PLAN FORMULATION APPENDIX

MIAMI-DADE BACK BAY COASTAL STORM RISK MANAGEMENT FEASIBILITY STUDY

MIAMI-DADE COUNTY, FLORIDA

APPENDIX A

MAY 2020

U.S. Army Corps
of Engineers
Norfolk District

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1 PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

A comprehensive list of prior USACE reports dating back to the early 1950s for Miami-Dade County can be found in Table 1. These studies and additional information acquired are being used to characterize existing conditions

Table 1. List of Prior USACE Studies, Reports, and Existing Water Projects

Title	Author	Date
Miami River Locks and Dam, Survey Review Reports	USACE	1950-1957
Evaluation Report on Hurricane-Protection Measures for Biscayne Bay, Florida, 1958, 1963	USACE	1958, 1963
A Planning Study on the Miami River, 1962	USACE	1962
Dade County, Florida Beach Erosion Control and Hurricane Protection Report	USACE	various starting in 1965
Environmental Chemistry of Florida Estuaries: Deepwater Ports Maintenance Dredging	USACE	1984
Final Recommendations of the Miami River Management Committee	USACE	1984
Miami River Dredging Study	USACE	1986
Preliminary Evaluation of Proposed Waterway Design Improvements in Support of Deep Draft Vessel Operation in Miami, FL	USACE	1987, 1988
Navigation Study for Miami Harbor (Miami River), Florida, 1989, 1990	USACE	1989, 1990
Coast of Florida Erosion and Storm Effects Study Region III, Assessment of Wave Conditions During Hurricane Andrew at Miami Beach	USACE	1993
Miami River Sediments, Seybold Canal	USACE	1995
Coastal Engineering Report, Dade County Regional Sediment Budget	USACE	1997
Shoreline Stabilization Report and Final EA Virginia Key, Florida	USACE	2002

Useful reports by others, including commissioned or authored by Miami-Dade County, are in Table 2.

Table 2. List of Prior Miami-Dade County Studies, Reports, and Existing Water Projects

Title	Author	Date
Economics of Climate Adaptation: Shaping Climate Resilient Development, a Framework for Decision Making	Economics of Climate Working Group	2009
Institutionalizing Climate Preparedness in Miami-Dade County, Florida	ICLEI - Local Governments for Sustainability	2010
Miami-Dade Water and Wastewater WWTP Vulnerability Assessment Presentation	Hazen and Sawyer	2013
Adaptation Action Areas: Policy Options for Adaptive Planning for Rising Sea Levels	South Florida Regional Planning Council	2013
Sea Level Rise and Storm Surge Rapid Action Plan	Miami-Dade	2015
Design Guide for Hardening Wastewater Treatment Facilities against Flooding from Surge, Sea Level Rise, and Extreme Rainfall	CH2M Hill	2015
Unified Sea Level Rise Projection Southeast Florida	SE FL Regional Compact Work Group	2015
Flood Protection Level of Service Analysis for the C-4 Watershed	SFWMD	2015
Surge and Flood Modeling for Miami-Dade County (Task 2.10 as part of the 2015 OOL Validation Program)	CH2M Hill	2015
Sea Level Rise Task Force Final Report for Resolution R-48-15	Miami-Dade	2016
Assessment of Available Tools to Create a More Resilient Transportation System, 2016	Miami-Dade	2016
Design Guide for Hardening Wastewater Pump Station Facilities against Flooding from Surge, Sea Level Rise, and Extreme Rainfall	CH2M Hill	2016
Arch Creek Basin Adaptation Study Report	Urban Land Institute	2016
Pump Station Prioritization Based on Criticality and Risk of Flooding	CH2M Hill / Hazen and Sawyer	2017

Title	Author	Date
South Miami Coastal Resilience: The Value of Mangrove Restoration	CH2M Hill / Nature Conservancy	2017
Assessment of Alternative Flood Mitigation Strategies for the C-7 Basin	Deltares	2017
Miami-Dade Whole Community Hazard Mitigation, Local Mitigation Strategy	Miami-Dade	2018
Septic Systems Vulnerable to Sea Level Rise Final Report for Resolution R-911-16, 2018	Miami-Dade	2018
Rapid Action Plan: Vulnerability of County Assets to Sea Level Rise and Future Storm Surge	Miami-Dade	2018
Adapting Land Use and Water Management Plans to a Changing Climate in Miami-Dade and Broward Counties	Rand Corp.	2018

2 TABLE OF CRITICAL ASSUMPTIONS IN THE PLANNING PROCESS

Table 3 provides a summary of the important planning decisions and their risks and consequences.

Table 3. Critical Assumptions and Decisions in the Planning Process

Discipline	Scoping Choice or Event	Risk and its Cause	Consequence
Economics	Use G2CRM for economic modeling	The study is a coastal-based study making the G2CRM model the best fit. There aren't many previous studies that used the model since it is relatively new. Given the lack of knowledge in model performance and a limited number of G2CRM model subject matter experts, there is a potential risk of over or under estimating project benefits.	Damages assessed could be under or over estimated.

