to make that distinction.

Application

Given these justifications, the following describes how the maps captured this fundamental consideration.

In general, existing developed lands 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 the color Brown.

Similarly, future development within extensively developed areas and/or designated growth areas was also assigned a value of "Protection Almost Certain" and the color Brown. These areas were determined using landuse codes from the Future Land Use Map (FLUM).

Finally, extensively-used parks operated not for conservation, areas with current protection and areas already surrounded by protected areas were assigned "Protection

Almost Certain" and the color 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 Reasonably Likely (Red)

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 elected officials 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 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 general approach to identifying lands where shore protection is likely, but not certain, focuses on three broad categories of land: 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 not for development.

South Florida has many types of land where one can articulate a reason for being less than certain about shore protection. Due to the rapidly rising costs of land in South Florida, however, planners in South Florida are certain that nearly all developed and developable land would be protected if the sea level was to rise incrementally, such as one foot every forty 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 buy-outs might be feasible if land owners are faced with increasing floods, or if purchases for other public purposes prevail. Land 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 be allowed to follow natural processes.

In all of these areas, shore protection 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 may be possible that a policy decision or a private transaction can prevent development. This is particularly true adjacent to environmentally sensitive lands where purchases are possible. Statewide, the most common land use which, though not developed, may be protected are intensively used parks. In South Florida, especially Miami-Dade County, perhaps 60,000 acres of agricultural land may be protected due to 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 likely 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 locations are sometimes transferred to environmental agencies.

Application

Existing development within less densely developed areas (as defined in the statewide report) or outside designated growth areas or not on central water and sewer or within coastal high hazard areas were assigned the value "Protection Reasonably Likely" and the color 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 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 Reasonably Likely" and the color 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 due to locations in which development is strongly discouraged. In South Florida, this is particularly true of land outside the levees, the development of which would negatively impact conservation areas, or would be subject to frequent flooding from rainfall events. 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 assigned the color 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 the color 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 shore 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 Appendix VII for Federal Policies). These areas were assigned a value of "No Protection" and the color Light Green.

4. ANALYSIS OF COUNTY MAPS

A. 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. With a total area of almost 2,000 square miles, nearly 1,300 of these are covered by wetlands. A significant portion of the wetlands form part of Everglades National Park, Biscayne National Park and Big Cypress National Preserve. Population exceeded 2.3 million people in the year 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 sea level. Beginning in 1950, levees were built west of the established agricultural areas to keep Everglades waters from inundating those areas and the urban areas to the east. In a reversal of roles, it is the same levees which 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 potential sea level rise, represent a significant county-specific deviation from the general criteria used throughout the state to identify the likelihood of protection.

Discussion of Shore Protection Map

Please refer to **Appendix VIII**, **Miami-Dade County: Likelihood of Sea Level Rise Protection Map**, for the following discussion. A high-resolution color version in Adobe Acrobat PDF format is also provided suitable for online review and printing.

The map is dominated on the south and west by vast areas of **Dark Green Wetlands**. Interspersed among the wetlands are upland forests in National Park lands, which, by federal policy, will receive **No Protection** and are shown **Light Green**.

Starting in the northwest along **Levees L-33 and L-30**, the **Red Protection Reasonably Likely** areas to the east are mostly comprised of agricultural lands, with some developed areas outside the county's growth area or not on central water and sewer. The **Blue Protection Unlikely** areas also east of the levees include recreational and open spaces, forests, mining, barren lands and other undeveloped areas. These are also outside 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 the blue color.

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 **Blue Protection Unlikely** areas adjacent and immediately west of these levees are comprised primarily of agricultural lands. On the northern edge of the blue lands is the "**8 ½ Square Mile Area"**, which are designated as **Red Protection Reasonably Likely** on the draft maps. Although west of the levee (on the "wet" side), negotiations are under way for the addition of a second levee in this area, which would make it reasonably possible to protect them.

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, would likely be protected. Also included on the eastern fringe of the red areas are developed lands not served by central water and sewer or outside the county's Urban Development Boundary.

The red and blue areas 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.

It should be noted that 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 **Brown Protection Almost Certain**.

The large brown area located 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, the significant color is Brown.

The **Coastal Ridge**, with its elevation of ten feet or more, is clearly visible thanks to its **White** color and designation as **Outside the Study Area**. Although near the coast, the ridge only approaches within 1,000 feet in two spots, both near Downtown Miami. Not only are these spots located in urban and built-up areas but they also have man-made shoreline protection.

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 currently already have man-made protection by seawalls, rip rap or beach renourishment programs. As such, they are **Brown** with "**Protection Almost Certain**".

The draft maps had several exceptions on Key Biscayne and Virginia Key to the southeast of Miami and one small section in the northern part of the county. These areas have no current protection, contain wetlands, and are located within CoBRA Zones. Many of these became exceptions as a result of the stakeholder review, described below.

