Memorandum

MIAMI-DADE COUNTY

Date: September 21, 2016

To: Honorable Chairman Jean Monestime
and Members, Board of County Commissioners

From: Carlos A. Gimenez
Mayor

Subject: Final Status Reports In Response to Multiple Resolutions Pertaining to Recommendations by the Sea Level Task Force

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The following report is pursuant to multiple resolutions, sponsored by Commissioner Rebeca Sosa and adopted by the Board of County Commissioners (Board) on January 21, 2015, which support the implementation of the recommendations presented by the Miami-Dade Sea Level Rise Task Force (Task Force).

This report is also in response to Resolution No. R-1008-15, sponsored by Commissioner Rebeca Sosa, which directed the Mayor or Mayor's designee to apply for the Rockefeller Foundation's 100 Resilient Cities Program with the support of the Miami Foundation. The County, along with the municipalities of Miami and Miami Beach, applied for and were selected to The Rockefeller Foundation's 100 Resilient Cities Program as "Greater Miami and the Beaches." With the selection of Greater Miami and the Beaches into the Rockefeller Foundation's 100 Resilient Cities global network, the County will have access to resources to work with its grant partners, the municipalities of Miami and Miami Beach as well as all other municipalities within the geographic boundaries of Miami-Dade County, to develop a resilience strategy that considers critical socioeconomic issues in addition to the growing threats as a result of climate change and sea level rise. While sea level rise is an important component, the resilience strategy will have a broader focus for the community to prepare for, recover from, and successfully adapt to adverse acute events (shocks) such as extreme weather and flooding, and will also address our long-term chronic challenges (stresses) such as pronounced poverty, lack of affordable housing, a lacking transportation system, and changing climatic conditions. My Administration will be focusing efforts and resources to develop this community-wide resilience strategy that will address the shocks and stresses in the coming year mentioned above, which is also reflected in my FY 2016-17 Proposed Budget.

As required by the January 21, 2015 resolutions, a final report for each one is attached. However, the County, through the Office of Resilience in the Department of Regulatory and Economic Resources, will continue to address the challenge of sea level rise in a holistic way far into the future as its impacts cannot be addressed effectively without continued collaboration between County departments, local governments, academia, and the private sector. For example, the potential public health implications of rising sea levels, which were recently highlighted in a report from The Florida Institute for Health Innovation, are a concern though they are not explored in the reports. This issue will be examined in more detail moving forward and will be part of the resiliency strategy.

Background

In July 2013, the Board created the Sea Level Rise Task Force to review relevant science and assess the potential impacts of sea level rise and storm surge on the County. On July 1, 2014, the Task Force presented the "Miami-Dade Sea Level Rise Task Force Report and Recommendations" to the Board, providing guidance on how to prepare for the projected impacts. On January 21, 2015, the Board passed seven (7) resolutions supporting the implementation of those recommendations. While each of the supporting resolutions dealt with a different facet of the issue, all elements are interrelated and fundamentally linked.

The final report determining the feasibility of implementing Adaptation Action Areas (Resolution No. R-44-15) was completed in October of 2015 (Attachment 1). This report recommended initiating Adaptation Action Areas as a pilot project in 2016 and outlined a recommended approach to structuring the program. The pilot phase will help accelerate the development of innovative, cost-effective adaptation options appropriate to the unique geology and land use patterns of Southeast Florida. By creating Adaptation Action Areas and working with an interdisciplinary team to develop a suite of solutions for each area, it will be possible to continue to build the community's and the County's internal capacity to respond creatively and effectively to the challenges of climate change and changing sea levels.

The remaining reports focus on a number of related issues, including the County's natural protections and finding sustainable funding for the Environmentally Endangered Lands Program (Resolution No. R-47-15), potential approaches to enhancing the resiliency of the County's infrastructure (Resolution No. R-46-15), the increasing risks of flooding and salt water intrusion (Resolution No. R-48-15), the potential implications of sea level rise on insurance (Resolution No. R-49-15), and revisiting the recommendations of the Climate Change Advisory Task Force (Resolution No. R-45-15). The attached reports are intended to provide an update; however, work on all of these issues is on-going.

As mentioned previously, these reports are meant to provide an update on the state of recent advances, as well as provide a solid foundation upon which a broader, community-wide resilience strategy will be developed. In the meantime, work continues on all the discussed issues. In addition, other issues such as potential impacts of sea level rise on County facilities, planned infrastructure projects, septic tanks, and natural infrastructure will be integrated into the larger resilience strategy. Development of this strategy, in combination with the work plan of the Office of Resilience and identification of potential funding, such as a reserve fund proposed in Resolution No. R-514-16, will help integrate consideration of climate adaptation into all relevant County activities. The Office of Resilience will continue working across departments, municipalities and partner agencies to connect them to the technical resources necessary to ensure sea level rise is being considered as we move ahead in making our community and region more sustainable and resilient. The attached reports, in the following focus areas, contain a wealth of research and information and will be used to inform this important process.

Natural Protections

Southeast Florida is one of the most vulnerable areas in the world to the impacts of climate change, due to its low-lying topography, porous substrate, and extensive coastal development. Miami-Dade County is fortunate; however, to have tremendous natural assets including the Everglades, Biscayne Bay, and the barrier islands that will help it adapt to climate change and reduce the damage from tropical storms.

In addition to a number of other benefits, the Everglades serve as the primary source of drinking water for the County. Preserving and restoring the hydrology and surface water levels is an effective way to reduce the risk of saltwater intrusion, which could compromise the County's main water source. For these reasons, the Task Force identified Everglades restoration as an area of immediate concern and an essential part of the County's resilience strategy. Resolution No. R-63-15 urged the United States Congress and the Florida Legislature to fund and pass legislation in support of Everglades restoration.

Locally, many of the parcels acquired by the Environmentally Endangered Lands (EEL) Program will help protect the County's freshwater resources and help adapt to the other impacts of sea level rise such as increased erosion, higher storm surges, and loss of coastal habitats. To date, the EEL Program has acquired more than 21,000 acres of preserves, which provide open land for aquifer

recharge critical to ensuring clean and reliable water supply, in addition to providing municipal and rural flood protection.

Recognizing the importance of these natural assets and the EEL Program, the Board passed Resolution No. R-47-15, which directed to continue strategic implementation of the program and to identify potential long-term funding sources. The EEL Program has been successful in leveraging the original $90 million investment made by the County taxpayers and has accrued $198 million in revenue since its inception. Despite past achievements, it is important to identify long-term and sustainable funding options to assure that program activity levels can be sustained. The attached report details additional potential funding sources including Amendment 1 (Attachment 2).

County Infrastructure

Recognizing that our built environment and existing infrastructure will be impacted by sea level rise, Resolution No. R-46-15 directed to evaluate, "the engineering and other relevant expertise needed to conduct a comprehensive expert analysis and to develop an enhanced capital plan involving all levels of government to reinvent Miami-Dade County's urban infrastructure in a timely, sequenced manner." This mandate builds on Resolution No. R-451-14 and Ordinance No. 14-79, which were adopted in 2014 and require that the planning, design, and construction of County infrastructure consider potential sea level rise impacts.

Attachment 3 is a report that outlines the process other governments have taken to improve the resilience of their infrastructure, areas of expertise that exist within the County, areas where external expertise is needed, potential approaches, and a recommended approach to develop an enhanced capital plan. Creating an enhanced capital plan could provide the County with a full toolbox of potential adaptation measures and an understanding of their order of magnitude costs, benefits, and trade-offs. This exercise could help evaluate the financial feasibility of various solutions and ensure that the proposed solutions are achievable and implementable. Furthermore, this would help the County prioritize and develop consensus around the most promising and cost effective opportunities, as well as help the County better articulate infrastructure needs and improve its position when applying for funding from federal, state, and private entities.

The report describes multiple approaches to developing such a plan and recommends adopting a hybrid approach similar to that of Boston, MA or New York City, NY. This proposed hybrid approach would incorporate both the best elements of a holistic longer-term planning approach while taking advantage of the opportunity to move expediently by leveraging the work already completed by other departments. This hybrid approach would simultaneously develop an enhanced capital plan while also developing a "rapid action plan" to identify and prioritize projects needed sooner to address vulnerabilities in the County's critical infrastructure.

Potential Risks of Flooding and Saltwater Intrusion

The first step to increasing the resiliency of the County's infrastructure is to understand how key climate variables are expected to change. For Miami-Dade County, key climate risks include changing sea levels, groundwater heights, temperatures, precipitation, and storm patterns. Fortunately, the County already has very good data on many of these variables and several major research efforts are underway to address data gaps. As described in detail in the final report in response to Resolution No. R-48-15, millions of dollars have been spent by various entities to understand the implications of sea level rise on the risks of flooding and saltwater intrusion (Attachment 4). The investment in research and adaptation measures has been steadily increasing and will likely continue in the foreseeable future. The level of activity around these issues is exceptional and Miami-Dade County is fortunate to have the support of many world-class institutions. Most importantly, Miami-Dade County continues to benefit tremendously from the close collaboration

with the South Florida Water Management District, the United States Geological Survey, the Southeast Florida Regional Climate Change Compact partners, the Army Corps of Engineers, and regional and national universities.

These extensive research efforts summarized in this final report will be vital input to the County's capital planning efforts. The County will integrate the best available data into planning efforts and intends to further the collaboration with partners, such as the South Florida Water Management District, by creating a research steering committee.

Insurance and Long-term Risk Management

Recognizing that the County's vulnerability to flooding cannot be completely eliminated, Resolution No. R-49-15 focused on other critical supporting pillars of resilience - insurance and risk management. This directive built upon previous efforts, including a roundtable discussion with key leaders from the insurance and business communities held in September 2014, hosted by my office, The Beacon Council, the British Consulate General in Miami, and the British Ambassador to the United States. To further the discussion, a second roundtable took place on January 11, 2016 with key representatives from the private and public sectors. The three (3) principal goals of this discussion were to draw upon the technical expertise of the private sector to help County staff: a) better understand the physical and economic risks of climate change and rising sea levels to Miami-Dade County, b) improve the future insurability of County and privately-owned assets, and c) understand best practices and their potential implementation in Miami-Dade County.

Attachment 5 describes key considerations likely to impact the County and the ability of local and regional private businesses and residents to acquire affordable insurance coverage. More importantly the report also includes recommendations for long-term risk management practices, including: a) mitigating the County's own exposure, b) promoting the Community Rating System, c) working to address gaps in coverage, particularly for sub-groups that are more vulnerable to disasters and least able to afford insurance coverage, d) working more closely with the insurance and reinsurance sector, and e) promoting more resilient development.

The Office of Resilience will continue to coordinate with The Beacon Council and the British Consulate to reconvene regular discussions around this topic. The Office of Resilience will also engage local universities - business schools in particular - to identify opportunities to leverage their expertise and resources to further these discussions. Beginning immediately, a smaller internal County working group will continue to meet in order to implement and refine recommendations discussed in the report. Working groups will report back and provide my office and the Office of Resilience with specific recommendations on how Miami-Dade County can stay ahead of these issues.

The Climate Change Advisory Task Force

The Climate Change Advisory Task Force was created in 2006, and chaired by the Honorable Harvey Ruvin, Clerk of Courts. The Task Force released its first set of recommendations in May of 2008 and final recommendations in April 2011. These recommendations were taken into consideration in the development of initiatives within GreenPrint, Miami-Dade County's community-wide sustainability plan, and the 2011 Regional Climate Action Plan, developed by the Southeast Florida Regional Climate Change Compact. In January of 2015, the Board passed Resolution No. R-45-15 directing to review the status of the recommendations and to put forward an action plan. The final report in response to this directive is Attachment 6.

In accordance with Ordinance No. 14-65, this memorandum and report will be placed on the next available Board meeting agenda.

If you have questions concerning the above, please contact James F. Murley, Chief Resilience Officer, Department of Regulatory and Economic Resources, at 305-375-5593 or murleyj@miamidade.gov.

Attachments

c: Honorable Harvey Ruvin, Clerk of Courts, Eleventh Judicial Circuit
Abigail Price-Williams, County Attorney
Office of the Mayor Senior Staff
Department Directors
James F. Murley, Chief Resilience Officer, Department of Regulatory and Economic Resources
Lourdes M. Gomez, Deputy Director, Department of Regulatory and Economic Resources
Mark R. Woerner, Assistant Director for Planning, Department of Regulatory and Economic Resources
Neil Singh, Interim Commission Auditor
Eugene Love, Agenda Coordinator

Attachment 1

ADAPTATION ACTION AREAS: FEASIBILITY ASSESSMENT

September 2015

Final report for Resolution R-44-15 in support of the Sea Level Risk Task Force final recommendations

BACKGROUND: THE NEED FOR ADAPTATION

Many communities within Miami Dade County (MDC) are already experiencing the effects of higher sea levels and more frequent flooding. Over the past several years the scientific understanding and ability to model future impacts from climate change and climate variability has improved greatly. As a result, dozens of studies have been published by local universities, regional, national and international organizations which have examined the vulnerability of our region and our economy to the impacts of sea level rise, tropical storms and variations in precipitation levels. While more work needs to be done, these studies have underscored the potential implications of climate change to the Southeast Florida region if proactive steps are not taken to minimize vulnerability. Left unaddressed, these vulnerabilities could affect property values, public safety, and insurance rates, potentially leaving the County more exposed in the event of a storm. Many tested approaches and technologies exist to reduce these vulnerabilities. It is important to move ahead with adapting to anticipated impacts of climate change and sea level rise even as we continue to refine and improve our vulnerability assessments and modeling efforts.

Communities such as Miami Beach have already begun this work and Miami-Dade County departments, such as the Water and Sewer Department, Public Works and Waste Management, Parks and Recreation, and Emergency Management, are already working to ensure our public infrastructure will continue to serve our residents in the face of extreme events and longer-term trends such as sea level rise. There are many adaptation measures that can be taken, such as beach nourishment and dune enhancement, which will have many additional co-benefits between storms and will improve the quality of life for residents and the experience for visitors.

While adapting to climate change is a new challenge, preparing for it and building resilience to it will build on many established policies and practices already employed by Miami-Dade County, such as preparing for hurricanes, managing stormwater and regional water resources, and planning for smart growth. However, addressing the complexity of climate change and interdependency of infrastructure networks requires new approaches to coordination and planning. Without this coordination there is the potential that repairs and retrofits will be done independently and/or incrementally, or using outdated approaches and technology, which could result in wasted time and resources and lost opportunities to leverage complementary efforts. For this reason, the Board of County Commissioners adopted Policies LU-3K and LU-3L addressing Adaptation Action Areas in the Comprehensive Development Master Plan and is again recommending their

implementation as one tool to help the County accelerate adaptation and develop best practices which are tailored to our needs and unique geography.

ADAPTATION ACTION AREAS: ONE TOOL IN THE TOOLBOX

Adaptation Action Areas (AAAs), as defined in the box below, have been used as one approach to bridge the gap between vulnerability assessments and implementation. Adaptation Action Areas can be used as a flexible tool to help begin the complicated task of addressing these interrelated risks more holistically. This concept has been recommended because it allows challenges to be addressed on a more manageable scale, creates an environment for testing and development of best practices, fosters collective learning and

The History of Adaptation Action Areas

In 2011 the Florida Legislature created Adaptation Action Areas (S.163.3177 Florida Statutes). This statutory policy tool which is an optional designation within the Coastal Management Element is defined as:

"'Adaptation Action Area' or 'Adaptation Area' means a designation in the coastal management element of a local government's comprehensive plan which identifies one or more areas that experience coastal flooding due to extreme high tides and storm surge, and that are vulnerable to the related impacts of rising sea levels for the purpose of prioritizing funding for infrastructure needs and adaptation planning"

"At the option of the local government, develop an Adaptation Action Area designation for those low-lying coastal zones that are experiencing coastal flooding due to extreme high tides and storm surge and are vulnerable to the impacts of rising sea level. Local governments that adopt an Adaptation Action Area may consider policies within the coastal management element to improve resilience to coastal flooding resulting from high-tide events, storm surge, flash floods, stormwater runoff, and related impacts of sea-level rise. Criteria for the Adaptation Action Area may include, but need not be limited to, areas for which the land elevations are below, at, or near mean higher high water, which have a hydrologic connection to coastal waters, or which are designated as evacuation zones for storm surge." Section 163.3177(6)(g)(10), F.S.

Adaptation Action Areas have been recommended as a policy tool by the Southeast Florida Regional Climate Action Plan (recommendations SP 3-6, 8-9 & PP-11), by the Miami-Dade Sea Level Rise Task Force in their final recommendations, and in Miami-Dade County's Comprehensive Development Master Plan, which is explained in more detail subsequently.

The concept of AAAs has also been tested in Fort Lauderdale as part of a larger study led by the South Florida Regional Planning Council and the Florida Department of Economic Opportunity.

facilitates infrastructure investments and prioritization of capital improvement projects. The precise form and purpose of Adaptation Action Areas can be adjusted to the needs of each community.

RESOLUTION R-44-15

On January 21, 2015, the Board of County Commissioners (Board) passed seven (7) resolutions supporting the implementation of a recommendation included in the "Miami-Dade Sea Level Rise Task Force Report and Recommendations." One of these resolutions, R-44-15, directed the Mayor or his designee to study the feasibility of designating Adaptation Action Areas as recommended in the Comprehensive Development Master Plan (CDMP). The relevant policies of the CDMP which were adopted in 2013 are as follows:

> ***CDMP Policy LU-3K****: By 2017, Miami-Dade County shall determine the feasibility of designating areas in the unincorporated area of the County as Adaptation Action Areas as provided by Section 163.3177(6)(g)(10), Florida Statute, in order to determine those areas vulnerable to coastal storm surge and sea level rise impacts for the purpose of developing policies for adaptation and enhance the funding potential of infrastructure adaptation projects.*
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> ***CDMP Policy LU-3L:*** *Miami-Dade County shall work with its local municipalities to identify and designate Adaptation Action Areas as provided by Section 163.3164(1), Florida Statute, in order to develop policies for adaptation and enhance the funding potential for infrastructure projects.*

Pursuant to R-44-15, the Department of Regulatory and Economic Resources (RER) Planning Division has studied the feasibility of designating Adaptation Action Areas and has determined the adoption is feasible and is recommending initiation of the first pilot project in 2016/2017. This determination was based on the careful review of the AAA pilot project implemented in the City of Fort Lauderdale in partnership with the South Florida Regional Planning Council, the Florida Department of Economic Opportunity, and Broward County. This project produced a comprehensive planning guidebook for local governments that outlined how other jurisdictions could establish adaptation action areas. This report, which is currently available only as a draft, was carefully reviewed by staff, who identified opportunities to adjust AAAs to better fit the County's unique planning needs. Staff consulted with the technical and project leads for the Fort Lauderdale pilot project to understand which program components were successful and which may need to be revised for more effective implementation in Miami-Dade. On the whole, it was the opinion of the Fort Lauderdale staff that the AAA pilot project had been a successful tool for them to facilitate planning and infrastructure investments. Fort Lauderdale staff reported very positive responses from their initial community engagement efforts in designated areas, and they are planning to continue and expand the AAAs in future years.

It is the opinion of the RER Planning Division staff that Adaptation Action Areas are a feasible approach to adopt in Miami-Dade County because they are largely consistent with other designations and planning approaches that have been, and are currently being, used successfully. This includes the Coastal High Hazard Areas and small area studies used by the Planning Division, the priority stormwater basins used by the Public Works and Waste Management Department, and the Resilient Redesign studies conducted by the Southeast Florida Regional Climate Change Compact and participating regional partners. These approaches have successfully helped direct planning resources, prioritize investment and capital improvement projects, and draw out innovative and forward-looking solutions for these unique areas. There are sufficient staffing resources and existing expertise to implement adaptation action areas on a pilot basis within Miami-Dade County. Most importantly, it is the flexibility and inherent ability to tailor and adjust these areas to fit the needs of our communities which makes this approach an appropriate and feasible way to accelerate implementation. There are several potential approaches to designating an AAA which are outlined in the following section.

ADAPTATION ACTION AREAS: A FLEXIBLE TOOL

Adaptation Action Areas are inherently flexible and can be adjusted to meet the needs of each community. As part of this feasibility assessment, staff considered several alternative approaches to adopting AAAs to best address the specific needs of Miami Dade County. The following section outlines four of these approaches, which are not necessarily entirely distinct. Elements from each approach can be selectively adopted into a final approach, if desired. These potential approaches can be further refined or adjusted depending on priorities and resources available.

1 PROJECT-BASED

Description:

To designate AAAs, appropriate staff could review the list of planned County projects that are designed to reduce flooding risks, improve drainage or otherwise reduce vulnerability to storms, sea level rise or climate disruptions. Those planned or on-going projects could be used as the 'anchor' for AAAs. The boundaries of the AAAs could be delineated by the area benefiting from the project and/or improvement. For example, if a new pump station was being installed, a boundary could be drawn around that area benefitting from the new pumps. This "designation" could be temporary and the areas could be reviewed periodically. In areas where the projects have addressed the identified vulnerabilities, the AAA designation could be dropped from the list and those areas needing further

improvements could continue to be designated as AAAs. Every review period would revise the map of AAAs and new areas could be added to the list as new investments and projects are planned for that area. The process for identifying AAAs would be reliant on existing mechanisms for prioritizing investments and projects. This approach is very similar to the approach used in Fort Lauderdale.

Advantages:

- Relatively quick process to designate AAAs because it would utilize an existing list of planned projects
- No new process needed to suggest "solutions" because the infrastructure projects have already been vetted and approved to address flooding or other risks
- The process would be no more and no less equitable than the existing planning and investment decisions
- This approach could draw directly from the experience of Fort Lauderdale

Disadvantages:

- Heavily focused on infrastructure and engineering solutions and does not explicitly include space for non-structural solutions or spatial planning
- May miss opportunities to improve community design, quality of life, or further economic or community development or goals
- May be better at addressing acute short-term challenges and less able to address longer-term slower changes such as rising sea levels
- May miss other community needs such as rising insurance costs, failing septic systems, business disruptions, or other challenges
- Would require careful management of expectations to ensure that the public did not mistakenly believe that the completion of one drainage project or other improvement within an AAA would mean that the area was no longer vulnerable to storm surge or sea level rise. In many neighborhoods, a sustained investment over several years will be required and even with these investments it will be impossible to completely reduce the risk from storm surge, coastal flooding, and sea level rise
- Working on a project-by-project basis may miss opportunities to provide more innovative, comprehensive, or effective solutions because it might miss opportunities to solve several issues simultaneously (such as integrating resiliency with planned road works or redevelopment projects)
- May miss areas that have not had historic problems but may likely be vulnerable to future changes

2 ENHANCED ADAPTATION PLANNING FOR PREVIOUSLY IDENTIFIED AREAS

Description:

While climate change will exacerbate existing hazards, many of the challenges it will present are already partially known and understood, such as flooding due to heavy rains, storm surge from tropical storms, beach erosion, etc. Therefore, climate adaptation planning has significant overlap with on-going efforts such as the stormwater management planning, hazard mitigation planning, and maintaining compliance with the Federal Emergency Management Agency's (FEMA's) National Flood Insurance Program requirements and the Community Rating System. The County could take advantage of this overlap and use one of these existing plans as a starting point and expand upon it. For example, FEMA flood zones could be sub-divided into smaller neighborhood scales and then existing hazard mitigation plans could be rounded out with other considerations. For example, key stakeholders could be brought in to review the transportation, economic development, and drinking water vulnerabilities within these existing boundaries. Alternatively, the Stormwater Master Plan could be used as the starting point and particular stormwater basins that have already been identified as a priority by the Public Works and Waste Management Department (PWWMD) could be identified as the first AAAs. These priority basins could be identified as the boundaries of the AAAs and then a subsequent planning process could be used to enhance the Stormwater Master Plan with other considerations such as the vulnerability in other infrastructure systems (transportation, healthcare), or community and economic development goals.

Advantages:

- Baseline planning has already been completed. For example, planning efforts would be able to take advantage of the fact that flood depths have already been mapped within the FEMA flood zones, stormwater basins have already been prioritized, and capital projects identified in stormwater basins
- Baseline regulations may exist for these zones. For example, enhanced building requirements already exist for properties in FEMA flood zones (i.e. requiring certain building materials, prohibiting basements, specifying specific elevations for the first floor, etc.)
- Boundaries already exist, and in some cases, already carry additional legal requirements
- Additional review processes may already exist for planned projects within these areas

Disadvantages:

- May be difficult to subdivide existing boundaries into a manageable planning scale
- May be difficult to align existing boundaries with other existing neighborhoods and planning areas

- May not fully benefit from the most recent research and integrated modeling efforts (groundwater/surface water modeling) indicating which areas will be most vulnerable to the impacts of sea level rise and climate change

3 SYSTEMS-BASED ADAPTATION PLANNING

Description:

The County could work systematically through critical systems (water, sewer, power, transportation, health care, etc.) and identify areas of the highest vulnerability within each of these systems. Much of this information could likely be pulled from existing hazard mitigation plans, individual sector plans or through targeted meetings with key stakeholders familiar with each system. Meeting with stakeholders familiar with each system could reveal future projects and/or existing challenges and vulnerabilities that are known and may not be publicly discussed. The County could then identify areas where there is significant clustering of risk across major systems and designate these areas as Adaptation Action Areas. The County could then work with those same stakeholders to reduce the vulnerability to the major systems and potentially identify multi-purpose solutions to these vulnerabilities.

Advantages:

- Would highlight areas where there are potential synergies between sectors. For example, this approach could reveal where establishing a micro-grid could support a new healthcare facility, or where raising utilities could be combined with road work or new housing developments, to reduce total project costs
- Would also highlight areas where significant investment will be needed to just maintain the status quo and existing levels of service. This might allow the County to better prioritize resources and more efficiently allocate future resources and capital improvement projects
- May be easier to convene relevant stakeholders, develop adaptation solutions, and secure implementation funding because each individual is vested in their own system and is aware of potential funding sources
- May be easier to secure engagement and support from key decision-makers because adaptation would be addressing issues that have already been identified as key issues and priorities by various groups

Disadvantages:

- Might be more difficult to integrate community priorities and less tangible needs into the planning and infrastructure prioritization process

- Might be a more subjective and/or political process to identify the "risk clusters" that should be prioritized first
- This approach might have "blind spots" and wouldn't necessarily identify all vulnerable areas. For example, this approach might miss areas of low population density, areas with fewer redevelopment projects, beaches, or natural areas, etc.
- May be more difficult to coordinate with private companies that are responsible for maintaining key infrastructure systems

4 AREA PLANNING FOR NEWLY-IDENTIFIED VULNERABLE AREAS

Description:

The County could use the best-available science on vulnerable areas (including the USGS integrated surface/groundwater modeling results) to designate Adaptation Action Areas on the basis of their vulnerability to climate change. These physical boundaries based on future inundation and groundwater heights could be smoothed to more closely conform to existing neighborhood and planning boundaries. Within these boundaries the County could do a comprehensive assessment of adaptation needs. All of the vulnerable areas could be designated as AAAs at the beginning of the program or they could be designated on a rolling basis. If they were to be selected on a rolling basis, pilot sites could be chosen with different existing conditions, growth forecasts, and demographic characteristics to inform broader deployment of the designation. The AAA designation could be temporary and removed if the vulnerabilities were substantially reduced.

To begin the planning process the County could hold an "in-house" charrette and bring together key personnel with expertise in stormwater, floodplain management, hazard mitigation, planning, economic development, redevelopment, transportation planning among others. These in-house charrettes could be used to understand what projects are in the pipeline and how they might be amended to better serve multiple purposes and be more robust in the face of future changes. These charrettes could also be used as a learning experience for the County to identify which key players would be needed for future planning efforts and to build up internal capacity. They could also help identify existing barriers to better decision making (for example where incentives are misaligned, where regulations are outdated, or conflicting mandates exist across agencies that may be encouraging vulnerable development). Subsequent public charrettes could identify ways to better incorporate and facilitate economic and community development objectives into the process.

Identifying the barriers in these AAAs would benefit the planning process by facilitating more effective recommendations for the adaptation planning procedure needed countywide, and could help identify the policy changes needed. The first round of AAAs could also be distributed between the unincorporated areas and within municipal boundaries to strengthen working relationships with municipal partners.

Advantages:

- Utilizes the best available science to identify the areas that will be most at risk to sea level rise and storm surge
- Facilitates a comprehensive review of community needs within a given area and may help identify ways to address multiple issues at once (for example, a coastal berm can reduce wave damage during storms and also serve as a linear park and bikeway between storm events)
- Utilizes an area planning approach (as opposed to an infrastructure project-based approach) which could create more opportunities to identify innovative ideas rather than just relying on off-the-shelf technologies
- Helps develop internal technical capacity to address the challenges of flooding and sea level rise which may reduce the need to contract with external experts in the future
- Illuminates policy barriers and misaligned incentives which are impeding more effective decision making and planning
- Facilitates grant applications for designated AAAs

Disadvantages:

- May be a more difficult and/or subjective process to choose pilot areas among all the vulnerable areas identified
- May require a phased approach with priorities identified first and implementable projects identified after

Recommended Next Steps

As highlighted in the previous section, there are multiple approaches to designing the Adaptation Action Areas which can build upon existing processes, internal expertise, and the best available science. All four of the approaches above could feasibly be adapted and implemented with existing staff and resources. However, the fourth approach, area planning for newly-identified vulnerable areas, is the most desirable approach to begin implementing AAAs. This approach would allow for a more accurate assessment of vulnerability, a more comprehensive assessment of potential adaptation measures, and can help develop internal technical capacity and working relationships across departments, as well as the community. The intention is to partner

with select municipalities to work in tandem on AAAs within the incorporated and unincorporated areas of the County.

This approach will likely need to be adjusted and refined with time, therefore staff recommend beginning the AAAs with a pilot project in 2016. The USGS integrated surface/groundwater modeling outputs are currently pending and will be used by The Stormwater Master Planning staff to develop new inundation maps to highlight vulnerable areas. While the preliminary information is expected to be available to the RER Planning Division staff in the fall of 2015, it would be premature to use this information in lieu of a more comprehensive vulnerability analysis. A complete vulnerability analysis will require several months to a year to prepare. Nevertheless, pilot AAAs can be selected based on available information. This pilot phase will provide valuable experience and, most importantly, will help accelerate the development of innovative, cost-effective adaptation options appropriate to the unique geology and land use patterns of Southeast Florida.

The Planning staff will work with WASD and PWWMD staff during the fall of 2015 to obtain the preliminary map of areas vulnerable to sea level rise and storm surge. It is important to note that due to the County's geology, hydrology, and regional water management system, changing sea levels will have cascading impacts throughout the County, and not only on the coast. Areas in the western part of the County are expected to be affected by changing groundwater levels and by changes in the management of the regional water resources network, therefore AAAs may be designated in interior areas of the County as well.

This information about vulnerable areas will serve as the basis for the selection of initial pilot locations. The pilot location(s) in the unincorporated area of the County will be selected in early 2016. For vulnerable areas within incorporated areas, County staff will contact municipalities to solicit two (2) to four (4) partner communities that are willing to pursue a parallel planning process for an AAA within their municipality. County staff resources would be concentrated on organizing the meetings and planning efforts for the unincorporated areas while the municipalities would be expected to provide that support for their own communities. However, pursuing these efforts in parallel would allow County and municipal staff to gain insights and lessons from the other AAA sites, and would facilitate a more comprehensive and effective planning process.

Collaboration with municipalities is an important component of the AAA process because it will allow County staff to work in a variety of urban conditions and develop solutions that cross jurisdictional boundaries. Both the problems of, and the solutions to, climate change and sea level rise will be closely tied to the urban condition and will vary substantially across the County. For example, lower density areas may be more challenged by failing septic tanks, whereas more densely populated areas may be more impacted by flooded and impassable roadways, while more densely populated areas may be challenged to find the space to

accommodate protective structures and pump stations, and less densely populated areas may be more challenged to secure the needed funding for infrastructure improvements. Similarly, the social and economic conditions of different communities will strongly influence which solutions will be more appropriate, and/or more feasible. Therefore, it is important that AAAs span a representative range of conditions to help the County develop appropriate adaptation approaches which can be applied to the various urban conditions across the County.

After pilot AAA locations and partnerships with the municipalities are secured in early 2016, research can begin on the pilot sites through early 2016. During this phase, staff will gather information on the vulnerability of the area, existing infrastructure and critical facilities, demographic and community information, as well as compile existing area plans such as plans for redevelopment and capital projects. This phase will likely focus on identifying the key public and community sectors' stakeholders to participate in the in-house charrette. The charrettes would be scheduled in a staggered manner from late spring to early fall of 2016. The fall of 2016 would be used as a time for municipal and County officials to come together to finalize the products of the charrettes, exchange lessons learned, and develop recommendations for the final form of the Adaptation Action Areas. By then it is expected that a more detailed vulnerability assessment should be available to help support the designation of the next round of AAAs.