Discipline	Scoping Choice or Event	Risk and its Cause	Consequence
Economics	G2CRM data requirements.	G2CRM model requires .H5 formatted wave characteristic data input based on STWAVE or ADCIRC models. The Coastal Hazards System (CHS), where this information can be obtained from, does not currently have the .H5 files for Southeast Florida. Save points were taken from FEMA's South Florida Storm Surge Study data and .h5 files were created.	If the data isn't available, the G2CRM model will not be able to run.
Economics	Effective age for building inventory was selected as 30 years.	The average building stock age is currently unknown, but expected be greater than 30, however, it is assumed that the existing structures have been, at least, minimally maintained with the expectation of remodeling in a select number of structures.	Damages assessed could be under or over estimated.
Economics	Consider community continuity / cohesion for nonstructural measures after TSP.	Would result in a possibly lower BCR for total area, but better planning outcome than cherry picking individual structures based on positive or highest BCR	Some structures in an area selected for nonstructural implementation (e.g. Elevation) may not be individually economically justified.
Economics	Use of depth damage functions (DDF) developed as part of NACCS and depth-damage relationships from 2013 expert elicitation sessions for non-residential occupancies	Since there are not more appropriate or site-specific DDFs and contents-to-structure value ratios (CSVRS) available in the area then the structure and content damages	DDFs and CSVRs are an important input to developing flood damages for the project alternatives. If the flood damages are not accurate or do

Discipline	Scoping Choice or Event	Risk and its Cause	Consequence
	rather than generic residential depth-damage relationships	produced in G2CRM may be over- or under-estimated	not meet Corps guidelines, then the plan selection and economic justification of alternatives could be determined with a high level of uncertainty.
Economics	Foundation Height calculation	Miami-Dade County parcel data did not contain any foundation type for structures. National Structure Inventory 2.0 data was used for foundation types for structures which may not be accurate on a structure by structure basis.	Foundation types may be inaccurate which would lead to a under or over estimation of foundation heights which results in under or over estimation of first floor elevation which is used to determine damage occurring at structures
Economics	LiDAR was used to determine lowest adjacent grade (LAG) to help determine first floor elevations.	First floor elevation will not be exact.	May over or under estimate damage by over or under estimating first floor elevation
Engineering	Complex H&H modeling may not be possible due to limited funding and schedule to remain in 3 x 3	Limiting the analysis will result in lower level of detail for assessing impacts that measures will have on hydraulics and water quality.	Engineering or environmental impacts may not defined to a level that fully characterizes the quantity and/or magnitude of impacts causing a change in design.
Engineering	Limited funding for 3 x 3 will limit opportunities for geotechnical exploration	Limited geotechnical exploration will increase the uncertainty in the subsurface condition for the study designs.	Study designs may not reflect subsurface conditions which may impact cost.
Engineering	Formulate alternative plans which include barriers and floodwalls along inland bay areas.	Structural issues due to karst geology may induce piping failures. T-walls may be required. Rising sea	Constructed structural measures in the project area become structurally deficient. Flooding

Discipline	Scoping Choice or Event	Risk and its Cause	Consequence
		levels and groundwater levels could travel under any structural measure during more severe high tides.	risk may still exist during extreme high tides.
Engineering	Defer soil borings/ geotechnical exploration to the Pre-construction, Engineering, and Design (PED) phase for beach project areas only.	Discovery of subsurface conditions that vary from those assumed from existing information could negatively impact construction cost and schedule.	Additional cost and schedule for design and construction.
Environmental	Need for hydraulic/water quality modeling on the impacts from the alternatives	Risk might include finding contractor to perform the modeling and the time it will take to perform the task	Modeling may take longer than expected if a contractor is not found this may cause a time delay in the study. Also modeling issues might arise when performing the task
Formulation	Scope the study to fit 3 x 3 budget and schedule	The study encompasses all of Miami-Dade County, less the Atlantic beaches. The geographic area and complex H&H could easily justify a study larger than 3 x 3 to capture all the problems and opportunities. However, communication from the vertical team suggests the supplemental studies need to scope for completion in a 3 x 3 paradigm. Risk is that the study will not be able to capture all the problems and opportunities and potential “better” solutions may be missed.	Comprehensive solutions or other goals of the non-Federal sponsor may be missed. Residual risk may be higher.

Discipline	Scoping Choice or Event	Risk and its Cause	Consequence
Real Estate	All alternatives include privately owned property	Acquisition of property rights from private owners. Permanent real estate owned by the county is required for project implementation but non-Federal sponsor-owned property will be more easily made available.	Time and additional cost for the county to acquire land and/or get easements necessary for the project
Real Estate	In-water structures (Ex. tide gate/seawalls)	COV does not allow non-COV ownership of property rights on river bottoms and submerged lands	May be difficult to obtain rights to construct in-water structures.
Real Estate	Utility relocation cost estimation.	They are typically identified later in design and can be complex to estimate. Cost may end up being higher than estimated due to lack of design.	Additional costs

3 PROJECTS AND EFFORTS IMPLEMENTED BY OTHERS

The following section provides brief descriptions of resiliency efforts in Miami-Dade County either through extra building requirements or seeking out resolutions related to sea level change. It also includes completed, ongoing, or funded projects in the Miami-Dade County vicinity.