Stakeholder Collaboration

Council staff presented the initial maps showing the extent of sea level rise prior to the determination of areas likely to be protected 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 future 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 six inches by the year 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 over 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.

An additional meeting with Miami-Dade County land use and emergency management planners was held in the SFRPC offices on June 13, 2005. Representing the County were Paula Church of the Miami-Dade County Department of Planning and Zoning, and Frank Reddish and Jonathan Lord, both of the Miami-Dade County Department of Emergency Management. Also present were Jim Titus of the U.S.E.P.A. and Dan Trescott of the SWFRPC. County staff were initially uncomfortable with the notion that

any part of the County would be given up to the sea, but after having the rationale for lands outside the levees being designated as unlikely to be protected, saw the utility of identifying the areas with the greatest chance of not being protected from the rising sea. County staff comments included making exceptions for heavily utilized parks on the barrier islands similar to those in Broward County for Bill Baggs Cape Florida State Park and Crandon Park on Key Biscayne, Virginia Key, and Haulover County Park. Also recommended were to change the Frog Pond and Rocky Glades areas outside the levees from red to dark green, as they are part of the Comprehensive Everglades Restoration Plan (CERP) and are likely to be restored to wetlands. Similarly, the western third of the "8 1/2 Square Mile Area" will be restored to wetlands as a part of CERP and is colored dark green. Other comments were taken on the location of the map categories with respect to future protection from sea level rise. Those comments have been incorporated in the final maps.

B. 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 ten 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 over 10 feet.

Discussion of Shore Protection Map

Please refer to **Appendix IX, Broward County: Likelihood of Sea Level Rise Protection Map**, for the following discussion. A high-resolution color version in Adobe Acrobat PDF format is also provided suitable for online review and printing.

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 for the purpose of keeping freshwater in the water preserves from intruding into 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 **Brown Protection Almost Certain**.

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 **Red Protection Reasonably 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 **Red Protection Reasonably Likely** in the draft maps.

Stakeholder Collaboration

Council staff presented the initial maps showing the extent of sea level rise prior to the determination of areas likely to be protected to the Broward County Hazard Mitigation Task Force in 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 and protection of its vulnerable residents during hurricane events. The County is committed to continuation of periodic beach renourishment activities. Task Force participants noted the potential for damage to the potable water aquifer from sea level rise to the west, which had not been anticipated. Council staff will continue to participate in LMS activities to keep the sea level rise issue in the consciousness of County staff.

An additional meeting with Broward County land use and emergency management planners was held in the SFRPC offices on June 13, 2005. Representing the County were Peter Schwarz, of the Broward County Department of Urban Development Planning and Ryan Williams with the Broward County Department of Emergency Management. Also present were Jim Titus of the U.S.E.P.A. and Dan Trescott of the SWFRPC. Comments were taken on the location of the map categories with respect to future protection from sea level rise. Those comments led to exceptions made regarding heavily utilized parks on the barrier islands in Broward County (including Hugh Taylor Birch State Park, Fort Lauderdale Beach, John U. Lloyd State Park, and North Beach County Park). These lands are the recipient of millions of dollars in beach renourishment currently underway, are significant tourism assets for the local economy, and are almost certain to be protected as sea level rises in the decades ahead. They were proposed to be redesignated from Red (Protection Reasonably Likely) to

Brown (Protection Almost Certain), and those changes have been incorporated in the final maps. With these changes, all of the dry land in Broward County is shaded Brown with the exceptions of high ground out of the study, and sparsely settled agricultural land.

C. Monroe County

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. Although encompassing slightly more than 1,000 square miles, a significant portion of the county's landmass is on the mainland, is entirely within Everglades National Park and is mostly wetlands. In 2002, the county had a population of only 79,000 people, all of them residing in the Florida Keys, a string of islands encompassing 102 square miles.

Please refer to **Appendices X** through **XII,** which contain maps of **Monroe County: Likelihood of Sea Level Rise Protection** for the **Upper**, **Middle** and **Lower Keys** respectively, for the following discussion. High-resolution color versions in Adobe Acrobat PDF format are also provided suitable for online review and printing.

Virtually the entire landmass of Monroe County lies below ten feet elevation. The few exceptions are either within 1,000 feet of the coast or completely surrounded by developed areas, thus, all areas of the county are in the Study Area.

Available 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 already developed lands are likely to protect their investments.

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. This includes the military facilities in the Naval Air Station. These areas are designated **Brown Protection Almost Certain**. A few exceptions, notably those within CoBRA designated areas and turtle-nesting areas, were changed to **Red Protection Reasonably Likely**.