This approach is recommended because adapting to sea level rise will require extensive collaboration, coordination, and collective learning. Small changes in average sea levels will have cascading impacts throughout the system because of the interconnected nature of our regional water management systems. Addressing these changes often requires more than simple upgrades of the water and sewer infrastructure and therefore it is desirable to work across departments and directly with residents to find multi-purpose and cost-effective solutions. In many instances, it will be possible to find solutions that also enhance the quality of life in these neighborhoods between storms. For example, increasing the buffer areas along our canals, rivers, and the ocean can reduce the vulnerability to flooding while also creating an opportunity for new linear parks and green spaces. By creating Adaptation Action Areas and working with an interdisciplinary team to develop a suite of solutions for each area, it will be possible to continue to build the County's internal capacity to respond creatively to the challenges of climate change and changing sea levels.

Attachment 2

STRATEGIC IMPLEMENTATION OF THE ENVIRONMENTALLY ENDANGERED LANDS PROGRAM

September 2016

Final Report for Resolution R-47-15 in support of the Sea Level Rise Task Force final recommendations

Table of Contents

Note on all figures:

If you have any questions or trouble reading any of the figures, please contact the Office of Resilience at green@miamidade.gov to request additional information or a higher resolution version.

Figure 1: Natural areas protect Miami-Dade County from climate change and extreme weather.

Source: Bing Maps, 2016

Introduction

Supporting Resolution & Context

On January 21, 2015, the Board of County Commissioners passed Resolution R-47-15, which directs the Mayor or Mayor's designee,

> "to continue strategic implementation of Miami-Dade County's Environmentally Endangered Lands (EEL) Program, consistent with Program objectives as approved by the voters, and to identify potential additional long-term funding sources for the continued acquisition and management of EEL lands."

This final report is provided pursuant to R-47-15. The report first presents a history of the Environmentally Endangered Lands (EEL) Program and its importance for adapting to climate change and sea level rise. The Program's recent progress is also described, including information on the acquisition of approximately 250 acres during this past year. A primary focus of this report is to identify additional potential funding mechanisms. The report includes six (6) potential sources and Program staff continue to evaluate which resources are appropriate to meet short-term and long-term needs. A combination of sources will likely be required moving forward; however, additional funding from the recent passage of Amendment 1 is an important potential source.

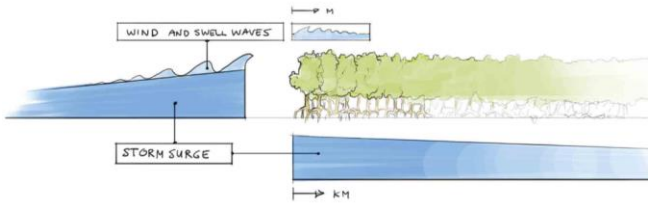
Figure 2: The EEL Program provides essential habitat and has protected more than 24,000 acres.

The Environmentally Endangered Lands Program Supports Climate Change Adaptation

Miami-Dade County's natural environments, like coastal barrier islands, mangrove forests, shallow bays, estuaries, and wetlands, are an important first line of defense against climate change (Figure 1). In addition to their intrinsic value as conservation lands, these rich natural resources are also the best insurance to protect our fresh drinking water and our coasts from the impacts of gradual sea level rise and extreme weather.

In 1990, the electorate of Miami-Dade County authorized the County to levy a two year ad valorem tax for acquisition, preservation and maintenance of environmentally endangered lands for the benefit of present and future generations. The initial funding allowed for the creation of the EEL Program. Through the EEL Program, the County has been able to protect more than 24,000 acres of natural areas that are critical to our region's ecological health and our ability to adapt to climate change. These properties provide numerous ecosystem services to the developed areas of the County. The ecological health of these environments also provides important social and economic benefits to our communities by preserving our natural heritage and green spaces for our families, and supporting our tourism economy (Figure 2).

Figure 3: Protected lands provide natural flood protection.

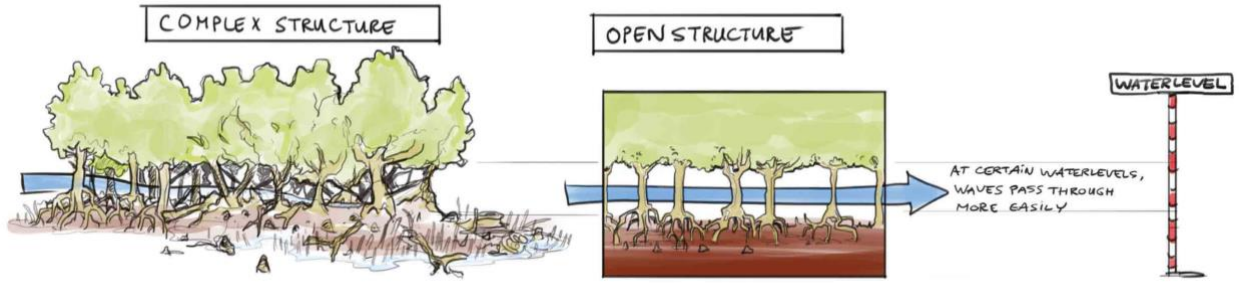


Source: Spalding M, McIvor A, Tonneijck FH, Tol S and van Eijk P, 2014

One of the key values these areas provide is protection for our coastlines from erosion and storm surge.[1] The wider and the thicker the natural buffer, the more the mangrove forest can protect the communities behind it by dampening wave energy and potentially delaying or reducing the height of storm surges (Figure 3). For example, a mature and healthy forest with a complex root system could help dissipate wave energy more effectively than a thinner or fragmented forest (Figure 4).[2] Though exact values will vary by location, research has shown that a mature mangrove forest can reduce wave energy by 20 percent for every 300 feet of forest.[3] A local study found the mangrove forest effectively attenuated surge and reduced the area inundated during Hurricane Wilma (a Category 2 storm).[4] The wider the buffer the more effective it is likely to be at protecting communities from surge caused by tropical storms. The acquisition of wetlands in the southern portion of the County along the natural mangrove coast has helped protect the communities behind those properties. These natural barriers can also be used in concert with "grey infrastructure" or manmade coastal defenses; however, it is essential to first preserve and enhance the natural defense to reduce the need and cost of other protective mechanisms.

[1] Horstman, E.M., Dohmen-Janssen, C.M., Narra, P.M.F., *et al.*,"Wave Attenuation in Mangroves: A Quantitative Approach to Field Observations" Coastal Engineering (2014) 94, 47-62
[2] Spalding M, McIvor A, Tonneijck FH, Tol S and van Eijk P (2014) Mangroves for coastal defence. Guidelines for coastal managers & policy makers. Published by Wetlands International and The Nature Conservancy. 42 p
[3] Mazda, Y.,Magi, M.,Kogo,M. &Hong, P.N. (1997a) Mangroves as a coastal protection from waves in the Tong King delta, Vietnam.Mangroves and Salt Marshes, 1, 127–135.
4 Zhang, K, Liu, H., Li, Y., Zu, H, et al., "The Role of Mangroves in Attentuating Storm Surges" Estuarine, Coastal and Shelf Science (2012) 102-103, 11-23. Available at http://sofia.usgs.gov/publications/papers/mang_storm_surges/

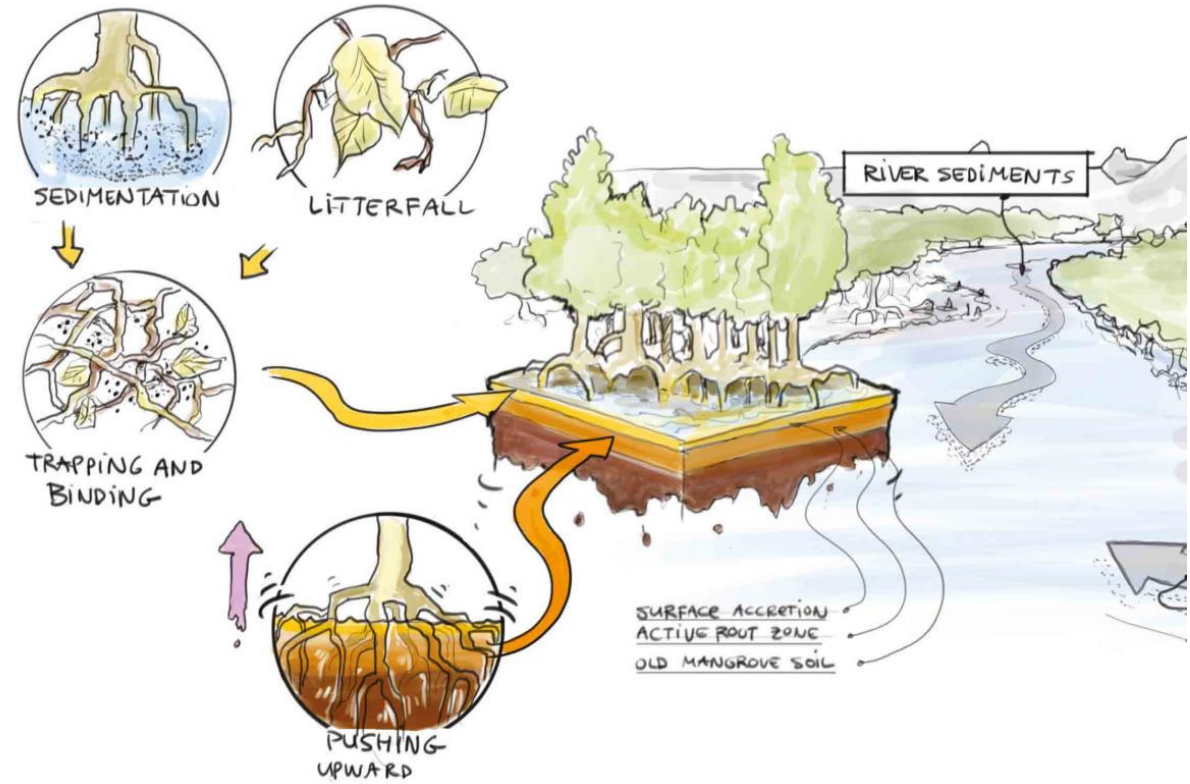
Figure 4: Dense mangrove forests can help diminish wave energy.



Source: Spalding M, McIvor A, Tonneijck FH, Tol S and van Eijk P, 2014

In contrast to manmade flood defenses, mangrove forests have a natural ability to adapt in place and keep pace with rising sea levels if the environmental conditions are favorable (Figure 5). However, many factors may compromise their ability to acclimate. If the rate of sea level rise is too great, if there is a shortage of sediment, or if development or environmental stressors impact the mangroves, they may not be able to keep pace with sea level rise. As a result, if the forests are too stressed, the width of the buffer area and their protective value would diminish.[5] Protecting the health and integrity of these ecosystems can therefore contribute to the long-term safety and ability to adapt to sea level rise for the communities protected by them.

Figure 5: Mangrove forests ability to trap sediment and adjust to changing water levels.



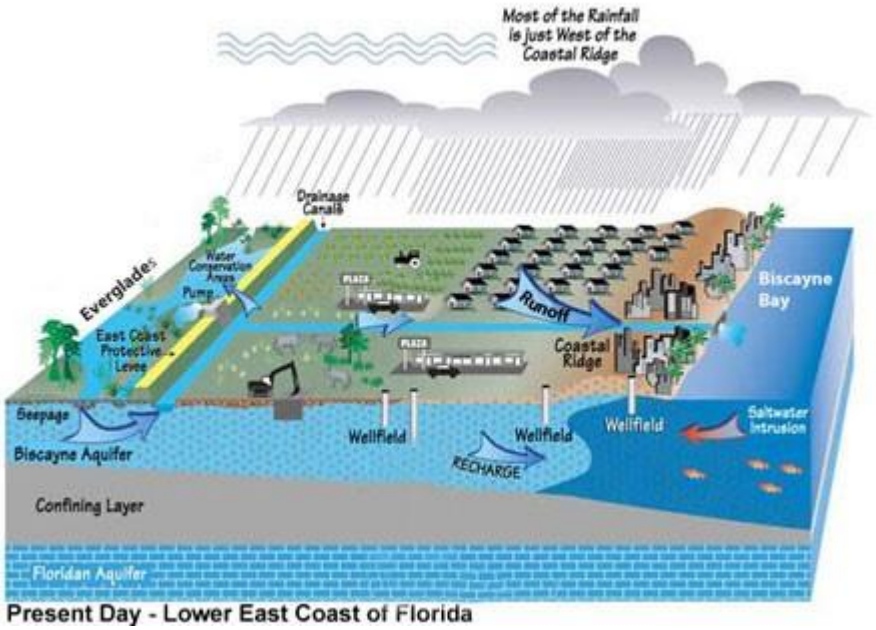
Source: Spalding M, McIvor A, Tonneijck FH, Tol S and van Eijk P, 2014

[5] Yip Lee, S., Primavera, J., Dahdouh-Guebas, F., et al., "Ecological Role and Services of Tropical Mangrove Ecosystems: A Reassessment". Global Ecology and Biogrography (2014) 23, 726-743

As sea levels rise, coastal ecosystems naturally shift with the changing conditions. When development constrains the ability for ecosystems to shift or migrate in the face of changing conditions "coastal squeeze" can happen. This means that the coastal ecosystems are squeezed between higher water levels and development inland. As a result they can erode or diminish with time, reducing the protective and ecological capacity and value they provide. [6]

In order to guard against this, it is crucial to protect these vital resources through conservation and preservation with the help of the EEL Program. In order to further the goals of this successful program more sustainable funding sources need to be found. This funding will support the continued acquisition and management of these natural assets. Strategic acquisition of these resources is critical, especially in communities, such as those in south Dade, that currently benefit from their protection.

Figure 6: Open space helps recharge freshwater acquifers.



Source: South Florida Water Management District

Our aquifers provide the main source of drinking water for Miami-Dade County. Wetlands and open space also protect our freshwater resources. Conservation lands protect the water quality by reducing the possibility of contamination in the wellfield area. In addition to improving the quality of water, these areas allow water to infiltrate and recharge the acquifer. This recharge can help reduce saltwater intrusion, a threat to our water supply (Figure 6). At the base of the Biscayne Aquifer in southern Miami-Dade County, saltwater intrusion now extends more than six (6) miles inland and gradual sea level rise will increase the risk of further intrusion. Maintaining open space and the ability to recharge the freshwater acquifers will help the County protect clean and reliable water supplies into the future. These areas also can help reduce flooding risks by storing or delaying the discharge of water during periods of heavy rain.

EEL lands also help mitigate climate change by sequestering carbon. These areas can also help regulate temperatures and improve water and air quality for adjacent areas. For example, wetlands can help treat stormwater runoff and reduce the level of pollution that reach the bays and beaches. They also provide passive recreational space and educational opportunities for residents. Miami-Dade's unique ecosystem can also attract tourism to the region.

[6] Yip Lee, S., Primavera, J., Dahdouh-Guebas, F., et al., "Ecological Role and Services of Tropical Mangrove cosystems: A Reassessment". Global Ecology and Biogrography (2014) 23, 726-743

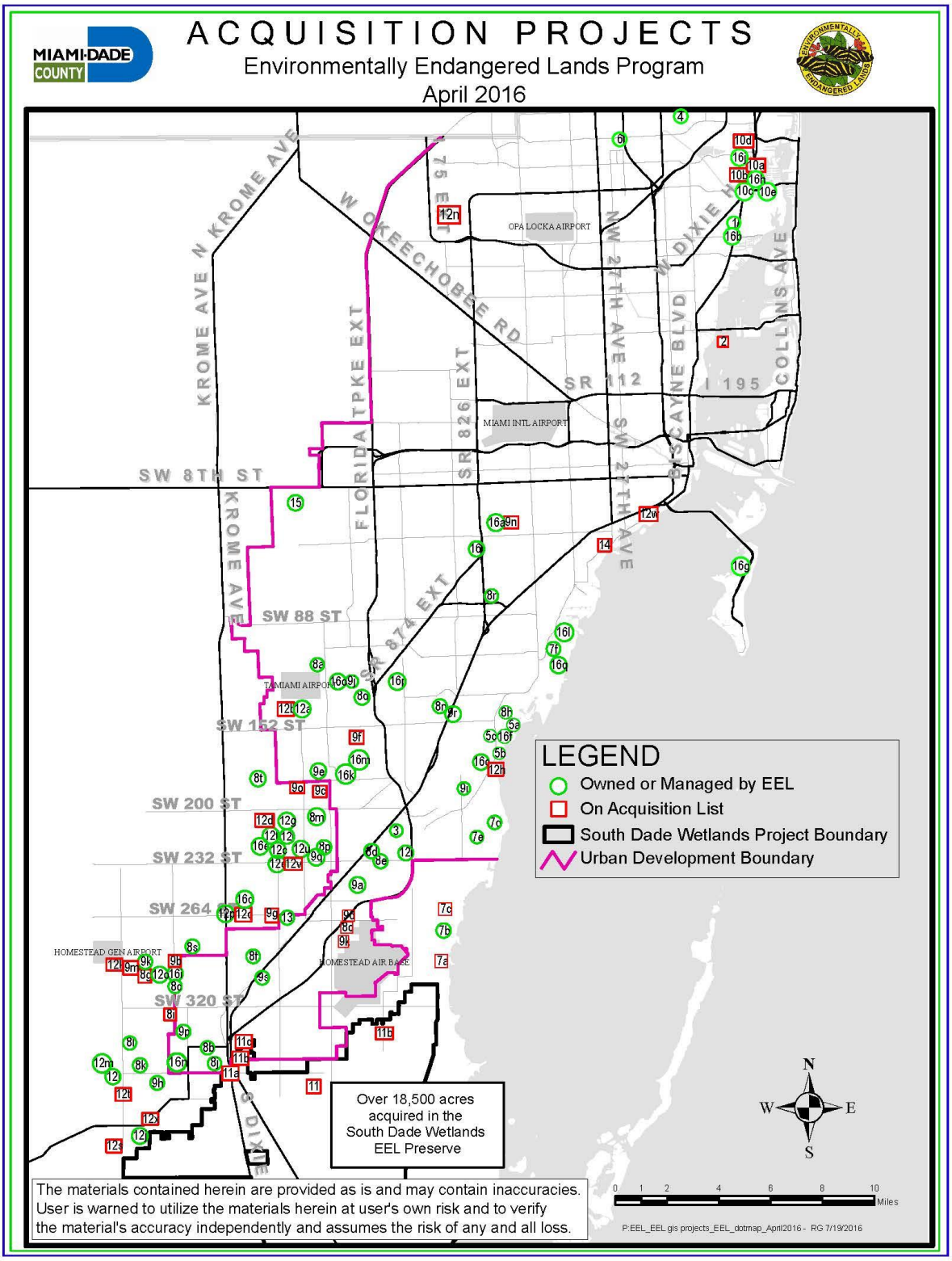
These areas have an intrinsic ecological value as conservation areas. EEL Preserves have high biological diversity and provide critical refuge for rare species that could otherwise be lost, especially in the face of climate change. The EEL Program helps mitigate the well documented historic loss, fragmentation, and degradation of native wetland and upland forest communities, considered globally-imperiled ecosystems. These areas support the wider food web and can enhance fisheries.

The Program has been strategically complementing other regional restoration efforts to maximize their value as conservation lands and reduce fragmentation. By acquiring larger, contiguous areas and completing the acquisition of partially acquired preserves, the Program can provide ecological and managerial benefits. From an ecological perspective, contiguous areas can improve habitat value, reduce encroachment of invasive species, and can facilitate ecosystem migration with climate change. From a management perspective, contiguous parcels can be more efficiently managed. For example, it is easier to control illegal access, remove invasive plants or implement prescribed burns to contiguous conservation areas, than to work around and between private property boundaries. Comprehensive ownership of the preserves will help further Program goals and allow for more efficient use of resources. Miami-Dade County benefits from several long-range plans that advise how we preserve open space including the Parks and Open Space Master Plan and the Comprehensive Everglades Restoration Plan (CERP). The EEL Program is a key component of this comprehensive effort to ensure the health and protective value of our natural resources. Another positive development is the recent passage of HB 989, the Legacy Florida bill. The bill was signed by the Governor on April 7 and would likely help the County coordinate land acquisition with the South Florida Water Management District and support restoration efforts, particularly in south Dade.

Recent Progress

Since the Program's inception, EEL along with its partners has successfully acquired and managed more than 24,000 acres of environmentally endangered land (Figure 7). The Program has also identified strategic priorities for future acquisitions. Together these properties represent a wide range of habitats, which provide a myriad of ecosystem services to the community.

Figure 7: Environmentally Endangered Lands Program acquisition projects as of February 2016.



As summarized in the table below, between January 21, 2015, and January 7, 2016, the EEL Program has acquired 249.78 acres at a total cost of $1,177,081 (Table 1). These acquisitions were partially funded in General Obligation Bonds ($1,090,081) and funding from the EEL Trust Fund ($87,000). This acreage includes the purchase of 15 parcels ranging in size from 1.17 acres to 160 acres. These recent acquisitions include lands within the Goulds Pineland Preserve (Figure 8) and the South Dade Wetlands Preserve (Figure 9). The figures below show how these acquisitions have helped reduce fragmentation between other EEL preserves and lands owned by the South Florida Water Management District. As mentioned before, reducing fragmentation has important benefits in reducing management costs and increasing impact of environmental conservation efforts.

Table 1: Lands acquired during the report period Jan 21, 2015- Jan 7, 2016.

Folio Number	Project name	Acreage	Purchase price
3089180000070	South Dade Wetlands Preserve	24.9	$104,367.24
3089170000030	South Dade Wetlands Preserve	160.0	$670,632.76
3089230000920	South Dade Wetlands Preserve	5.0	$15,027.00
3089230000900	South Dade Wetlands Preserve	5.0	$15,027.00
3069130000780	Goulds Pineland Preserve	1.17	$60,700.75
3069130000710	Goulds Pineland Preserve	2.3	$119,326.25
3089120000510	South Dade Wetlands Preserve	5.0	$15,000.00
3089120000520	South Dade Wetlands Preserve	5.0	$15,000.00
3089120000550	South Dade Wetlands Preserve	5.0	$15,000.00
3089120000540	South Dade Wetlands Preserve	5.0	$15,000.00
3089120000530	South Dade Wetlands Preserve	5.0	$15,000.00
3089120000500	South Dade Wetlands Preserve	5.0	$15,000.00
3089120000480	South Dade Wetlands Preserve	5.0	$15,000.00
3089070010220	South Dade Wetlands Preserve	7.61	$42,000.00
3089070010210	South Dade Wetlands Preserve	8.8	$45,000.00
Total		**249.78- Acres**	**$1,177,081**

The EEL Program considers multiple criteria when exploring acquisition strategies: rare and critically imperiled habitat; projects involving regional restoration efforts, such as CERP; and the completion of partially acquired preserves. The acquisition of the red parcels below in the Goulds Pineland Preserve (Figure 8) and the South Dade Wetland Preserve (Figure 9) are examples of such efforts.

Figure 8: Lands acquired in the Goulds Pineland Preserve during the report period.

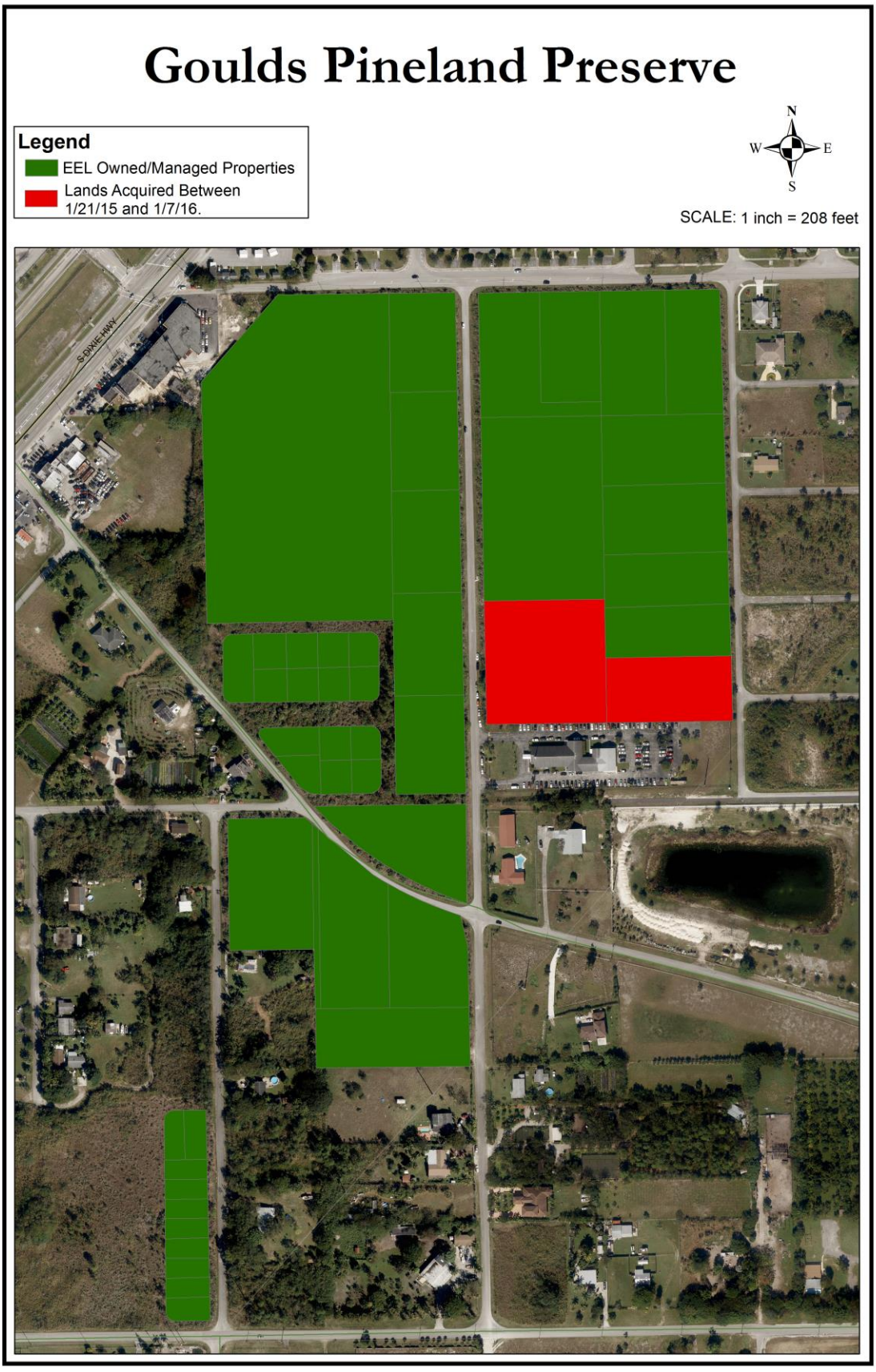
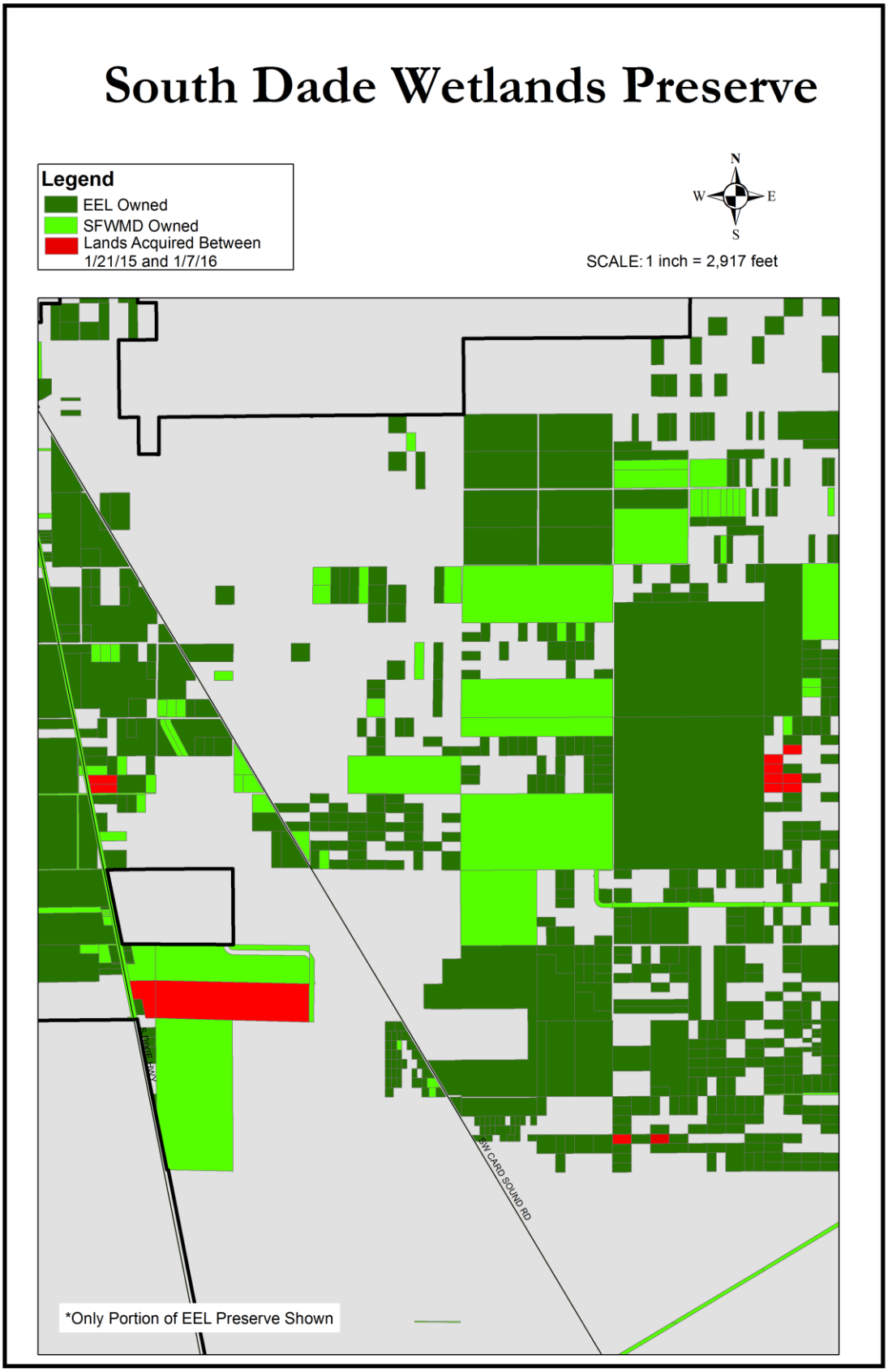


Figure 9: Lands acquired in South Dade Wetlands Preserve during the report period.



Existing EEL Program Funding

A key consideration affecting the EEL Program's long-term success is the ability to fund the perpetual management of EEL Preserves and to acquire the remaining land on the current Acquisition List (Appendix 1). The voter-approved collection of the ad valorem tax provided $90 million in initial funding to the EEL Trust Fund. This amount was allocated primarily to acquisition ($80 million) and to management ($10 million).

The Program has succeeded in leveraging this original investment made by County taxpayers and has accrued $198 million in revenue since its inception. This revenue has been attained from a variety of sources including grants, General Obligation Bond funds, interest and other sources.

Since its inception, the Program has expended $157 million on acquisition, management and administration.[7] The balance of the EEL Trust Funds at the end of fiscal year 14-15 was approximately $41 million. This amount is approximately evenly divided between the Acquisition Fund and the Management Fund (Table 2). The balance of the EEL acquisition allocation of the Building Better Communities-General Obligation Bond program at the end of fiscal year 14-15 was over $12.7 million.

Table 2: Balance of EEL Trust Fund at the end of fiscal year 14-15.

Balance of the EEL Trust Funds	
Acquisition Fund	$20,613,878.91
Management Fund	$20,045,968.82
Total	**$40,659,847.73**

Funding for the acquisition of new properties comes from either the EEL Acquisition Trust Fund or from Building Better Communities General Obligation Bond funds. These funding sources are specifically designated for EEL land purchases by referendum and Board of County Commissioners approval. Any other future source of funding that becomes available for EEL purchase, such as grants, is also subject to approval by the Board.

Funding for Management

Figure 10: Volunteers supporting EEL areas.

Land management activities are funded through the EEL Program's Management Fund. However, ongoing land management costs currently exceed the $3 million dollars budgeted for these activities on an annual basis and cannot be sustained under the current model. The Program has endeavored to address land management needs by engaging community partners and volunteers and by securing additional intermittent sources of funds; however, additional or recurring revenue sources need to be identified and secured to assure that funding for program objectives can be sustained into the future.

