South Florida

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Chapter 8: SOUTH FLORIDA

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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: Titus et al. 2009. State and local governments plan for development of most land vulnerable to rising sea level along the U.S. Atlantic Coast. Environ. Res. Lett. **4** (2009) 044008 (7pp), based on the procedures in 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).

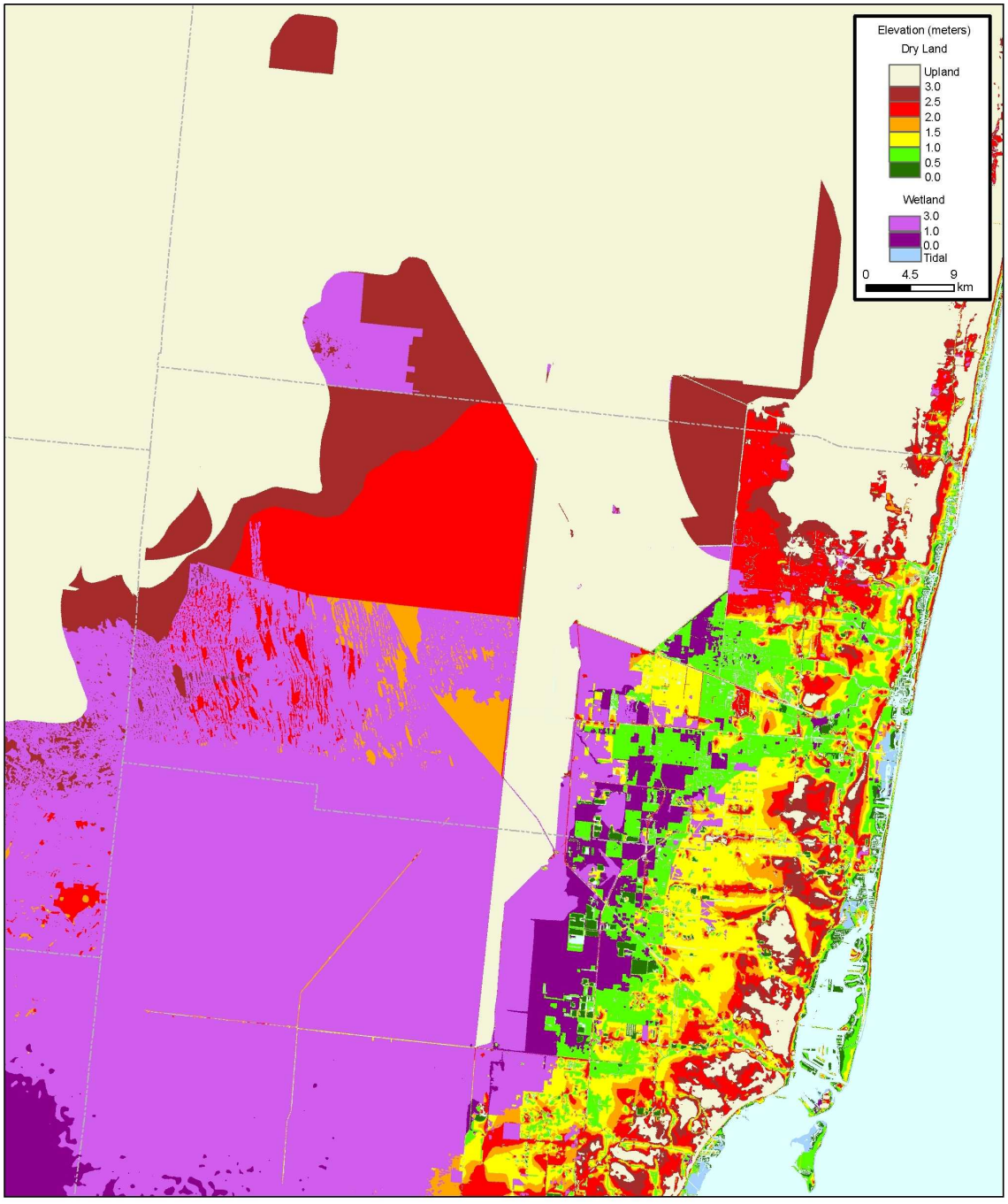


Figure 1a: Lands Vulnerable to Sea Level Rise in Broward County. Source: See Table 1.