The **Light Green No Protection** designated areas shown form part of the many federal, state and local parks, wildlife refuges, sanctuaries, etc. located in the Florida Keys.

Northward through the Middle Keys, most non-wetlands uplands are developed as well and designated **Brown Protection Almost Certain**. The exceptions in this area are a few **Red Protection Reasonably Likely** CoBRA areas and several Conservation parcels designated **Dark Blue Protection Unlikely**.

Similarly, the Upper Keys' uplands are mostly developed and/or already protected. These areas are also designated **Brown Protection Almost Certain**. A few CoBRA designated areas are shown as **Red Protection Reasonably Likely** with Conservation parcels designated **Dark Blue Protection Unlikely**. Additional federal, state and local parks, wildlife refuges and sanctuaries are designated **Light Green No Protection**.

The Monroe County mainland, not shown on the map, represents more than 880 of the county's 1,000 square miles. This area is almost entirely comprised of wetlands within Everglades National Park.

Stakeholder Collaboration

Council staff presented the initial maps showing the extent of sea level rise prior to the determination of areas likely to be protected 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 near shore 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 six inches by the year 2050, the expected completion of plan implementation. With an estimated price tag of $8 billion in year 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.

An additional meeting with Monroe County land use and emergency management planners was held in 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 U.S.E.P.A. and Dan Trescott of the SWFRPC. Jeff Stuncard invited Jim Titus to visit the planning staff in Monroe County to discuss the maps in greater detail. Follow-up meetings were held with Jim Titus and Monroe County planners in the Florida Keys on June 16. Present at the meetings were Jeff Stuncard and Jason King from the Key Largo office, Beth La Fleur and Andrew Trivette from the Marathon office, and Tim McGarry, Director of Growth Management.

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. The proposed Tier System, which has not yet been accepted by the Florida Department of Community Affairs, the state land planning agency, nevertheless informed much of the discussion. At the outset of this study, parcel level data was not available for all of the counties. As a result, the SFRPC used polygons from the South Florida Water Management District (SFWMD) for future land use to maintain consistency throughout the study. The Monroe County planners noted that the polygons used by the SFWMD were too general, 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, resulting in a change of color to either light or dark green, depending on the characteristics of the property. Other coastal areas were identified as sea turtle-nesting areas, within which armoring of the shore is prohibited, making adjacent developed lands an exception from brown to red. Finally, Tier 3 areas, which are targeted for future development, were recommended to be changed to brown. Using aerial photographs, comments were taken on the specific locations of the map categories with respect to future protection from sea level rise. The SFRPC has attempted to make all of the changes requested by local officials, and, to the extent feasible, given the available polygons in the GIS coverage, those comments have been incorporated in the final maps.

D. 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 a rising sea level, a question that has not been previously addressed in South Florida. How the SFWMD 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 upon 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, or freshwater, portions of the Everglades 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 how best 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.[2]

Therefore, the possible interests of the Park in wetland migration do not directly change shore protection prospects in the areas depicted on the maps in this study of the three counties (which exclude much of the Everglades). Within the Park boundaries, however, the 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. However, the Atlanta Office of the National Park Service has suggested that Flamingo be considered an historic site. The Park Superintendent has indicated that such a designation would be ill advised, and has also indicated that Flamingo would not be rebuilt if it was destroyed by a hurricane. Under these circumstances, park staff indicated that depicting Flamingo as "shore protection unlikely" is the most appropriate designation.[3]

[2] 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.

[3] 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).

5. QUANTIFICATION OF LAND USE IMPACTS BY COUNTY

Miami-Dade County

Table 4 - Miami-Dade County Acreage by Sea Level Rise Category

Polygons	Acreage	Color	Category
70,191	1,268,450	N/A	County
14,883	65,401	White	Outside Study Area
11,797	829,991	Dark Green	Wetlands
9,241	39,313	Light Blue	Water
838	26,403	Light Green	No Protection
998	35,598	Dark Blue	Protection Unlikely
2,426	61,751	Red	Protection Reasonably Likely
30,008	209,993	Brown	Protection Almost Certain

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Broward County

Table 5 - Broward County Acreage by Sea Level Rise Category

Polygons	Acreage	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	Light Green	No Protection
125	1,644	Dark Blue	Protection Unlikely
147	5,017	Red	Protection Reasonably Likely
27,749	183,860	Brown	Protection Almost Certain

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Monroe County

Table 6 - Monroe County Acreage by Sea Level Rise Category

Polygons	Acreage	Color	Category
25,545	641,596	N/A	County
0	0	White	Outside Study Area
10,011	559,556	Dark Green	Wetlands
7,424	49,251	Light Blue	Water
778	8,649	Light Green	No Protection
620	3,121	Dark Blue	Protection Unlikely
477	1,591	Red	Protection Reasonably Likely
6,235	19,428	Brown	Protection Almost Certain