[7] As of the end of fiscal year 14-15

Potential Future Funding Sources

While the County has funding for the coming years, additional or recurring funds will need to be identified to address long-term sustainability of both acquisition and maintenance. Therefore, in addition to continuing to seek intermittent sources of funds, it is also important that long-term funding options be identified. The following are some potential options for consideration:

- **Florida Constitutional Amendment 1**
  Amendment 1, also called the Florida Water and Land Conservation Initiative, was approved in 2014. The measure was designed to dedicate 33 percent of net revenue from the existing excise tax on documents to the land Acquisition Trust Fund at a state level. Over the next 20 years this amendment may result in more than $10 billion in revenue for conservation, management, and restoration of water and land resources. As the most populous county in Florida, Miami-Dade County generates a significant share of Florida's total stamp tax revenues which provides funds to Amendment 1 Programs. The EEL Program already partners with the State of Florida to acquire conservation lands within Miami-Dade County using local funds supplemented with $14.5 million in grants from the State. The EEL Program is responsible for managing both County-owned and State-owned lands.

  The Board has already approved R-173-15 which urged the Florida Legislature to allocate funding for Miami-Dade County's EEL Program for conservation land acquisition pursuant to Amendment 1. Although the state did not provide funding to the EEL Program under this urging, Miami-Dade County could continue to seek Amendment 1 funds for Program activities. Signed by the Governor on April 7, HB 989, the Legacy Florida bill, could potentially help the County better coordinate land acquisition with the South Florida Water Management District and would support restoration efforts, particularly in south Dade.

- **Green Utility Fee**
  Counties with a population of 500,000 or more and municipalities with a population of 200,000 or more are authorized to create one or more green utilities or adopt fees to plan, restore, and manage urban forest resources, greenways, forest preserves, wetlands, and other aquatic zones. They may also create a stewardship grant program for private natural areas.[8] The fee is collected on a voluntary basis as set forth by the county or municipality. The fee is calculated to generate sufficient funds to plan, manage, operate and administer a greenspace management program. The fee proceeds are used to plan, restore and manage urban forest resources, greenways, forest preserves, wetlands, and other aquatic zones. Miami-Dade County could consider the implementation of a Green Utility Fee as authorized under state statute to fund EEL Program activities.

- **State Legislative Proposal to Allocate Funds to the EEL Program for Exotic Plant Removal and Management**
  In the 2016 legislative session, a proposed bill would modify state statutes to provide an exception from certain restrictions on the use of governmental lands for mitigating the impacts of the mining of construction aggregate materials. Although the bill did not pass during this session, if such a bill were

[8] information from the Florida Legislature's Office of Economic and Demographic Research December 2015 Local Government Financial Information Handbook available at http://edr.state.fl.us/Content/local-government/reports/lgfih15.pdf

passed in the future, it would include the removal and management of exotic plants as approved mitigation and therefore this funding could become available for EEL land management activities.

- **New EEL Referendum**
  The ability of local governments to raise revenue for governmental operations is limited by the state constitution.[9] However, the state constitution provides two exceptions to limitations, including a voted debt service millage and a voted millage, not to exceed a period of two years. No property may be subject to more than twenty mills of ad valorem tax for municipal and county purposes without elector approval. Currently, the 2015 millage rate for unincorporated Miami-Dade County is 18.2576, which is below the twenty-mill cap. Proposing a millage increase for the purpose of conserving valuable natural resources could be feasible especially given historic support for this kind of initiative.

  Florida has demonstrated a high level of support toward initiatives that protect its environmental resources. Between 1990 and 2009, voters in 78 of 96 local governments throughtout Florida have approved funding measures for open space acquisition (including in Miami-Dade County). When asked on a local ballot, Florida voters overwhelmingly (more than 81 percent) said "yes" to the use of their taxes for land conservation, including residents of Alachua, Brevard, Broward, Charlotte, Collier, Duval, Flagler, Hillsborough, Indian River, Lake, Leon, Martin, Miami-Dade, Osceola, Pinellas, Palm Beach, and Polk counties. At the state level, voters have also spoken loudly in support of land conservation. In 2014, Florida Amendment 1 passed with more than 74.95 percent of the statewide vote and 75.64 percent of the Miami-Dade County vote. Voter-approved funding mechanisms have included property taxes, sales taxes, and bonds and have ranged from $20 million to $250 million per referendum. Miami-Dade County could consider a new voter referendum to gage public support for a millage increase to fund EEL Program activities into the future.

- **Continued use of Miami-Dade County's Wetlands and Tree Trust Funds**
  The Miami-Dade County Wetlands Trust Fund and Tree Trust Fund, Sections 24-37 and 24-39 of the Code of Miami-Dade County, respectively, receive mitigation funds for permits issued for work in wetlands or for the removal of trees. The mitigation funds in these trust funds can only be spent on the acquisition, restoration, enhancement, management, or monitoring of wetland properties or natural forest communities or for planting trees on public property. The total balance of the Wetland Trust Fund at the end of fiscal year 14-15 was $7.2 million with an unencumbered balance of approximately $4 million. The balance of the Tree Trust Fund at the end of fiscal year 14-15 was approximately $2.8 million with an unencumbered balance of $1.5 million. These mitigation funds have been used by EEL to acquire and manage lands, and to plant trees in publicly owned natural areas. Since September, 2004, the Wetland Trust Fund has provided more than $18.7 million to the EEL Program for acquisition, enhancement and management of wetlands in south Miami-Dade County. The EEL Program could continue to pursue these funding opportunities for the acquisition of natural areas or planting of trees in areas acquired by EEL.

- **Stormwater Utility Fee**
  Conservation lands can provide protection for surface and groundwater resources, as wetlands naturally provide areas for water storage and water quality improvement. The Miami-Dade County

[9] Millage information from the Florida Legislature's Office of Economic and Demographic Research December 2015 Local Government Financial Information Handbook available at http://edr.state.fl.us/Content/local-government/reports/lgfih15.pdf

Stormwater Utility was established on June 18, 1991 by Ordinance 91-66. It operates through Chapter 24 Environmental Protection Ordinance, Section 24-51, of the Code of Miami-Dade County. Section 24-51 implements the provisions of sections 403.0893 and 403.0891 of the Florida Statutes by creating a countywide stormwater utility to plan, construct, operate, and maintain stormwater management systems. Fees collected by the Stormwater Utility go toward the planning, construction, operation and maintenance of stormwater management systems in Miami-Dade County. Efficiently managing stormwater can reduce pollution caused by silt, oil, gasoline, fertilizers, pesticides, and other litter carried by run-off. Although the ability to use Stormwater Utility Fees for EEL Program activities is limited, evaluation of the applicability of these funds may be considered on a case-by-case basis under certain circumstances where acquisition and management of the site provides direct benefits to the county's stormwater management systems.

Conclusion and Next Steps

The County's rich natural areas provide significant ecological, economic, and protective values today. These resources are also an essential component to the County's long-term ability to adapt to climate change and weather passing tropical storms. Climate change and other environmental pressures stress these natural resources and initiatives such as the EEL Program can help mitigate those impacts to ensure our communities can continue to enjoy the benefits of a healthy environment.

To continue advancing the Program's goals it will be necessary to secure additional sources of future long-term funding, particularly to support ongoing land management. Program staff have identified several measures to stretch available resources. The Program will work to maintain land management expenses at or below $3 million per year. This can be partially achieved by continuing to rely on volunteer assistance to support management activities. Staff will also continue to pursue acquisitions in existing preserves to maximize management efficiencies. This can be achieved by using grant funding, Building Better Communities General Obligation Bonds, and other available trust funds. Staff will also solicit a recommendation from the Land Acquisition Selection Committee about the potential transfer of funds from the Acquisition Trust Fund to the Management Trust Fund.

The County will also continue to work closely with federal, state, regional, and non-profit partners to identify potential project and funding opportunities. One of the most promising opportunities is to continue to seek Amendment 1 funds. This amendment may result in more than $10 billion in revenue over the next 20 years for conservation, management, and restoration of water and land resources. Miami-Dade County is the most populous county in Florida and generates a significant share of Florida's total stamp tax revenues which will provide funds to Amendment 1 Programs. The EEL Program has partnered with the State of Florida to acquire conservation lands within Miami-Dade County using local funds supplemented with $14.5 million in grants from the State. Miami-Dade County should continue to seek Amendment 1 funds for Program activities.

Appendix 1: Environmentally Endangered Lands Program Acquisitions

The following EEL Acquisition List consists of the Priority A List and the Priority B List. The Priority A List contains projects selected by the Board of County Commissioners where the County shall actively pursue acquisition. The Priority B List contains all acquisition proposals which are deemed worthy of acquisition, but which have not been assigned to the Priority A List. The County may not actively pursue acquisition of a property on the Priority B List unless a partner matches at least fifty percent of the total purchase price. The projects have been selected based on the following criteria: the biological value and viability of the resource; the vulnerability of the resource to degradation or destruction; the requirements (including costs) for managing the resource to maintain its natural attributes, and the feasibility of meeting those management requirements. The list organizes the projects by name and provides the acquisition status, acreage information, and a relative location of the preserves within the projects.

ACQUISITION PROJECTS: Environmentally Endangered Lands Program

February 2016

MAP #		PRESERVE	EEL ACQUISITION, LIST STATUS OR MANAGEMENT	ACRES Acquired	ACRES Unacquired	LOCATION
1		**Arch Creek Addition**	Acquired	1.5	0	NE 135 St. & US-1
2		**Bird Key**	A List	0	38	NW 79 St. & Biscayne Bay
3		**Black Creek Forest**	A List	7	45	SW 214 St. & 112 Ave.
4		**County Line Scrub Site (FCT, ATT)**	Acquired	15	0	NE 215 St. & 4 Ave.
5		**Deering Estate Additions**				
	5a	Deering Coastal (North) Addition (FCT)	Acquired	41	0	SW 152 St. & 67 Ct.
	5b	Deering South Addition (CARL)	Acquired	32	0	SW 168 St. & Old Cutler Rd.
	5c	Deering Glade Parcel (P&R, SNP, SAMP)	Acquired	10	0	15850 Old Cutler Rd.
6		**Dolphin Center Addition**	Acquired	4	0	NW 196 St. & 17 Ave.
7		**Coastal Wetlands:**	A List-unless otherwise noted			
	7a	Biscayne Wetland (FCT)		0	445	SW 280 St. & 107 Ave.
	7b	Biscayne Wetlands North Addition (GSA)	B List	300	0	SW 270 St. & 107 Ave.
	7c	Black Point Wetlands (FCT)		79	192	SW 248 St. & 97 Ave.
	7d	Cutler Wetlands (FCT)		454	787	SW 216 St. & 85 Ave.
	7e	Cutler Wetlands Addition (P&R)	Acquired	19	0	SW 210 St. & 85 Ave.
	7f	R. Hardy Matheson Preserve Add'n		20	21	Old Cutler Rd. & SW 108 St.
8		**Miami Rockridge Pinelands: (CARL)**	A List-unless otherwise noted			
	8a	Camp Matecumbe (CARL)	Acquired	77	0	SW 120 St. & 142 Ave.
	8b	Florida City (CARL 15)	Acquired	24	0	SW 344 St. & 185 Ave.
	8c	Fuchs Hammock Addition (CARL)	Acquired	14.8	0	SW 304 St. & 198 Ave.
	8d	Goulds (CARL 6)	Acquired	36.47	0	SW 224 St. & 120 Ave.
	8e	Goulds Addition (CARL)		7	28.8	SW 232 St. & 120 Ave.
	8f	Ingram (CARL 12)	Acquired	10	0	SW 288 St. & 167 Ave.
	8g	Kings Highway (CARL14)		0	31.1	SW 304 St. & 202 Ave.
	8h	Ludlam Pineland (CARL)	Acquired	10	0	SW 146 St. & 67 Ave.
	8i	Navy Wells 2 (CARL)		0	20	SW 324 St. & 197 Ave.
	8j	Navy Wells 23 (CARL)		20	9	SW 352 St. & 182 Ave.
	8k	Navy Wells 39 (CARL)		16	4	SW 354 St. & 210 Ave.
	8l	Palm Drive (CARL 16)	Acquired	20	0	SW 344 St. & 212 Ave.
	8m	Quail Roost (CARL 7)	Acquired	48	0	SW 204 St. & 147 Ave.
	8n	Rockdale (CARL 2)	Acquired	26	0	SW 144 St. & US-1
	8o	School Board (CARL 10)		0	19	SW 268 St. & 129 Ave.
	8p	Silver Palm Groves (CARL 8)	Acquired	20	0	SW 232 St. & 142 Ave.
	8q	Tamiami Complex Addition (CARL)	Acquired	26	0	SW 136 St. & 122 Ave.
	8r	Trinity (CARL 1)	Acquired	10	0	SW 76 St. & 73 Ave.
	8s	West Biscayne (CARL 13)		15	2	SW 288 St. & 190 Ave.
	8t	Wilkins-Pierson (CARL)		10	10	SW 184 St. & 164 Ave.
9		**Other Rockridge Pinelands:**	A List-unless otherwise noted			
	9a	Andrew Dodge New Pines Preserve**	**Managed not Acquired	3.42	1.58	SW 248 St & 127 Ave
	9b	Bowers Pineland		0	10	SW 296 St. & 197 Ave.
	9c	Calderon Pineland		0	17.5	SW 192 St. & 140 Ave.
	9d	Dixie Heights Pineland	B List	0	27	SW 268 St. & 130 Ave.
	9e	Eachus Pineland	Acquired	17	0	SW 184 St. & 142 Ave.
	9f	Federal Richmond Pinelands (Martinez)		142	212	SW 152 St. & 130 Ave.
	9g	Hattie Bauer Pineland		0	5	SW 266 St. & 157 Ave.
	9h	Navy Wells 42 (Sunny Palms)	Acquired	40	0	SW 364 St. & 202 Ave.
	9i	Ned Glenn Nature Preserve	Acquired	11	0	SW 188 St. & 87 Ave.
	9j	Nixon Smiley Addition (Tamiami 8)	Acquired	63	0	SW 124 St. & 127 Ave.
	9k	Northrop Pineland	Acquired	12	0	SW 296 St. & 205 Ave.
	9l	Notre Dame Pineland	B List	0	32	SW 280 St. & 132 Ave.
	9m	Pine Ridge Sanctuary		0	14	SW 300 St. & 211 Ave.
	9n	Pino Pineland	B List	0	2	SW 39 St. & 69 Ave.
	9o	Railroad Pineland	B List	0	18	SW 184 St. &147 Ave.
	9p	Rock Pit 39	Acquired	9	0	SW 336 St. & 192 Ave.
	9q	Rock Pit 46	Acquired	5	0	SW 232 St. & 142 Ave.
	9r	Rockdale Addition	Acquired	11	0	SW 144 St. & US-1
	9s	Seminole Wayside Park Addition	Acquired	5.5	0	SW 300 St. & US-1.

ACQUISITION PROJECTS: Environmentally Endangered Lands Program

10	**Oleta River Corridor:**		A List			
	10a.	Tract A		0	3	NE 171 St. & US-1
	10b.	Tract B (FCT)		0	8	NE 165 St. & US-1
	10c.	Tract C (FCT)	Acquired	2.5	0	NE 163 St. & US-1
	10d.	Tract D		0	8	NE 191 St. & 24 Ave.
	10e.	Terama Tract (DEP)	Acquired	30	0	IN OLETA PRESERVE
11	**South Dade Wetlands (SAMP, SOR)**		A List	18,911	11,905	SOUTH DADE COUNTY
	11a	Keyhole Wetlands		45.0	154	US 1 & Cardsound Rd.
	11b	South Dade Wetlands Addition		199	2,135	SW 344 St. & 137 Ave.
	11c	Wink Eye Slough Addition		0	57	SW 344 St. & 167 Ave.
12	**Tropical Hammocks:**		A List-unless otherwise noted			
	12a	Big & Little George (CARL 6)	Acquired	20	0	SW 141 St. & 149 Ave.
	12b	Big George Addition		0	3	SW 141 St. & 149 Ave.
	12c	Castellow 28 (CARL)	Acquired	18.7	0	SW 226 St. & 157 Ave.
	12d	Castellow 31 (CARL)		0	10	SW 218 St. & 157 Ave.
	12e	Castellow 33 (CARL)	Acquired	10	0	SW 226 St. & 157 Ave.
	12f	Castellow Addition (CARL 7)	Acquired	7.8	0	SW 223 St. & 157 Ave.
	12g	Chernoff Hammock	Acquired	4.5	0	SW 216 St. & 154 Ave.
	12h	Cutler Wetlands North Addition Hammock	B List	0	37	SW 184 St. & Old Cutler Rd.
	12i	Harden Hammock (CARL)	Acquired	12.4	0	SW 226 St. & 107 Ave.
	12j	Holiday Hammock (CARL 5)		30	27	SW 400 St. & 209 Ave.
	12k	Homestead General Aviation Hammock	B List	0	4	SW 296 St. & 217 Ave.
	12l	Loveland Hammock (CARL 3)	Acquired	16	0	SW 360 St. & 222 Ave.
	12m	Lucille Hammock (CARL 2)	Acquired	20	0	SW 352 St. & 222 Ave.
	12n	Maddens (CARL 10)	B List	0	60	NW 154 St. & 87 Ave.
	12o	Meissner Hammock (CARL 1)	Acquired	10	0	SW 302 St. & 200 Ave.
	12p	Owaissa Bauer Addition #1 (CARL)	Acquired	9	0	SW 264 St. & 177 Ave.
	12q	Owaissa Bauer Addition #2		0	10	SW 264 St. & 176 Ave.
	12r	Ross (CARL 8)	Acquired	20	0	SW 223 St. & 157 Ave.
	12s	Round Hammock (CARL)		0	32.6	SW 408 St. & 220 Ave.
	12t	SW Island Hammock (CARL 4)		0	12.5	SW 392 St. & 207 Ave.
	12u	Silver Palm Hammock (CARL)	Acquired	10	0	SW 228 St. & 149 Ave.
	12v	Silver Palm Hammock Addition		0	19	SW 228 St. & 149 Ave.
	12w	Vizcaya Hammock Addition	B List	0	2	3300 South Miami Ave.
	12x	Hammock Island	B List	0	100	SW 360 St. & L-31 W.
13	**Hattie Bauer Hammock (FCT, P&R)**		Acquired	15	0	SW 267 St. & 157 Ave.
14	**Barnacle Addition (CARL, City of Miami)**		B List	0	6	Main Highway
15	**Tree Island Park (FCT, P&R, SAMP, SNP)**		Acquired	120	0	SW 10 St.& 147 Ave.
	TOTAL EEL Acres			**21,203**	**16,584**	
16	**Park Natural Areas**					
	16a	A. D. Barnes Park	Managed by EEL	25	0	3775 SW 74 Ave
	16b	Arch Creek Park	Managed by EEL	8.5	0	NE 135 St. & US-1
	16c	Bill Sadowski Park	Managed by EEL	23	0	17555 SW 79 Ave.
	16d	Camp Owaissa Bauer	Managed by EEL	80.1	0	17001 SW 264 St.
	16e	Castellow Hammock Park	Managed by EEL	55	0	22301 SW 162 Ave.
	16f	Charles Deering Estate	Managed by EEL	332	0	16701 SW 72 Ave.
	16g	Crandon Park	Managed by EEL	444	0	7200 Crandon Blvd.
	16h	East, East East Greynolds Park	Managed by EEL	33	0	17530 W Dixie Hwy
	16i	Fuchs Hammock	Managed by EEL	24	0	SW 304 St. & SW 198 Ave
	16j	Greynolds Park	Managed by EEL	53	0	17530 W Dixie Hwy
	16k	Larry & Penny Thompson	Managed by EEL	194	0	12451 SW 184 St.
	16l	Matheson Hammock Park	Managed by EEL	381	0	9610 Old Cutler Rd.
	16m	Metrozoo Pinelands	Managed by EEL	142.4	0	12400 SW 152nd Street
	16n	Navy Wells Preserve	Managed by EEL	239	0	SW 360 St. & SW 192 Ave.
	16o	Nixon Smiley Preserve	Managed by EEL	60	0	SW 124 St. & SW 135 Ave.
	16p	Pineshore Park	Managed by EEL	7.8	0	SW 128 St. & SW 112 Ave.
	16q	R. Hardy Matheson Preserve	Managed by EEL	791	0	SW 112 St. & Old Cutler Rd.
	16r	Tropical Park	Managed by EEL	4.4	0	7900 Bird Rd.
	TOTAL Park/EEL Acres			**2,897**		

NOTE: Acronyms in parentheses following the project name indicate the source of funds or matching funds for which the project has been approved. Funding sources are:
CARL=Conservation And Recreation Lands; ATT = AT&T Corp.; DEP=Dept. of Environmental Protection; FCT =Florida Communities Trust; GSA = General Services Administration;
P&R = Miami-Dade Park & Recreation; SAMP = Bird Drive Special Area Management Plan; SNP = Miami-Dade Safe Neighborhood Parks Bond Program; SOR = Save Our Rivers.

TOTAL A/B List Acres to be Acquired	**16,584**
TOTAL Acquired/Managed Acres	**24,100**

Appendix 2: Quarterly Reports

First Quarter Update (January 3, 2015 – April 30, 2015)

On January 21, 2015, the Board of County Commissioners (Board) passed seven (7) separate resolutions, each supporting the implementation of one of the seven (7) recommendations included in the "Miami-Dade Sea Level Rise Task Force Report and Recommendations." Resolution R-47-15, which requires quarterly status reports and a final report within 364 days, directs the Mayor or Mayor's designee to continue strategic implementation of Miami-Dade County's Environmentally Endangered Lands (EEL) Program, consistent with Program objectives as approved by the voters, and to identify potential additional long-term funding sources for the continued acquisition and management of EEL lands. Pursuant to R-47-15, this quarterly status report is submitted for your review.

Background

In July 2013, the Board created the Miami-Dade Sea Level Rise Task Force (Task Force) for the purpose of reviewing current and relevant data, science and reports, and to assess the likely and potential impacts of sea level rise and storm surge on Miami-Dade County over time. On July 1, 2014, the Task Force presented a report to the Board entitled, "Miami-Dade Sea Level Rise Task Force Report and Recommendations," providing the requested assessment along with recommendations on how Miami-Dade County can begin planning and preparing for projected sea level rise impacts. In addition, Resolution R-451-14 and Ordinance 14-79 were adopted in 2014, requiring that planning, design, and construction of County infrastructure consider potential sea level rise impacts.

The historic loss, fragmentation, and degradation of native wetland and upland forest communities in Miami-Dade County are well documented. In 1990, the electorate of Miami-Dade County authorized the County to exceed the constitutional millage limitation by levying a two year ad valorem tax of three-quarters of one (1) mil for acquisition, preservation, and maintenance of environmentally endangered lands for the benefit of present and future generations. Collection of the ad valorem tax provided $90 million in initial funding in the EEL Trust Funds ($80 million allocated to acquisition and $10 million allocated to management). The County's EEL Program has been very successful in leveraging the original $90 million investment made by County taxpayers. Since its inception and through the end of fiscal year 13-14, the EEL Program has accrued $198 million in revenue, which includes grants, General Obligation Bond funds, interest, and other revenue and expended $154 million on acquisition, management, and administration. The balance of the EEL Trust Funds at the end of fiscal year 2013-14 was $44 million, of which $21.6 million is in the Acquisition Fund and $22.4 million is in the Management Fund.

Lands acquired by EEL provide numerous environmental, social, and economic benefits to the public including carbon sequestration, protecting wellfields, reducing the impact of stormwater

runoff, complementing regional restoration efforts, providing recreational space, as well as providing our community with opportunities to adapt to the effects of climate change. Saltwater intrusion now extends more than six (6) miles inland at the base of the Biscayne Aquifer in southern Miami-Dade County. EEL preserves provide open land for aquifer recharge, which is critical to ensuring clean and reliable water supplies for urban and agricultural areas as well as providing municipal and rural flood protection. EEL acquisition of wetlands in the central and southern portion of the County preserves public lands along the natural mangrove coast and provides hazard mitigation in terms of storm surge attenuation. EEL acquisition of uplands throughout the County provides protection of globally-imperiled ecosystems and open space in the urban and agricultural sectors of the county. EEL Preserves also have great biological diversity and provide critical refuge for rare species that would otherwise be lost, especially when considering the impacts of climate change.

Quarter 1 Progress (January 31, 2015 – April 30, 2015)

Strategic Implementation through Acquisitions

Between January 21, 2015, (the date the Board approved R-47-15) and April 9, 2015, the EEL Program has acquired 41.410 acres within the South Dade Wetlands EEL Preserve at a total cost of $162,000 ($75,000 in General Obligation Bonds and $87,000 in EEL Trust Funds). This acreage includes the purchase of seven (7) folios ranging in size from five (5) acres to almost nine (9) acres.

Potential Future Funding Sources

Funding for acquiring properties on the EEL acquisition lists includes the EEL Acquisition Trust Fund and the Building Better Communities General Obligation Bond funds. These funding sources have been specifically designated for EEL land purchases by referendum and Board approval. Any other source of funding that becomes available for EEL purchase, such as grants, is also subject to approval by the Board. The EEL Program's land management activities are currently funded through the EEL Program's Management Fund. The EEL Program has been increasingly successful in the last few years at securing other funds for land management and at engaging community partners and volunteers to help meet unmet management needs in EEL Preserves. However, these are non-predictable remedies and do not provide long-term assurance that Program activity levels can be sustained. Therefore, it is important that long-term and sustainable funding options be identified. One potential option includes allocation of funds made available under Florida Constitutional Amendment 1.

Amendment 1 may result in more than $10 billion over the next 20 years for conservation, management, and restoration of water and land resources. Miami-Dade County is the most populous county in Florida and generates a significant share of Florida's total stamp tax revenues which will be directed to Amendment 1 Programs. The EEL Program has partnered with the State of Florida to acquire conservation lands within Miami-Dade County using local funds supplemented with $14.5 million in grants from the State. Annually, the EEL Program spends

over $3 million on the management of state and County-owned conservation lands. On February 18, 2015, the Board approved R-173-15 urging the Florida Legislature to allocate funding for Miami-Dade County's EEL Program for conservation land acquisition and management pursuant to the Florida Water and Land Conservation Initiative, Florida Constitutional Amendment 1. Through the development of the final report required under this resolution, staff will continue to research and identify any further funding options for this important program.

In accordance with Ordinance 14-65, this memorandum and report will be placed on the next available Board of County Commissioners meeting agenda.

If you have questions concerning the above, please contact Lee Hefty, Assistant Director, Environmental Resources Management, Department of Regulatory and Economic Resources, at (305) 372-6754 or heftyl@miamidade.gov.

c: Honorable Harvey Ruvin, Clerk of Courts, Eleventh Judicial Circuit
Robert A. Cuevas, Jr., County Attorney
Office of the Mayor Senior Staff
Jack Osterholt, Deputy Mayor/Director, Department of Regulatory and Economic Resources
Lee Hefty, Assistant Director, Environmental Resources Management, Department of Regulatory and Economic Resources
Lester Sola, Director, Water and Sewer Department
Lourdes M. Gomez, Deputy Director, Department of Regulatory and Economic Resources
Mark R. Woerner, AICP, Assistant Director for Planning, Department of Regulatory and Economic Resources
Christopher Agrippa, Clerk of the Board
Charles Anderson, Commission Auditor
Eugene Love, Agenda Coordinator

Second Quarter Update (May 1, 2015 – July 30, 2015)

R-47-15: Continue Strategic Implementation of Miami-Dade County's Environmentally Endangered Lands (EEL) Program and Identify Potential Additional Long-Term Funding Sources

This resolution directs the Mayor or the Mayor's designee to continue strategic implementation of Miami-Dade County's Environmentally Endangered Lands (EEL) program, consistent with program objectives as approved by the voters, and to identify potential additional long-term funding sources for the continued acquisition and management of EEL lands.

The following actions have been taken to implement this resolution in the second quarter:

Between April 10, 2015, and July 29, 2015, the EEL Program has acquired 10.00 acres within the South Dade Wetlands EEL Preserve at a total cost of $30,000 (all Building Better Communities

General Obligation Bonds Program funds). This acreage includes the purchase of two (2) folios, both five (5) acres in size.

Through the development of the final report required under this resolution, staff will continue to research and identify any further funding options for this important program.

Third Quarter Update (July 31, 2015 – October 31, 2015)

R-47-15: Continue Strategic Implementation of Miami-Dade County's Environmentally Endangered Lands (EEL) Program and Identify Potential Additional Long-Term Funding Sources.

This resolution directs the Mayor or the Mayor's designee to continue strategic implementation of Miami-Dade County's Environmentally Endangered Lands (EEL) Program, consistent with program objectives as approved by the voters, and to identify potential additional long-term funding sources for the continued acquisition and management of EEL lands. This resolution requires quarterly status reports and a final report within 364 days of the effective date.

The following actions have been taken to implement this resolution in the Third Quarter:

- Strategic implementation through acquisition: Between July 30, 2015, and October 15, 2015, the EEL Program has acquired 3.47 acres within the Goulds Pineland EEL Preserve at a total cost of $180,000 (all Building Better Communities General Obligation Bond Program funding). This acreage includes the purchase of two (2) folios, one of which is 2.3 acres and the other is 1.17 acres.

- Identify potential long-term funding for acquisition and land management: The balance of the EEL Trust Fund as of July 31, 2015, was $41,886,142. Approximately $12.9 million dollars of additional funds for land acquisition remains available under the Building Better Communities General Obligation Bond Program. County staff continue to evaluate additional potential funding opportunities.

Attachment 3

RECOMMENDATIONS FOR AN ENHANCED CAPITAL PLAN

September 2016

Final report for Resolution R-46-15 in support of the Sea Level Risk Task Force final recommendations

Table of Contents

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Note on all figures: If you have any questions or trouble reading any of the figures, please contact the Office of Resilience at green@miamidade.gov to request additional information or a higher resolution version.

1 Introduction

1.1 History and Context

In January 2015, the Miami-Dade County Board of County Commissioners passed Resolution R-46-15. This resolution directed the Mayor or the Mayor's designee,

> "to prepare an action plan and report to accomplish the acceleration of the climate change adaptation planning process by evaluating the engineering and other relevant expertise needed to conduct a comprehensive expert analysis and to develop an enhanced capital plan involving all levels of government to reinvent Miami-Dade County's urban infrastructure in a timely, sequenced manner that includes but is not limited to flood protection, salinity structures, pump stations, and road and bridge designs, and to determine the costs of retaining the experts needed."

This is the final report in support of Resolution R-46-15; however, this report builds on a long history of climate change work and research (Figure 1).

1.2 Process to Develop This Report

To prepare this report, staff within the Office of Resilience (staff) worked with other Miami-Dade County (County) departments, local municipal governments, such as Miami Beach and Fort Lauderdale, major metropolitan areas, and interviewed major engineering and planning firms.

As an initial step, staff spoke with the Water and Sewer Department (WASD) and the City of Miami Beach about their existing contracts to plan for rising sea levels with private firms. To evaluate which components could be useful to support the County's own efforts, staff reviewed the technical products from each project as well as the contracts themselves, where possible. A preliminary "gap analysis" was also conducted with other departments to discuss what information, expertise, and internal capacity exist within the County and which skills and expertise could be best provided by external consultants.

Staff also spoke with peers in Seattle, Boston, New York, and San Francisco to discuss how these metropolitan areas had incorporated climate change risks into their capital planning efforts. These conversations focused on the cities' processes to create comprehensive resiliency or adaptation strategies. Interviewed cities shared information about the time and costs involved in developing their various plans and why they had brought in external consultants for certain components, as opposed to managing the process internally. Additional details from these conversations were included in previous quarterly reports (Appendix 4).

Finally, staff interviewed eight major planning and engineering firms to ascertain the approximate cost, timeline, and scope of work that would be required to develop "an enhanced capital plan involving all levels of government to reinvent Miami-Dade County's urban infrastructure." The intention of these interviews was not to evaluate the firms, but rather to conduct market research, gather order-of-magnitude cost estimates, and understand how an enhanced capital plan could be structured. Firms were asked to provide relevant examples from other cities and details about the approximate time and resources required for each project. They were asked how capital planning could be phased to provide more flexibility based on funding availability, including which components they would include in the first phase. Because Miami-Dade County has such extensive data on projected climate change impacts (e.g. localized sea level rise projections, storm surge, groundwater, and stormwater modeling etc.), firms were asked how they could build upon this strong foundation to maximize project outcomes. The firms also described how they integrated community engagement into prior projects.