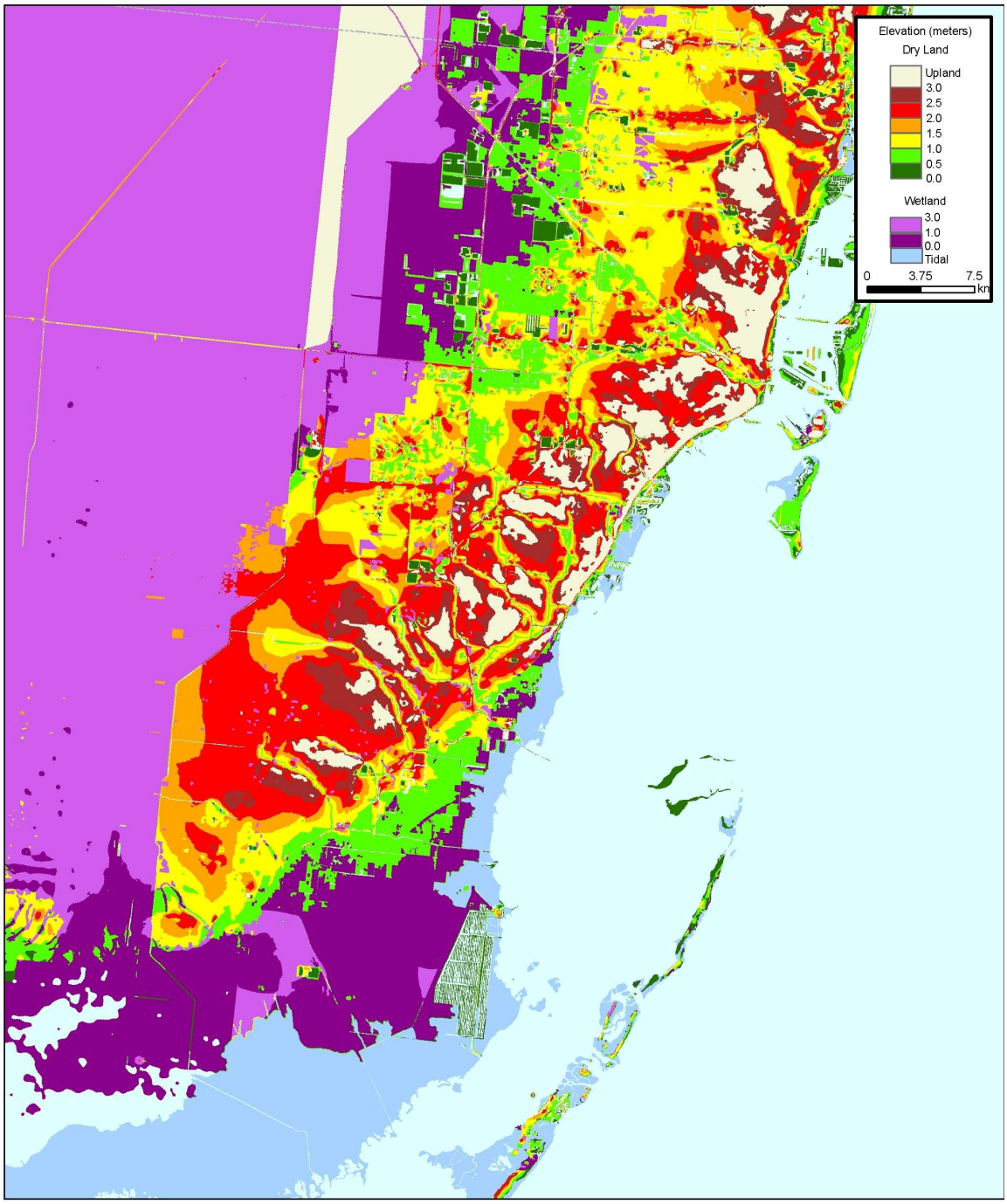


Figure 1b: Lands Vulnerable to Sea Level Rise in Miami-Dade County

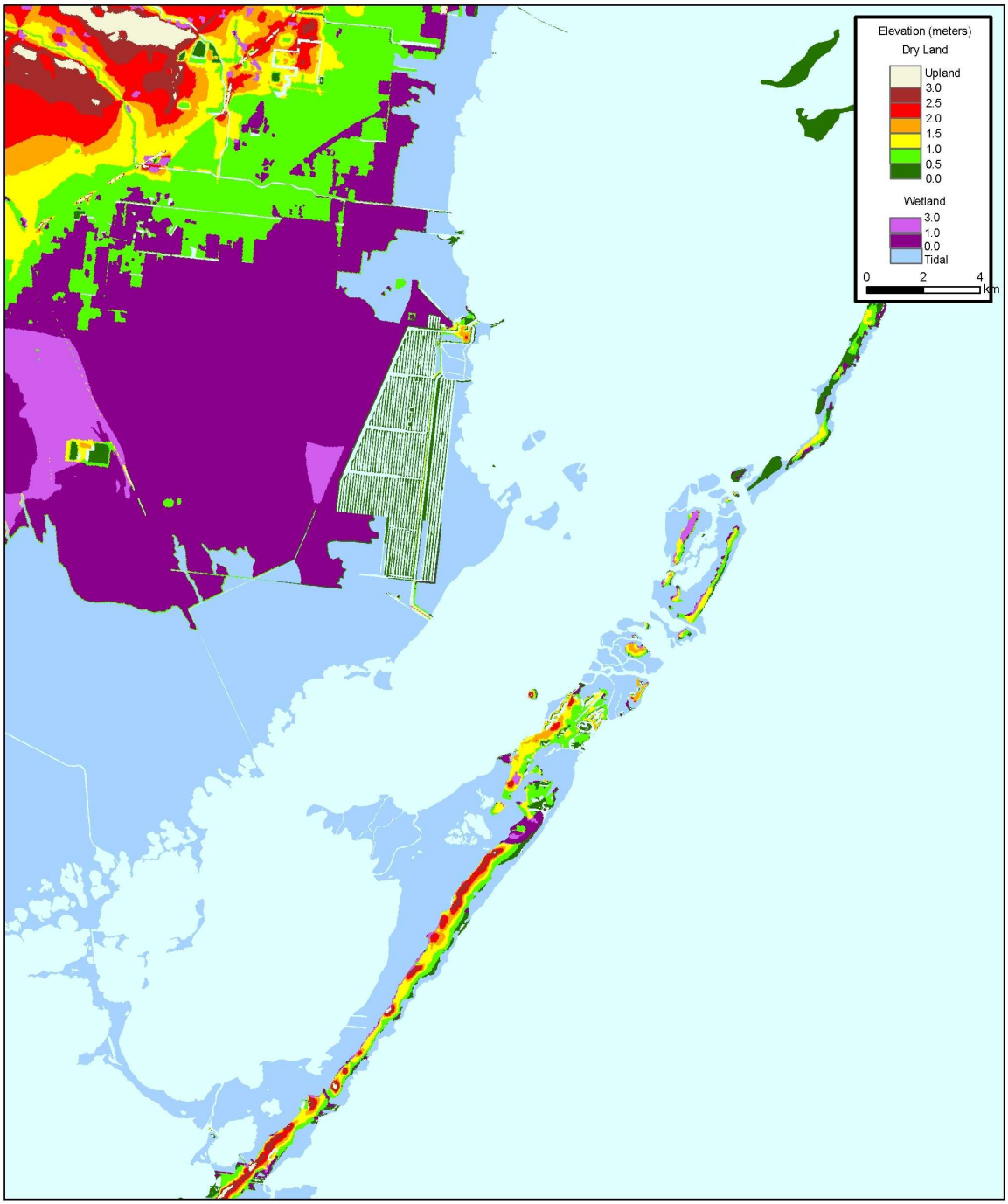


Figure 1c. Grayvik and Card Sound to Key Largo and Tarpon Basin

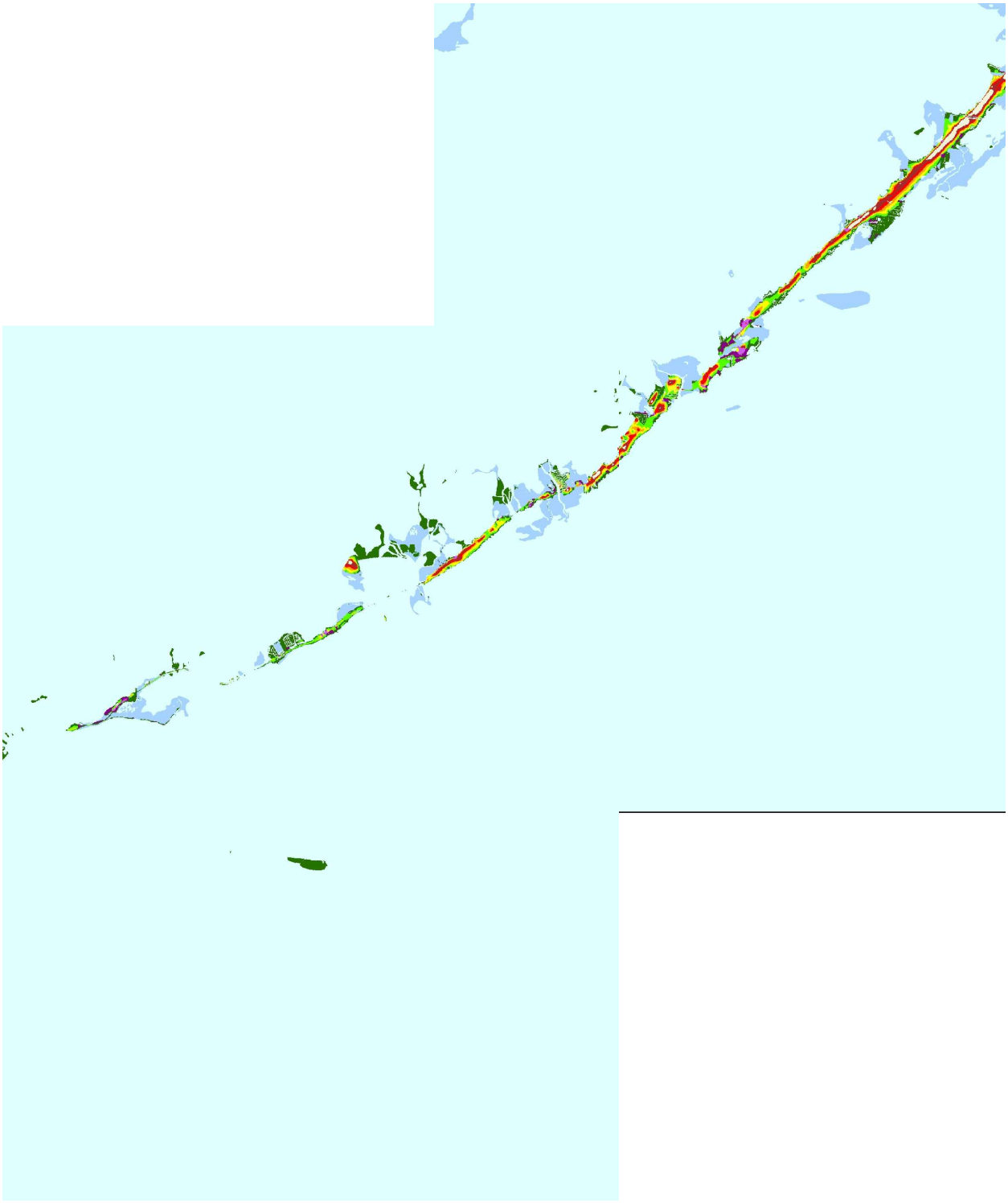