3.1 RESILIENCY

The following are some of the resiliency actions by Miami-Dade County:

Increased Freeboard Requirements

Freeboard is defined by FEMA as "An additional amount of height above the Base Flood Elevation (BFE) used as a factor of safety in determining the level at which a structure's lowest floor must be elevated or floodproofed to be in accordance with state or community floodplain management regulations."

Effective March 15, 2012, the Florida Building Code (FBC) required non-residential structures in the effective FEMA 1% annual chance flood (also called 100-year floodplain or BFE) to be built with an additional 1 foot of freeboard above the effective BFE. Category IV structures (critical or essential facilities such as fire, rescue, ambulance, police, etc.) were required 2 feet of additional freeboard above the effective FEMA BFE. Effective December 30, 2017, the 1 foot of freeboard was included for single family residences, duplexes, triplexes, and townhomes three stories or less.

These freeboard requires not only apply to new construction, but also any substantial improvements which is defined by FEMA as reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the start of construction of the improvement.

Southeast Florida Regional Climate Change Compact

Broward, Miami-Dade, Monroe, and Palm Beach Counties united to form this compact in January 2010 to coordinate mitigation and adaptation activities across county lines. This compact established a Climate Action Plan to help reduce greenhouse gas emission and adapting to the effects of climate change. More information can be found at their site below:

https://southeastfloridaclimatecompact.org/

In 2019, the Unified Sea Level Rise Projection document was revised to provide an update to the amount of anticipated sea level rise in Southeast Florida through 2120.

Minimum Elevation of Roadways

Miami-Dade County requires the minimum elevation of roadways and lots to be equivalent to the 10-year groundwater table plus 3.5 feet of freeboard.

Participating in NFIP

Community Rating System (CRS) is a voluntary program for communities that participate in the National Flood Insurance Program (NFIP). CRS was formed to provide incentives such as flood insurance premium discounts for communities that went beyond minimum floodplain management requirements. CRS uses a class system with 10 being the lowest (no discount) and 1 the highest. Insurance premiums are discounted in 5% intervals for structures in the SFHA so a class of 9 would be 5% discount and a class of 1 would be 45% discount.

As of May 1, 2019, 23 of the 34 municipalities (plus Unincorporated Miami-Dade County) are part of the CRS program ranging from class 5 to class 9. According to the Miami-Dade County Local Mitigation Strategy, below are just some of the activities some municipalities in Miami-Dade County are performing to participate in CRS:

- Maintain Elevation Certificates for New/Substantially Improved Buildings
- Enforce Floodplain Management Regulations
- Inspect/Repair/Maintain Drainage Systems
- Preserve Open Space in Floodplain
- Provide Flood Protection Assistance
- Provide Flood Zone Information
- Keep Old and Current Flood Insurance Rate Maps (FIRMs)
- Produce/Distribute Property Protection Information to Repetitive Loss Areas
- Maintain Flood Protection Materials at Library

100 Resilient Cities Program

100 Resilient Cities (100RC) is a $164 million effort founded by The Rockefeller Foundation in 2013. Its main goal is focusing on helping communities around the world build resilience to the many challenges of the 21st century. The Greater Miami and the Beaches, which includes Miami-Dade County, the City of Miami and the City of Miami Beach, joined the 100RC in the spring of 2015. Although the 100 Resilient Cities organization disbanded the 100RC program on July 31, 2019, communities are continuing their resiliency efforts through other means.

Resilient305

In the spring of 2019, Greater Miami and the Beaches released the Resilient305 Strategy, a living document that addresses resilience challenges prioritized through intergovernmental and community collaboration. Throughout the process – in public meetings, surveys and focus groups – Greater Miami and the Beaches engaged thousands of stakeholders to help shape the strategy and make sure it reflected the input from a wide range of expertise, ages, ethnicities, cultures, income levels and geographic areas. The Resilient305 Strategy will help prepare for an increasing occurrence of shocks, such as hurricanes, and infrastructure failures, as well as to better mitigate stresses, such as sea level rise and sunny day flooding, crippling traffic and severe economic inequities. More information can be found at https://resilient305.com/.

Applying for grants

The Florida Department of Economic Opportunity (DEO) selected Miami-Dade County to receive $4.5 million in Community Development Block Grant-Disaster Recovery funds to help eligible and interested property owners who were impacted by Hurricane Irma. The grant funds will help these residents, if they so choose, to relocate to less flood-prone areas and reduce future flood risk.

Local Mitigation Strategy

The Local Mitigation Strategy was developed to reduce or eliminate the long-term risk to human life and property from hazards. It is typically reviewed and needs re-approval every 5 years by FEMA. The current strategy plan is approved by FEMA, and maintains a list of projects that could potentially be funded in the future. Having a mitigation plan helps a CRS community obtain more points.

Sea Level Rise

Miami-Dade County requires that all capital projects consider the impacts of sea level rise, per Resolution No. R-451-14.

Rapid Action Plan

Miami-Dade County completed the Rapid Action Plan in 2017. The plan assessed the vulnerability of over 700 County owned assets and ranked them based on criticality.