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South Florida Region

Table 7 - South Florida Region Acreage by Sea Level Rise Category

Polygons	Acreage	Color	Category
155,628	2,707,988	N/A	Region
36,042	587,068	White	Outside Study Area
22,623	1,453,432	Dark Green	Wetlands
26,562	110,433	Light Blue	Water
1,616	35,052	Light Green	No Protection
1,743	40,363	Dark Blue	Protection Unlikely
3,050	68,359	Red	Protection Reasonably Likely
63,992	413,281	Brown	Protection Almost Certain

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6. SEA LEVEL RISE AND LAND USE SOLUTIONS

Summary solutions to sea level rise impacts on land uses, including but not limited to:

- 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)

7. CURRENT FEDERAL AND REGIONAL PLANNING FOR SEA LEVEL RISE

Please refer to **Appendix VII** for Federal Policies.

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 non-governmental 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 which address Sea Level Rise in our Region.

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.

8. 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 people 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. Due to 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 will likely 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.

9. APPENDICES

I. Estimating Sea Level Rise at a Specific Location

II. Historic Rate of Sea Level Rise at Various Locations in the United States

III. Estimated Sea Level Rise for Southeast Florida

IV. Statewide Approach for Identifying the Likelihood of Land Use Protection

V. Florida Land Use, Cover and Forms Classification System (FLUCCS)

VI. SFWMD Future Land Use Map (FLUM) Attribute Definitions

VII. Federal Policies Affecting the Likelihood of Shoreline Protection

VIII. Miami-Dade County: Likelihood of Sea Level Rise Protection Map

IX. Broward County: Likelihood of Sea Level Rise Protection Map

X. Monroe County-Upper Keys: Likelihood of Sea Level Rise Protection Map

XI. Monroe County-Middle Keys: Likelihood of Sea Level Rise Protection Map

XII. Monroe County-Lower Keys: Likelihood of Sea Level Rise Projection Map

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 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

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 Reasonably 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 ; Non-growth areas identified from planner input, local comprehensive plans, Flood Insurance Rate Maps for COBRA and current regional hurricane evacuation studies.
	Unbridged barrier island & 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 & the boundaries have not yet been defined so we are unable to designate which areas are brown & 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 & site-specific departures are discussed in the county-specific sections.
2. Colored line file should be used in areas where less than 10 ft. elevations exist within 1,000 feet of the rising sea or color can't 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.

Source: Dan Trescott, Southwest Florida Regional Planning Council and Jim Titus, United States Environmental Protection Agency.

Appendix V

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 Residential, 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 Construction
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 (street 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 Shrubs and Brushland
321 Palmetto Prairies
322 Coastal Shrubs
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 lands 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 Long Dist Trans Lines
818 Auto Parking Facilities
819 Transportation Facilities Under Construction
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 VI

South Florida Water Management District
Future Land Use Map 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

Appendix VII

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 will 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.[4] As a coastal landowner, the federal government has made several very large parcels of land unavailable 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 over one thousand feet inland on a special-purpose railroad track at a cost of over $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 it does not directly discourage development in the coastal zone. However, 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

[4] For further details on federal policies that might allow wetlands to migrate inland,. See James 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.

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.

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.[5] 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