Figure 1d. Key Largo to Long Key

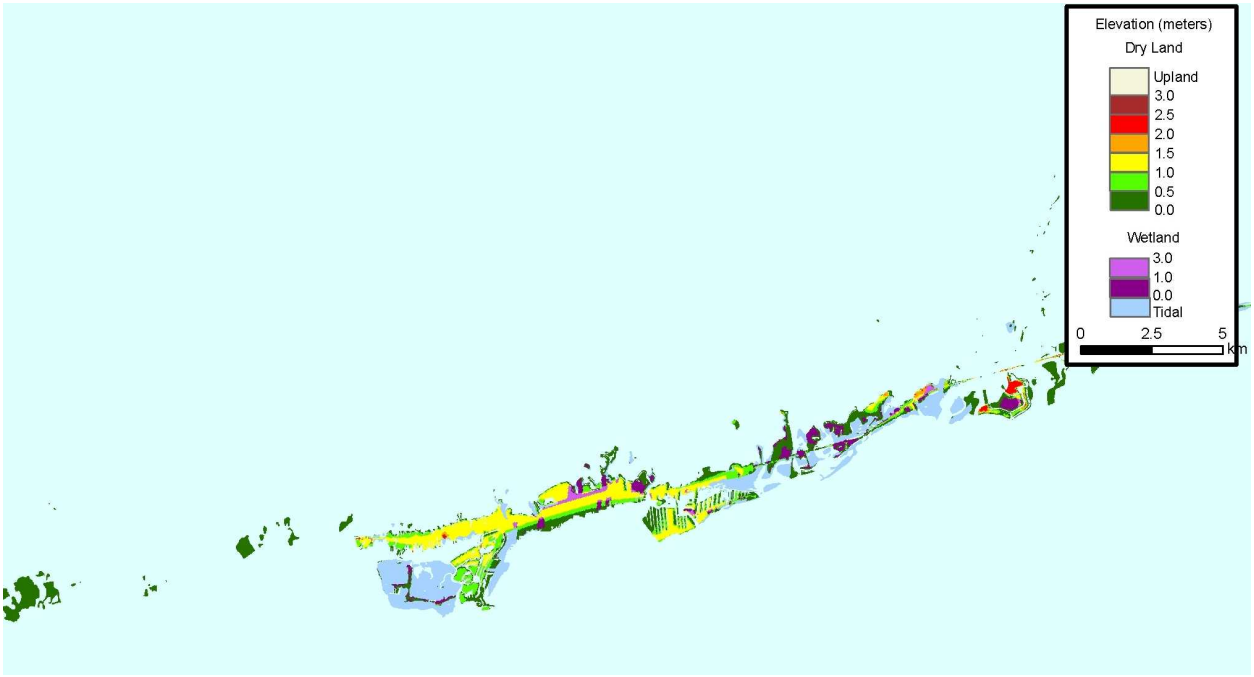


Figure 1e. Duck Key to Boot Key

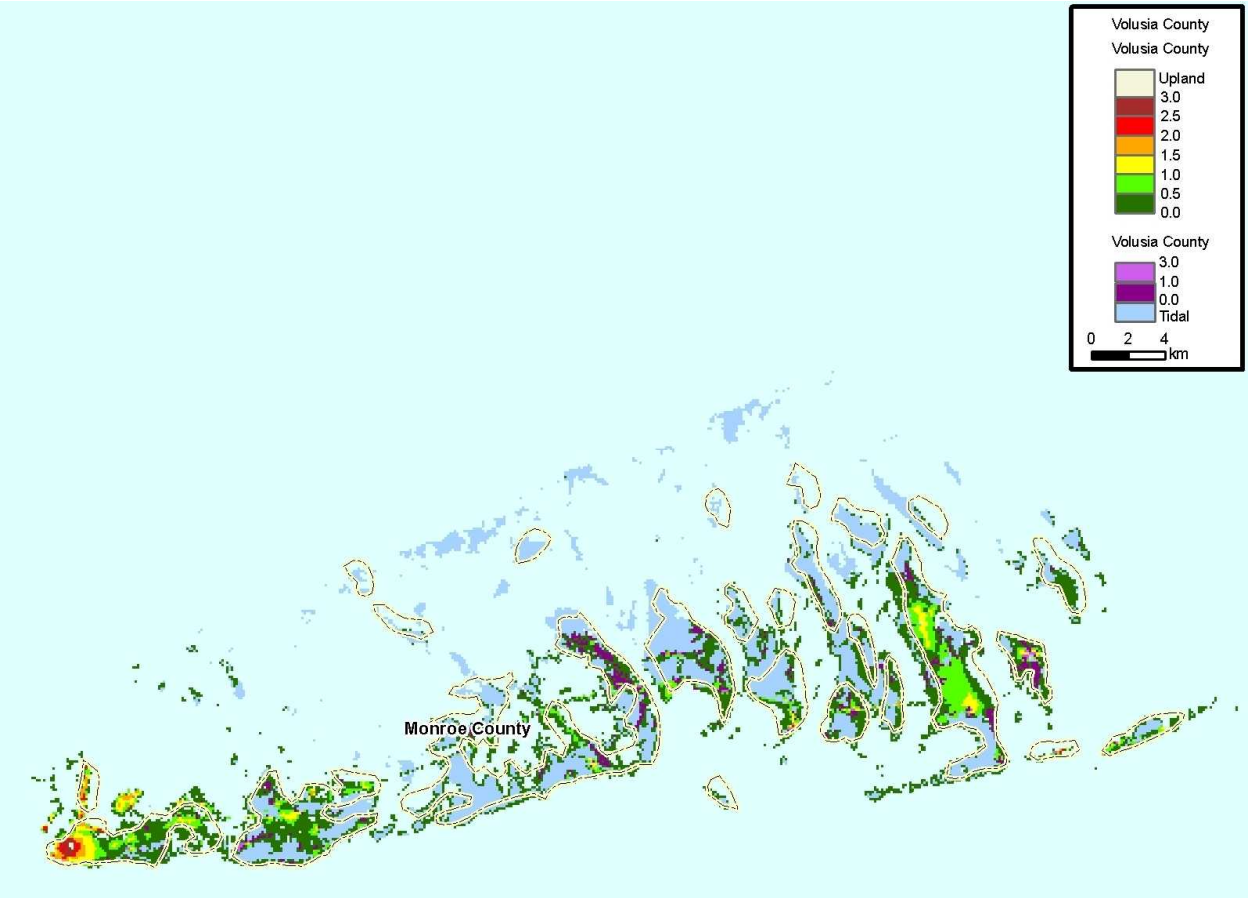


Figure 1e. Big Pine Key to Key West.

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.