Beach Renourishment

USACE worked with Miami-Dade County as part of the Miami Beach Hotspots beach renourishment project which is part of the Miami-Dade County Beach Erosion Control and Hurricane Protection Project. 220,000 cubic yards of beach-quality sand was placed on more than 3,000 feet of critically eroded shoreline in two locations, near 46th Street and 54th Street. Between 18,500 and 22,000 truckloads of sand will be hauled from an upland sand mine to reduce the damages – economic, environmental, infrastructure, human health and safety – of tropical storms and hurricanes.

Environmentally Endangered Lands (EEL)

The Miami-Dade County Environmentally Endangered Lands (EEL) Program was established in 1990 due to growing concern about the continued loss of pine rocklands and other natural areas unique to southeast Florida. Its main focus is the protection and conservation of endangered lands. EEL has so far acquired over 9000 ha of land including 619 ha of pine rocklands, 269.9 ha of tropical hardwood hammock, 7109 ha of fresh water wetlands, 1238 ha of coastal wetlands, and approximately 16.2 ha of scrub habitat. EEL has brought over $103,000,000 worth of property into public ownership (Alonso and Heinen 2011). These acquisitions ensure that they will be protected from any future developments and will allow the areas to thrive in their natural habitats.

Climate Change Programs

Miami-Dade County has several initiatives to help against the impacts of climate change some of which are described below:

- Reducing greenhouse gas emission carbon pollution from 2008 levels by 80% by 2050.
- Miami International Airport has made many changes to their facility that saves over 9 million gallons of water each year, reduces energy by 35.2 million kilowatt hours per year, and is currently making more updates that will save an additional 9 million gallons of water a year. According to Miamidade.gov, all these changes have contributed to savings of more than $10 million and a reduction of 17 million tons of greenhouse gas emissions.
- Sustainable Buildings Program which incorporates green building practices for County owned, financed, and operated buildings. The County also requires new County owned, leased, or managed construction projects to obtain the United States Green Building Council's Leadership in Energy and Environmental Design (LEED) silver certification and remodeling and renovation projects to obtain basic LEED certification.
- Miami-Dade County partnered with the Florida Power and Light (FPL) to install the largest floating solar array in the Southeastern United States on January 28, 2020. According to FPL, the solar array generates 160 kilowatts of power and prevents 165 tons of carbon dioxide emissions each year.
- According to the U.S. Department of Energy, Miami-Dade County has the third largest public hybrid fleet in the nation. These vehicles result in a reduction of approximately 500,000 gallons of gasoline which in turn prevents the release of over 6000 tons of greenhouse gas emissions into the environment. The County has made further commitments to have at least 50% of their buses being electrically powered by 2035.

More initiatives and information can be found at
https://www.miamidade.gov/global/economy/resilience/county-climate-programs.page

Table 4 shows some of the local policies, legislations and resolutions related to sea level rise and climate change started by the non-Federal sponsor (NFS) available on Miami-Dade County's planning library. These efforts show the extra level of resiliency and goals of public awareness regarding sea level change and flooding provided by the NFS.

Table 4. Resolutions by Miami-Dade County relative to this study

Legislation Number	Title	Description	Date Adopted
R-35-91	Participation in ICLEI's cities for climate protection campaign	Resolution authorizing Dade county's participation in International Council for Local Environmental Initiatives' (ICLEI) cities for climate protection campaign	1991
06-113	Creation of climate change advisory task force	Ordinance creating the Miami-Dade County climate change advisory task force; providing for membership, organization and procedure, appointment and tenure, function and responsibility; providing severability, inclusion in the code, and an effective date	July 18, 2006
R-1388-09	Resolution on climate change compact	Resolution establishing southeast Florida regional climate change compact; committing to develop joint policy positions and legislative policy statements with Broward, Palm Beach and Monroe Counties with respect to climate change issues; committing to develop a southeast Florida regional climate change action plan with Broward, palm beach, and Monroe counties; committing to participate in a regional climate team and in the second southeast Florida regional climate change summit	December 1, 2009
R-51-13	Southeast Florida regional climate compact	Resolution supporting the 2013 state & federal legislative program of the southeast Florida regional climate change compact; incorporating the compact's legislative program into Miami-Dade County's 2013 federal and state legislative package	January 23, 2013
R-451-14	Sea level rise, infrastructure	Resolution setting policy for Miami-Dade county; directing the mayor or designee to require all county infrastructure projects to consider potential impacts of sea level rise during all project phases including but not limited to planning, design, and construction, and further directing the mayor or designee to evaluate the existing infrastructure in the face of sea level rise	March 31, 2014
14-79	Sea level rise bcc rule amendment	Ordinance relating to the rules of procedure of the board of county commissioners amending section 2-1 of the code of Miami-Dade county, Florida, to require that in all agenda items related to planning, design and construction of county infrastructure a statement be included that the impact of sea level rise has been considered; providing	May 23, 2014