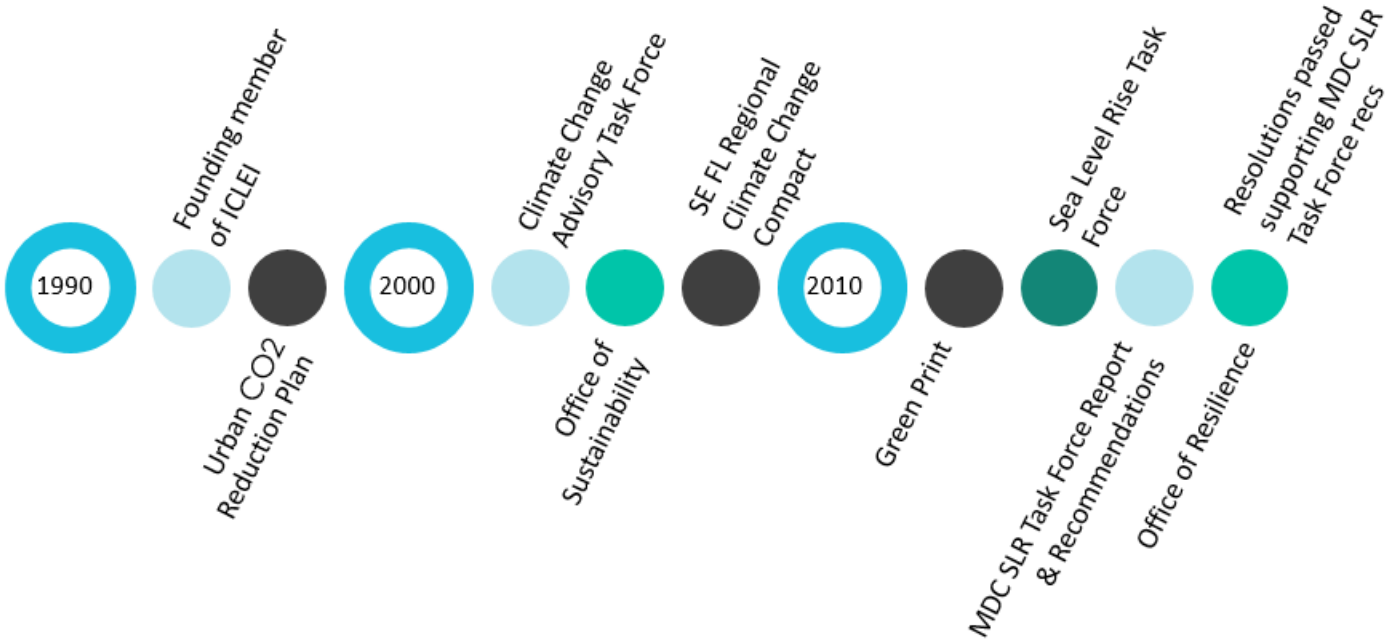
Staff also considered how climate change risks are currently being incorporated into the County's capital planning process. The evaluation revealed ways in which the support of external experts could improve upon the existing process. One shortcoming of the current process stems from the fact that it is the responsibility of each department to consider sea level rise during the planning, design and construction of all infrastructure projects following Resolution R-451-14 and Ordinance 14-79 adopted in 2014. However, technical expertise in this area varies across departments and therefore many departments have not yet integrated sea level rise into their capital planning. Another limitation is that no department is explicitly required to construct or maintain infrastructure to protect the community from coastal flooding, despite the fact that it has the potential to cause significant damage. There is also no requirement for departments to coordinate their actions or investments associated with preparation for sea level rise. Closer coordination could reveal opportunities to leverage investments and improve the resiliency of multiple infrastructure networks simultaneously. An enhanced capital plan, for example, could identify opportunities to simultaneously upgrade the stormwater management system, wastewater system and roadways at a lower cost than if those improvements were pursued as three separate projects.

Creating **an enhanced capital plan**, as directed by this resolution, has the potential to address these challenges and improve the existing process. It could also help articulate funding needs to state and federal agencies and engage the community. Ensuring that the right policies are in place for today's capital investments, can create a system where today's incremental investments help build the long-term resiliency of Miami-Dade County.

1.3 Structure of This Report

This report will outline the typical process other governments have taken to improve the resilience of their infrastructure, areas of expertise that exists within the County, areas where external expertise is needed, potential approaches to developing an enhanced capital plan, and finally, a recommended approach.

Figure 1: A Brief History of Miami-Dade County's Work on Climate Change 1990-2016



2 Typical Planning Process

Miami-Dade County can leverage the experience of other cities that have already initiated similar work developing enhanced capital plans to respond to climate change. Many planning processes have followed a generalizable pattern summarized in Figure 2 and described in greater detail below.

Figure 2: Typical Climate Adaptation Planning Process

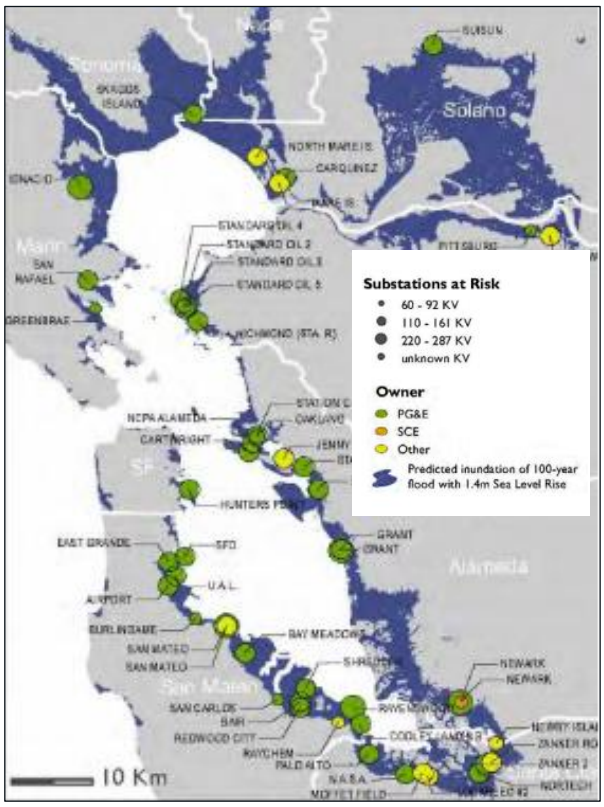
2.1 Identify Climate Risks

The first step to increasing the resiliency of the County's infrastructure is to understand how key climate variables are expected to change. For example, asking questions like: "How high will water levels be?", "How high could storm surge be during a hurricane?", and "How much rain could fall during the rainy season?". For Miami-Dade County, key climate risks include changing sea levels, groundwater heights, temperatures, as well as precipitation and storm patterns. Fortunately, the County already has very good data on many of these variables and several research efforts are underway to address data gaps. These extensive research efforts are summarized in the final report for Resolution R-48-15 and will be vital inputs to Miami-Dade's capital planning efforts.

There are a number of good examples of this type of work including climate assessments for New York City,[1] San Francisco,[2] and The Netherlands.[3] To fully understand the risks to critical infrastructure, the best assessments include a range of climate scenarios. For example, it is important to consider whether infrastructure would be vulnerable in the event of increased precipitation or increased drought, because both are potential risks in Miami-Dade County.

This stage requires highly technical expertise in the fields of climatology, hydrology, meteorology, and oceanography.

Figure 3: San Francisco Vulnerability Analysis



Source: California Energy Commission- Climate Change Center, 2012

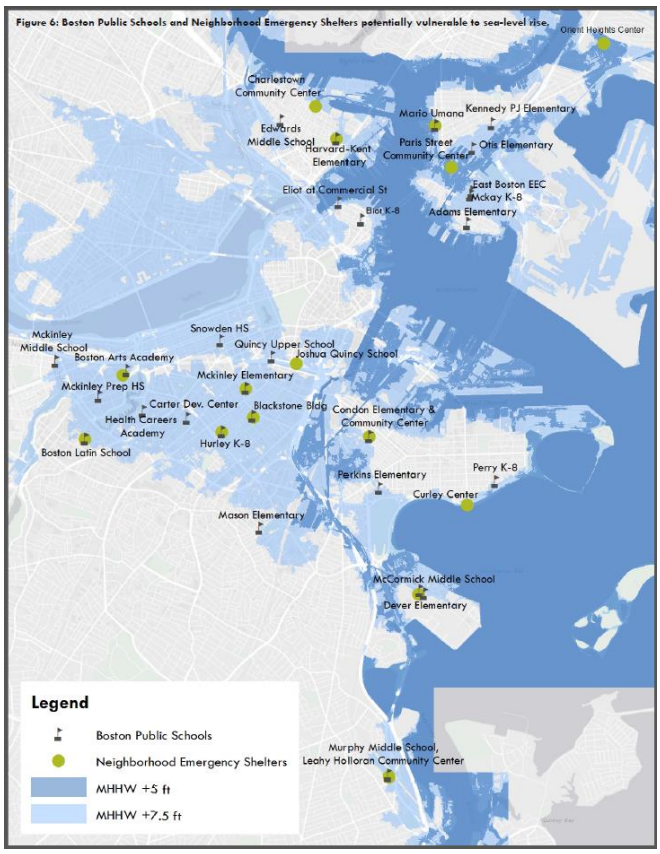
[1] The City of New York. Special Initiative for Rebuilding Resiliency. A Stronger, More Resilient New York: Ch 2 Climate Analysis. By Susan Van Gelde. N.p., n.d. June 11, 2013. Web.
[2] California Energy Commission. California Climate Change Center. By Julia A. Ekstrom and Ph.d. Susanne C. Moser. N.p., July 2012. Web. <http://www.energy.ca.gov/2012publications/CEC-500-2012-071/CEC-500-2012-071.pdf>.
[3] The Netherlands. Netherlands Environmental Assesment Agency. The Effects of Climate Change in the Netherlands: 2012. By Guus De Hollander. N.p., 2013. Web. <http://www.pbl.nl/sites/default/files/cms/publicaties/PBL_2013_The...>.

2.2 Vulnerability Analysis

Typically, the second planning step reviews which assets are vulnerable to the expected changes. For example, if sea levels are expected to be two feet higher, which infrastructure systems will be impacted by those changes? Analysis at this stage is often done using mapping overlays and comparing areas expected to be flooded with other layers containing information about transportation infrastructure, critical facilities or sensitive environmental areas. One example of this type of work from San Francisco (Figure 3) shows critical power infrastructure at risk from a 100-year flood after accounting for sea level rise. A second example from *Climate Ready Boston*[4] (Figure 4) shows the vulnerability of Boston's Public Schools and neighborhood emergency shelters. Another very comprehensive example is Los Angeles' sea level rise vulnerability analysis.[5]

A preliminary analysis of the County's vulnerability to sea level rise was completed in 2012;[6] however, that study was not detailed enough to inform infrastructure planning. A more thorough analysis is needed to determine, not only which assets are located in vulnerable areas, but also how those assets will be impacted. For example, a screening analysis may show a portion of a park, a roadway, and substation fall within an area that will be affected by sea level rise. A second step is then required to determine the potential damage and disruption that could result from this exposure. The park may be relatively unharmed by inundation, whereas any inundation at the substation could potentially cause severe disruption like electrical outages. Similarly transportation experts would need to assess the level of disruption caused by the loss of use of affected roadways. Fortunately, future vulnerability analyses can build upon the work recently completed for Miami-Dade's Water and Sewer Department (WASD), which provides many components for future studies.

Figure 4: Boston Vulnerability Analysis and Table of Public Schools High-Priority Vulnerabilities



Facility Name	Emergency Shelter	Vulnerabilities	Next steps
Marion Umana MS	Yes	Roof needs replacing (immediate). Heating and water systems in basement are old and may be destroyed by flooding (20-50 yearrs). Elevators are subject to breakdown due to flooding.	Future work must address climate change. Replacing roof. Seawall needs to be rebuilt. Complete HVAC upgrade needed.
West Roxbury HS	Yes	Adjacent to river and basement prone to flooding (immediate). Elevator is subject to breakdown due to flooding or loss of electricity.	Paving and site work is needed. Work will take into account flooding vulnerability.
Condon ES	Yes	School experiences flooding now. Electrical switchgear (which is shared with BHA) needs replacing (immediate). Flooding from sea level rise and storm surge (50-100 years) may impact HVAC in basement. Elevator is subject to breakdown due to flooding or loss of electricity.	Replace electrical switch gear and complete a study to determine cost for relocating equipment to higher floors.
Eliot K-8	No	Flooding potential from storm surge (immediate).	Renovation/addition being planned for the school 2013-2015. Flooding and storm surge potential will be a factor when designing the project.
Eliot at Commercial St	No	Flooding potential from storm surge (immediate). Elevator is subject to breakdown due to flooding or loss of electricity (immediate).	Building being renovated to house Eliot school students. 1st phase being completed for Sept. 2013, other floors will be renovated 2013-2015.

Source: Climate Ready Boston, Climate Preparedness Task

[4] City of Boston. Office of the Mayor. Climate Preparedness Task Force. Climate Ready Boston. By Carl Spector and Leah Bamberger. Massport, Oct. 2013. Web. <https://www.massport.com/media/266281/2013-October_Climate-Ready-Boston.pdf>.
[5] Grifman, P. M., J. F. Hart, J. Ladwig, A. G. Newton Mann, M. Schulhof. (2013) Sea Level Rise Vulnerability Study for the City of Los Angeles. USCSG-TR-05-20. Web. <dornsife.usc.edu/assets/sites/291/docs/pdfs/SeaLevelRiseDocs/City_of_LA_SLR_Vulnerability_Study_FINAL_Online_w_appen_sm.pdf>
[6] Southeast Florida Regional Climate Change Compact Inundation Mapping and Vulnerability Assessment Work Group. August 2012. Analysis of the Vulnerability of Southeast Florida to Sea Level Rise. p. 103. Web. <http://www.southeastfloridaclimatecompact.org//wp-content/uploads/2014/09/vulnerability-assessment.pdf>

To complete this component, expertise is needed in the technical understanding of various infrastructure systems, such as stormwater and transportation, as well as expertise in GIS mapping and planning.

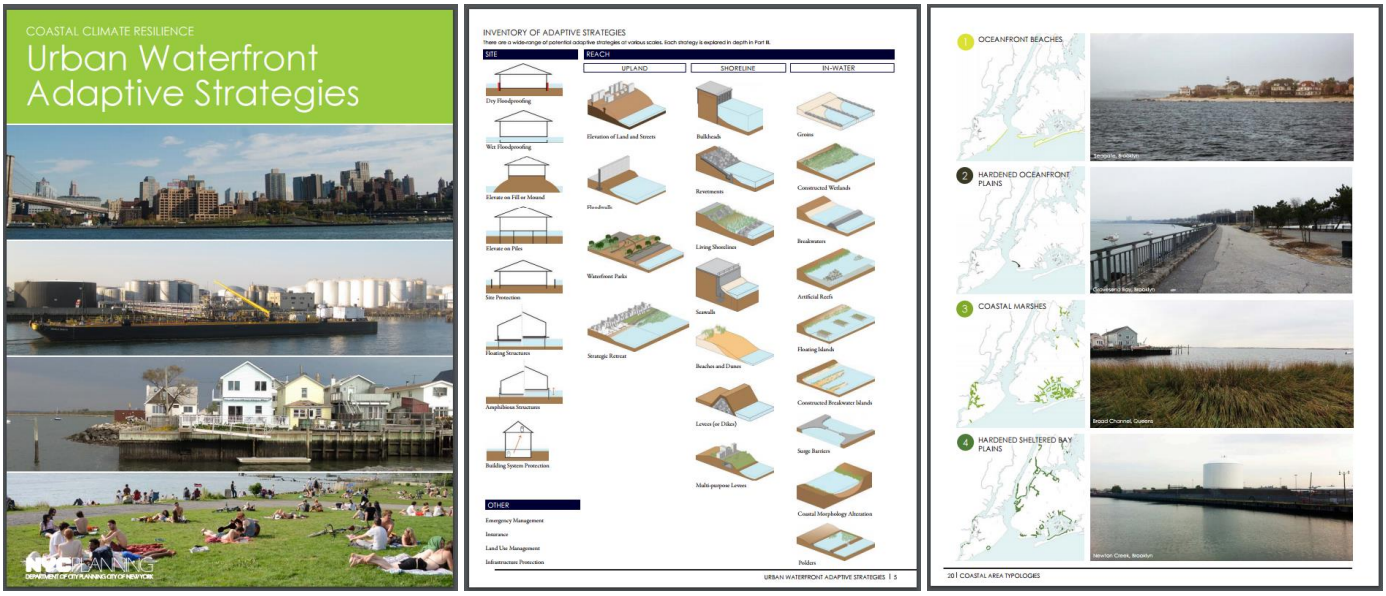
2.3 Strategy Development

Once the vulnerabilities are known, the next step frequently involves developing a list of potential strategies to reduce or eliminate the identified vulnerabilities. One of the best examples of this type of work is New York City's Department of City Planning's publication *Urban Waterfront Adaptive Strategies.*[7] This guide (Figure 5) outlines the potential adaptation measures available and describes where they would be suitable based on the urban coastal typology. This example is focused on adapting to rising sea levels, but similar studies exist for adapting to other hazards.

Several initiatives in the region have outlined potential adaptation strategies to sea level rise, including the Southeast Florida Regional Climate Change Compact's *Resilient Redesign* workshops, however, this information has not been systematically pulled together in one place. More importantly, additional work is needed to gather information about costs, technical effectiveness, suitability, trade-offs, and co-benefits of different adaptation measures. Developing a detailed adaption plan for the County's infrastructure will require creating strategies specific to our unique conditions. Adaptation measures will need to be developed at various spatial scales (facility, block, neighborhood, city, and county). These measures will also need to be tailored to different infrastructure systems including measures specific to roadways, drainage networks, septic systems and existing building stock. There are many advantages to beginning this planning effort at the largest spatial scale.

This type of work requires expertise in engineering, economics, planning, and design.

Figure 5: Strategy Development in New York City



Source: City of New York, Department of City Planning, 2013

2.4 Strategy Prioritization and Phasing

After the potential strategies have been developed, the next stage typically involves assessing the costs, effectiveness, feasibility and desirability of different options. The *Greater New Orleans Urban Water Plan* is an excellent example of the result of this process. Selections from the plan (Figure 6) show cohesive strategies for

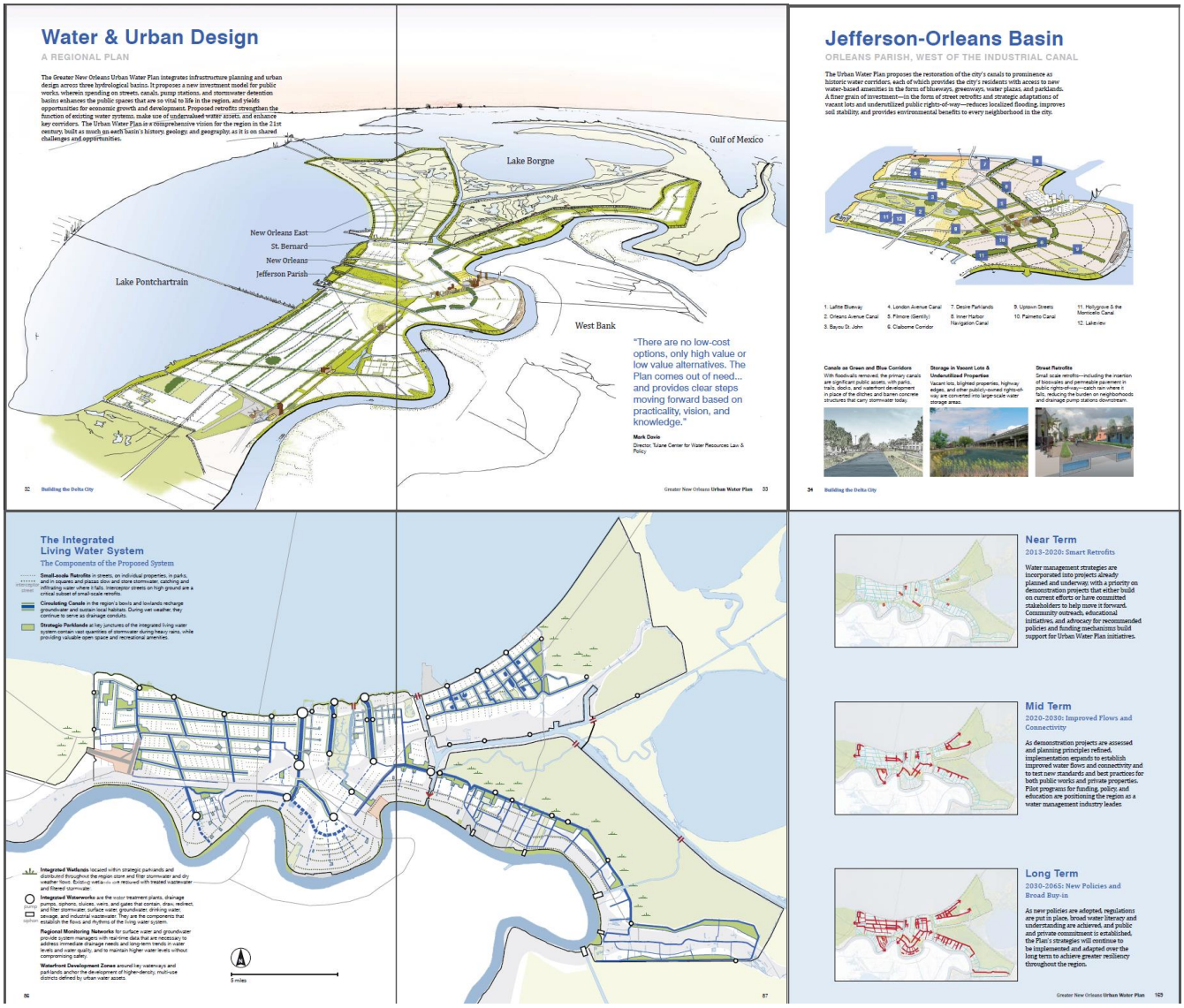
[7] The City of New York. Department of City Planning. Coastal Climate Resilience. Urban Waterfront Adaptive Strategies. N.p., June 2013. Web. <http://www.nyc.gov/html/dcp/pdf/sustainable_communities/urban_waterfront_print.pdf>.

different neighborhoods. The plan also outlines a phasing strategy for implementation. This plan was created with extensive collaboration between technical experts, planners, designers, and the community. The strategy prioritization and phasing stage often involves the most extensive community engagement and a focus on consensus building.

This stage would involve extensive planning and negotiation to prioritize strategies and develop short and long-term phasing. While many strategies will likely focus on building or enhancing infrastructure, ensuring that the County's infrastructure is resilient will also require many strategies that focus on internal processes, codes, policies, and regulations. Accomplishing the Resolution's goal of "involving all levels of government to reinvent Miami-Dade County's urban infrastructure" would also require new levels of coordination between federal, state, regional, and local government agencies.

Successful completion of this component requires technical expertise to assess the validity and feasibility of different adaptation options, as well as expertise in visualization, communication, spatial planning, and consensus building. Many firms with engineering and technical expertise in adaptation have also developed the capacity to clearly communicate the benefits, and trade-offs of different strategies to non-experts and build consensus around the most desirable approaches.

Figure 6: Strategy Development in New Orleans



Source: Greater New Orleans Urban Water Plan

2.5 Project-scale Planning and Design

Once there is agreement on the adaptation strategies and prioritizing and phasing is complete, then project-scale planning and design begins. This stage evaluates selected projects with the intention to determine the specific design of each project. For example, if there were agreement that raising the bulkhead heights along the Miami River was a desirable measure, this stage would involve developing engineering designs for that specific project. This stage would follow the development of an enhanced capital plan and is therefore beyond the scope of this report.

2.6 Project Construction and Monitoring

The final stage would include project construction and monitoring. Monitoring the effectiveness of different measures in partnership with the private sector and academia will also help foster innovation and more effective and efficient technologies. This stage would follow the development of an enhanced capital plan and is therefore beyond the scope of this report.

3 Expertise and Information Needed

3.1 Existing Expertise and Information

The County and regional partners already have significant expertise and data on local climate risks, including localized sea level rise projections, expected changes in groundwater levels, potential storm surge heights (including sea level rise), as well as potential temperature and precipitation scenarios. This depth of knowledge and local expertise can help springboard the County's adaptation efforts. **While additional research can always be done to refine and improve local knowledge, existing information is sufficient to begin creating an enhanced capital plan.**

Miami-Dade County also has partial information and internal expertise on the vulnerability of County infrastructure to expected climate change impacts. While certain departments such as the Water and Sewer Department and Parks, Recreation and Open Spaces have completed comprehensive assessments, many departments have not begun this process. Some programs, such as the Water Management Division in the Regulatory and Economic Resources Department, have the tools and expertise to thoroughly assess the impact of climate change on the functionality of their systems, whereas, other divisions or departments may not have the required tools or experts in-house. Excellent guidance for conducting vulnerability assessments exists and many guides are tailored to the needs of specific systems, such as transportation.[8] A complete vulnerability assessment of all systems could likely be completed with the aid of existing guides and cross departmental collaboration. The support of external experts could, however, greatly expedite and add depth to this process.

The County also has internal expertise on capital planning, spatial planning, and community engagement, however, there is less experience using these processes to specifically address climate change risks.

3.2 External Expertise and Information Needed

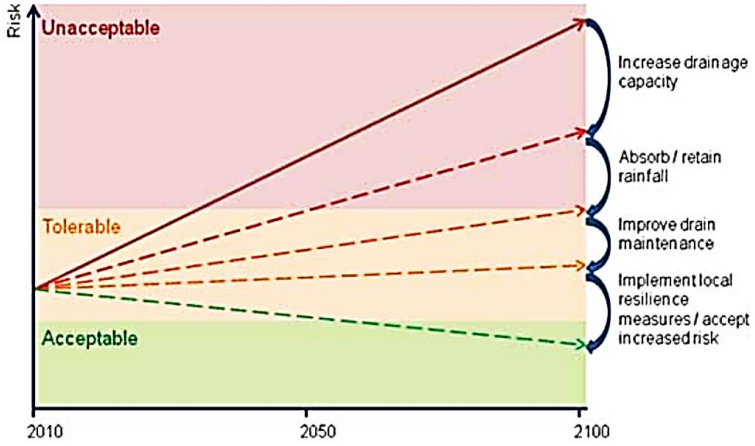
External expertise could be most useful in evaluating the technical and cost-effectiveness of different adaptation strategies to create a cohesive capital plan. Evaluating the technical effectiveness would involve comparing alternative adaptation measures (e.g. a new bulkhead or new drainage infrastructure) to determine which investment most effectively reduces flooding damage at a given location. The technical evaluation would address questions such as the height a building should be elevated to, or the elevation a

[8] The Federal Highway Administration has compiled a number of resources to assess the vulnerability of transportation networks available at www.fhwa.dot.gov/environment/climate_change/adaptation/publications_and_tools/vulnerability_assessment

sea wall should have, in order to meaningfully reduce flood damage. This requires technical engineering expertise in disciplines such as coastal, geotechnical, and hydraulic engineering.

It is important to pair the technical analysis with an economic analysis to develop feasible adaptation measures. For example, from a technical perspective, nourishing the beach every year and raising the height of dunes to 18 feet may provide the most protection, however, this strategy may not be economically feasible. Completely eliminating risk would likely be prohibitively expensive, therefore, the County needs to systematically determine a reasonable level of risk.[9] As seen in Figure 7, adaptation measures such as increasing drainage capacity, absorbing more rainfall, or improving drainage maintenance do not completely eliminate the risk of flooding but help gradually manage those risks and lower them to acceptable levels. Many tools exist to help decision makers weigh the relative benefits and costs of additional protection to arrive at some optimum middle ground. These tools can also help assess how spatial distribution of adaptation measures may impact the economy. For example, high dunes along Miami Beach may prevent millions in storm damage, however, similar dunes may have a negligible economic impact if placed in front of a natural park area that would be less affected by a storm. This analysis requires expertise in cost benefit analysis, risk management, economics, and cost engineering. Given that the future sea level rise remains uncertain, the timing of investment in adaptation is critical. **Tools exist to help optimize investments and phase them, based on certain flexible adaptation pathways tied to certain physical triggers** (such as a given rate of sea level rise or the occurrence of a major hurricane). Economic analysis can also reveal where risks pose the greatest financial threat to economic growth or recovery.

Figure 8: Managing Risk with Adaptation



Source: Managing risks and increasing resilience-The Mayor's adaptation strategy, Government of London

Developing a cohesive plan requires coordinating projects so that individual improvements are technically complimentary and not working at cross-purposes. Effective coordination requires both technical and economic assessments so that infrastructure investments are well allocated between different projects. **This requires expertise in engineering, economics, cost-benefit analysis, risk modeling, infrastructure prioritization, and spatial planning. Specific tools have been developed to support this type of planning** (Figure 8).

Figure 7: Interactive spatial planning tools

Source: Deltares

Subject matter experts could also add value to the County's enhanced capital plan by developing communication and visualization tools that help convey information about the physical,

[9] For example, a recent economic analysis found that "protecting Miami against all possible storms would be extremely expensive, costing several billion US dollars for construction work alone." Source: Elisabeth Genovese and Colin Green "Assessment of storm surge damage to coastal settlements in Southeast Florida" Journal of Risk Research (2015) Vol. 18, No. 4, 407-427.

socioeconomic, and infrastructure systems to a wider audience. Many firms have developed excellent tools that make complex information accessible and manageable to non-experts. These tools (Figure 8) allow users to move beyond reacting to a pre-defined plan and instead allow them to dynamically interact and experiment with different combinations of investments and infrastructure projects. **These visualization and scenario building tools allow planners and community members to explore different views, showing critical infrastructure, relevant landmarks, and other information**.[10] This allows decision makers and the community to understand physical and economic impacts, test alternative outcomes, and identify tradeoffs associated with alternative adaptation solutions.

4 Potential Approaches to Developing an Enhanced Capital Plan

4.1 Top Down: Replicating the Dutch Approach

The Dutch approach to adaptation planning is integrated with spatial planning and begins with a comprehensive assessment of the risks, vulnerabilities, and potential benefits and trade-offs associated with different adaptation options. The Dutch begin with a comprehensive assessment of the appropriate level of protection for each area of the country.[11] For example, areas with very low population density have a lower level of protection than densely-settled areas which are national centers of commerce and tourism (Figure 10). In this way, the Dutch integrate adaptation planning with spatial planning and use economic analysis to help determine the appropriate level of investment in adaptation.

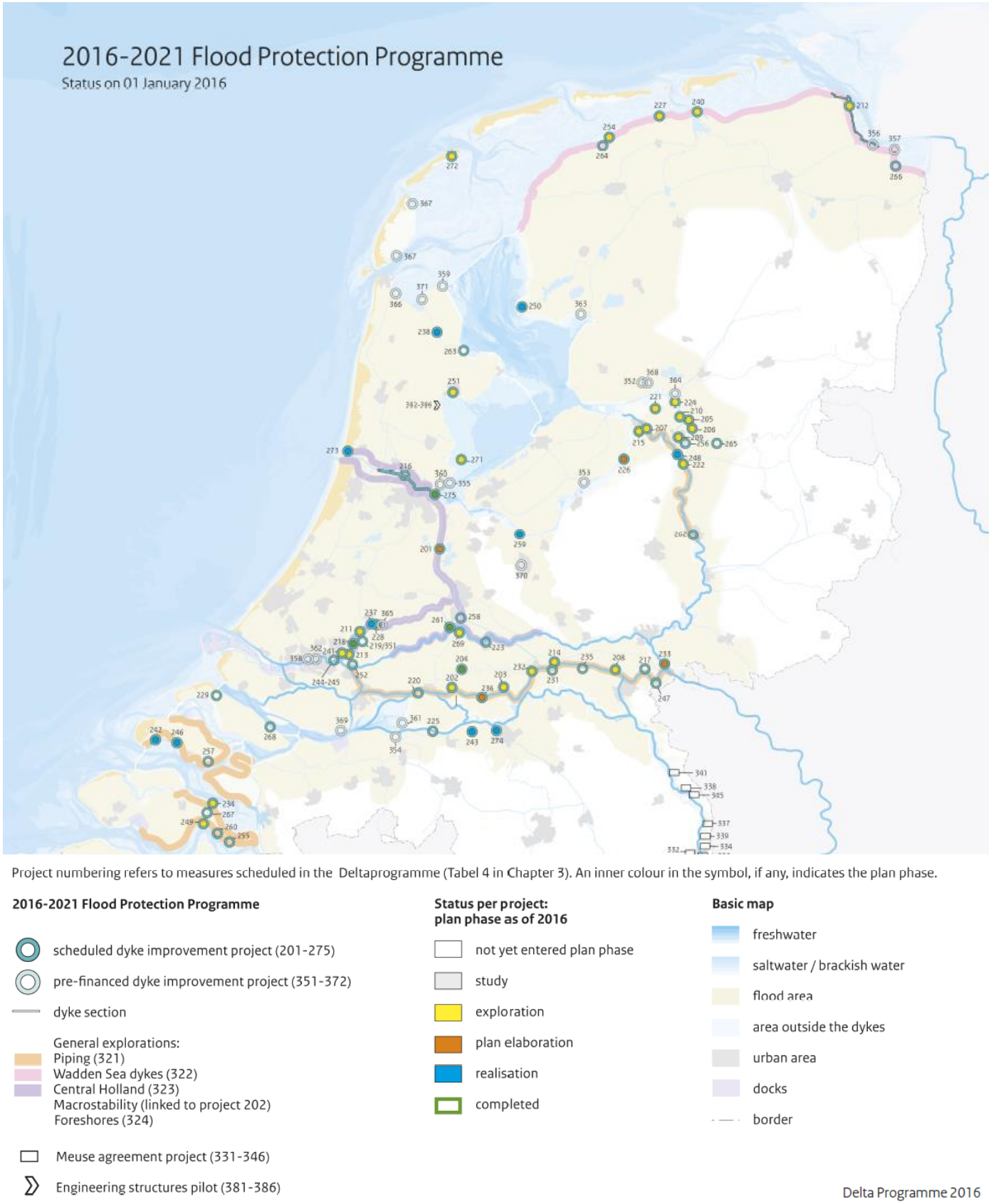
The Dutch approach could be considered "top down" in the sense that planning begins at the largest spatial scale by describing the plan for the entire country (Figure 9). Then, through successive steps, it becomes more refined and specific as plans are developed for each province, city, and neighborhood. **By beginning with the overarching plan, the process ensures that local adaptation efforts are building blocks that support the larger, country-wide effort.**

This approach reduces the risk that a local area would construct something (such as reinforced dunes or a surge barrier) that would increase the vulnerability of a neighboring area. Secondly, this approach reduces the risk that a local area could see its own investment in adaptation undermined by the action of a neighbor. For example, if one city invested in higher sea walls along a river but the neighboring area did not, the investment in the sea walls would be undermined because the water could simply flow over the lower portion of the wall and flood both areas. Effective coordination is one of the primary advantages of a top down approach where local actions support a comprehensive adaptation strategy.