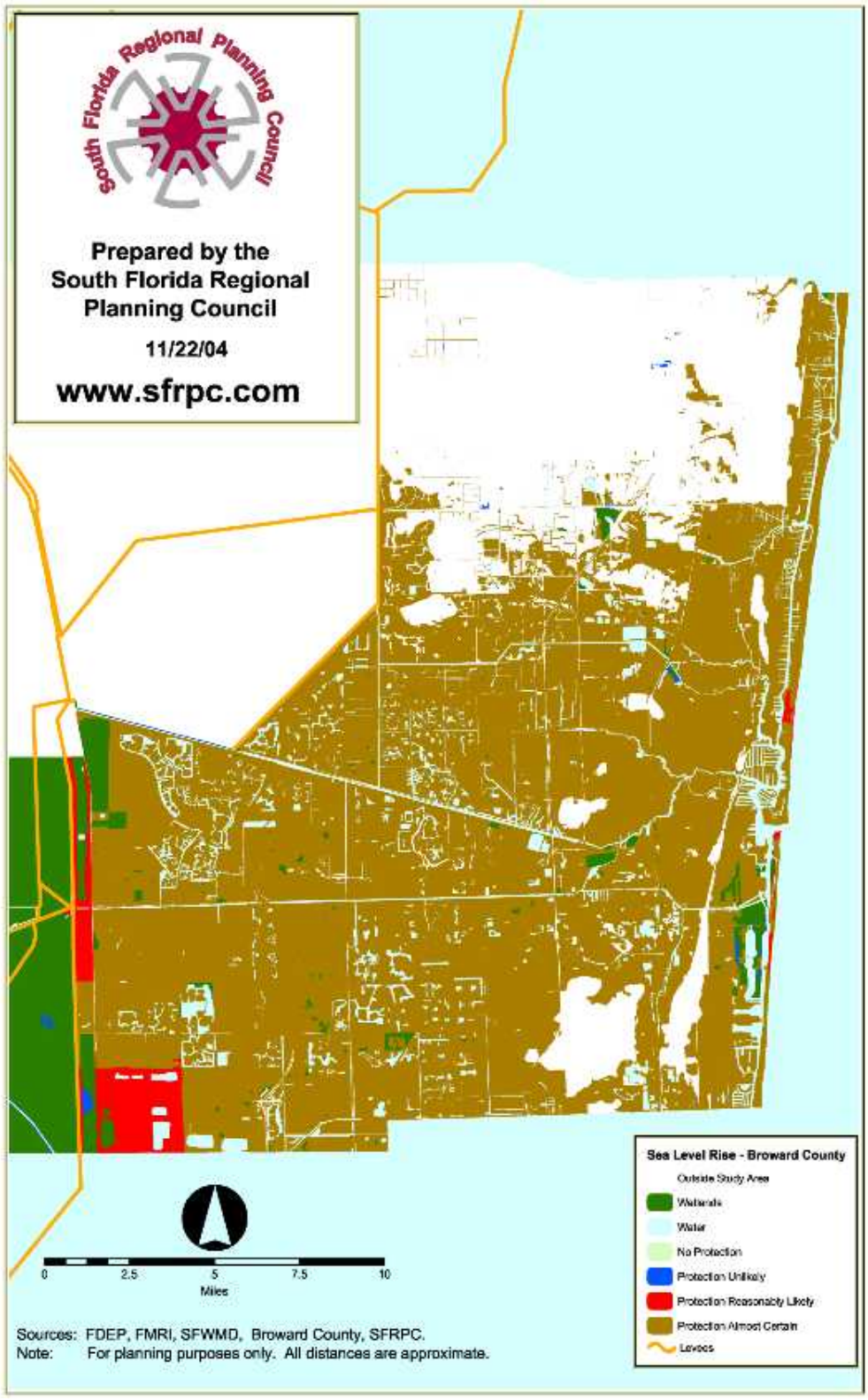


Figure 2. Likelihood of Shore Protection in Broward County: Stakeholder Review Draft Map

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

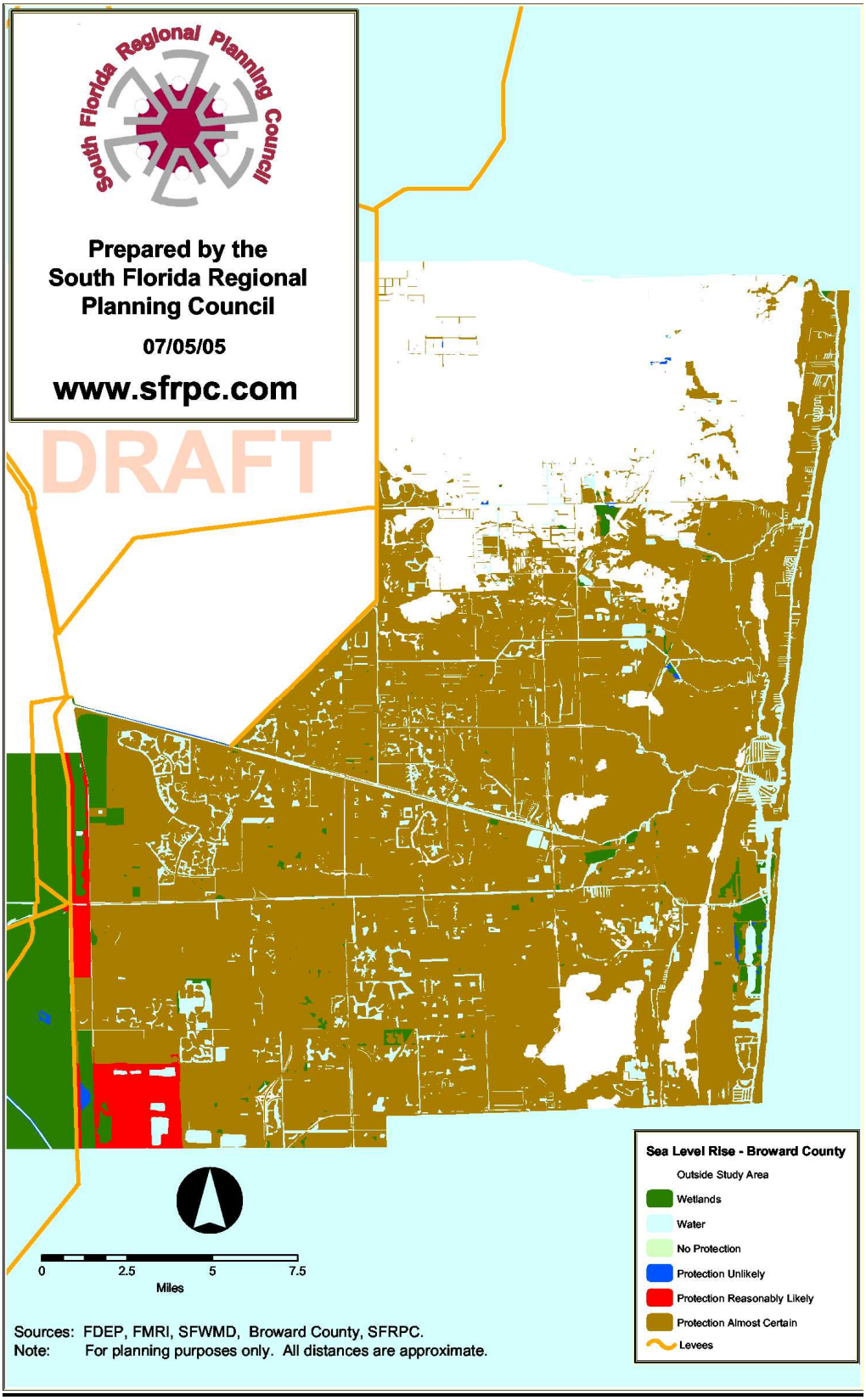
Peter Schwarz, Broward County Department of Urban Development Planning
Ryan Williams, Broward County Department of Emergency Management

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..