Legislation Number	Title	Description	Date Adopted
		severability, inclusion in the code, and an effective date	
R-1008-15	Directing mayor to apply to Rockefeller foundation's 100 resilient cities program	Directing the county along with the city of Miami beach and city of Miami applied as greater Miami and the beaches to the Rockefeller foundation's 100 resilient cities program.	November 3, 2015
R-427-16	Coordinate with municipalities on sea level rise	Directing the county mayor to coordinate and collaborate with municipalities within Miami-Dade county on sea level rise and related issues; directing the county mayor or county mayor's designee to prepare a report for this board	May 17, 2016
R-396-17	Programming on Miami-Dade TV	Resolution directing the mayor or mayor's designee to create programming on Miami-Dade TV to educate the public about sea level rise and the county's sea level rise related work	March 1, 2017
R-1011-18	Approval of Miami Back Bay Study Agreement	Board approved the Miami Back Bay Study Agreement ("Agreement") between Miami-Dade County and the United States Department of the Army.	October 2, 2018
193015	Urging USACE to consider the Board's recommendations	Resolution urging USACE to consider the Board's recommendations related to this study including continuous flood protection, use of nature-based features, coordination with related projects and studies, design fostering access to Biscayne Bay, and coordination with landowners.	December 17, 2019

3.2 PROJECTS COMPLETED

Table 5 shows the project statuses according to Miami-Dade County's local mitigation strategy's website:

Table 5. List of projects in Miami-Dade County and their status

Project Status	Number of Projects
Projects in Planning Stage	74
Funding Applied For	52
Funding Secured	38
Construction / Project Begun	29
Other	12

Project Status	Number of Projects
Projects 25% complete	95
Projects 50% complete	15
Projects 75% complete	15
Projects complete	339

4 EXISTING DATA

Figure 1 shows the effective FEMA flood zones. These maps are in the process of being updated with preliminary maps set for release by FEMA around spring of 2020.

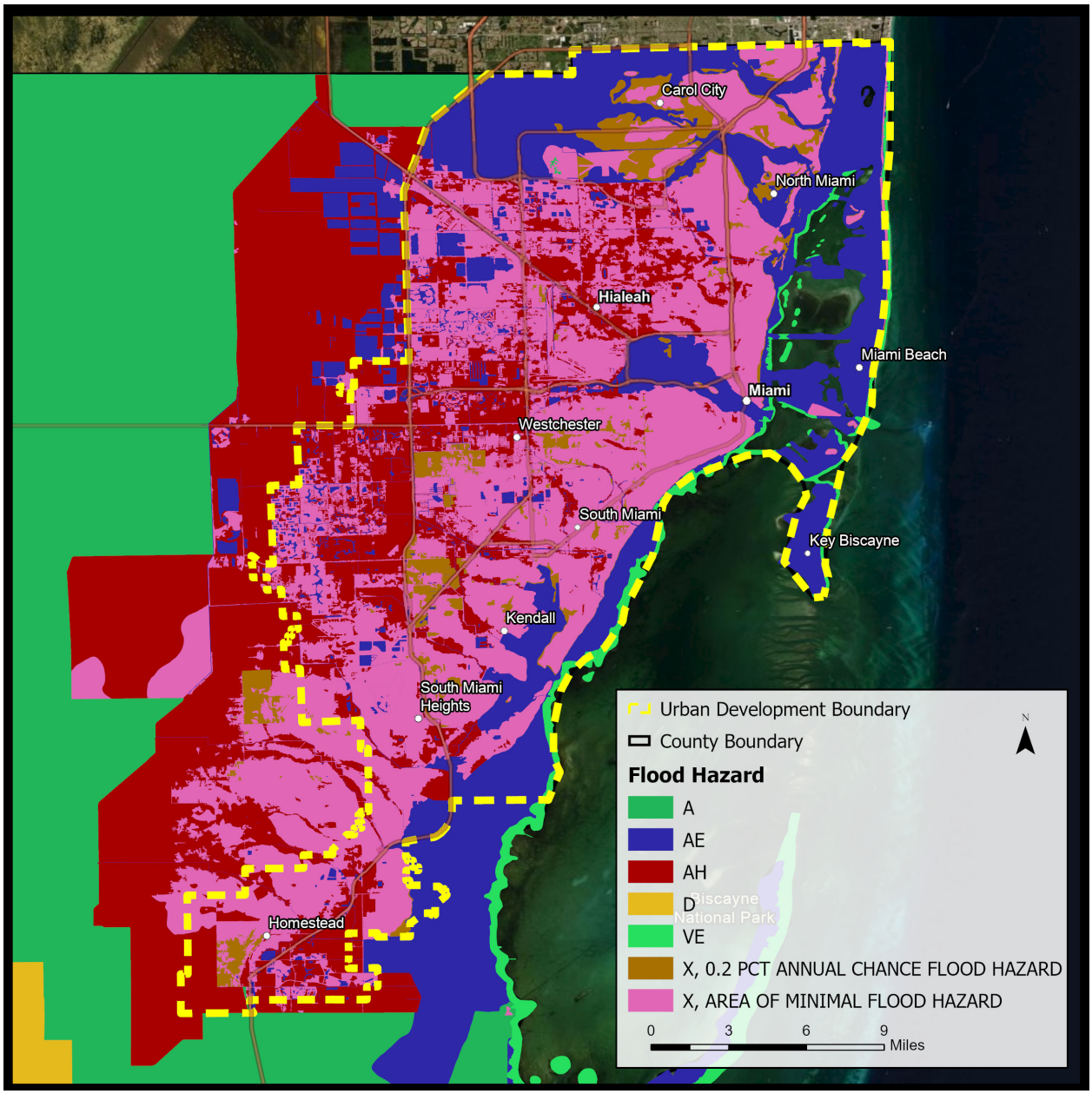

Figure 1. FEMA flood zones

Figure 1 shows the maximum of maximums (MOM) storm surge for a Category 5 hurricane in Miami-Dade County. The southern portion of the county in the Homestead area is particularly impacted by such an extreme scenario. FEMA is currently updating their Flood Insurance Rate Maps (FIRM) for the county. The maps are anticipated to be available in spring of 2020. Draft modeling results are available for nearshore stillwater elevations with wave setup.