[10] The DELta Analysis and Adaptation Strategy viewer is one example of this type of interactive planning tool. More information is available at: http://www.delta-alliance.org/toolboxoverview/DELTAAS

[11] For more information on the Dutch planning approach see the Delta Program available at: deltacommissaris.nl/delta-programme

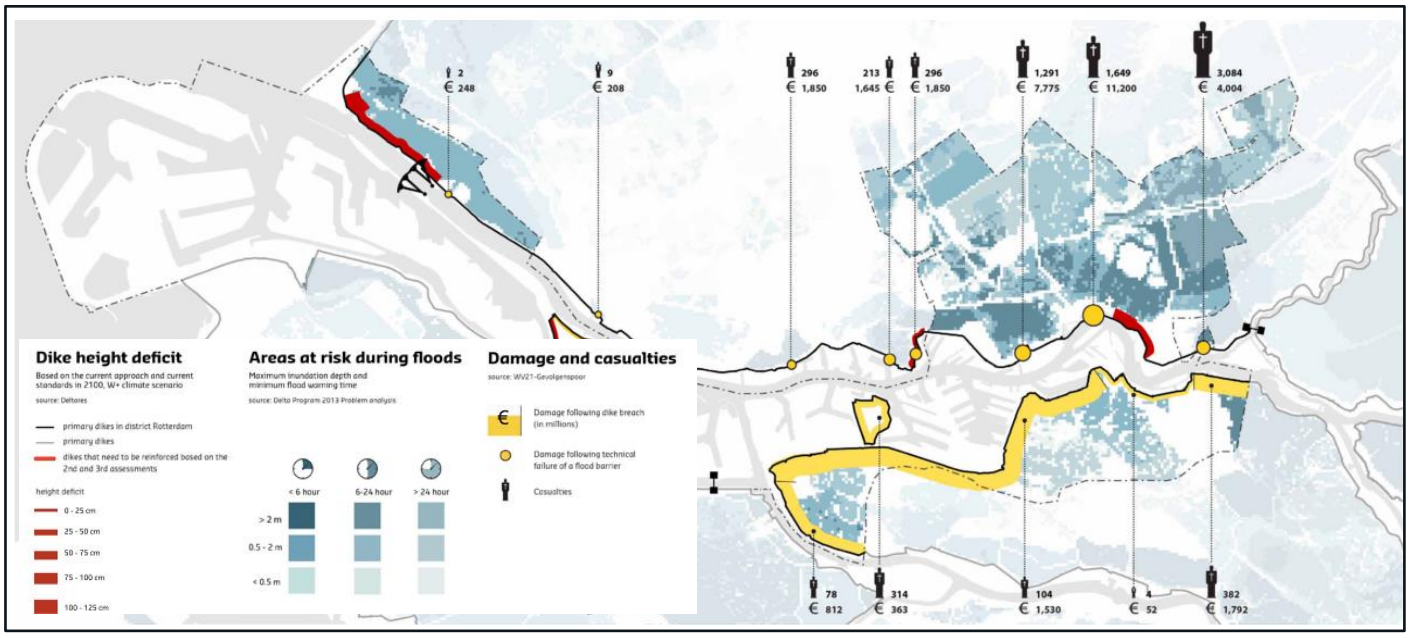
Figure 9: Example of "Top Down" Adaptation Planning



Source: Delta Program Commission. The Netherlands, 2016

A "top down" approach also allows for a comprehensive evaluation of the technical and cost-effectiveness of different adaptation measures at the outset. This helps determine the appropriate level of investment in protective measures for different areas. It also helps to efficiently allocate resources between different areas to both identify "weak links" and create multiple lines of defense. Weak links are vulnerable, under protected areas that may have no protective infrastructure or are totally reliant on a single system for protection. Creating multiple lines of defense means relying on multiple systems for protection. For example, a house in Miami Beach could be protected by the beach, dunes, a waterfront park, drainage infrastructure, and being elevated above the floodplain. **Creating an enhanced capital plan allows decision-makers to allocate investment between multiple lines of defense.** Looking at the economics at a larger spatial scale, it may be possible to determine the most efficient mix of complimentary adaptation measures. For example, it may be most efficient to increase investment in the beach and dunes and reduce the investment needed by residents to protect their individual structures. Using this approach, it is also possible to adjust the level of protection and investment to suit the needs of different areas. For example, additional adaptation measures could be put in place to protect areas with clusters of hospitals, high population density or critical infrastructure.

Figure 10: Example of Incorporating Economics into Adaptation Planning in the Netherlands

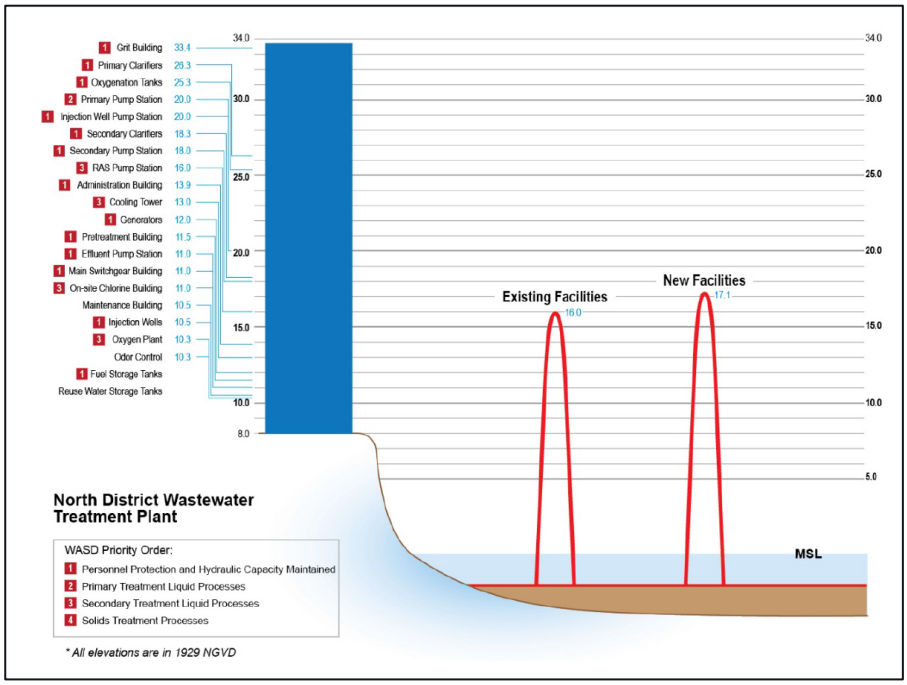


Source: Rotterdam Climate Initiative, Climate Proof. Climate Change Adaptation Strategy, 2012

4.2 Bottom Up: Replicating WASD's approach

Developing an enhanced capital plan could alternately begin from the point of identifying the vulnerabilities and needs of each individual infrastructure system. For example, the Water and Sewer Department (WASD) recently completed a very comprehensive assessment of their infrastructure's vulnerability to sea level rise and future storm surges. This assessment, illustrated in Figure 11, compared the elevation of expected storm surge, including sea level rise, to the elevation of their individual assets (e.g. pumping stations). They then assessed which improvements were critical to maintaining key services. Through this process, led by a large engineering firm, **WASD gained a detailed assessment of the vulnerability of each of its assets, a prioritization of infrastructure improvements, and a roadmap for how to design future projects** to be resilient to sea level rise and future storms.

Figure 11: Analysis for WASD showing recommended design elevations and prioritization of critical facilities



Source: Design Guide for Hardening Wastewater Treatment Facilities against Flooding from Surge, Sea Level Rise, and Extreme Rainfall

This process could be replicated for each infrastructure system such as transportation, emergency services, the airport, and the sea port, to name a few. Each entity responsible for the system could replicate WASD's approach to understand where each system is vulnerable and where new infrastructure or enhancements are necessary. These analyses and planning efforts would likely need to be supported by external consultants.

The described process could be considered a "bottom-up" approach in the sense that each individual system would identify and reduce its own vulnerabilities, but would create a more resilient community infrastructure network through these individual improvements. This approach has the benefit of being adaptable to fit the needs and unique characteristics of each infrastructure system and its individual capital planning process. The process could also be managed principally by each department with the support of technical experts, where needed. Each department could also take advantage of the existing information on future water levels prepared by WASD and their consultants.

Figure 12: Rendering of the Lafitte Blueway from the New Orleans Urban Water Plan

Source: New Orleans Urban Water Plan

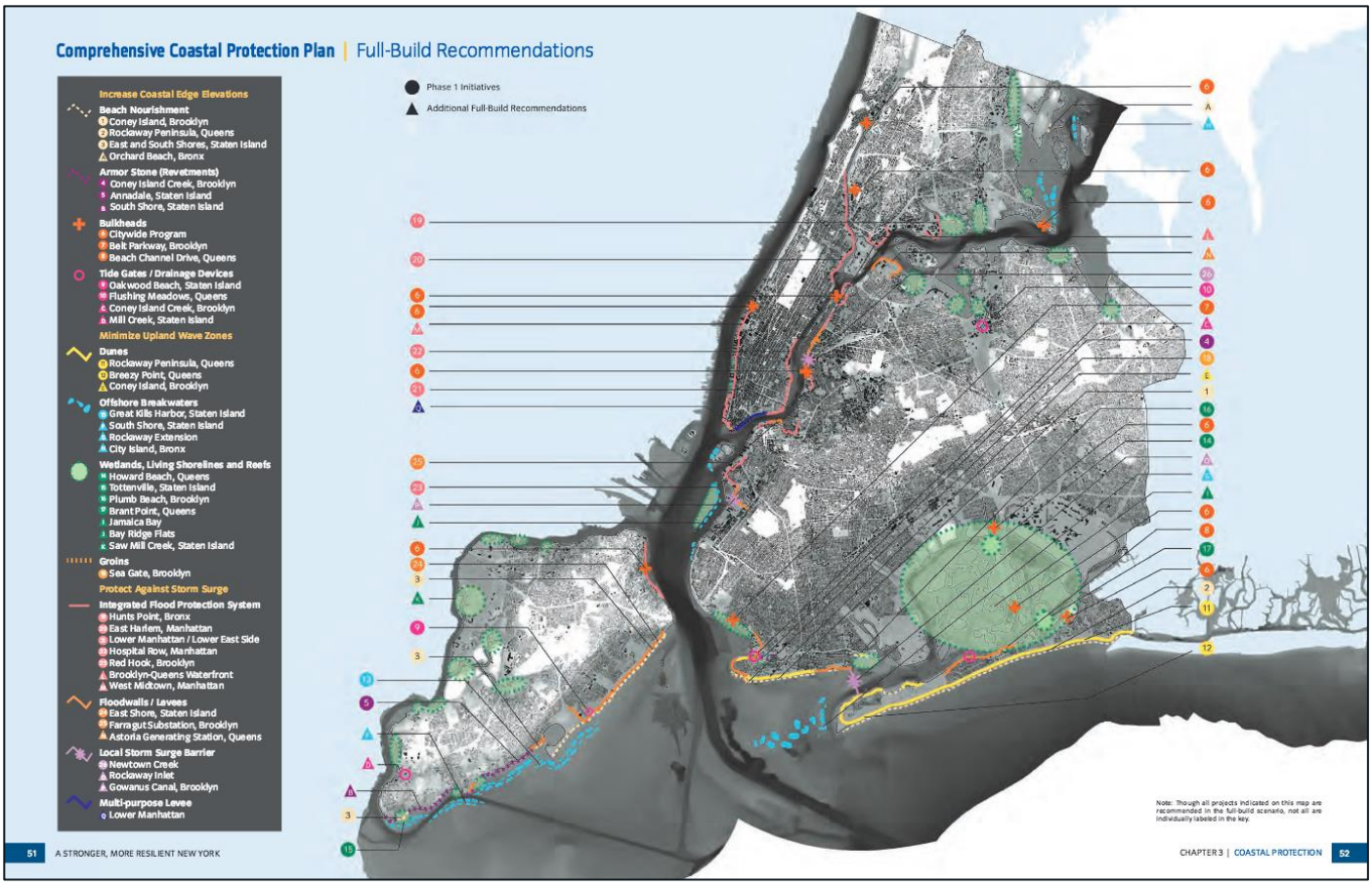
When pursuing a bottom-up approach, the timing would be controlled by each department. This approach could help integrate adaptation needs into on-going capital planning efforts, but could also mean that departments can pursue adaptation measures at different times. Such a method would require very close collaboration between entities to ensure that adaptation measures were coordinated and not working at cross-purposes. It may also be more difficult to coordinate investments across departments to pursue complimentary infrastructure projects. This approach may also rely heavily on implementing known engineering solutions and may miss opportunities for effective, innovative and creative solutions. Another drawback is the potential to miss vulnerabilities that fall between departments' areas of responsibility. For example, currently there is no department responsible for reducing the risks of coastal flooding due to storm surge. Nevertheless the potential damage from surge is substantial and there are cost-effective ways to reduce this vulnerability. A bottom-up effort may also miss opportunities to engage the community and improve quality of life through multi-purpose infrastructure solutions such as creating new buffers that reduce flooding damage but also serve as new linear parks between storms (Figure 12).

A bottom-up approach would be most effective if the County also developed a more formal process to ensure all capital projects adequately considered their vulnerabilities to climate change. Replicating the City of San Francisco's model could be one way to accomplish this goal. San Francisco's Public Utilities Commission requires each department to identify and map project sites included in the 10 year capital plan and verify whether they fall within a "vulnerability zone". For each project exceeding $5 million, departments are required to fill out a Sea Level Rise Checklist and submit it for review to the Capital Planning Committee and the City Engineer's Office. Departments are also required to submit specific long-term strategies to address the adaptive capacity of proposed projects. Miami-Dade County could develop a similar mechanism.

4.3 Hybrid Approach: Replicating Boston and New York's Approach

Other major metropolitan areas vulnerable to sea level rise, such as New York and Boston, have pursued a hybrid approach. These cities built upon detailed analysis of individual infrastructure systems (i.e. wastewater treatment) and knit these assessments together into an overarching adaptation strategy. Through this process they identified and filled gaps where necessary.

Figure 13: New York City's Comprehensive Coastal Protection Plan



Source: A Stronger, More Resilient New York, 2013

In the case of New York City, substantial work to assess the vulnerability of different assets had already been completed before Hurricane Sandy hit. After Sandy, however, there was a massive effort, involving more than 40 city staff members and numerous consultants working around the clock for five months, to create a unified adaptation plan: *A Stronger, More Resilient New York.*[12] This comprehensive plan contained actionable recommendations, specific infrastructure projects, and potential funding sources. The plan was structured around key infrastructure systems (transportation, telecommunications, water, and waste water) and neighborhoods (Southern Manhattan and South Queens). The plan outlined over 250 initiatives necessary to protect the city, totaling approximately $20 billion in required investments. To put this in context, Sandy (which was not a hurricane when it hit the city) caused approximately $19 billion in damages. The 250 recommended initiatives were a mix of suggested policy changes and discrete infrastructural investments, such as beach nourishment, bulkheads, tide gates, dunes, offshore breakwaters and living shorelines. The final comprehensive coastal protection strategy (Figure 13) was designed on the basis of a number of factors including the likelihood of coastal hazards, the impact of those hazards on the environment and infrastructure, the social

[12] The City of New York. Special Initiative for Rebuilding Resiliency. A Stronger, More Resilient New York. By Susan Van Gelde. N.p., n.d. June 11, 2013. Web.

vulnerability of different areas, and the cost-effectiveness of different strategies. The plan was developed iteratively, testing the effectiveness of different measures together and integrating community feedback. The city held numerous workshops and roundtables engaging more than 1,000 New Yorkers during the plan development.

Similarly, Boston has completed a number of detailed climate assessments including *Building a Resilient City: Preparing Our Infrastructure for Climate Change, Preparing for the Rising Tide, Climate Adaptation Challenges for Boston's Water and Sewer Systems,* and a *Regional Climate Change Adaptation Strategy*. **Boston is now in the process of knitting together these studies to create a unified plan as part of the comprehensive planning process, *Imagine Boston 2030*.** In less than a year the City hopes to work with consultants to create an integrated vulnerability assessment, prioritize recommended resiliency initiatives, and develop consensus on climate risk variables to use for planning efforts. This initiative is similar to New York City's as it draws on years of previous work, completed for a variety of purposes and different clients and audiences, and is attempting to create a cohesive strategy that builds upon earlier work without needless replication.

4.4 Recommended Approach

Given the clear value of a large scale systematic plan, but recognizing the relevance of pre-existing efforts, Miami-Dade County would be best served by adopting a hybrid approach similar to Boston or New York. A hybrid approach would incorporate both the best elements of the Dutch holistic planning approach, while taking advantage of the opportunity to move more quickly by leveraging the work done by WASD and other departments. **This could be done by simultaneously developing an enhanced capital plan while also developing a rapid action plan to identify and prioritize projects that should be implemented first to address the most immediate vulnerabilities in the County's critical infrastructure.**

Rapid Action Plan

This portion would focus on identifying the most urgent vulnerabilities to critical infrastructure. A project team comprised of key County staff from selected departments and the consultants should be created. This project team would help filter up critical needs, compare all proposed projects, quickly prioritize them, and create a phasing strategy to expedite implementation of the most urgently needed projects.

The project team would identify the most urgent vulnerabilities by collaborating with key departments. Each department would be responsible for identifying the most pressing needs in the system they manage. Departments would be asked to focus on elements of the system which would cause an overall system failure if they were compromised. For example, a key vulnerability would be one which causes the loss of electricity at the airport or the loss of the ability to receive new ships at the Port. This vulnerability analysis would rely heavily on the County's internal expertise and knowledge of its own systems and existing climate data including the information developed for WASD's vulnerability analysis. It is helpful to address known vulnerabilities first because many will be exacerbated by climate change. For example, if a key electrical system at the airport is vulnerable to flooding today, that risk will likely increase with time as sea level rises.

A consultant could then help the County review the projects suggested by the departments, prioritize among them, and create a phasing strategy for implementation. The consultant could develop a methodology for comparison of all projects and help screen for urgency, feasibility, and cost-effectiveness. The consultant working with the County could then create a phasing strategy for the "tier 1" projects. This prioritization process would help expedite funding and construction of the most critical projects and immediately address known vulnerabilities. Completion of a rapid action plan could also help departments improve their proposed projects, improve their position for funding, revise their own capital improvement plan to expedite resiliency measures, and help flag overlap in areas multiple departments have identified as vulnerable.

Stakeholder Engagement

Stakeholder engagement should be central to developing an enhanced capital plan. Creating the framework for an **iterative design** process will allow for flexibility and provide a way of integrating community knowledge into the technical design work. An iterative process can facilitate **collective learning**, wherein residents learn more about the technical considerations and technical experts can learn more about the community's preferences, use of and vison for an area. Close collaboration with stakeholders such as local institutions, business leaders, private utilities, community based organizations and others will also help the County prioritize its investments and focus on the most critical infrastructure that supports community resiliency more broadly.

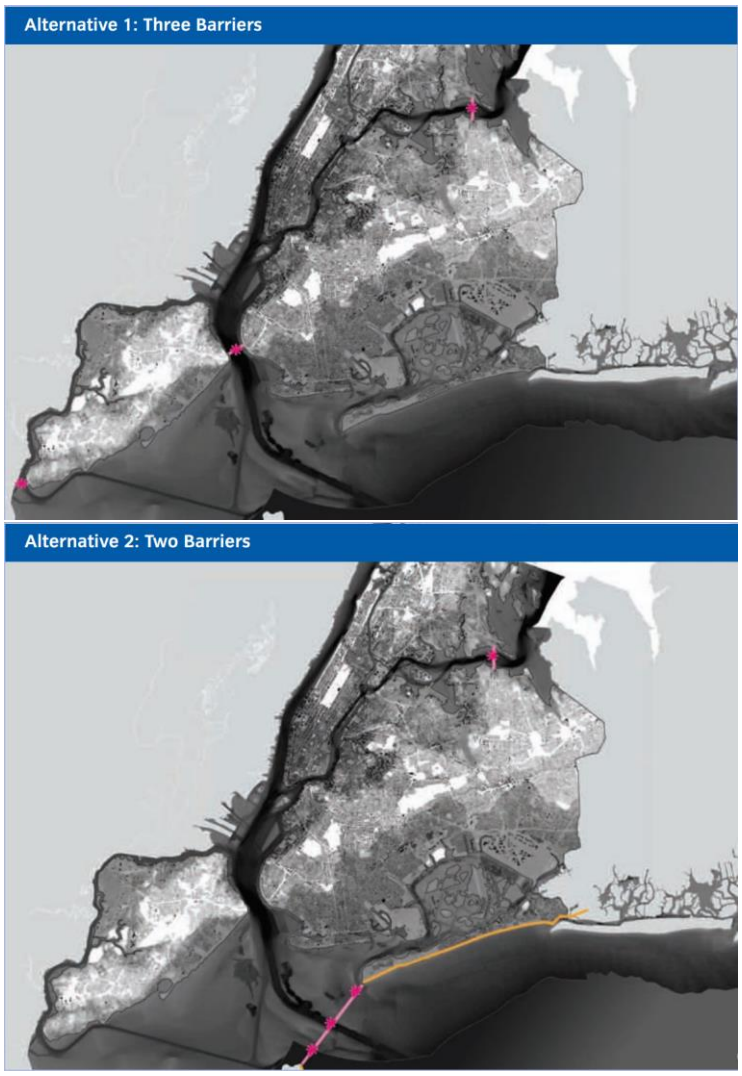
The scope of this portion could be adjusted depending on resources. For example, if resources are limited, the first phase could focus on selected critical infrastructure such as the airport or rely more heavily on County staff to assess and prioritize projects. If additional resources are available, the scope could be expanded to incorporate other systems such as transportation, stormwater management, the Seaport and the Internal Services Department.

Enhanced Capital Plan

Simultaneously, the County could create an enhanced capital plan that addresses medium and long-term risks. This plan would evaluate alternative resiliency strategies on the basis of their technical efficacy, economic impacts, and co-benefits to the community. Evaluation of alternative strategies would require external expertise in the fields of engineering, economics, adaptation planning, and community engagement.

One recommended method of developing an enhanced capital plan is to use scenario planning as used in the Netherlands and many other locations. This top down approach looks comprehensively at all infrastructure systems simultaneously to develop potential response plans. For example, before developing the city's comprehensive coastal protection strategy, New York also explored alternative scenarios of creating large storm surge barriers at the entrances to New York harbor (Figure 14). After exploring different alternatives, New York rejected them due to their expense, long time to completion, environmental impacts, and the projected creation of an "insider-outsiders" dynamic where some communities would be protected while others outside the barriers remained vulnerable.

Figure 14: Alternative adaptation scenarios for New York City



Source: A Stronger, More Resilient New York, 2013

The initial scenarios could be developed cooperatively with technical experts and key stakeholders. One scenario would quantify the costs and implications of inaction and others would explore different combinations of infrastructure investments and land use patterns. The specialized consultants could then evaluate their technical effectiveness and economic implications. Through the iterative development of scenarios the County could explore the technical effectiveness of various measures. For example, one suite of infrastructure investments could be compared to alternatives in terms of their ability to provide protection from a 100-year storm, ability to slow or stabilize the loss of wetlands or sandy beaches, and ability to protect critical infrastructure. An economic assessment could be paired with each technical assessment to evaluate scenarios in terms of metrics such as construction, operation, maintenance costs, ability to reduce losses or

economic disruption from hurricanes, or ability to protect property value and other critical, cultural, and environmental assets such as Biscayne Bay.

It would be fruitful to present interim scenarios to key stakeholders and the wider community to gain input and help build consensus around preferred options. Each scenario could be summarized in high-level terms including its key components, potential to prevent damage, benefits, trade-offs, and costs. An illustrative example of this type of scenario planning, from Portsmouth, England, describes three potential responses to sea level rise and their relative merits (Figure 15). Providing accessible summaries and renderings of these scenarios would allow the community and non-experts to contribute and provide feedback.

Figure 15: Example of Scenario Planning from Portsmouth, England

Source: Facing up to Rising Sea Levels: Retreat? Defend? Attack? Future of Our Coastal and Estuarine Cities. Institution of Civil Engineering.

Following this interim input, the scenarios could be further refined and reanalyzed. The scenarios could then be summarized into an accessible, narrative style report, which might include order of magnitude cost estimates, co-benefits, and potential impacts. If resources allow, the preferred scenario could be developed in much greater detail and include specific projects, detailed cost estimates, detailed descriptions of the benefits and trade-offs, phasing strategies, and funding mechanisms. It is important to include a phasing strategy so that the plan can be flexible and respond to changing environmental conditions. For example, the plan's phased implementation strategy could be structured around certain "triggers" such as a given rate of sea level rise or the occurrence of a tropical storm.[13] Other cities have proven that very detailed plans can be developed very quickly. However, working in a short period of time requires additional resources to support external experts and requires strong coordination between departments.

Developing these scenarios would provide the County with a full toolbox of potential responses to climate change and an understanding of the order of magnitude costs associated with various responses. It could help clarify the benefits and trade-offs associated with different approaches, helping the County to prioritize and develop consensus around the most promising opportunities. It would also help the County better articulate infrastructure needs and improve its position when applying for funding from federal, state, and private entities. **Creating an enhanced capital plan will also help evaluate the financial feasibility of various solutions and ensure that the proposal is achievable and implementable**. Without a comprehensive evaluation it is possible that a bottom up evaluation would generate a significant number of projects for each infrastructure system, which could grow in magnitude as climate risks increase.

[13] For more information on the concept of flexible "adaptation pathways" see this video by Deltares http://english.deltacommissaris.nl/delta-programme

4.5 Potential Costs of Retaining External Experts

The cost of retaining external experts to develop an enhanced capital plan depends directly on how comprehensive and detailed the County would like the plan to be. Another important cost driver is how quickly the County would like such a plan to be published. As demonstrated by the costs of other similar projects detailed in Appendix 2, it could cost between $1.5 and $5 million to complete a comparable project in Miami-Dade County. As one example, creating *A Stronger, More Resilient New York* required approximately five months and approximately five million dollars.

It is possible to phase the development of such a plan to match available resources. The resources currently allocated to the Office of Resilience ($800,000) will be used to initiate this process. If additional needs arise, they will be addressed in future budgets. Total funding needed for external experts could be reduced by drawing more heavily on internal County resources to manage the project and by limiting the consultant's scope of work to the technical and economic assessments. Following Hurricane Sandy, New York City temporarily pulled together more than 40 staff members from a variety of different agencies to work cooperatively for five months to develop their resiliency plan. Miami-Dade County could consider pursuing a similar strategy.

5 Conclusions

An enhanced capital plan developed with the support of external experts would address many of the County's current challenges with incorporating climate risks into capital planning. It has the potential to create a strong foundation for medium and long-term development. There are many useful precedents to draw upon including the experiences of New York, Boston, and the Netherlands. Similarly there are several different approaches the County can take to develop its own plan. Following a hybrid approach similar to New York or Boston and developing a rapid action plan and enhanced capital plan simultaneously may be the most expedient path forward for the County.

There are also many firms with very specific expertise in the range of disciplines needed to develop an enhanced capital plan, including engineering, economics, planning, community engagement, and communication. There may be benefits to working with several of these firms to take advantage of their individual expertise. There are also advantages to involving local universities and community-based organizations to the greatest extent possible. For example, a technical review board could be created in partnership with local universities to ensure the proposed adaptation measures are in line with known best practices. This review board could also potential help infuse the process with innovative ideas and connect with cutting edge research from the universities.

Most importantly, completing an enhanced capital plan has the potential to help prioritize and develop consensus around preferred adaptation measures. This could be very useful to ensure that short-term investments are not simply reacting to visible, short-term issues, such as nuisance flooding, but are instead proactively contributing to the long-term resilience of the community. Proactive collaboration with the private sector and local academic institutions is recommended to help ensure Miami-Dade County's proposed plan is innovative, multipurpose, and forward looking.

Appendix 1: Conceptual Scope of Work

This conceptual scope of work provides one proposed outline for how the County could proceed with developing an enhanced capital plan that, "reinvents the County's urban infrastructure in a timely, sequenced, and economically efficient manner." The intent is to create a process to develop effective actions that the County can undertake to protect its infrastructure in the face of increasing flood risks and ensure new projects are designed appropriately. The overall project objective is to identify and recommend actions for the short, medium, and long-term that would provide the County with a flexible and adaptable path forward in the face of changing climatic conditions and related risks associated with climate change including sea level rise.

Miami-Dade County: Enhanced Capital Plan

The project would provide the following:

1. A baseline vulnerability assessment
2. An enhanced capital plan including:
    a. An assessment of different adaptation pathways in terms of their technical feasibility, economic implications, and impact on natural and urban environments
    b. A structured stakeholder engagement process to solicit input on the different adaptation pathways and the enhanced capital plan
    c. Recommendations for implementation and phasing
    d. Identification of potential funding mechanisms
3. A rapid action plan:
    a. A review and prioritization of tier-1 projects identified by key Miami-Dade County departments in order to accelerate the implementation of the most urgent capital improvement projects
4. Development of a methodology for incorporating sea level rise into all capital projects[14]

1. Baseline Vulnerability Assessment

Significant investment and staff time has been dedicated to understanding the potential environmental changes associated with climate change and climate variability in Miami-Dade County. The project team will be provided with resources in order to expedite the implementation of adaptation actions. These resources include, but are not limited to, localized sea level rise projections, associated changes in the wet-season groundwater heights, storm surge modeling including sea level rise, areas of repetitive flood losses, areas of concern identified by the Stormwater Master Plan, and potential future precipitation patterns.

This will be a technical, internally-focused phase of work which is intended to build upon existing work already completed by the County.

Task 1.1 Review and confirm vulnerability parameters (month 1)

Review the sea level rise, flooding, and other data provided by the County. The County will provide a climate planning forecast, based on analysis and synthesis of the most recent data on climate impacts for the region. The forecast will be grounded in the extensive work done to date by the Water and Sewer Department, The South Florida Water Management District, Regulatory and Economic Resources, the Southeast Florida Regional Climate Change Compact and the Florida Climate Institute. The consultant will work with the County to confirm the key assumptions and planning horizon that will

[14] This component could be completed by County staff if resources dictate

be used for the development of the enhanced capital plan and the rapid action plan. Data will be provided as shapefiles where possible.

Task 1.2 Review and confirm exposure data (month 1)

The County will provide information on the key infrastructure and critical facilities, property, and population that will be impacted by sea level rise and flooding. The consultant will work with the County to confirm which exposure data can be reasonably assessed during the project timeframe. Data will be provided as shapefiles where possible.