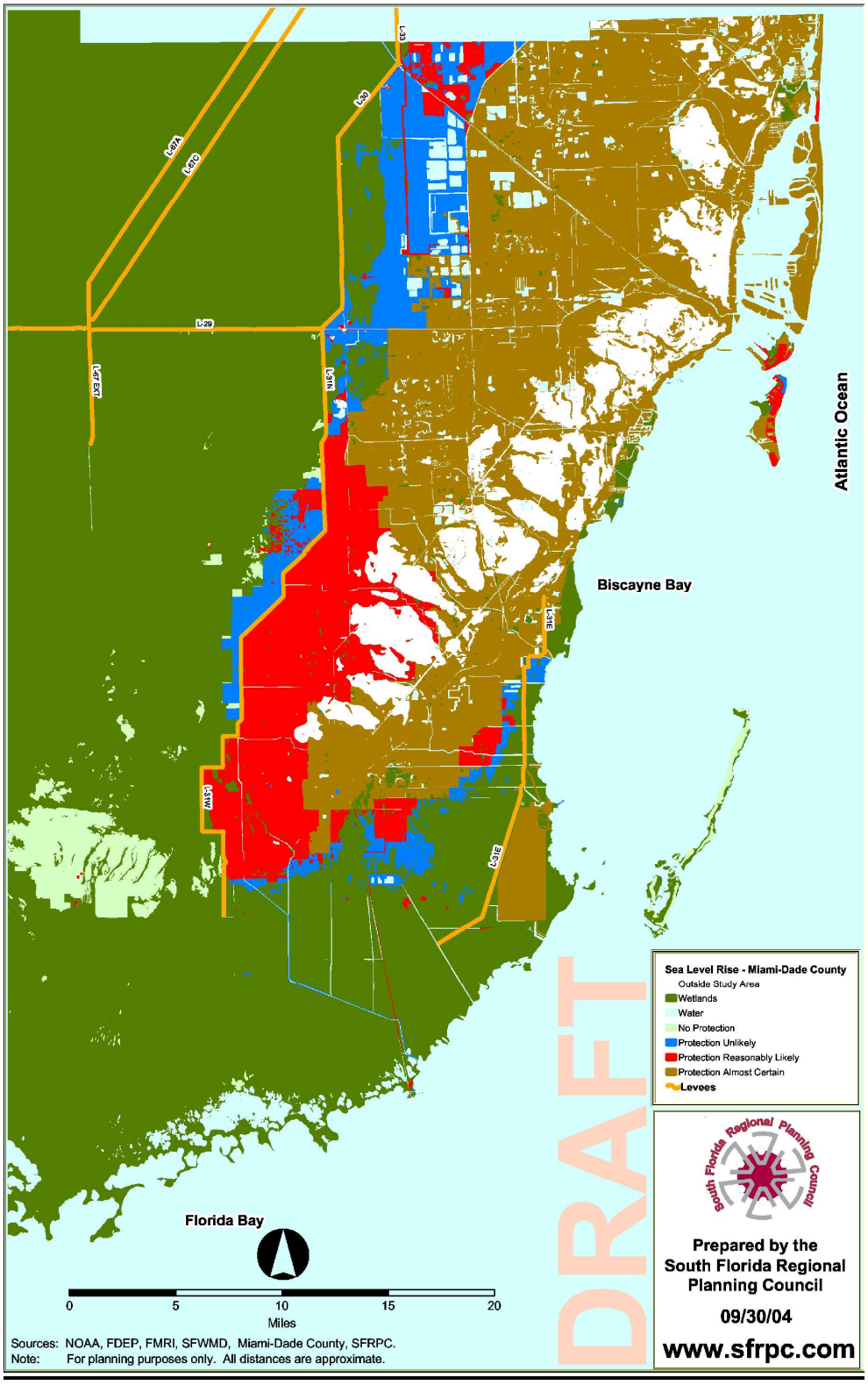


Figure 3. Likelihood of Shore Protection in Miami-Dade County: Stakeholder Review Draft Map

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.*

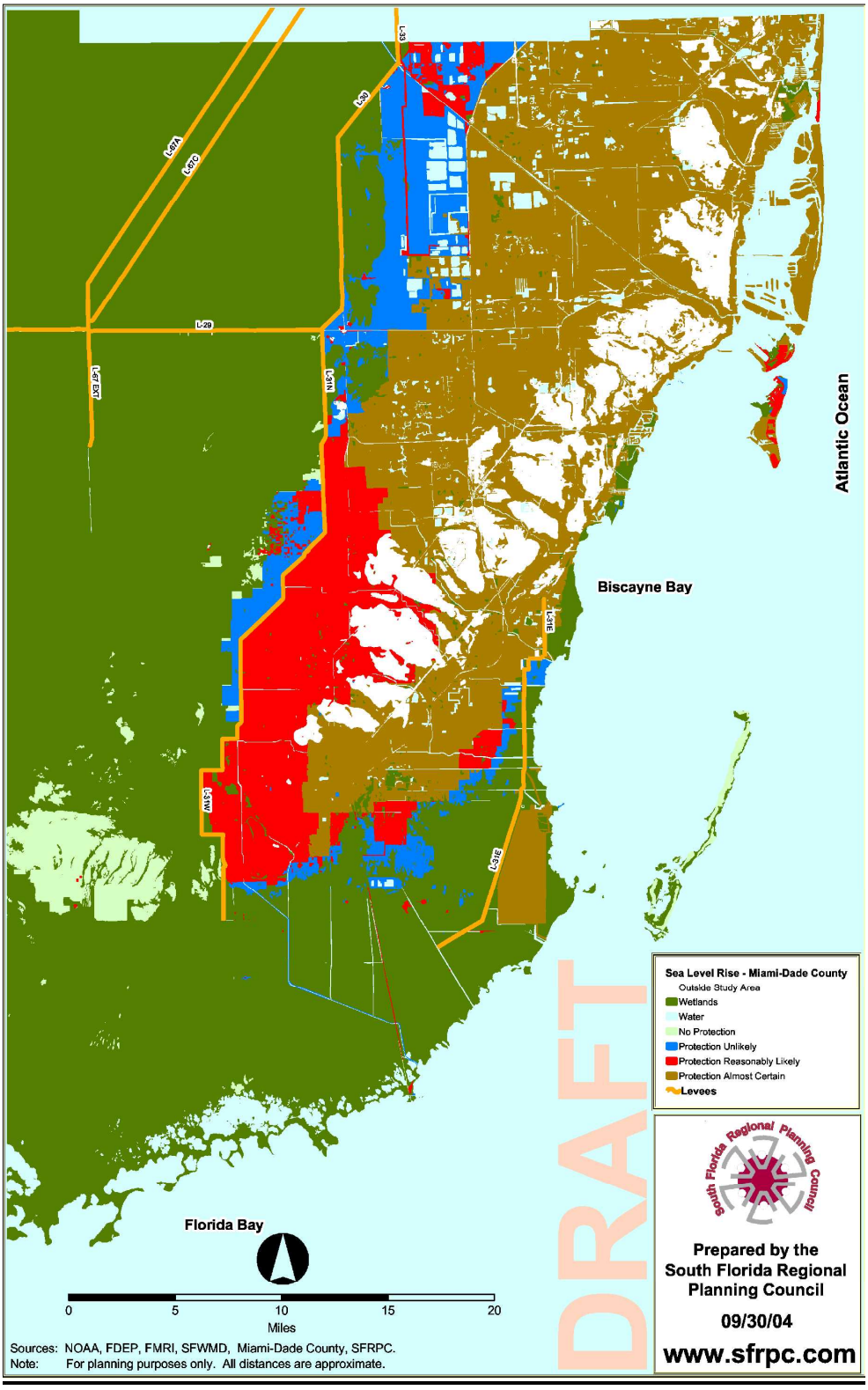
5. *From Miami Beach north, change all parks on the barrier island depicted as red to brown.*. These parks are extensively used, receive beach renourishment, and are next toor surrounded by—other lands that are certain to be protected.
6. *Change Frog Pond from red to purple or dark green, and the Rocky 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.