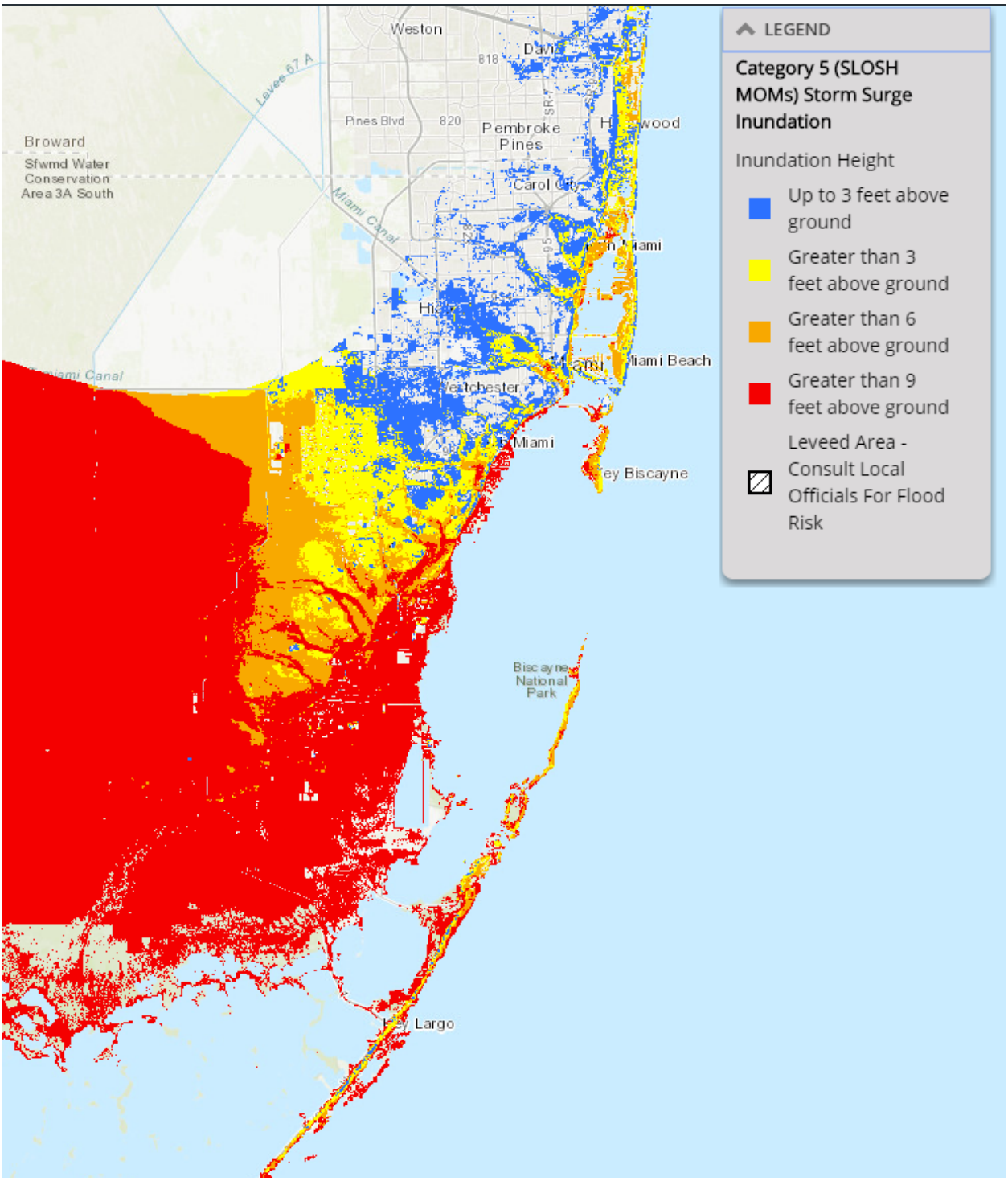

Figure 2. National Storm Surge Hazard Maps showing SLOSH MOM Map of Miami-Dade County for a Category 5 Hurricane

Table 6 shows the number of structures per municipality within Miami-Dade County.