2. Enhanced Capital Plan

The consultant will deliver a spatial plan detailing which adaptation measures are feasible and recommended for different portions of the county. These adaptation measures may include, but should not be limited to, new flood protection infrastructure, enhancing the existing drainage network, elevating key infrastructure, enhancing natural buffers, flood-proofing existing assets, or changing land use patterns. This plan will be based on a review of the technical feasibility of different adaptation measures, their economic benefits, their impacts on the natural and urban environment, and stakeholder input.

This phase of work will be an externally-focused.

Task 2.1 Stakeholder Engagement and Review of Precedent Work (Month 1)

The consultant will work with the County to develop a list of key stakeholders who should be initially consulted. These initial stakeholder discussions will discuss present issues and potential responses to inform the development of different adaptation scenarios.

The County will also provide the consultant with relevant background documents including:

- The Stormwater Master Plan
- The Local Mitigation Strategy
- The Comprehensive Development Masterplan
- GreenPrint (the County's Sustainability Plan)
- SE Florida Regional Climate Change Compact Regional Climate Action Plan
- One Community, One Goal

Task 2.2 Scenario Development

Task 2.2a Technical Assessment (Month 1-4)

The consultant will work the County and key stakeholders to develop a small number of adaptation scenarios that could feasibly be pursued in Miami-Dade County. These spatially-explicit adaptation scenarios will then be assessed to determine their technical feasibility, protective value, and ability to be altered in the future should conditions change. These scenarios should include a range of protection and accommodation strategies and include both structural and non-structural solutions.

Task 2.2b Economic Assessment (Month 2-4)

It is important to consider the economic feasibility and implications of investment in different adaptation measures in the initial planning phase. This assessment will consider the relative return-on-investment of alternative adaption approaches and explicitly consider the costs to protect different portions of the County from climate risks. The purpose of this analysis is to

estimate the economic or financial feasibility of protection strategies. These would be initial, order-of-magnitude estimates.

Through the use of scenario planning the consultant will consider the economic implications of different strategies in order of magnitude terms. The exact metrics used to complete this assessment would be developed by the consultant in consultation with the County. These could include, for example, the cumulative costs of adaptation, the replacement costs of lost infrastructure (roadway, sewer, water, electric, and critical public facilities such as police and fire stations), the loss of fiscal generating revenue, and lost economic activity. The analysis would compare the potential costs of alternative solutions and the underlying economic value preserved or enhanced by the adaptation measures. The costs could include the estimated cost of implementation of a strategy, the opportunity cost of lost net fiscal resources, real estate value, infrastructure, jobs, wages, and economic output associated with each scenario. The benefits could include an aggregate estimate of real estate value, infrastructure value, net fiscal revenue, jobs, wages, and economic output protected, and increases in property values attributable to adaptation investments. The consultant will work with the County to develop these high-level scenarios and estimates.

The consultant will work with the County and key stakeholders to present a summary of this information in a way that can be easily understood by the general public. This information will be presented during the stakeholder engagement process.

Given that the future sea level rise remains uncertain the timing of investment in adaptation is critical. The consultant will also work with the County to explore the potential to optimize investments and phase them in over time, based on certain flexible adaptation pathways tied to certain physical triggers (such as a given rate of sea level rise or the occurrence of a major hurricane).

Task 2.3 Scenario Refinement (Month 4-5)

The consultant will work with the County and key stakeholders to refine the adaptation scenarios based on the technical and economic assessments. The consultant will develop three or four potential scenarios, which will be presented in a way that they can readily be understood by the general public. They will be presented in a way designed to illicit feedback and educate the community about trade-offs and benefits associated with different approaches.

Task 2.4 Mid-way Stakeholder Engagement (Month 4-5)

The consultant will work with the County and key stakeholders to present the high-level adaptation scenarios to the public and solicit their feedback and input. The purpose of this engagement will be to educate the community about the trade-offs and benefits of different adaptation approaches as well as to listen to residents' priorities and concerns. To ensure ample opportunity for dialogue it is suggested that at least a portion of the engagement be structured in an open house or workshop format.

Task 2.5 Scenario Refinement (Month 5-8)

The consultant will use the input from the engagement process to further refine the adaptation scenarios. The consultant will reevaluate their technical or economic benefits to the extent necessary. The consultant will also further refine the presentation and communication of the information.

At this stage the consultant will also be asked to provide additional detail on project feasibility including: identifying potential funding sources, potential partners, potential financial or regulatory

incentives, regulatory or legal changes required, and critical coordination between public, private, and non-profit entities needed for implementation.

Task 2.6 Final Stakeholder Engagement (Month 8)

The consultant will work with the County and key stakeholders to present the second iteration of the adaptation scenarios to solicit final feedback. At this stage the consultant will also present information about feasibility including details on resources required, funding sources, and potential project phasing.

Task 2.7 Scenario Refinement and Feasibility Assessment

The consultant will work within the County to complete a final refinement of the scenarios based on feedback received.

Task 2.8 Final Report

Based on the analysis and stakeholder engagement the consultant will prepare a final report summarizing the refined adaptation scenarios as well as providing a recommendation on the preferred approach. In addition to containing the outputs of the technical and economic analysis the report should also summarize the feedback received and include examples of how the plans were refined to incorporate this feedback. The final report should also include a chapter on potential feasibility including potential funding sources, incentives, regulatory or governance changes necessary for implementation, community engagement needs, and a potential phasing strategy.

The final report should also include a short, high-level summary of adaptation scenarios which includes, to the extent possible, graphical representations of these scenarios. This summary should be aimed at the general public and should be easily understood by non-experts.

A draft of the final report will be provided to the County for review and comment before being finalized.

3. Rapid Action Plan

For this portion of the project the consultant will work closely with the County's infrastructure advisory group, which will be created and composed of key staff from selected departments responsible for critical infrastructure. The consultant will work with this group to review each department's list of improvements needed to address critical vulnerabilities. The consultant will then assess and prioritize these needs and develop a Rapid Action Plan, which will outline a phasing strategy for these more urgent projects.

This will be a technical, internally-focused portion of the project.

Task 3.1 Kick-Off Meeting (month 1)

Hold an in-person kick-off meeting with the Infrastructure Advisory Group. This meeting will finalize project goals and schedule. Infrastructure Advisory Group members will be asked to provide information on past vulnerability assessments and review infrastructure resiliency efforts already underway. Advisory group members will be asked to discuss potential data sources and/or other contributions from their agencies. This group may include, would not be limited to:[15]

- Internal Services Department
- Transportation and Public Works
- Water and Sewer
- Aviation

[15] The size of this group could be adjusted to match available resources. If funding is limited this group could be limited to just the most critical systems.

- Seaport
- Regulatory and Economic Resources
- Parks, Recreation and Open Spaces
- Police
- Fire Rescue

The County will support the logistics and invitations for this meeting.

Task 3.2 Identify Key Infrastructure Needs and Vulnerability (month 1-3)

The consultant will meet with department liaisons individually, or in groups as appropriate, to review the projects each department has identified as important to address critical vulnerabilities. This phase will focus on urgently needed improvements, such as where a major roadway is compromised at high tide, where access to a fire station is limited due to flooding, or where key electrical equipment is located at the ground level.

Each department will be responsible for providing the consultant with details about each needed improvement. Characteristics relevant to the vulnerability including location, elevation, flood-sensitivity, age, current condition, and planned service life will be described and cataloged and provided as shapefiles where possible.

Task 3.3 Assess and Prioritize Potential Projects (month 4-6)

Following the interviews with the Infrastructure Advisory Group the consultant will work with the County to develop a method to assess and prioritize the projects in terms of their cost-benefit and criticality. This could build on existing methods used by Emergency Management to prioritize mitigation projects. Factors may include, but are not limited to: life safety needs, criticality to ongoing operations for an infrastructure system, time sensitivity to gaining protection, lack of current or planned hazard protection projects, and high vulnerability to flooding. The exact method of prioritization would be developed in close cooperation with the members of the Infrastructure Advisory Group.

The goal of this prioritization process is to identify projects that should be implemented immediately to begin reducing the County's vulnerability.

Task 3.4 Final Report – Rapid Action Plan (months 6-8)

The consultant will develop a list of prioritized projects and recommend project phasing.

4. Develop a methodology for incorporating sea level rise into all capital planning

Moving forward all capital projects should incorporate future sea levels and flooding risks into the project design. Some departments, such as Water and Sewer, have already systematically evaluated their infrastructure and have a plan in place to incorporate climate change risks into new project designs. Other departments have not yet taken those steps. This portion of the project would develop a standard method and review process for incorporating climate risks into the design of all capital projects.[16]

[16] This portion of the project could be developed by County staff, building on precedents from other areas such as San Francisco. Alternatively this portion could be developed by a consultant.

Appendix 2: Potential Costs & Completion Times

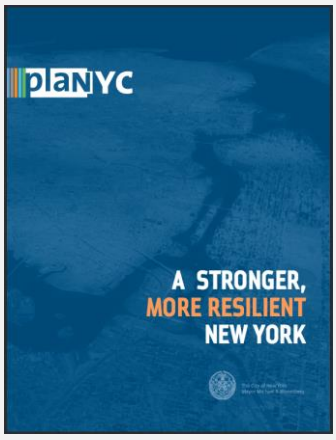
The following projects are a selection of relevant examples that can help inform Miami-Dade County's own adaptation planning efforts. Below are both examples of other projects from other areas as well as professional estimates provided by the interviewed firms. The examples are organized based on their completion time. Many of the project descriptions and cost estimates were provided by the engineering and planning firms that developed them.

Project and Location	Description	Time	Approximate Cost
New York City	*A Stronger More Resilient New York* was developed in a highly expedited manner in the immediate aftermath of Hurricane Sandy. Developing this plan relied on approximately 40 full time city staff and numerous consultants. This plan drew upon years of detailed and thorough assessments of climate risk, vulnerability of sub-systems (such as wastewater), and urban waterfront planning	5-6 months	Approximately $5 million
Norfolk, Virginia	Norfolk is in the process of developing a comprehensive resiliency strategy. They are developing a multi-layered strategy and phasing in different protective components over time. Developed quickly (less than a year) under time constraints imposed by an external competition. Developed with several consultants estimated to be approximately equivalent to 10-12 full time employees.	6-12 months	$600,000 - $800,000
WASD Ocean Outfall Program	Under Ocean Outfall program developed up-to-date climate scenarios for sea level rise (SLR), storm surge, extreme rainfall, and wind to incorporate climate risks and vulnerability assessments to build resilience into the $13.5B capital wastewater program. Focused on assessing WASD wastewater facility vulnerability and risk to projected changes in precipitation intensity, duration, and frequency (IDF), sea level rise (SLR), and storm surge. Climate scenarios were selected and were used to estimate coastal surge conditions. Those surge elevations were then coupled with rainfall to estimate inundation depths at each of 3 of WASDs critical treatment plants and 140 critical pump stations (140 out of over 1000). Flood hardening options were evaluated for different levels of risk. This data was used for flood risk evaluation and facility hardening evaluation and design guidance.	9 months	$600,000
Hoboken	This project, *Resist, Delay, Discharge,* was developed through the Rebuild by Design Competition. The plan is a comprehensive urban water strategy that addresses the risks of storm surge, sea level rise, and intense rainfall. Because of the competition timeline the project was developed in a very short time span.	9 months (initial design phase), implementation is ongoing	(design phase unknown; $230 million was awarded to support implementation)
Wilmington, North Carolina	A pilot project developed guidance on potential strategies to adapt to future SLR and extreme storm events on water and wastewater infrastructure for the Wilmington, N.C. area. It is built on a previous NC SLR Risk Management Study as well as an asset management study for the Cape Fear Municipal Utilities Authority.	9 months	$75,000
Engineering firm #1 estimate	For many local coastal resiliency plan projects, this company completes a thorough gap-analysis of all development, infrastructure planning and building to recommend across the board changes. For state level mitigation plans, they have looked across all agencies and programs with policies, programs or regulations that impact resilience and completed gap-analysis with recommendations for improvements. Many times changes to codes, policies, regulations and capital spending are very effective resiliency strategies that can come at low costs. Depending on the scope, such a study could be completed for Miami-Dade County in 6 months to a year for $40,000 to $100,000.	6 months – 1 year	$40,000 - $100,000
Engineering firm #2 estimate	Studies in other areas range in scope, detail and length and the cost and timeline also vary accordingly. Other studies have ranged from	1 year (initial planning) to 5-8	$100,000 - $25 million

	$100,000 to $25 million. A project could be designed for Miami-Dade County which is structured to complete the initial planning in the first year and longer-term planning over a period of 5-8 years.	years (long-term planning)	
Engineering firm #3 estimate	Most of this company's resilience planning efforts range in duration from one to two years and have budgets from $100,000 to $3,000,000.	1-2 years	$100,000- $3 million
Engineering firm #4 estimate	Conducted a regional study program which resulted in a stakeholder supported, implementable, staged plan backed up by a quantitative basis of costs and benefits could be completed in 1.5 to 2 years for $1-1.5 million. This plan would not contain all design details needed for implementation of the different elements. The cost would depend on the division of work between consultants and the government and the availability of good system models.	1.5-2 years	$1- $1.5 million
Engineering firm #5 estimate	To complete a first phase, utilizing existing baseline information (surge modeling etc.) and focusing on outlining certain strategies at a high level could be done for $100,000 to $300,000. To develop a capital plan, it will require $1-2 million dollars; however funding for a first round of $100-200,000 could provide an adequate start.	1-3 years	$100,000 - $300,000 (phase 1) $1 - $2 million (full plan development)
New Orleans Urban Water Plan	This plan outlines a long-term vision for remaking the water management system of New Orleans.	+2 years	~$2.5 million
NYCDEP Wastewater Resiliency Plan	Comprehensive flood protection plans for all of NYC's wastewater infrastructure, including climate vulnerability assessments, development of a citywide framework for future adaptation actions that may be vulnerable under current and future conditions.	2.5 years	$3 million
City of Virginia Beach	Developing a Comprehensive Sea Level Rise and Recurrent Flooding Analysis and Planning Study. This study provides an integrated approach starting with a hazard/risk assessment that will inform adaptation planning, initial conceptual designs and implementation.	3-4 years	$3 million
California Statewide Flood Management Planning Program	"California's Flood Future: Recommendations for Managing the State's Flood Risk" provides information for developing California's flood management policies and investments in the coming decades. More than 7 million people and $580 billion in assets (crops, buildings, and public infrastructure) are exposed to the hazards of flooding in California. The program identified the immediate need for more than $50 billion to complete flood management improvements and projects. Stakeholder engagement included information from more than 140 local agencies located in all 58 counties and State and Federal agencies. The report recommended flood management using an Integrated Water Management approach to promote system flexibility and resiliency to accommodate changing conditions such as ecosystem needs, climate change, flood events, and financing capabilities.	4 years	$12 million
Los Angeles	Through a Department of commerce grant they are beginning the adaptation planning for some components with a preliminary vulnerability assessment, which will be the foundation for the longer term study	5+ years	$4 million
Alexandria Virginia Storm Sewer Capacity Analysis	Consultants prepared a stormwater master plan, including assessments of capacity limitations based on projections of increased rainfall and sea level rise, and prioritization of problem areas and alternatives based on assessment of critical infrastructure	6 years	$3.5 million
Central Valley Flood Protection Plan, California	Consultants updated flood risk mapping in the Central Valley of California and provided public education, communications, and outreach. Developed state-of-the art data management tools to support California Department of Water's flood risk management program. Other uses include land-use planning, levee maintenance prioritization, programming of infrastructure investment, and preparations for emergency response plans.	7+ years	$25 million
Thames Estuary 2100	Consultants completed a comprehensive flood risk management for lower Thames River in London, including SLR and riverine and coastal surge risk to all infrastructure assets	10 years	14 million pounds (~$21 million)

Appendix 3: Examples from Other Cities

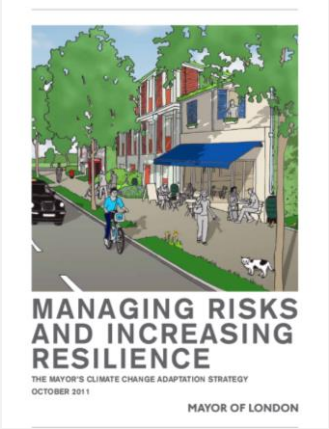
New York City



This comprehensive plan contains actionable recommendations for increasing the resilience of the city's infrastructure and buildings. The plan is organized by infrastructure systems such as telecommunications, transportation, water and wastewater and by communities such as South Queens and Southern Brooklyn. The plan covers all five boroughs and includes a comprehensive coastal protection plan. The plan's recommendations cover both infrastructure improvements and policy changes.

Available at: http://www.nyc.gov/html/sirr/html/report/report.shtml

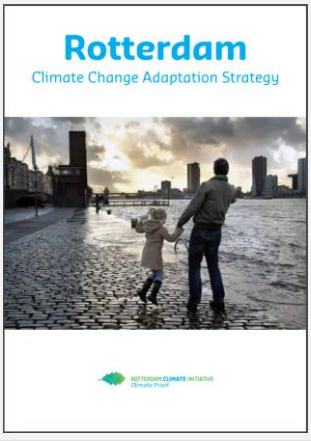
London



This plan outlines the Mayor's adaptation strategy for managing flooding, drought, and heat. The plan outlines tangible short-term benefits, such as improving parks and public spaces, that will help the city adapt to long-term challenges. Chapter 9 focuses on the city's infrastructure as one component in a larger system. This plan is more focused on identifying vulnerabilities and policy recommendations than on specific infrastructure improvements.

Available at: https://www.london.gov.uk/what-we-do/environment/environment-publications/managing-risks-increasing-resilience-mayors

Rotterdam



This very comprehensive plan frames the city's adaptation efforts in terms of the protective system (inner and outer dike systems) and in terms of different urban typologies (port, suburban, urban). This differentiation of strategies by typology could be very relevant to development of Miami-Dade's own plan. This plan developed in partnerships with external research centers.

Available at: http://www.rotterdamclimateinitiative.nl/documents/Documenten/20121210_RAS_EN_lr_versie_4.pdf

Appendix 4: Quarterly Reports

First Quarter Update (January 3, 2015 – April 30, 2015)

On January 21, 2015, the Board of County Commissioners (Board) approved Resolution No. R-49-15, which requested quarterly status reports and a final report within one year of adoption regarding the initiation of discussions related to climate change by the Mayor, in conjunction with the Office of Intergovernmental Affairs, with private insurance and reinsurance professional organizations, member local governments in the Southeast Florida Climate Change Compact, the Florida Office of Insurance Regulation's Department of Finance Services, and other key stakeholders to develop long-term risk management solutions. This is the first Quarterly Status Report submitted for your review. In accordance with Ordinance 14-65, this memorandum and report will be placed on the next available Board of County Commissioners meeting agenda.

Background

In July 2013, the Board created the Miami-Dade Sea Level Rise Task Force (SLRTF) for the purpose of reviewing current and relevant data, science and reports, and to assess the likely and potential impacts of sea level rise and storm surge to Miami-Dade County over time. On July 1st, 2014, the Task Force presented a report to the Board entitled, "Miami-Dade Sea Level Rise Task Force Report and Recommendations," providing the requested assessment along with recommendations of how Miami-Dade County may more specifically begin planning and preparing for projected sea level rise impacts. In addition, Resolution R-451-14 and Ordinance 14-79 were adopted in 2014, requiring that planning, design and construction of County infrastructure consider potential sea level rise impacts. On January 21st, 2015, the Board passed seven separate resolutions, each supporting the implementation of one of the seven recommendations included in the Sea Level Rise Task Force's Report. Resolution R-49-15 directs the Mayor to initiate discussions related to climate change with the insurance sector and other key stakeholders to develop long term risk management solutions.

On September 29, 2014, the Mayor and the Beacon Council co-hosted a meeting with the UK Ambassador, the UK Consul General, and key leaders in the business and insurance sectors of Miami-Dade to discuss issues and opportunities associated with climate change and sea level rise in Southeast Florida. In addition, the Mayor announced in his opening remarks at the Sixth Annual Southeast Florida Climate Leadership Summit on October 1st, 2014, that he will convene a group of business, financial and insurance leaders to begin a dialogue around these critical business and financial issues.

Quarter 1 Progress (January 31, 2015 – April 30, 2015)

The following steps have been taken during the first quarter towards implementation of this Resolution:

The Nature Conservancy contacted Miami-Dade County in March 2015 with information regarding their collaborative work with Swiss Re to demonstrate the cost effectiveness of coastal ecosystems in adaptation and risk reduction. They have developed "a set of tools and approaches for quantifying risks from coastal hazards and climate change," and provided a Project Note (see attached), summarizing the methodologies used and tools and models developed. They are proposing consideration of parametric insurance policy based on their existing model. Staff from the Regulatory and Economic Resources Department and Internal Services Department's Risk Management Division are currently evaluating the information provided for applicability and use by Miami-Dade County.

In addition, RER staff are working with the Office of Intergovernmental Affairs to identify appropriate stakeholders and candidates to include in an initial meeting, which will occur during the next Quarter.

If you have questions concerning the above, please contact Mark R. Woerner, AICP, Assistant Director for Planning, Department of Regulatory and Economic Resources, at (305) 375-2835 or mwoerner@miamidade.gov .

Second Quarter Update (May 1, 2015- July 30, 2015)

R-46-15: Prepare Action Plan and Report to Accelerate the Climate Change Adaptation Planning Process by Evaluating the Engineering and Other Relevant Expertise Needed to Develop an Enhanced Capital Plan

This resolution directs the Mayor or the Mayor's designee to prepare an action plan and report to accelerate the climate change adaptation planning process by evaluating the engineering and other relevant expertise needed to develop an enhanced capital plan that includes but is not limited to flood protection, salinity structures, pump stations, and road and bridge designs, and to determine the costs of retaining the experts needed.

Staff conducted the following research and interviews during the Second Quarter to address the preparation of the action plan required by this resolution:

- In September 2014, San Francisco's Capital Planning Committee adopted a new policy "Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco." RER staff have consulted with the Climate Program Director from the San Francisco Public Utilities Commission who helped create a consistent and comprehensive review, planning and implementation process to carry out that policy. San Francisco has addressed this challenge by requiring each department with responsibility for implementing capital projects to identify and map project sites included in the 10 year capital plan and verify whether they fall within a "Vulnerability Zone" as defined and mapped by San Francisco's sea level rise committee. For each project exceeding $5 million, departments are required to complete a Sea Level Rise Checklist and submit it for review to the Capital Planning Committee and the City Engineer's Office. Departments are also required to submit specific long-term strategies to specifically address the adaptive capacity of the project. The San Francisco Public Utilities Commission makes its consulting firm (AECOM) available for training and assistance to individual departments who are unsure of how to comply with the requirements. Aspects of the approach adopted in San Francisco may have direct applicability to addressing some of the needs of Miami-Dade County. In particular, this approach may be useful to evaluating routine capital projects across departments.

- RER staff have reviewed the U.S. Department of Transportation Federal Highway Administration's training series "Building a Climate Resilient Transportation System". While it is focused on transportation infrastructure, the methods and tools available for assessing a system's criticality and sensitivity to climate and extreme weather, and therefore its vulnerability, would be applicable across other systems. At a minimum, these tools, as well as tools available from the Florida Department of Transportation, could be immediately useful for informing the capital planning process for future transportation projects.

- The City of Miami Beach has commissioned the engineering firm AECOM to conduct a study focused on performing modelling of the existing stormwater infrastructure to support collection system and conveyance improvements along with stormwater pump stations to mitigate flooding potential for low lying areas. The study also involves elevating roadways, sidewalks, and other public infrastructure. While this study is being conducted at a smaller scale than that needed to assess the vulnerabilities of Miami-Dade County, it serves as a useful precedent and benchmark to estimate the potential resources required for a larger scale study. The City of Miami Beach is also conducting a study to evaluate stormwater utility rates. The study is exploring what changes may be needed to support the necessary major capital improvements required to mitigate flooding. The results of this study will also provide useful information on a potential financing mechanism for future infrastructure investments.

- RER staff are continuing to consult with other county departments - Water and Sewer Department, WASD); Public Works and Waste Management (PWWM); and Parks, Recreation and Open Spaces (PROS) - which all have various levels of experience integrating flood risks into capital planning and prioritization. This work is being reviewed in consideration of developing a broader process for all County departments.

- RER staff also consulted with City of Fort Lauderdale staff about their approach to incorporating sea level rise considerations into their capital planning process. These considerations have been incorporated through the use of Adaptation Action Areas. They shared their prioritization process with RER staff, but the

approach adopted by the City of Fort Lauderdale is not directly applicable to the capital planning and prioritization process employed at Miami-Dade County's scale.

- The Compact's Sea Level Rise Consensus Workgroup has finalized a revised Sea Level Rise Projection for Southeast Florida. This projection differs to some degree from the original sea level rise projection developed in 2011, and will be utilized for planning purposes by Miami-Dade County and the other partners of the Compact. This revised projection and accompanying document are expected to be publicly released in the fall of 2015, and are currently available for internal review.

Third Quarter Update (July 31, 2015- October 31, 2015)

R-46-15: Prepare Action Plan and Report to Accelerate the Climate Change Adaptation Planning Process by Evaluating the Engineering and Other Relevant Expertise Needed to Develop an Enhanced Capital Plan

This resolution directs the Mayor or the Mayor's designee to prepare an action plan and report to accelerate the climate change adaptation planning process by evaluating the engineering and other relevant expertise needed to develop an enhanced capital plan that includes but is not limited to flood protection, salinity structures, pump stations, and road and bridge designs, and to determine the costs of retaining the experts needed. This resolution requires a status report within 90 days and a final report within 180 days of the effective date. A resolution authorizing an extension to provide the final report is pending final Board approval.

Staff conducted the following research and interviews during the third quarter to address the preparation of the action plan required by this resolution:

- RER staff continued many tasks initiated in previous quarters including working with the Water and Sewer Department (WASD), the Stormwater Utility Planning Division (formerly in the PWWM department) at RER, and the City of Miami Beach, to evaluate the applicability of their existing contracts with various firms to plan for adaptation to rising sea levels. Each of these existing contracts provide very useful information which can serve as a springboard for the County's own efforts. The technical products from these projects are also being collected by RER staff to inform the final reports for this resolution and Resolution R-48-15.

- On August 31, 2015, RER had a conference call with the city of Seattle staff to discuss how the city has incorporated sea level rise into its capital project planning process. The City staff explained how consideration of sea level rise implications were integrated into their Public Works department's "stage gates" process, which is designed to rationalize investments and ensure that capital improvement projects make sense from a triple bottom line perspective. Before creating this review process Seattle had two rounds of studies developing localized sea level rise projections which were then mapped in GIS and used for a vulnerability analysis. Project managers and have adopted the sea level rise projection and have experienced a relatively low marginal cost to elevate projects to be resilient to sea level rise. City staff are beginning conversations with other agencies to ensure that these resilient projects do not become islands, but are instead supported by the surrounding infrastructure. The City has yet to encounter significant pushback against these new requirements and has generally found good buy-in. Seattle is considering strengthening their floodplain regulations in the future to better incorporate sea level rise, but have not determined the timing for this yet.

- On September 2, 2015, RER staff spoke with New York City to discuss how the City developed the comprehensive coastal protection strategy outlined in *A Stronger More Resilient New York*. This comprehensive strategy drew heavily upon the *Urban Waterfront Adaptive Strategies* guide (discussed later in this report) and previous supporting research such as that done by the New York City Panel on Climate Change. Building on this foundational research and working with an urgency provided by Hurricane Sandy, the New York City team developed a comprehensive strategy for coastal protection in a period of five months. Typically, an effort of this scale would take one to two years, at a minimum. With an internal team of over 40 people pulled from various departments, and with the support of external consultants and academics, the plan was published in June 2013. Even though the plan was prepared

over a short time period the team garnered significant community engagement and feedback that was incorporated into the final plan. This comprehensive plan serves as an excellent model that Miami-Dade County should consider drawing from as the County prepares its own strategy.

- On September 3, 2015, RER staff spoke with staff at the City of San Francisco about how the city has incorporated sea level rise into its capital planning process and to discuss the city's process to develop the sea level rise checklist summarized in the Second Quarter report. To support the development of the checklist and the accompanying comprehensive guidance document framing vulnerability and adaptive capacity, City staff worked with liaisons from key government departments for over a year. Through frequent meetings they were able to develop a process that had wide buy-in from other departments. Through that process they were also able to integrate additional training on climate change and sea level rise to bolster their internal capacity to respond to these changes. During this process the city was able to draw upon existing contracts with consulting firms with the relevant technical expertise. For example, the city was able to draw upon the engineering firm that was under contract to develop a comprehensive capital improvement plan for the city's sewer system. One of the many strengths of the approach adopted by San Francisco is that it provides considerable flexibility to account for the type of project, the project lifespan, and the marginal cost of future adaptations, as well as other considerations. This allows project managers to select the appropriate adaption scenario based on their project. For example, a fire station that is intended to function in place for 75 years, will be built to a much higher elevation than a new park gazebo with a lifespan of only 20 years. San Francisco has shared the materials they used to develop the guidance, their sea level rise project checklist, and their training materials. This process is also an excellent example of how Miami-Dade County can begin to systematically integrate considerations of sea level rise into its own capital planning process.

- During the week of September 21, 2015, RER staff interviewed eight major planning and engineering firms to ascertain the approximate cost, timeline, and scope of work that would be required to develop an enhanced capital plan involving all levels of government to reinvent Miami-Dade County's urban infrastructure. The intention of these interviews was not to evaluate any of the firms, but rather to conduct market research and gather order of magnitude estimates of the approximate costs to fulfil this resolution and better understand how this work could be structured. During these interviews, the firms were asked to discuss precedent projects where their firms had developed a comprehensive capital plan, flood protection plan, or resiliency plan that would be relevant to Miami-Dade County. For each example, the approximate time and resources required to develop it were discussed. Firms were also asked how this work could be phased and subdivided to provide more flexibility based on future funding availability. Specifically they were asked to detail which subcomponents (i.e. economic assessments of adaptation strategies) they would recommend including in phase one of the process. All firms were asked how they could build upon the extensive data and analysis the County has previously developed (i.e. localized sea level rise projections, surge, groundwater, and stormwater modeling etc.) to maximize project outcomes. All firms were asked how they would adapt their work to reflect the unique hydrology and geology in Southeast Florida, which precludes a number of typical flood defenses such as levees. All firms were asked if they have experience evaluating existing codes/regulations/procedures to understand how they could better encourage resilient investments in other capital projects. Finally, all firms were asked how they integrated community engagement into prior planning projects.

- On September 23, 2015, RER staff spoke with a senior climate scientist and coastal engineer from the Army Corps of Engineer's (USACE) Institute for Water Resources in Portland, Oregon. Both individuals are experts in how to incorporate sea level rise into capital project planning. During the conference call, the discussion focused on how Miami-Dade County could potentially implement the USACE's Engineering Technical Letter on sea level rise, which is already partially incorporated through the SE Florida Regional Climate Change Compact's (Compact) Unified Sea Level Rise projection.

Attachment 4

REPORT ON FLOODING AND SALT WATER INTRUSION

September 2016

Final Report for Resolution R-48-15 in support of the Sea Level Rise Task Force final recommendations

Table of Contents

Note on all figures:
If you have any questions or trouble reading any of the figures, please contact the Office of Resilience at green@miamidade.gov to request additional information or a higher resolution version.

Introduction – Supporting Resolution & Context

On January 21, 2015 the Miami-Dade County Board of County Commissioners passed Resolution R-48-15. This resolution directed the Mayor or the Mayor's designee to,

> "work in conjunction with the Office of Intergovernmental Affairs and jointly with the South Florida Water Management District, the United States Geological Survey, and the other member counties of the Southeast Florida Regional Climate Change Compact partners, to conduct a comprehensive study and develop adaptation strategies to address potential flood damage reduction and saltwater intrusion associated with sea level rise and to put forth a time frame for implementation and potential funding mechanisms."

This is the final report in support of the aforementioned resolution. This report provides a summary of the major efforts, complete or underway, to understand the implications of sea level rise on increased risks for flooding and saltwater intrusion. This report was developed over the past year in partnership with multiple agencies including the U.S. Geological Survey, The South Florida Water Management District, and The Army Corps of Engineers. The County has worked with these entities and many others to conduct a comprehensive review of all the studies and adaptation work that is going on to address flooding and saltwater intrusion.

Because of the large volume of work happening, it is not possible to describe each project and its findings in full detail. Instead, the report provides a summary and a roadmap of these initiatives. More detailed information on any of the initiatives included in the report can be provided by the Office of Resilience or the leading institution.