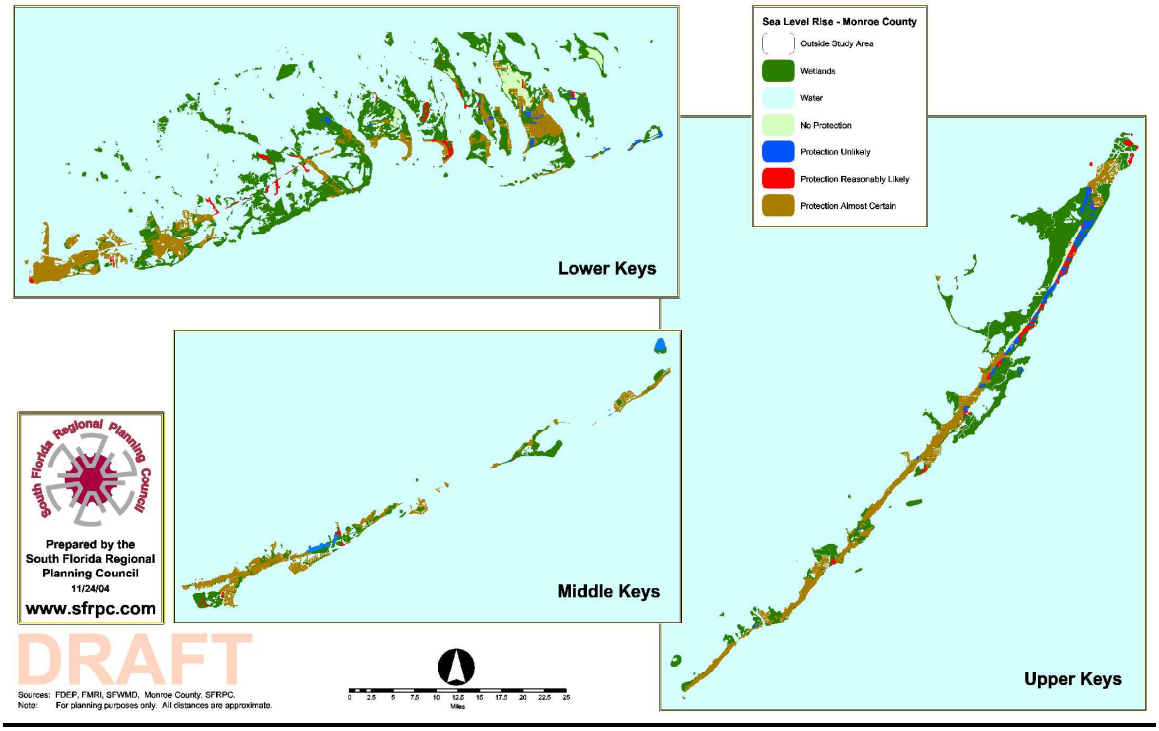


Figure 4. Likelihood of Shore Protection in the Florida Keys: Stakeholder Review Draft Map.

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.

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[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.

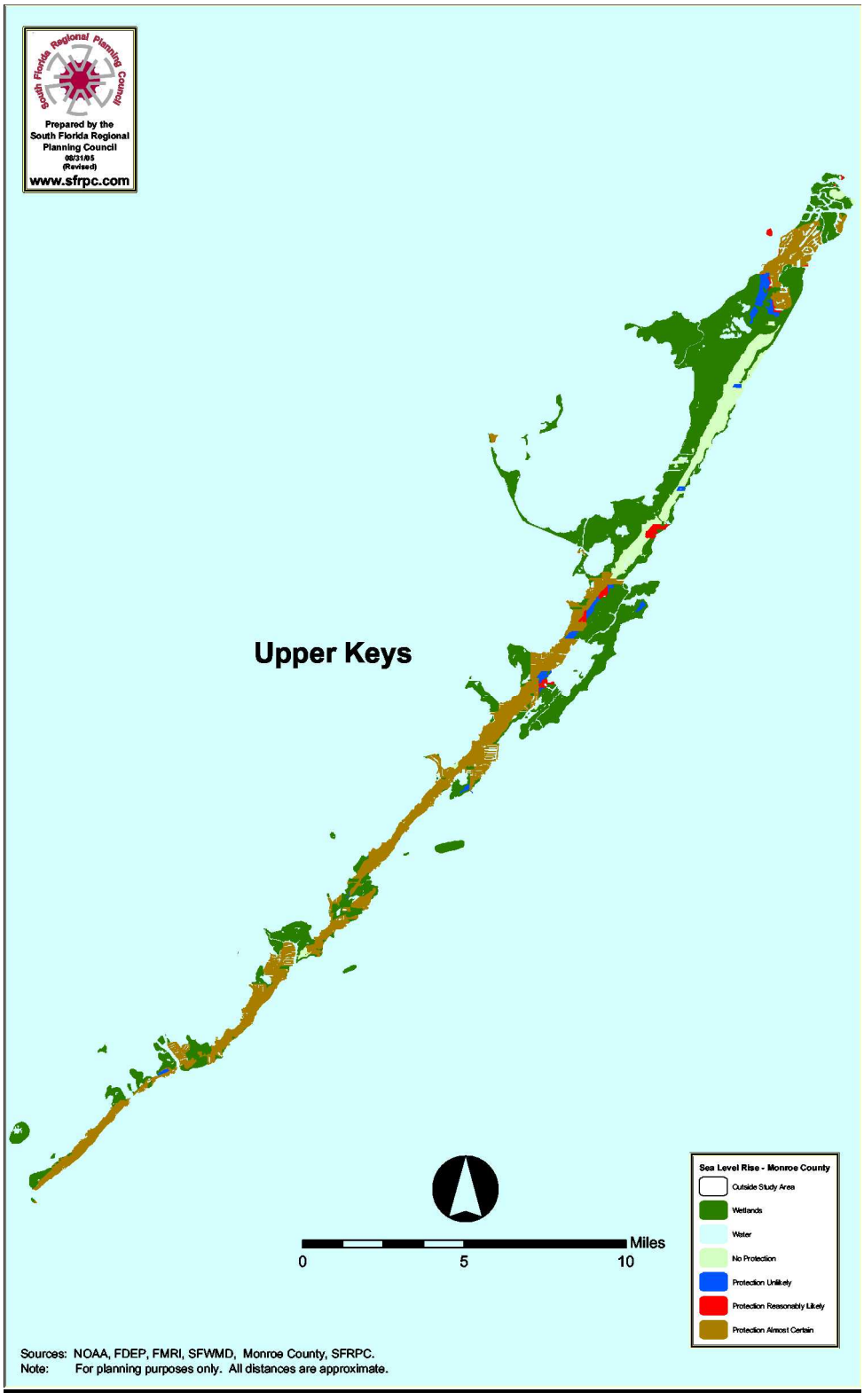
I. *Change the red polygon at the southern end of Key Largo to light green.* This land is zoned "natural area" and is owned by the county.

[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.

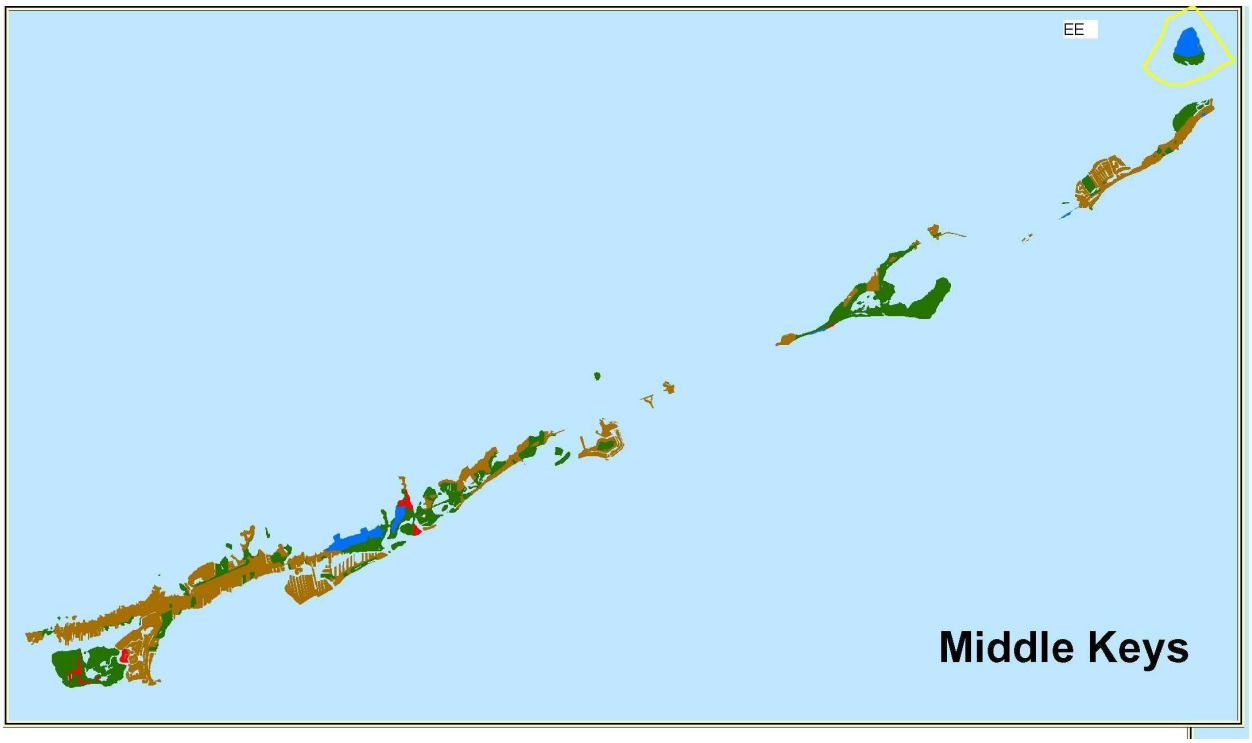
BB. *Change brown to blue*.