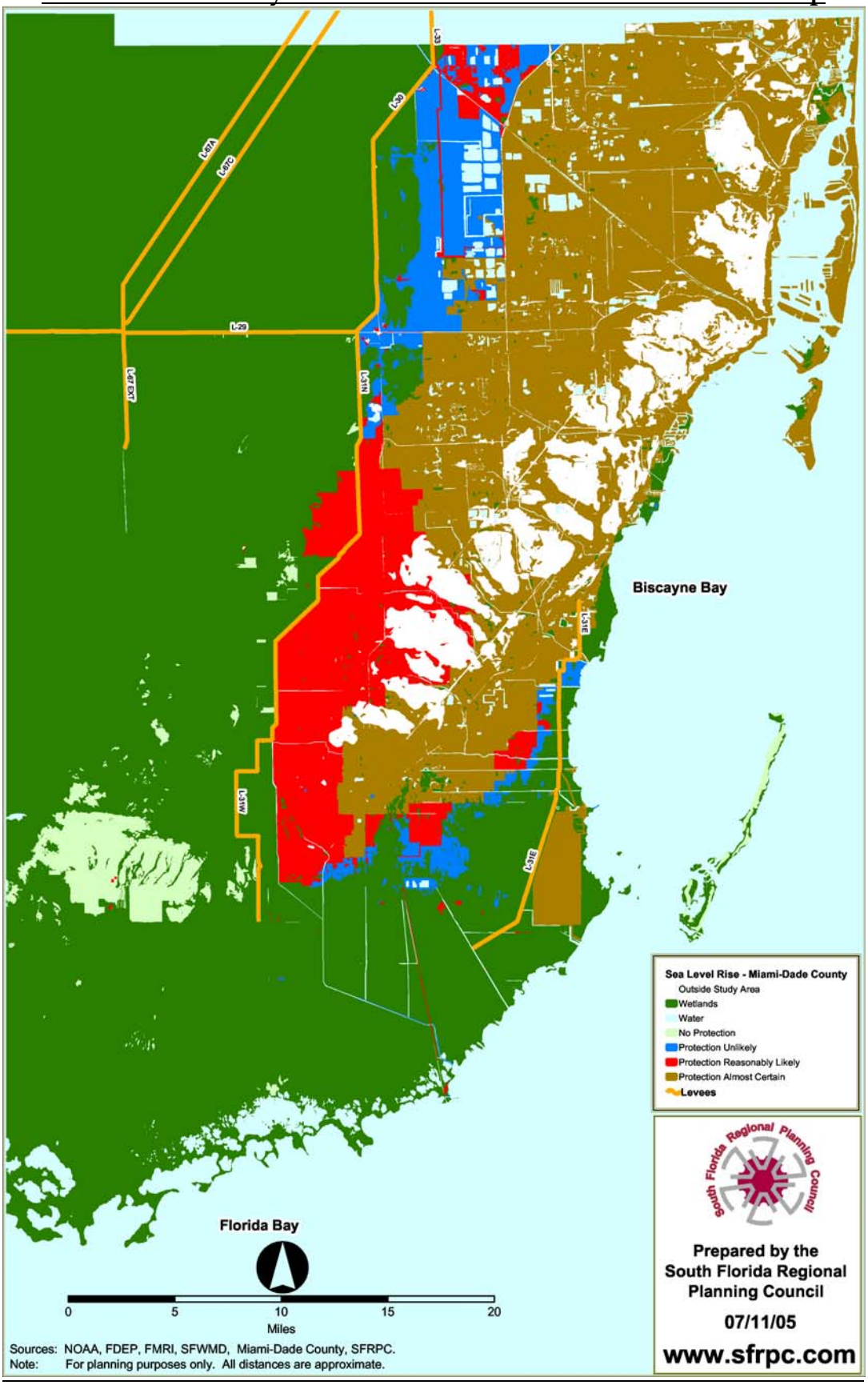
The federal government has long provided subsidies for jetties that stabilize harbor entrances, and beach nourishment along intensely developed shores. In areas like Miami Beach, seawalls did—and probably still would—protect development from eroding shores; so the subsidy for beach nourishment primarily alters the type of shore protection. Along more moderately developed shores in this region (name), 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.

[5] 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.