It is important to note that this report presents only a partial snapshot of the current efforts to understand these issues. Tens of millions of dollars have and are being directed to answering and addressing these questions. Multiple entities are engaged in directing this research including local and state universities, multiple federal, state, regional and local agencies, the private sector, non-profits and corporations, and the Southeast Florida Regional Climate Compact ("The Compact"). The level of research and planning in Miami-Dade County focused on adaptation to sea level rise and salt water intrusion is exceptional. Miami-Dade County is fortunate to have the support of many world class entities dedicated to understanding the issues and researching adaptation measures. Most importantly, Miami-Dade County continues to benefit tremendously from the close collaboration facilitated by The Compact and the Florida Climate Institute. Investments in research and adaptation measures have increased steadily and will likely continue for the foreseeable future. It is worth underscoring that the County has benefited significantly from outside funding from philanthropies, federal agencies, and universities.

It is worth underscoring that the County has benefited significantly from outside funding from philanthropies, federal agencies, and universities.

This report also provides a roadmap to where updated information can be found. Many institutions including the National Aeronautics and Space Administration, The National Climate Assessment, the South Florida Water Management District, National Oceanographic and Atmospheric Administration and many non-profit groups have helped synthesize the existing information and made it into publicly accessible, user friendly webpages.

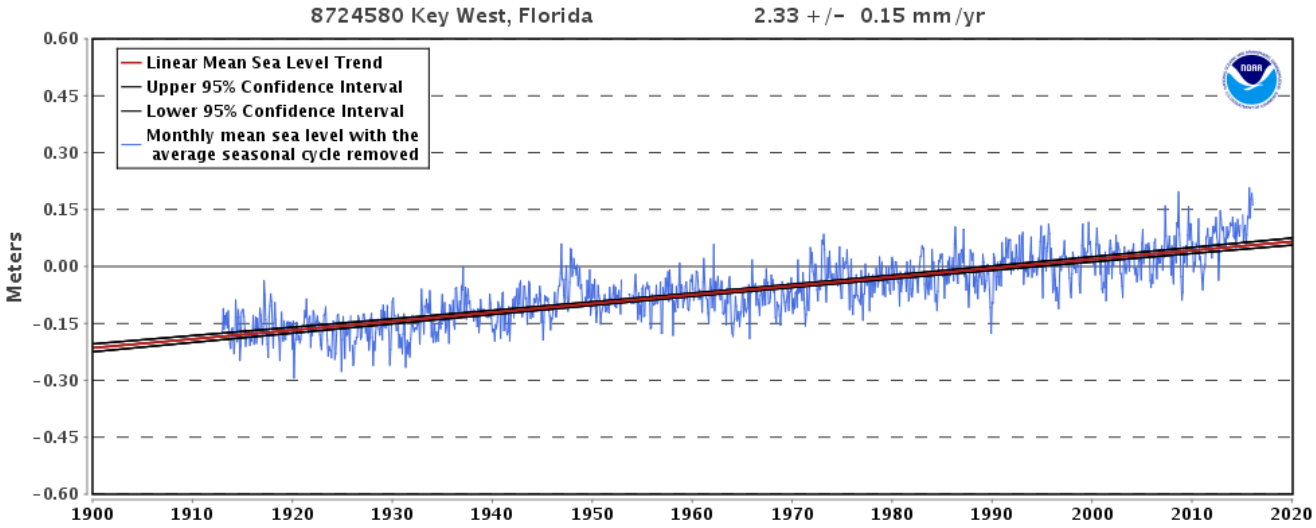
This report also includes a review of on-going efforts to mitigate the risks of flooding and saltwater intrusion. While these risks are being amplified by sea level rise, many entities including the Miami-Dade County Water and Sewer Department, the Miami-Dade Department of Regulatory and Economic Resources' Water Management Division, and the South Florida Water Management District have been monitoring these risks for years. The impact of sea level rise on these risks is an active area of study; however, the available information including the Compact's sea level rise projection, is being incorporated into on-going programs. Sea level rise has amplified the need to evaluate the effectiveness of specific infrastructure and general strategies. Re-evaluating these complex water management systems and evaluating the appropriate adaptation measures for different components of the system is underway, but will take years to fully complete. The process could be expedited with additional funding or it could be accelerated by prioritizing investments in known mitigation needs. For example, there are more than 1,000 projects that are part of the Local Mitigation Strategy that could reduce the Community's vulnerability to known hazards in the short term and the vulnerabilities to longer-term changes.

This report also includes potential funding mechanisms for adaptation measures, details research gaps and next steps. Overall the report provides a snapshot of the extensive work taking place to better understand the impact of sea level rise on flooding and saltwater intrusion. Given the breadth of this work it is only possible to provide a summary, however, more information can easily be provided by the Office of Resilience or the leading institution.

Sea Level Rise- What can be Expected

Since reliable record keeping began over 100 years ago at the tide gauge in Key West, the average sea level has risen approximately 228 millimeters (9 inches) (Figure 1). This means that sea levels have been increasing by approximately 2.33 (+/- 0.15) millimeters per year in the past century. This is slightly higher than the global average rise of 0.17-0.21 meters (or 6.69-8.27 inches) over the same period. The rise in average global average sea levels has been primarily due to thermal expansion (as warmer water occupies more volume) and to melting land-based ice from glaciers and ice sheets. Over the next century the rate of sea level rise is very likely to accelerate due to increased melting from land-based ice sheets, in particular Greenland, and continued thermal expansion.[1]

Figure 1: Sea level rise records from tide gauge data in Key West, Florida



Source: National Oceanographic and Atmospheric Administration

Recognizing the need for clear, consistent, and local information about future sea level rise projections, The Compact developed the, "Unified Sea Level Rise Projection for Southeast Florida".[2] The original projection was updated in 2015 by a panel of local scientists using the most recent and best available data.

The projection (Figure 2) describes the sea level rise expected compared to 1992 levels. From that starting point, the region can expect to see average sea levels 6 to 10 inches higher by 2030, 14 to 34 inches higher by 2060, and 31 to 81 inches higher by 2100. There is a more certain estimate for near-term changes and a greater uncertainty surrounding water levels at the end of this century. According to the Work Group that developed the projection, there is a wider

[1] For a more detailed review of the causes and contributions to changing sea levels see the IPCC's Fifth Assessment Report Chapter 12 "Sea Level Change" available at http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter13_FINAL.pdf

[2] Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact) October 2015. *Unified Sea Level Rise Projection For Southeast Florida*. A document prepared for the Southeast Florida Regional Climate Change Compact Steering Committee

range of future projections due to the uncertainty around "future greenhouse gas emissions and their geophysical effects, the incomplete quantitative understanding of all geophysical processes affecting the rate of sea level rise in climate models and current limitations of climate models to predict the future."[3]

Figure 2: Unified sea level rise projection for Southeast Florida

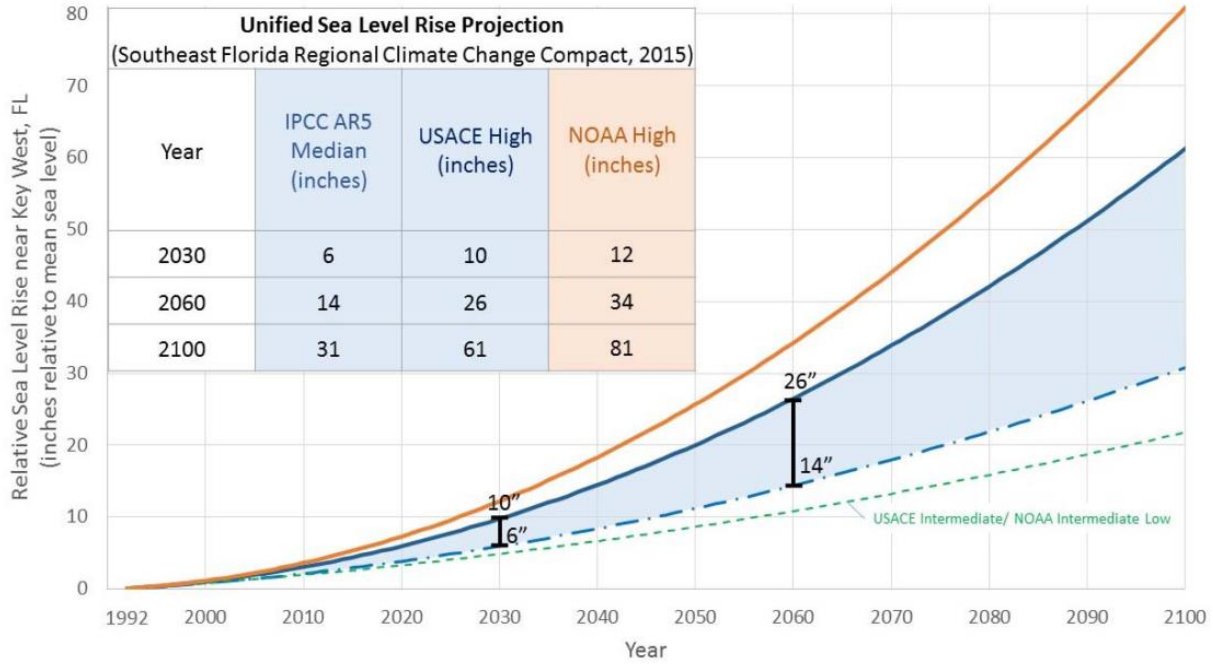


Figure 1: Unified Sea Level Rise Projection. These projections are referenced to mean sea level at the Key West tide gauge. The projection includes three global curves adapted for regional application: the median of the IPCC AR5 RCP8.5 scenario as the lowest boundary (blue dashed curve), the USACE High curve as the upper boundary for the short term for use until 2060 (solid blue line), and the NOAA High curve as the uppermost boundary for medium and long term use (orange solid curve). The incorporated table lists the projection values at years 2030, 2060 and 2100. The USACE Intermediate or NOAA Intermediate Low curve is displayed on the figure for reference (green dashed curve). This scenario would require significant reductions in greenhouse gas emissions in order to be plausible and does not reflect current emissions trends.

Source: Southeast Florida Regional Climate Change Compact

Due to the range of potential changes, the Work Group recommended including multiple sea level rise "curves". This was intended to give decision-makers flexibility to tailor information to suit different purposes. The lower curve could be used when designing projects that are low-risk, have a short design life, or low replacement costs. For example, this estimate may be appropriate when designing a surface parking lot or park gazebo that is intended to last for 20-30 years. The highest curve, or most conservative estimate, would be a more appropriate estimate to use for projects such as a new substation, a major evacuation route, or a hospital. The scientific members of the workgroup recommended using the shaded blue zone for most projects with a short planning horizon. This shaded area "reflects what the Work Group projects will be the most likely range of sea level rise for the remainder of the 21st Century."

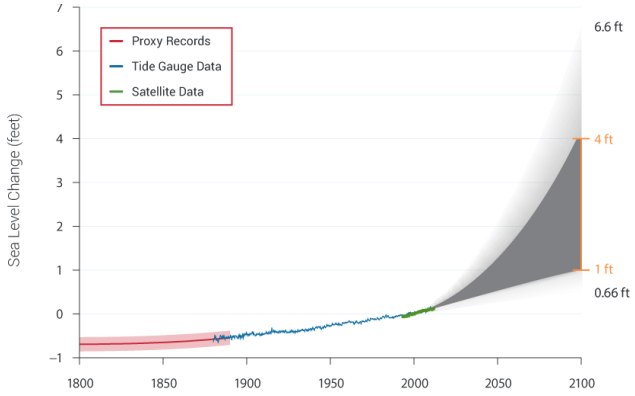
The projections developed by the Compact are most appropriate for use in local planning efforts because they incorporate local variables such as land subsidence, changing ocean

[3] Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact) October 2015. *Unified Sea Level Rise Projection For Southeast Florida*. A document prepared for the Southeast Florida Regional Climate Change Compact Steering Committee. p. 1

currents, and gravitational changes due to mass redistribution. However, for individuals interested in staying current on how global sea levels are changing there are a number of useful sources for general information:

- **The National Climate Assessment** report summarizes the impacts of climate change on the United States, now and in the future.[4] A team of more than 300 experts created the report. An entire chapter is dedicated to sea level rise (Figure 3).

Figure 3: National Climate Assessment's information on sea level rise

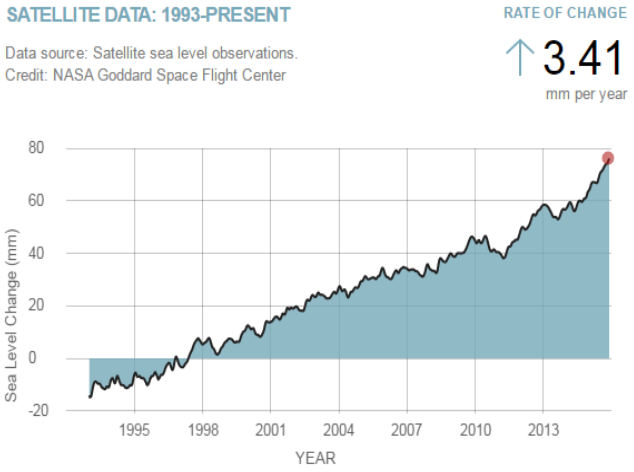


Source: National Climate Assessment

- **National Aeronautics and Space Administration's Global Climate Change** project maintains very up-to-date estimates of the rate of sea level rise based on satellite observations and tide gauge records (Figure 4).[5]

- **The Intergovernmental Panel on Climate Change** provides an up-to-date view of the current state of scientific knowledge relevant to climate change.[6] The most recent report, the Fifth Assessment Report, includes several chapters focused on sea level rise. This report includes very detailed information about the contributing sources to sea level change including warming oceans, melting ice sheets, melting glaciers, and others.

Figure 4: NASA's observations of sea level rise from satellite observations, 1993-present



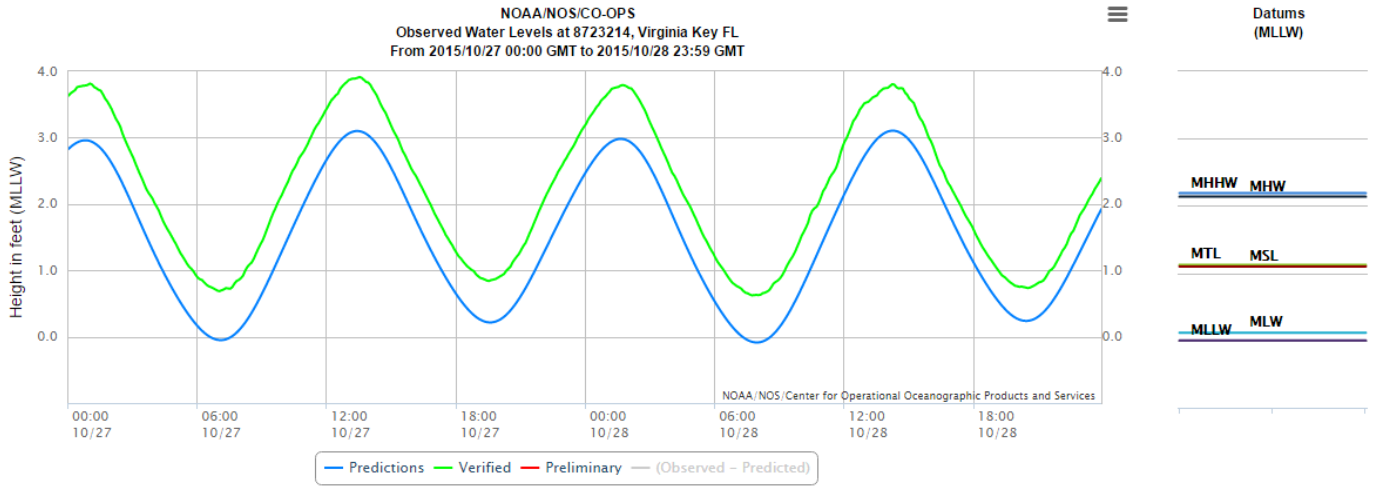
Source: NASA Goddard Space Flight Center

- **The National Oceanographic and Atmospheric Administration's Tides and Currents** provides near real time observation of local water levels across the country.[7] There are many stations in the region that provide high-quality data including a station on Virginia Key. This can provide valuable information about actual water levels to assist the County in monitoring king tides when the observed levels are higher than what has been predicted as they were this past October (Figure 5). This site also provides updated sea level rise trends based on observation from tide gauges across the country. This information can help verify

[4] The report is available at http://nca2014.globalchange.gov/
[5] This information is available at http://climate.nasa.gov/vital-signs/sea-level/
[6] Information is available at http://www.ipcc.ch/
[7] Information is available at https://tidesandcurrents.noaa.gov/

sea level rise projections and reveal the level of inter-annual variability that decision makers could plan for.

Figure 5: Observations of water levels at Virginia Key, FL in October 2015



Source: National Oceanographic and Atmospheric Administration/NOS Center for Operational Oceanographic Products and Services

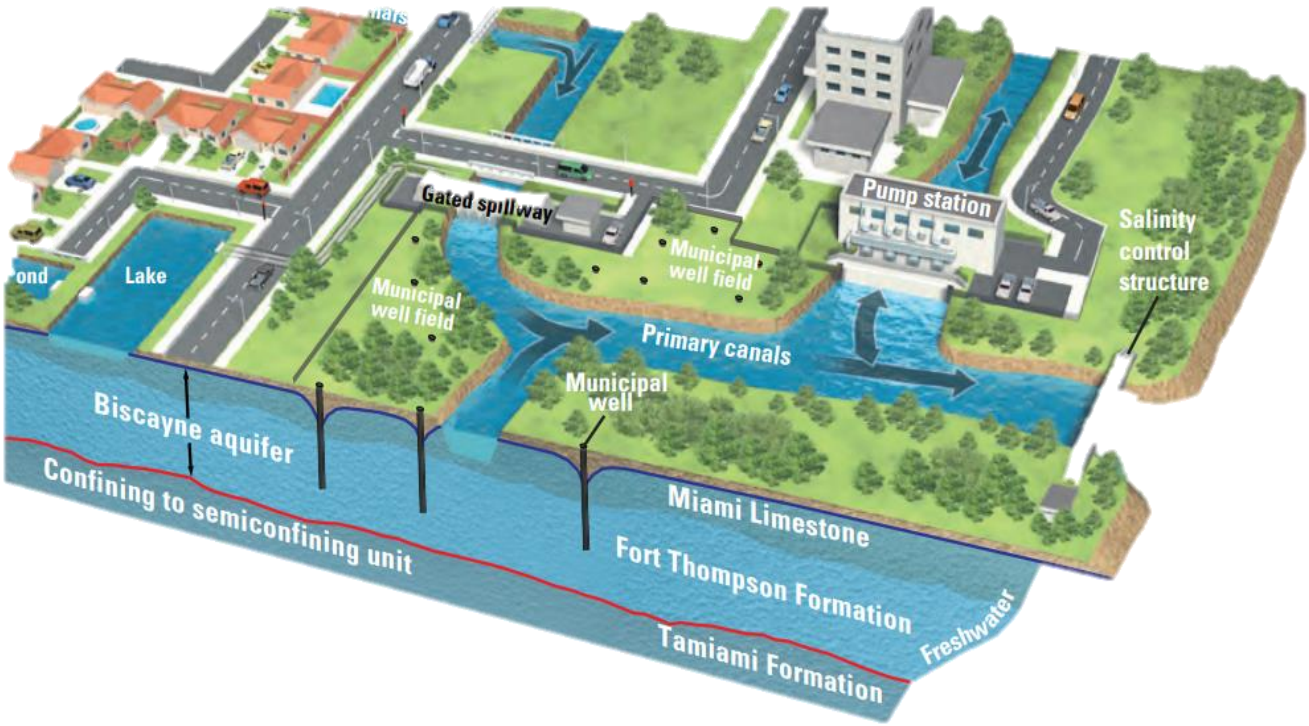
Flooding

Overview of the Risks

As sea levels rise the risks of flooding increases; however, just as there are multiple causes of flooding there are similarly many different impacts from rising sea levels. Higher average water levels can contribute directly to higher high tides and storm surges. This type of flooding can be observed most easily when water "overtops" existing sea walls and floods the urban areas of the County during seasonally higher tides.

Perhaps more importantly, higher sea levels also contribute indirectly to flooding by impacting groundwater levels and the drainage network. As groundwater levels rise, lands that were drained as a result of the canal project may be more difficult to protect from flooding. In certain areas it could become challenging to draw down the groundwater levels without active management and/or pumping. As the groundwater rises it is also possible to lose the storage capacity in the soil that typically helps alleviate flooding after rain events. With some loss of the capacity to infiltrate, water levels may remain higher for longer periods of time, particularly during the rainy season. Higher groundwater and sea levels may also incrementally reduce the effectiveness of the drainage infrastructure meaning that the extent or duration of flooding may

Figure 6: Conceptual diagram showing the components of the surface-water management in Miami-Dade County



Source: Image modified from South Florida Water Management District, 2010

last longer than it has in the past. For example, if French drains or other exfiltration systems become saturated this may compromise their effectiveness.

Sea level rise will likely amplify flooding risk across the region; however, the specific impacts will be highly local. These local difference can be attributed to local differences in topography or soil type, but more importantly due to the extensive manipulation of the local hydrology through management efforts. Across the region water is carefully managed by the South Florida Water Management District through the regional canal network, by the County and the secondary canal network and drainage infrastructure, and by the municipalities and even individual property owners through additional water and stormwater management efforts. These entities carefully monitor and manage water levels to reduce the risk of flooding to the greatest extent permeable. While Southeast Florida is inherently vulnerable to flooding due to its low topography, porous substrate and exposure to tropical storms, there are multiple efforts underway to reduce those risks. Several projects at the regional and local level are underway to ensure that the on-going planning and management efforts are fully incorporating the implications of changing sea levels. There is substantial regional expertise in water management and this will help the region adapt its infrastructure and operations to changing conditions.

The following section will provide additional details on how sea level rise is being studied and incorporated into on-going efforts.

Major On-Going and Planned Studies

The next section details the status of several of the most important studies that are focused on flooding risks in Miami-Dade County. These are a subset of the most important studies.

The South Florida Water Management District Level of Service Studies

One of the core responsibilities of the South Florida Water Management District is to operate and maintain an extensive water management network of canals, levees, water storage areas, pump stations and other water control structures (Figure 6). This system, called the "Central and Southern Florida Project", is one of the largest flood control systems in the world. The South Florida Water Management District is also the lead state agency responsible for restoring America's Everglades, currently the largest environmental project in North America.

Historical data shows that sea levels have risen about four inches in the last 50 years. The Compact's "Unified Sea Level Rise Projection" predicts sea level in South Florida's coastal areas will rise by 6 to 10 inches by 2030, relative to the 1992 mean sea level (Figure 2). Historic sea level rise is already causing challenges to some District operations. In Miami-Dade County some water control gates cannot be opened twice a day at high tide, when the level of the ocean is higher than the level of water in the canals.

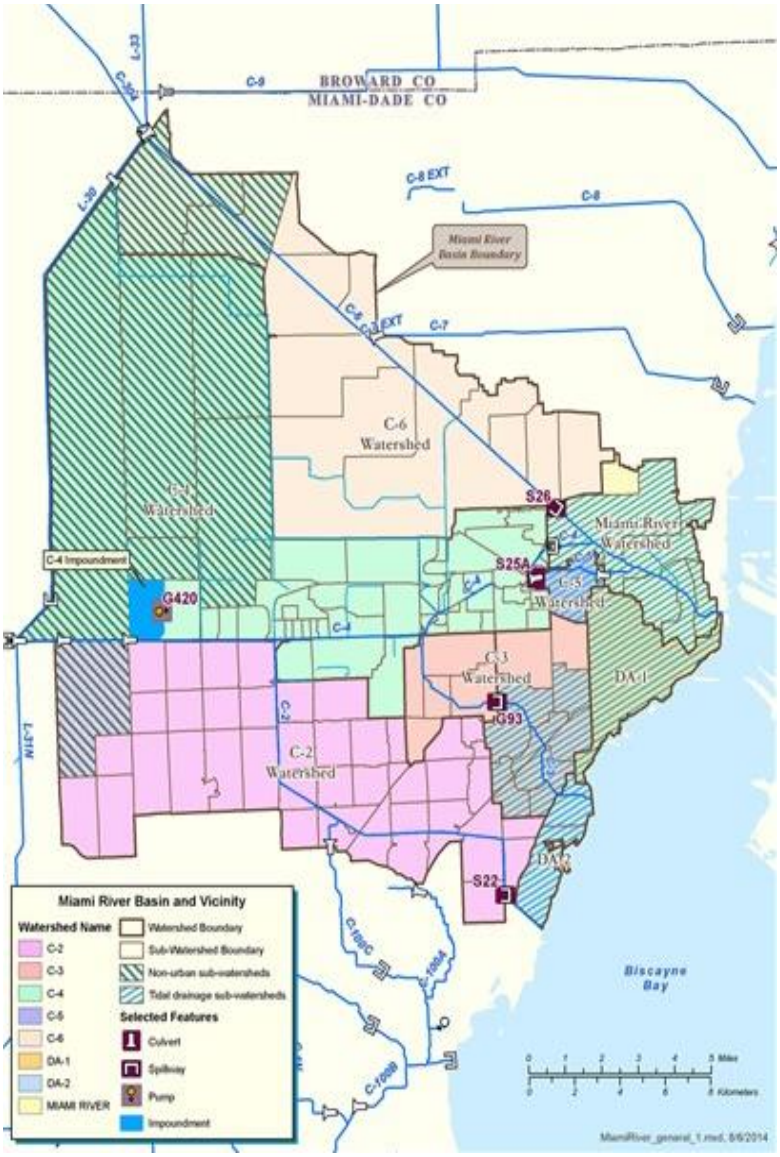
The existing Central and Southern Florida system was built by the federal government in the 1950s with minimal, if any, consideration given to potential future sea level rise. The South Florida Water Management District has worked extensively to coordinate at all levels of government to assist adaption to the impacts of current and projected sea level rise. The South Florida Water Management District has been examining the issue since 2008 to determine the best short-term and long-term strategies. As part of planning efforts, the District has written three white papers and two are currently available on the District's website.[8] Currently, the 2009 white paper on climate and sea level rise is being updated with the most recent information. The South Florida Water Management District has already installed two forward pumps in some of the most vulnerable areas near the Miami International Airport, in coordination with the Federal Emergency Management Agency. The project allows the District to continue draining floodwaters in the near future even as the sea rises. The South Florida Water Management District has also invested in the creation of a reservoir, or impoundment, in the western area of the county (C-4 basin) to reduce flooding in the more urbanized southern and eastern regions, and to facilitate groundwater recharge which can help reduce salt water intrusion.

The South Florida Water Management District has a new program to evaluate the current and future Level of Service for flood protection throughout the 16-county region as a means of

[8] These reports are available at: http://www.sfwmd.gov/portal/pls/portal/portal_apps.repository_lib_pkg.repository_browse?p_keywords=climatechange&p_thumbnails=no

identifying and prioritizing long-term infrastructure needs. Level of Service projects provide a process to establish flood protection thresholds for each basin. These thresholds inform and initiate retrofitting and adaptation efforts that will be implemented in conjunction with the annual structure maintenance program. Results of these studies will be used to identify sea levels at which existing infrastructure can no longer provide flood protection, facilities at risk of being impacted by flooding, and the potential need for improvements to operations, canal conveyance, or primary and secondary drainage facilities.

Figure 7: Miami River basin and vicinity



Source: South Florida Water Management District

The level of service study is a key component of an "adaptive resilience" approach to reducing potential flood risks and damages. Once levels of existing and potential future risks have been defined, the first step is to initiate non-structural and operational changes to reduce the extent and duration of flooding. Next, the District will need to monitor conditions over time and establish thresholds for hydrologic changes that trigger the need for infrastructure replacement. Finally, the District will initiate infrastructure replacement and upgrade strategies based on construction time once conditions are realized and thresholds met.

Despite being inadequate for present conditions, the original water management infrastructure has seen significant improvements to increase stormwater storage, improve drainage of excess surface water into groundwater, reduce groundwater inflow from the Everglades, provide pumping capacity to remove water from developed areas, and increase discharges from coastal structures. Because of all these changes and improvements, current capacity to protect developed areas from flooding and remove excess water has greatly increased; however, the

level of flood protection that exists within the system today remains uncertain in the face of increased pressure in the future. As coastal water levels increase in the future, this will result in corresponding increases of upstream water levels within each watershed.

The effects of these changes in water levels on the level of service (or level of flood protection) were first evaluated in a recent pilot study of the C-4 canal watershed in Miami-Dade County. This study assessed the level of flood protection within the watershed to identify risk to existing resources and needs for improvements to primary drainage system operations and infrastructure. The methodology used in this investigation will subsequently be applied to the remaining watersheds in the Miami River system (Figure 7) and to other watersheds throughout the District. This initial study of methods and criteria were based on a simplified hydrologic and hydraulic model and a set of performance measures that were developed for the study. The C-4 canal watershed was selected for this investigation because it has a mixture of residential, commercial, and industrial development, environmentally-sensitive wetlands, a major wellfield used for public water supply, and a long history of water management concerns. This area has seen extensive population growth and changes in land use since the design and construction of the original federal flood control project in the 1950s. Much of the western portion of the watershed has been dredged to create large lakes and rock pits and the rock has been used to provide fill for development. During the same period, sea level has increased approximately six inches, thereby reducing the discharge capacity of the coastal structures.

The South Florida Water Management District Pre-Disaster Mitigation Project

In April 2015, The South Florida Water Management District was awarded a Pre-Disaster Mitigation Competitive Grant from the Federal Emergency Management Agency through the Florida Division of Emergency Management.[9] The study, focused on the C-7, C-8, and C-9 basins in northern Miami-Dade County, seeks to reduce the potential for loss of life and property by developing and implementing a Local Mitigation Strategy to identify hazards and possible mitigation activities. The project includes two elements:

1) a technical assessment of the flood protection level of service for the existing infrastructure under current and future sea level rise scenarios; and
2) a strategic assessment of alternative mitigation strategies which can be incorporated into the Miami-Dade Local Mitigation Strategy.

Major work products expected from this study include:

- Updated Basin Atlases: The South Florida Water Management District will expand the recently completed Miami River Operations Atlas to include Basins 7, 8, and 9. The basin atlas will provide comprehensive descriptions of infrastructure and water management operations and identify emerging issues within each watershed.

[9] Federal Emergency Management Agency Grant Application Number PDMC-PL-04-FL-2014-004

- Assessment of existing level of flood protection: This contract will produce an assessment of the flood protection level of service that exists in Basins 7, 8, and 9 provided by the existing District infrastructure. Current sea level conditions are assumed for this assessment.
- Assessment of 2065 level of flood protection assuming no infrastructure changes: This contract will produce an assessment of the flood protection level of service for three sea level scenarios assuming no changes to the existing water management infrastructure.
- Identification of alternative flood mitigation strategies: Development of up to four alternative flood mitigation strategies will be identified by RAND Corporation working in collaboration with Miami-Dade County.
- Assessment of 2065 level of flood protection for flood mitigation strategies: The modeling tools under this contract will be utilized to evaluate the level of service provided by alternative flood mitigation strategies for three future sea level scenarios.

Collaboration between the South Florida Water Management District and the Netherlands

In April 2014, the South Florida Water Management District established a Memorandum of Agreement with the Ministry of Infrastructure and the Environment of the Netherlands and the Delfland Water Board to work cooperatively and share information, expertise, and strategies on flood control, water supply, spatial development, environmental ecosystem restoration, crisis management, modelling, service level practices, sea level rise, climate adaptation strategies, and salt water intrusion impacts. The Delfland Water Board is the water management authority for part of the Netherlands with expertise in many disciplines. Through this project the District is able to collaborate on various water management topics of mutual interest including saltwater intrusion, sea level rise, climate change, and emergency management. Because there are many similarities in the water management systems of South Florida and the Netherlands, these organizations agreed to work towards an annually updated comprehensive thematic work program on information and best practices exchange. The additional expertise of Dutch partners will contribute to the regional efforts of the District, the U.S. Geological Survey, Miami-Dade County and the Compact to better understand potential flood damage and saltwater intrusion and begin to develop adaptation strategies.

Additionally, the District participated in a project led by Deltares, a world-renowned research institute based in the Netherlands, to conduct a research effort addressing flood and drought risk management in Miami-Dade County. The ensuing project: "Flood and Drought Risk Management Under Climate Change: Methods for Strategy Evaluation and Cost Optimization," was funded by the National Oceanographic and Atmospheric Administration. This effort, nearing its completion, will use level of service modeling to determine hydrologic and economic flood damages in the C-4 basin within the County under future sea level and storm scenarios. The study aims to accomplish the following objectives:

- Further analyze the impacts of climate change on the occurrence of floods and droughts in the District;

- Gain more insight into the intended and unintended effects of flood and drought risk reduction measures;
- Develop and apply a method to evaluate the capability of the water management system to effectively address extreme events (floods and droughts), and use the outcomes to assess comprehensive adaptation strategies aimed at flood and drought risk reduction under climate change;
- Apply an economic optimization method for determining the optimal investment in flood risk reduction with the intention to have the project document the process of adapting the method from the Netherlands to Florida, and identifying what is required to apply the optimization method to other regions;
- Assess and communicate the usefulness of applying this optimization method for decision making in water resource management; and
- Publish the general outcomes on the methods and the specific outcomes for the case study area, through two stakeholder and expert workshops and scientific (journal) publications.