Table 6. Structures in FEMA Flood Zones per Municipality

Jurisdiction	A	AE	AH	D	VE	X	XE
Aventura		24,149				52	31
Bal Harbour		738				955	2250
Bay Harbor		2576					
Biscayne Park		991				42	42
Coral Gables		2770	1209		58	13209	1466
Cutler Bay		8840	1871			3886	
Doral		93	3768			16746	
El Portal		6	97			566	92
Florida City	3	2	1097			396	817
Golden Beach		262				98	
Hialeah Gardens		133	271			5802	
Hialeah		1304	18513			36496	
Homestead		222	8824			9098	746
Indian Creek Village		33				4	1
Key Biscayne		7056					
Medley		19	251			578	
Miami Beach		51049				4381	123
Miami Gardens		12103				9083	8638
Miami Lakes	0	8317				1263	
Miami Shores		843	3		19	2470	552
Miami Springs		11	2029			2125	21
Miami		43094	6441		3897	68535	2215
North Bay Village		3872					
North Miami Beach		5650				7212	653
North Miami		8190			261	5637	1995
Opa-locka		714	543			1319	1275
Palmetto Bay		4701			41	3590	80
Pinecrest		2168	268			3563	260
South Miami		2	784			3660	
Sunny Isles Beach		11351			1	7647	0
Surfside		1560				1878	
Sweetwater		1	582			367	
Virginia Gardens			122			445	86
West Miami						960	768
Unincorporated	582	44750	105976	2	28	169059	20053
Total:	585	247,570	152649	2	4305	381122	42164

5 REFINED FOCUS AREA PROCESS

As mentioned in Chapter 3 of the main report, the team developed a method to refine focus areas due to Miami-Dade County having such a large geographic size, population, and complexity of coastal flood risks. Below is further information regarding Hazus and the Centers for Disease Control and Prevention's (CDC) Social Vulnerability Index (SVI) that was used to determine the refined focus areas.

Hazus

FEMA's software Hazards of the U.S. (Hazus) (https://www.fema.gov/hazus) is a nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods, hurricanes, and tsunamis. Hazus uses Geographic Information Systems (GIS) technology and the national structure inventory database to estimate physical, economic, and social impacts of disasters. This tool is used to identify potential losses and vulnerable areas that enables better planning and can allow for improved infrastructure.

Hazus has several output features such as direct damage to general buildings, essential facilities, transportation systems, and utility systems. It also generated induced damage such as debris generation. It can also calculate cost of repair, income loss, crop damage, shelter needs, supply shortages, sales decline, opportunity cost, and economic loss. Hazus has a standard database which is considered Level 1 analysis although it has options for Level 2 and Level 3 analysis runs as well which require the user to have more in-depth input data.

Hazus was run in Miami-Dade County using FEMA's 1% annual chance flood and 1% annual chance of precipitation with 4 feet of sea level rise depth grid to determine areas at higher flood damage risk and identify preliminary damages to infrastructure. Hazus uses census blocks to determine damages so the outputs were not on a structure by structure basis. Originally, the team tried to sum up all the damages by basins or watersheds, but this was resulting in skewed mapping since it was benefiting larger areas which were showing as having more damage. The team then decided to make 4000 feet by 4000 feet grids across Miami-Dade County and then summed up the damage per grid cell. This allowed for better visualization and representation of the damage.

CDC SVI

The Centers for Disease Control and Prevention's (CDC) Social Vulnerability Index (SVI) (https://svi.cdc.gov/) was used to look at socially vulnerable areas. According to CDC's *A Social Vulnerability Index for Disaster Management*, the SVI uses U.S. Census data to determine social vulnerability of every census tract based on four main themes which are broken down into a total of 15 social index factors shown in Table 7. Additional descriptions are provided in the table for each social factor.

Table 7. CDC Social Vulnerability Themes, Index Factors, and Additional Description

Theme	Social Factor	Additional Description
Socio-economic Status	Percent individuals below poverty	Individuals below poverty = "under .50" + ".50 to .74" + ".75 to .99." Percent of persons below federally defined poverty line, a threshold that varies by the size and age composition of the household. Denominator is total population where poverty status is checked.
	Percent civilian unemployed	Based on total population 16+. Civilian persons unemployed divided by total civilian population. Unemployed persons actively seeking work.
	Per capita Income in 1999	The mean income computed for every person in the census tract.
	Percent persons with no high school diploma	Percent of persons 25 years of age and older, with less than a 12th grade education (including individuals with 12 grades but no diploma).
Household Compo-sition / Disability	Percent persons 65 years of age or older	N/A
	Percent persons 17 years of age or younger	N/A
	Percent persons more than 5 years old with a disability	Percent of civilian population not in an institution who are 5 years of age and older with a disability.
	Percent male or female householder, no spouse present, with children under 18	"Other family: male householder, no wife present, with own children under 18 years" + "Other family: female householder, no husband present, with own children under 18 years"
Minority Status / Language	Percent minority	Total of the following: "black or African American alone" + "American Indian and Alaska Native alone" + "Asian alone" + "Native Hawaiian and other Pacific Islander alone" + "some other race alone" + "two or more races" + "Hispanic or Latino – white alone."
	Percent persons 5 years of age or older who speak English less than "well"	For all age groups and all languages: the total of persons who speak English "not well" or "not at all."
Housing / Transpor-tation	Percent multi-unit structure	Percent housing units with 10 or more units in structure.
	Percent mobile homes	Percent housing units that are mobile homes.
	Crowding	At household level, more people than rooms. Percent total occupied housing units (i.e., households) with more than one person per room.
	No vehicle available	Percent households with no vehicle available.
	Percent of persons in group quarters	Percent of persons who are in institutionalized group quarters (e.g., correctional institutions, nursing homes) and non-institutionalized group quarters (e.g., college dormitories, military quarters).