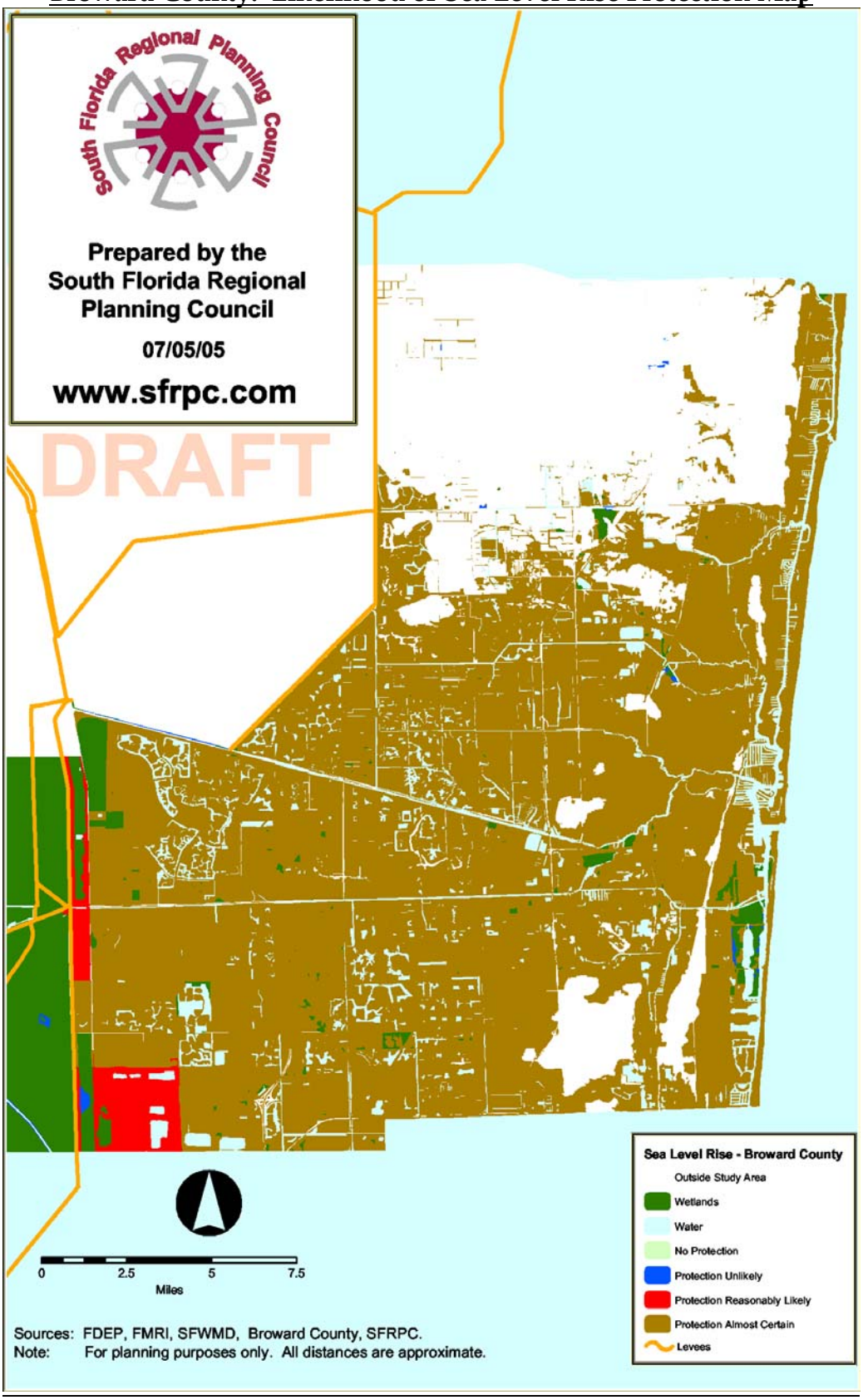
Appendix VIII

Miami-Dade County: Likelihood of Sea Level Rise Protection Map



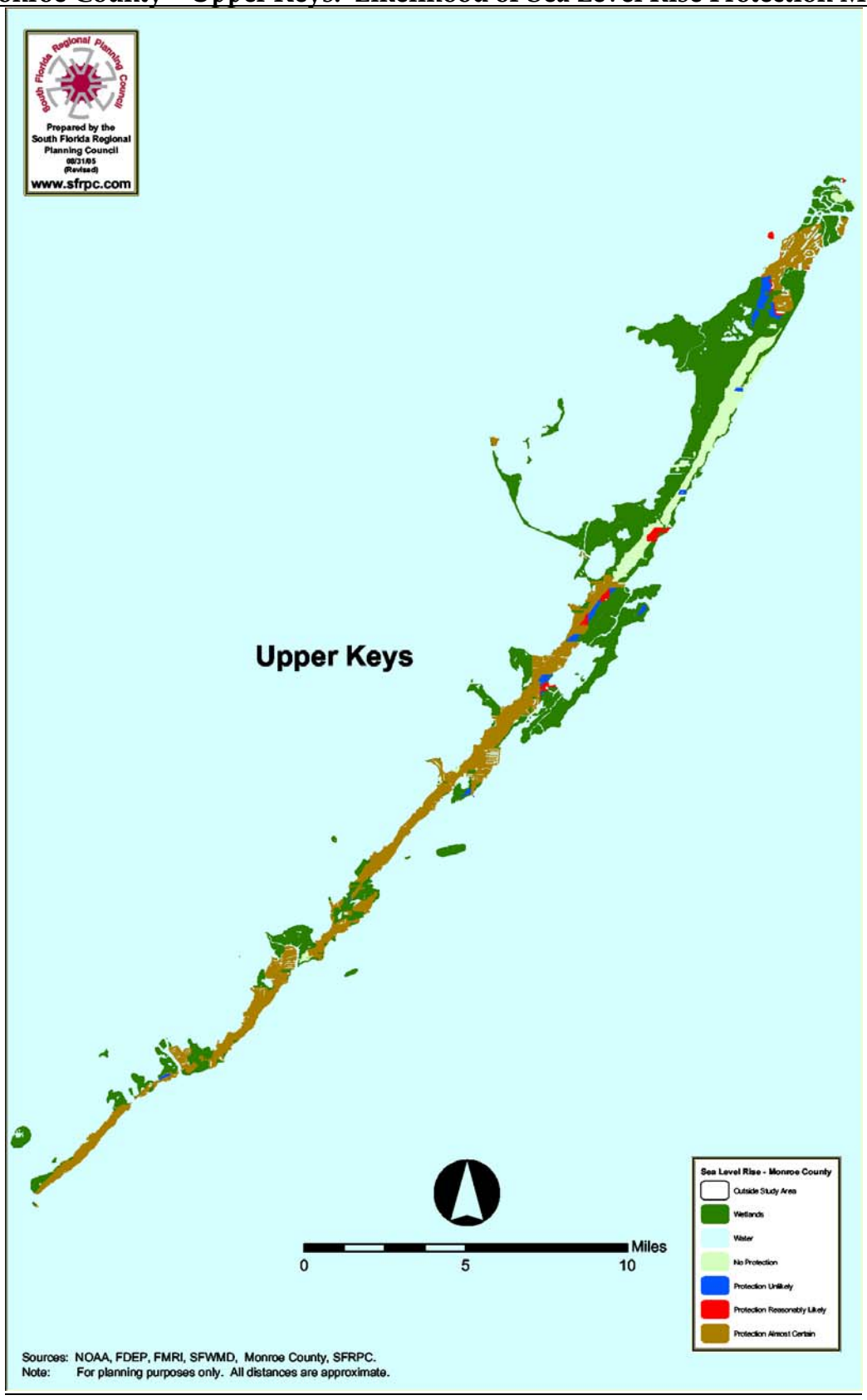
Appendix IX

Broward County: Likelihood of Sea Level Rise Protection Map