CC. *Change the Boy Scout Campground on West Summerland Kay from brown to red.*

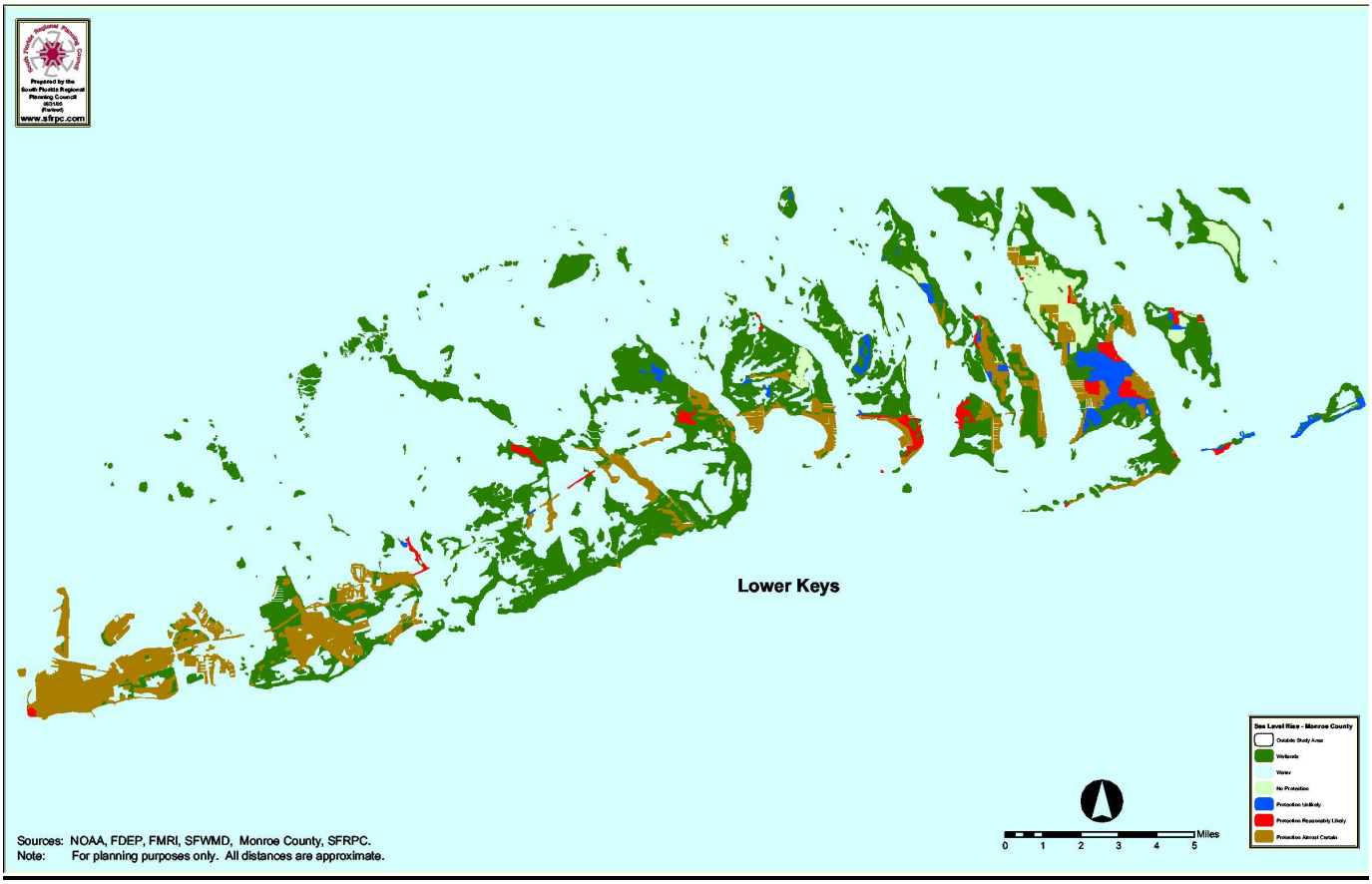
DD. *Change Bahia Honda State Park from red and brown to blue*

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.

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[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).