Source: https://svi.cdc.gov/Documents/Data/2016_SVI_Data/SVI2016Documentation.pdf

CDC SVI Ranking

CDC SVI ranked census tracts within each state (including District of Columbia) and then ranked tracts for all of U.S. against one another. Tract rankings are based on percentiles which are ranked 0 to 1 with higher values indicating greater vulnerability. Each of the four main themes were ranked by summing the percentiles for each theme to determine a theme-specific percentile ranking (CDC 2020). Below are the theme names for each theme.

- Socioeconomics – RPL_THEME1
- Household Composition & Disability – RPL_THEME2
- Minority Status & Language – RPL_THEME3
- Housing & Transportation – RPL_THEME4

All four themes were then added into an overall tract summary ranking variable called RPL_THEMES. A map of the social vulnerability rankings based on RPL_THEMES is shown in Figure 3. More detailed descriptions of SVI variable selection rationale and methods is available at:
https://svi.cdc.gov/A%20Social%20Vulnerability%20Index%20for%20Disaster%20Management.pdf

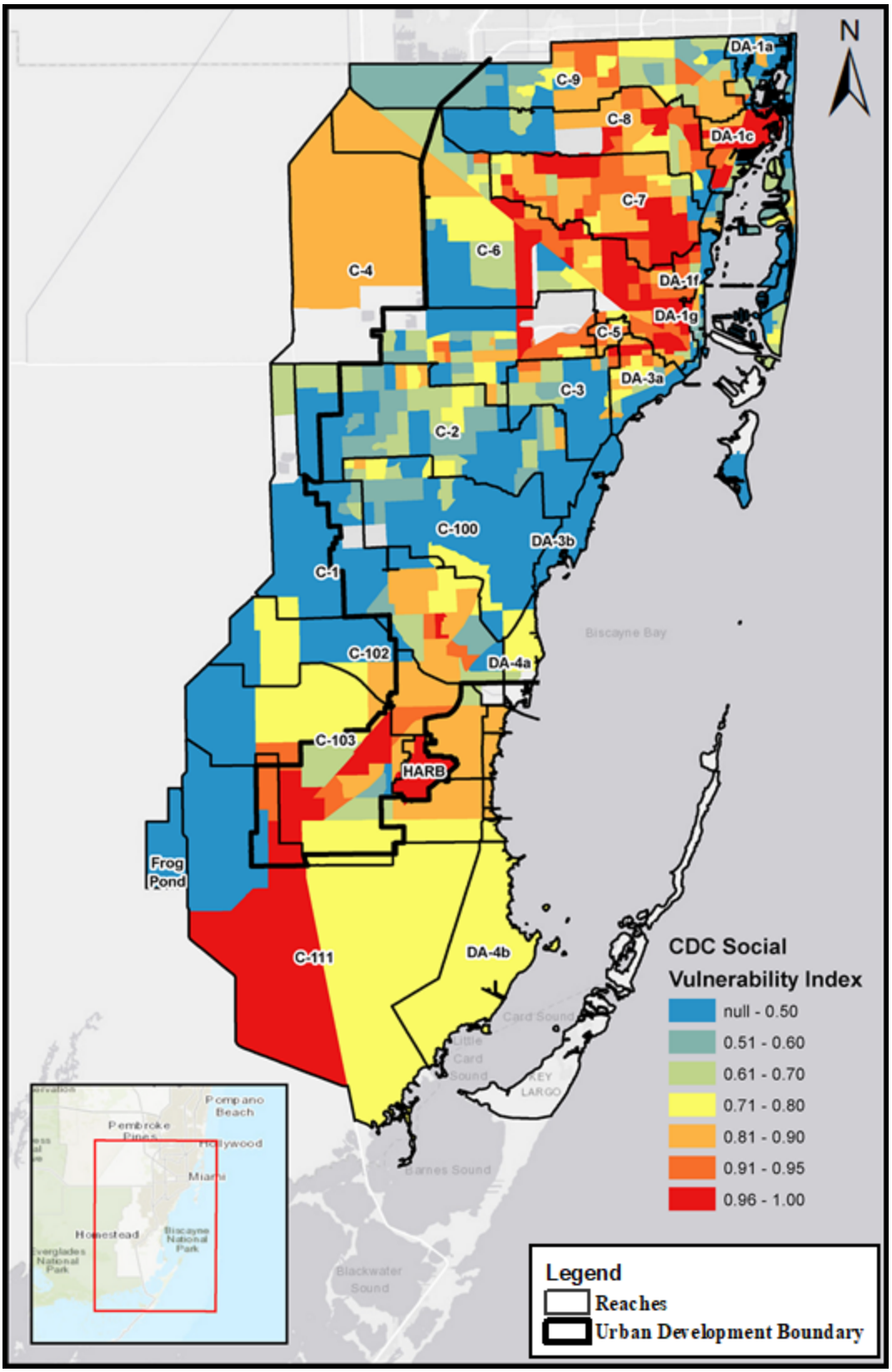

Figure 3. CDC Social Vulnerability Index in Miami-Dade Count