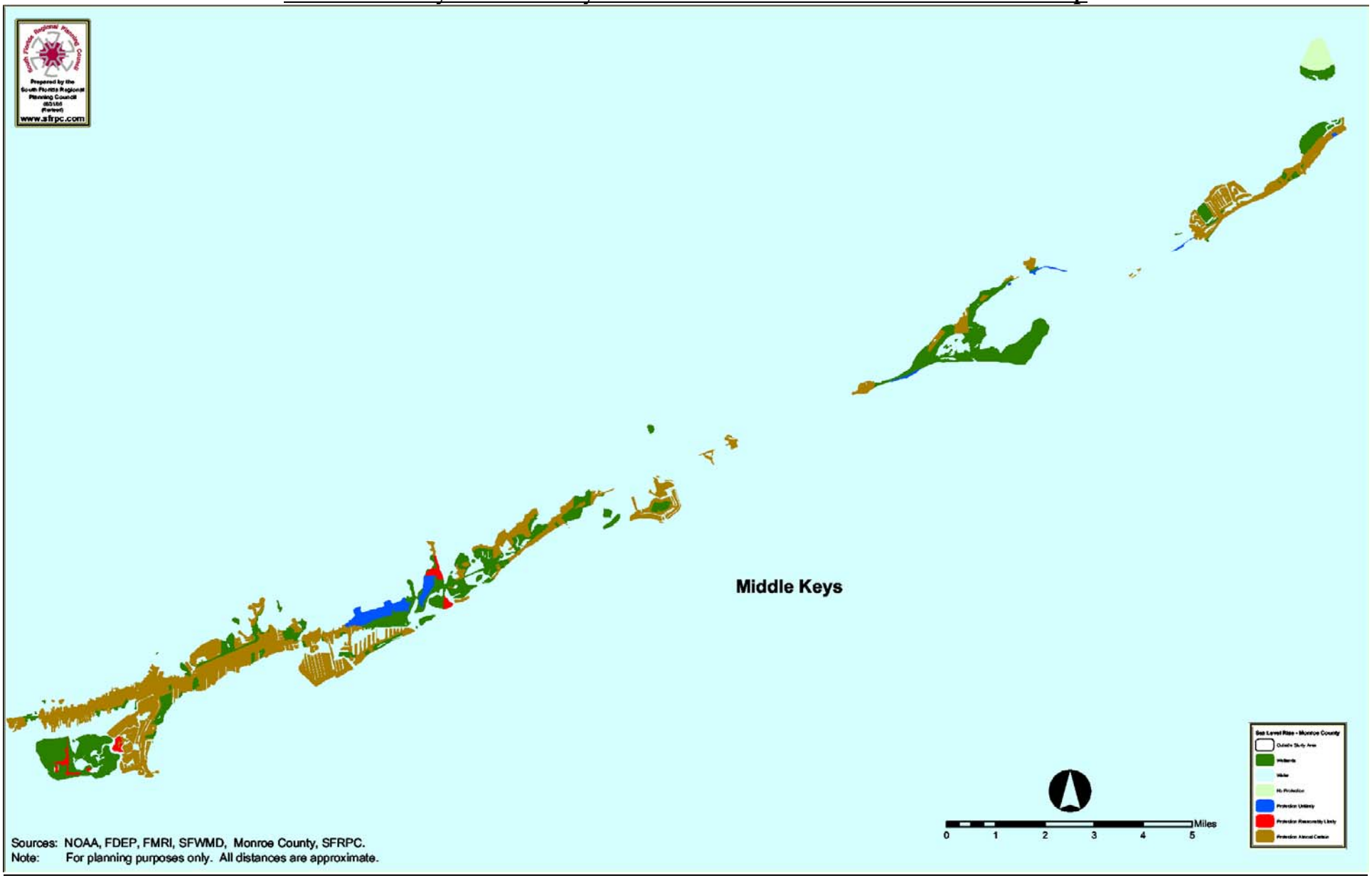
Appendix X

Monroe County – Upper Keys: Likelihood of Sea Level Rise Protection Map



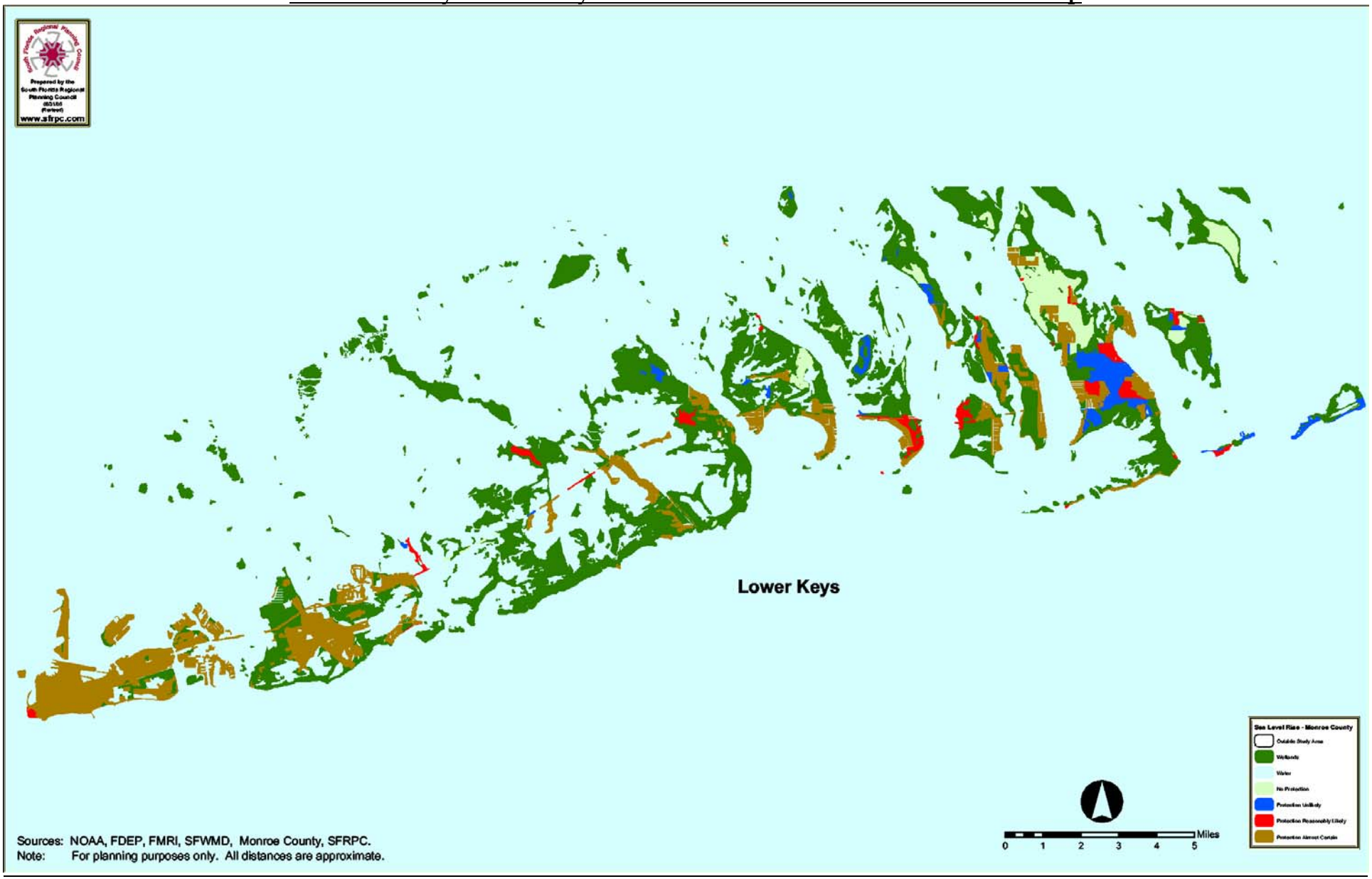
Appendix XI

Monroe County – Middle Keys: Likelihood of Sea Level Rise Protection Map



Appendix XII

Monroe County – Lower Keys: Likelihood of Sea Level Rise Protection Map



10. Glossary

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 Geologic Survey