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

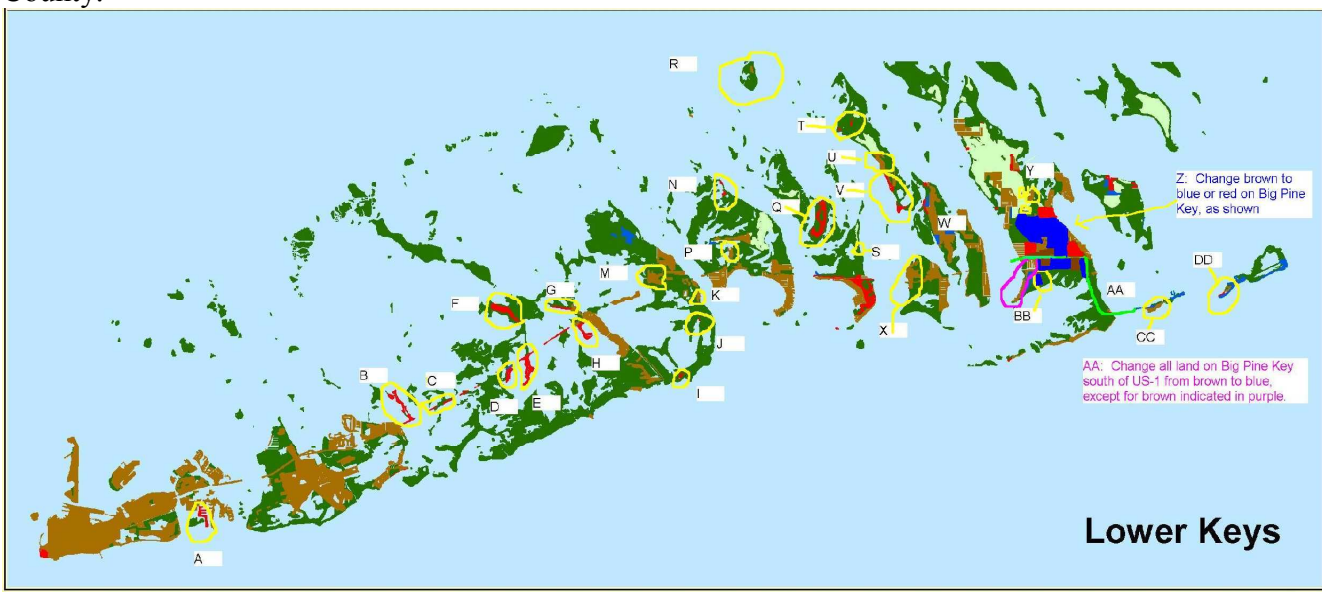
Appendix V

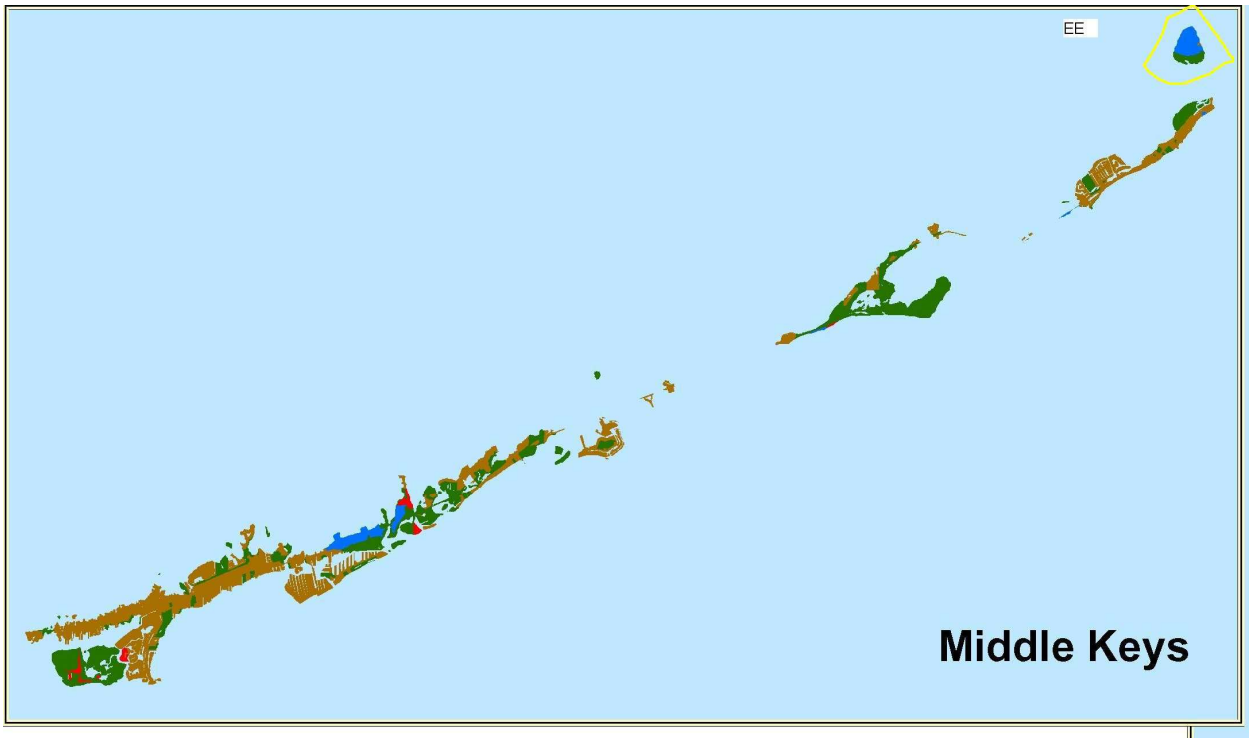
South Florida Water Management District (SFWMD)
Future Land Use Map (FLUM) Attribute Definitions

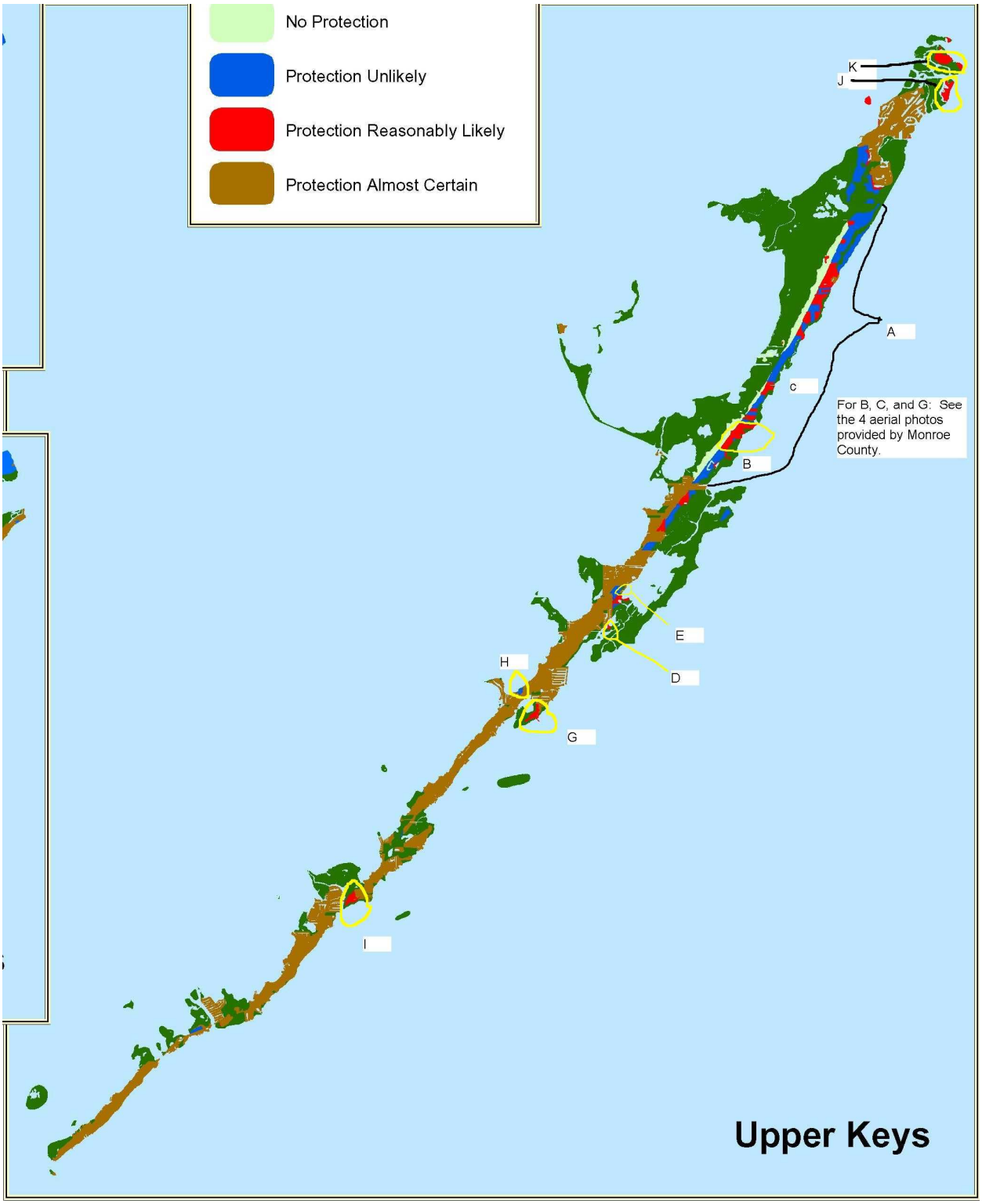
Code: AG =	Agriculture
Code: COF =	OFFICE & PROFESSIONAL SERVICES
Code: COM =	GENERAL COMMERCIAL
Code: CPD =	COMMERCIAL PLANNED DEVELOPMENT
Code: CR =	COMMERCIAL RECREATION
Code: CRS =	RETAIL SALES & SERVICES
Code: CW =	WHOLESALE SALES & SERVICES
Code: EXT =	EXTRACTIVE
Code: IND =	GENERAL INDUSTRIAL
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

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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.

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