The report will be presented to the stakeholders in the region during the summer of 2016.

U.S. Geological Survey- Surface Groundwater Interface Model

To evaluate the effects of pumping groundwater on canal leakage and regional groundwater flow, the U.S. Geological Survey developed and calibrated a coupled surface-water/groundwater model of the urban areas of Miami-Dade County.[10] The development of this model is an important component to understanding the effects of sea level rise on both the risks of flooding and saltwater intrusion. The model is designed to simulate surface-water stage (water levels) and discharge (water releases) in the managed canal system and dynamic canal leakage to the Biscayne Aquifer, in addition to seepage to the canal from the aquifer. The model was developed using the U.S. Geological Survey's MODFLOW–NWT.[11]

The model represents the complexities of the interconnected surface-water and groundwater systems that affect how the systems respond to pumping groundwater, sea-level rise, and other hydrologic stresses. The model also quantifies the relative effects of pumping groundwater and sea-level rise on the surface-water and groundwater systems. Supporting data and other information is available at the U.S. Geological Survey's publication library. [12]

The study found that analytical and simulated water budgets for the period from 1996 through 2010 indicated that most of the water discharging through the salinity control structures is

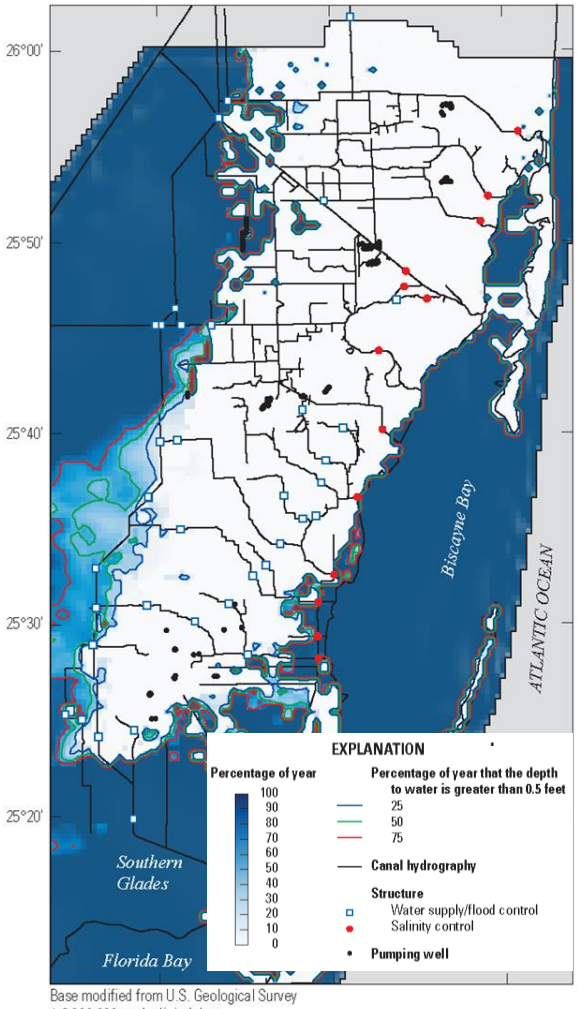
[10] Hughes, Joseph D., and White, Jeremy T., 2014, Hydrologic conditions in urban Miami-Dade County, Florida, and the effect of groundwater pumpage and increased sea level on canal leakage and regional groundwater flow: Scientific Investigations Report.
[11] MODFLOW-NWT is a standalone program that is intended for solving problems involving drying and rewetting nonlinearities of the unconfined groundwater-flow equation.
[12] Hughes, Joseph D., and White, Jeremy T., 2014, Hydrologic conditions in urban Miami-Dade County, Florida, and the effect of groundwater pumpage and increased sea level on canal leakage and regional groundwater flow: Scientific Investigations Report. http://pubs.usgs.gov/sir/2014/5162

derived from within the urban parts of the study area than from upstream releases, and that, on average, the canals drain more water from the Biscayne Aquifer than they supply to the aquifer by downward leakage.

Increased sea level caused higher water-table elevations in urban areas and decreased hydraulic gradients across the system. The largest increases in water-table elevations occurred seaward of the salinity control structures. Higher sea levels increased the extent of flood-prone areas and the percentage of time water-table elevations were less than 0.5 foot below land surface (Figure 8). The water table was less than 0.5 feet below land surface in a total of 5,672 onshore model cells (or approximately 547 square miles) in the increased sea-level scenario during the 30th year of the scenario simulation period (Figure 8). The 30th year of the simulation would represent the possible conditions in 2040. Increased sea level resulted in a 10.32 square mile increase in flood-prone areas and a 4-percent increase in the percentage of the time flood-prone areas have a water-table depth less than 0.5 feet below land surface during the 30 year simulation.

Increased sea level also resulted in landward migration of the freshwater-seawater interface. These findings are described later in the report.

Figure 8: Percentage of time water-table elevations are less than 0.5 ft. below land surface in the 30th year of the scenario simulation period for increased sea-level and groundwater pumpage conditions



Source: U.S. Geological Survey

U.S. Geological Survey Mapping of Water Levels and Trends in Miami-Dade County

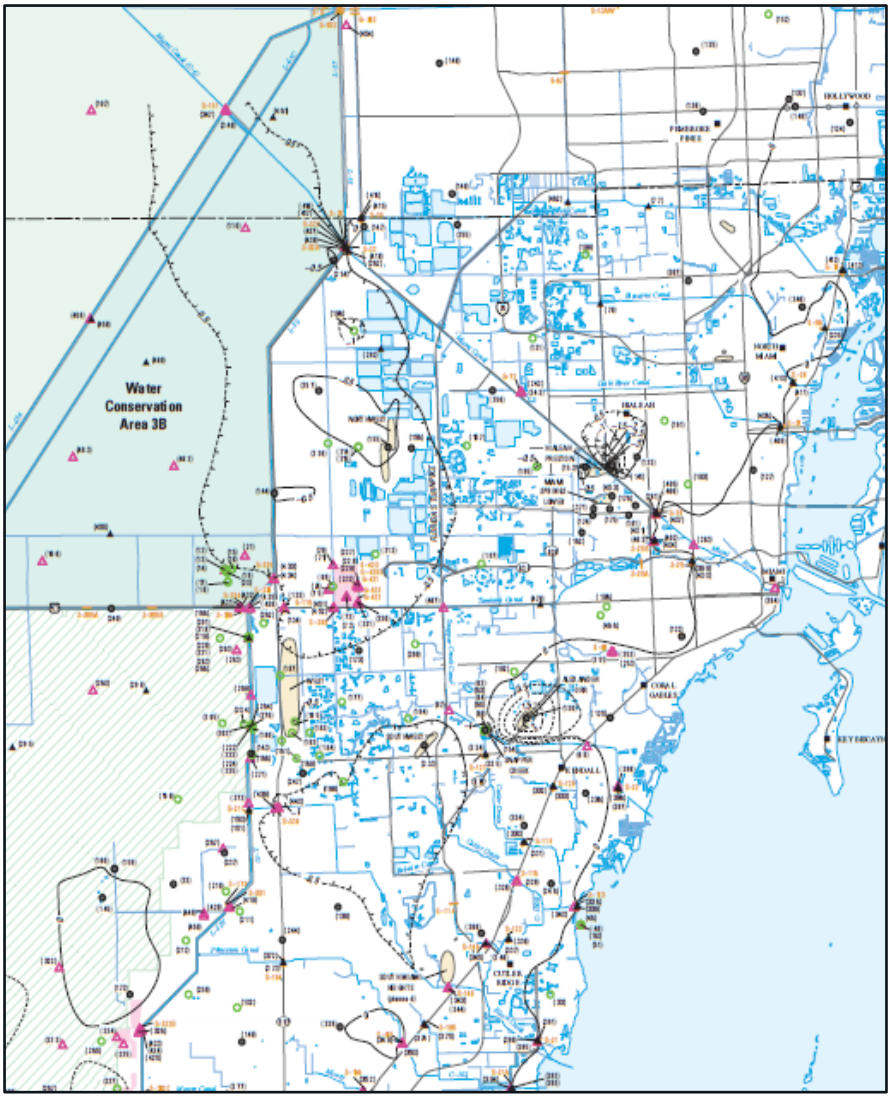
Statistical analyses and maps representing mean, high, and low water-level conditions in the surface water and groundwater of Miami-Dade County were made by the U.S. Geological Survey in cooperation with the Miami-Dade County Department of Regulatory and Economic Resources to help inform decisions necessary for urban planning and development.[13] Sixteen maps were created to show contours of:

[13] Prinos, S.T., and Dixon, J.F., 2016, Data, Statistics, and Geographic Information System Files, Pertaining to Mapping of Water Levels in the Biscayne Aquifer, Water Conservation Areas, and Everglades National Park, Miami-Dade County, Florida, 2000-2009 - Scientific data associated with USGS SIR 2015-5005: U.S. Geological Survey Data Release, http://dx.doi.org/10.5066/F7M61H9W.

(1) the mean of daily water levels at each site during October and May for the 2000-2009 water years;
(2) the 25th, 50th, and 75th percentiles of the daily water levels at each site during October, May, and all months during the period of 2000-2009; and
(3) the differences between mean October and May water levels, as well as the differences in the percentiles of water levels for all months, for the periods of 1990-1999 and 2000-2009.

These maps and statistics provide a generalized understanding of the variations of water levels in the aquifer, rather than a survey of concurrent water levels. Water-level measurements from 473 sites in Miami-Dade County and surrounding counties were analyzed to generate statistical analyses. The study monitored surface-water levels in canals and wetland areas and groundwater levels in the Biscayne Aquifer. Maps were created by importing site coordinates, summary water-level statistics, and completeness of record statistics into a geographic information system and interpolating between water levels at monitoring sites in the canals and water levels along the coastline (Figure 9).

Figure 9: Snapshot of groundwater level change



Source: U.S. Geological Survey, 2016

Although the ability of the maps to depict differences in water levels between 1990-1999 and 2000-2009 was limited by missing data, results indicate that near the coast, water levels were generally higher in May during the 2000-2009 study period than during 1990-1999 period and that inland water levels were generally lower during the 2000-2009 period than the 1990-1999 period. Generally,

the 25th, 50th, and 75th percentiles of water levels from all months were also higher near the coast and lower inland during later period as compared to the earlier period. Mean October water levels during 2000-2009 were generally higher than levels during 1990-1999 in much of western Miami-Dade County but were lower in a large part of eastern Miami-Dade County. The report notes that, "these increases could be related, at least in part, to the effects of sea-level rise."

This study will inform the review of the County Flood Criteria. Where conditions have changed substantially from when the criteria were last updated in 1990, the criteria may need to be updated to reflect current conditions. The changes in conditions have been most pronounced in coastal areas. The data and maps generated by this study are available at the U.S. Geological Survey's publication library.[14] The study also provides information on how the monitoring network could be improved.

RAND Corporation Study

The RAND Corporation is working with Miami-Dade County and the Southeast Florida Regional Climate Change Compact on a MacArthur Foundation funded project titled "Adaptation Planning for Sea Level Rise and Climate Change in Southeast Florida: Understanding the Interactions of New Infrastructure, Land Use Changes, and Water Management." The project will complement the very strong leadership and technical base that already has been established in the Southeastern Florida region and will focus on Miami-Dade and Broward Counties. The project's over-arching goal is to help improve the region's capacity to adapt to changing climate and development conditions with minimal economic and social disruption. Current planning methods are challenged by the difficulty of incorporating into the decision-making process the direct and indirect changes associated with new infrastructure. Similarly, it is difficult to incorporate these considerations during permitting and development decisions for individual projects. The project will develop an integrated system of simulation models for the region that will provide a transparent, interactive tool, and a level analytical playing field to assess potential interactions among water management, transportation, and land use decisions under a range of scenarios.

The project goal is to help decision makers and stakeholders in the region gain a better understanding of the costs and benefits of both action and inaction across a wide range of scenarios. In collaboration with technical experts and partners within the region, RAND's engagement will help support: rigorous evaluation of vulnerabilities of land-based assets, application of models to support economic loss and benefit-cost evaluations, assessment of alternative funding and financing strategies, and identification of preferred and phased risk-reduction strategies. The project will also seek to test several hypotheses including the following three suppositions:

[14] Prinos, S.T., and Dixon, J.F., 2016, Data, Statistics, and Geographic Information System Files, Pertaining to Mapping of Water Levels in the Biscayne Aquifer, Water Conservation Areas, and Everglades National Park, Miami-Dade County, Florida, 2000-2009 - Scientific data associated with USGS SIR 2015-5005: U.S. Geological Survey Data Release, http://dx.doi.org/10.5066/F7M61H9W.

(1) more compact development will reduce the costs of providing selected public services,

(2) current land use plans will raise the costs and increase the challenge of water management in the region relative to more coordinated efforts,

(3) uncoordinated local land use and water management plans (e.g. individual county or city permitting of projects without consideration of externalities imposed on neighboring jurisdictions) will have negative economic consequences at the regional scale. After initial discussions with the District, Miami-Dade and Broward counties, the RAND corporation staff has decided to use existing models developed by the District and the counties to investigate both flooding and water supply performance under future SLR and climate scenarios.

Federal Emergency Management Agency's Revision of Miami-Dade's Flood Insurance Rate Maps

The Federal Emergency Management Agency's National Flood Insurance Program, which provides the majority of flood insurance coverage for Miami-Dade County, relies upon Flood Insurance Rate Maps to set the price of insurance premiums and purchase requirements. The Flood Insurance Rate Maps are the official maps of a community which delineate the special hazard areas, based on the best available technical data.

The last Miami-Dade County Flood Insurance Rate Map was updated in 2009 and included a 100-year catastrophic rain event and storm surge under current conditions.

The Federal Emergency Management Agency is currently revising the Flood Insurance Rate Maps for other parts of the county. The County was awarded a $1.25 million grant in 2015 to continue working with The Federal Emergency Management Agency as a 'technical partner' in the development of the next update of the County's Flood Insurance Rate maps. These maps are anticipated to become effective in the next three to five years. The County's Stormwater Master Plan mapping and modeling data is used by The Federal Emergency Management Agency in their map updates. The maps are officially adopted by local communities and are legally part of the building code requirements to protect new construction and substantial improvements of private and public facilities. Insurance coverage and claims also rely on the official Flood Insurance Rate maps.

In addition to the datum change, The Federal Emergency Management Agency is also revising the Flood Insurance Rate maps to reflect updated hydrologic conditions and historical sea level rise resulting from increasing average tide data and historic surge events. This mapping does not incorporate future sea level rise projections. This is being performed in two separate map revision cycles as described below.

- Riverine Modeling Update: Draft maps will be released for public comment in 2019. The new maps will take effect (contingent upon public review process) one year later.
- Coastal Modeling Update: These maps are expected to consider historical tide gauge and surge data with possible flood elevation increases. Final changes in the base flood elevation

will be determined at the time of map release. In 2019 draft maps will be released for public comment. New maps are expected to take effect (contingent upon public review process) one year later.

Miami-Dade Interagency Coastal Flood Risk Reduction Study with the U.S. Army Corps of Engineers

To address the impacts of sea level rise, this study will utilize modeling tools to analyze the effectiveness of natural barriers and non-structural flood protection measures along the coastline, develop operating rules for the pre-storm operation of the regional water management system, and develop and implement a Decision Support System assisting in pre-storm operation decisions to reduce flood risk in communities along the coastline. The study is being conducted in partnership with Miami-Dade County, The U.S. Army Corps of Engineers, The U.S. Department of the Interior, The U.S. Geological Survey, the South Florida Water Management District, The Nature Conservancy, and Florida Atlantic University. This diverse group is studying and developing adaptive strategies to address flood damage reduction and saltwater intrusion associated with sea level rise.

This study will use existing numerical modeling tools, including the hydrodynamic model ADCIRC, to compute the surge generated by historic and synthetic storm scenarios along Miami-Dade's coastline. Outputs will be used to determine the effectiveness of non-structural flood control measures, such as dune restoration and/or enhancement, wetland or urban forest vegetation management, and/or land use changes, to protect existing infrastructure and structures from damaging storm surges and reduce coastal flooding. This study will also develop a Decision Support System tool to help officials prepare the region for pre-storm operations by providing probabilistic projections of storm surge scenarios and hydrologic responses of levels in canals). If implemented appropriately, those nonstructural measures that prove effective in this modeling exercise can result in decreased damages and reduce potential loss of life when hazardous weather conditions occur (Figure 10).

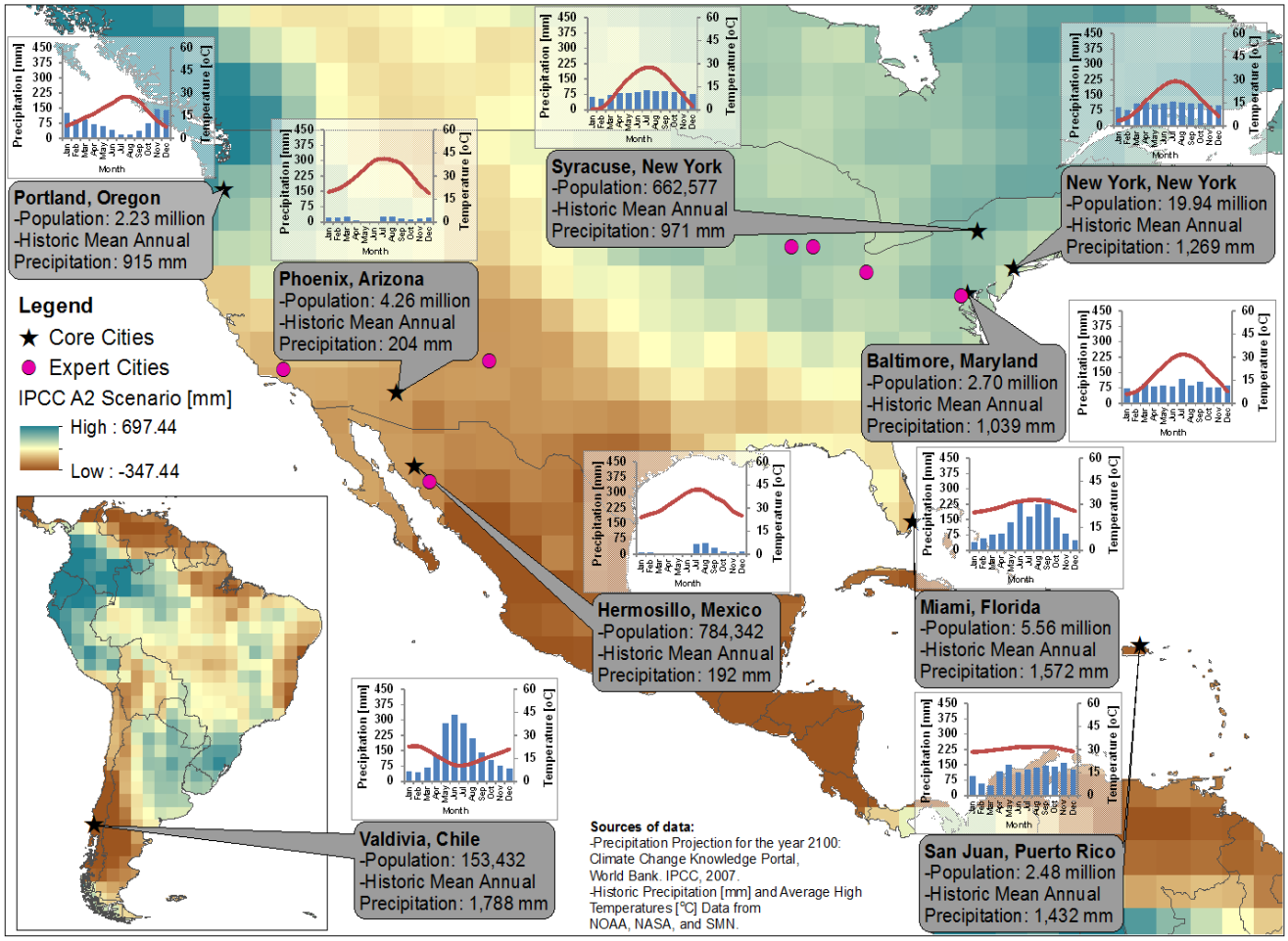
Figure 10: Dunes provide flood protection

Source: Miami-Dade County

Sustainability Research Network- Urban Resilience to Extreme

The Urban Resilience to Extremes Sustainability Research Network focuses on integrating social, ecological, and technical systems to devise, analyze, and support urban infrastructure decisions in the face of climatic uncertainty. Climate change is widely considered to be one of the biggest challenges to global sustainability. According to the Intergovernmental Panel on Climate Change, extreme events are likely to increase in frequency. Weather-related extreme

Figure 11: Urban Resilience Sustainability Research Network Cities



Source: The Urban Resilience to Extremes Sustainability Research Network

events are the most immediate way that people experience climate change. Urban areas are particularly vulnerable to such events, given their location, concentration of people, and increasingly complex and interdependent infrastructures.

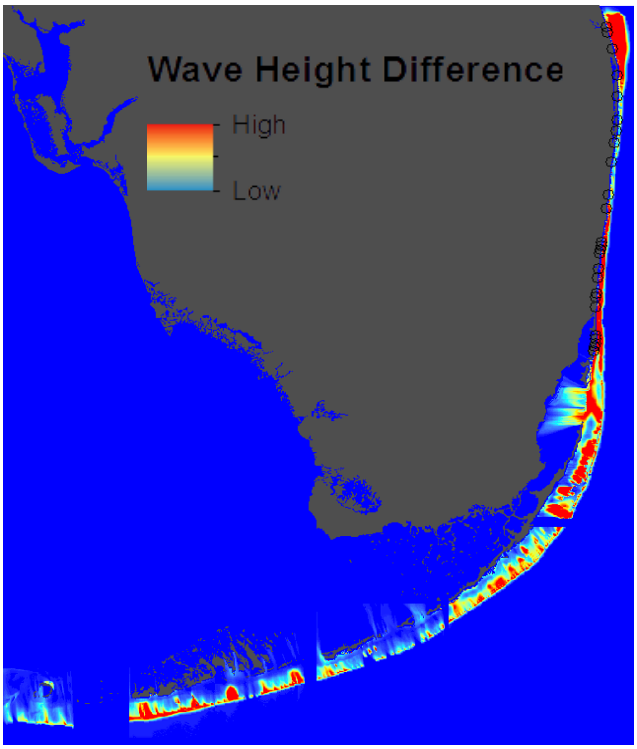
The current infrastructure of urban areas is aging and proving inadequate for protecting city populations. Infrastructure must be resilient, provide ecosystem services, improve social wellbeing, and exploit new technologies in ways that benefit all segments of urban populations and are appropriate to each particular urban context. To meet these challenges, the Urban Resilience to Extremes project envisions a new framework aimed at integrating social-

ecological-technical/infrastructural system dimensions to conceptualize and analyze infrastructure decisions in a more holistic way and to work directly with cities and practitioners to envision and implement transitions to more resilient and sustainable infrastructure. In addition to their collaboration with researchers in Miami at Florida International University, and practitioner group comprised of city of Miami Beach staff and other local stakeholders, as part of the Miami team, other project cities include Baltimore, Maryland, Hermosillo, Mexico, New York, Phoenix, Arizona, Portland, Oregon, San Juan, Puerto Rico, Syracuse, New York, and Valdivia, Chile (Figure 11).

Southeast Florida Regional Climate Change Compact's Shoreline Resilience Working Group- Assessment of The Potential for Nature-Based Coastal Defenses in Southeast Florida

This assessment of the potential for nature-based coastal defenses in Southeast Florida is aimed at quantifying the effectiveness of natural systems at protecting shorelines and coastal regions against the impacts of coastal hazards. Results from this effort will provide valuable information about the efficacy of different nature-based coastal defenses strategies in the region to protect against erosion and/or flooding. The anticipated results will also help better prioritize the location and craft the design components of nature-based solutions to protect against the impacts of coastal hazards.[15] This research project, which began in 2014 and is set to conclude in 2016, has created a clearinghouse for best practices and technical information about the effectiveness of nature-based coastal defense structures, compiled a list of completed projects, and identified the suitability of shorelines for various project types that will help protect the region. To date the project has catalogued opportunities to protect or restore coral reefs and nearshore hard bottom ecosystems, to close gaps in existing sand dunes, to protect or restore coastal wetlands, and to create living shorelines that combine natural and constructed element in most of Southeast Florida.

Figure 12: Analysis of the benefits of coral reefs in reducing wave heights during a strong storm



Source: The Nature Conservancy

The project's scientists completed their initial suitability analysis and have identified suitable sites for nature-based coastal defense based on ecological and physical conditions. For example,

[15] More information about the Shoreline Resilience Working Group is available at www.nature.org/southeastfloridareport and more information about the potential for nature-based coastal defenses is available at http://coastalresilience.org/

the analysis has revealed areas where coral reefs have the potential to significantly reduce wave heights during a storm (red areas in Figure 12). The analysis also identified 89 potential project sites for dune restoration in Miami-Dade County. Finally, the project's team completed a living shoreline suitability analysis for most of the inland waters and portions of the exposed shorelines of Palm Beach, Broward and Miami-Dade Counties.

The South Florida Water, Sustainability, and Climate Project

Every day in South Florida about 7.7 million people, companies, and farms use more than 3 billion gallons of water. Different water use optimization strategies are needed when considering expected population growth and impacts of climate change. In order to investigate various strategies, a 5-year $5 million dollar project focused on South Florida was initiated in 2013. Project researchers are seeking to develop hydrological and economic criteria for evaluating current and future water use and provide new insights into the value of water resources. With this knowledge, the trade-offs decision-makers face under various climate change, economic, population, and sea level rise scenarios can be evaluated.

The South Florida Water, Sustainability, and Climate Project is supported by the National Science Foundation's Water, Sustainability, and Climate Program, with joint support from the United States Department of Agriculture's National Institute of Food and Agriculture. The full research proposal title is "WSC-Category 2 Collaborative: Robust Decision-making for South Florida Water Resources by Ecosystem Service Valuation, Hydro-economic Optimization, and Conflict Resolution Modeling." The project's objectives are to:

(1) Develop a hydro-economic model for South Florida that optimizes water allocations based on the economic value of water;
(2) Develop new information on the economic value of ecosystem services to be incorporated into model formulations;
(3) Test management schemes designed to increase the resilience of water resources to climate variability, climate change, and SLR;
(4) Engage stakeholders to improve understanding of the cognitive and perceptual biases in risk management and decision-making; and
(5) Develop recommendations for adaptive water management that optimize economic and ecological productivity and foster sustained public support.

Social and behavioral scientists will also investigate how individuals' perceptions of risks to the water supply differ, and how these differences influence decisions made under uncertain conditions, such as those faced by South Floridians due to sea level rise. Finally, with agency and stakeholder involvement, the project will develop recommendations for adaptive water management policies. The project team is an interdisciplinary group of hydrologists, ecologists, economists, and social scientists from six Florida universities (Florida International University, Florida State University, University of Miami, University of Florida, South Florida and Central Florida University), Pennsylvania State University, the Universities of Pennsylvania and Hawaii, Michigan Technological University, Geodesign Technologies, the South Florida Water Management District, and the United States Geological Survey.

Storm Surge Modeling Efforts

Storm surge is the abnormal rise of water created by a strong storm.[16] In South Florida a significant storm surge is typically associated with a tropical storm. The storm surge results in temporarily higher water levels that recede after the storm has passed. Changing average water levels will have a non-linear impact on how storm surge affects Miami-Dade County. In very general terms, however, higher average water levels are likely to contribute to higher storm surges and potential wider area of land inundated by such a surge. As illustrated in the following studies, however, the precise changes will be much more complex.

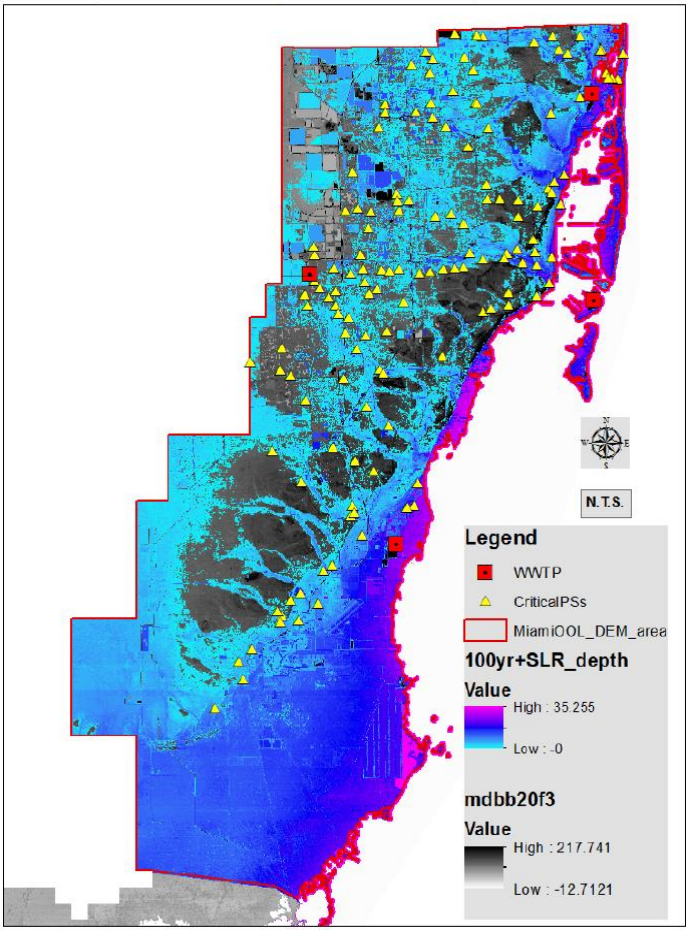
A number of different studies have been completed or are in process to understand and map the potential impacts of storm surges when accounting for higher future sea levels in Miami-Dade County. Though this report only summarizes them briefly, these studies offer key inputs to other efforts such as the County's vulnerability assessments, emergency management planning, and transportation studies, among others.

Miami-Dade Water and Sewer Department Facility Hardening Plan

This study applied the projections of changes in sea level rise and precipitation to estimate the resulting surge elevations and inland flood maps for specified climate events, which was used by other components of the Water and Sewer Department program to develop wastewater facility hardening plans (Figure 13). The purpose of the surge modeling is to provide surge boundary conditions to drive the flood model to assess flood propagation inland. The surge model, which couples waves, tides, and meteorologically induced surges, covers the entire North Atlantic, stretching from Newfoundland to South America. The mesh resolution is refined progressively landward to resolve bathymetric details in the project vicinity.

Based on a review of hurricane climatology of the Southeast coast of Florida, where the project site was located, Hurricane Andrew generated the largest surge event along

Figure 13: Storm surge estimates incorporating sea level



Source: CH2MHill

[16] For more information on storm surges see National Oceanographic and Atmospheric Administration's National Hurricane Center's webpage on the topic, available at http://www.nhc.noaa.gov/surge/

the project coastline and was selected as the base hurricane set. A strategy of parallel shifts in the historical track in the north-south direction was adopted to derive the largest surge elevation at each of Water and Sewer Department's three wastewater treatment plants. The peak surge elevations extracted from the Federal Emergency Management Agency's transects were combined by selecting the maximum of the three track-based results. The composite modeled peak surge elevations were pegged to The Federal Emergency Management Agency's stillwater elevations to derive the 100 year surge elevations under specified sea level rise scenarios using linear scaling.

Two sea level rise projections of 1.23 meters and 0.93 meters in the year 2075 were adopted based on guidance from the Compact's Sea Level Rise Workgroup. The results of the 1.23 meter scenario were applied as surge boundary conditions in flood modeling while the results of the 0.93 meter scenario were used to support the use of linear scaling of the 1.23 meter scenario results for other SLR projections as a first order estimate.

Assessing the Vulnerability of South Florida to Increased Storm Surge from Sea Level Rise

Another important study of the implications on sea level rise on storm surge has been completed by Professor Brian J. Soden from the Rosenstiel School for Marine and Atmospheric Science at the University of Miami.

Typically, in instances where sea level rise is of concern, the commonly used approach for determining inundation relies on computing mean high-water shorelines relative to contours of topography, given a constant increase in eustatic (uniform, global, high-pass filtered) sea level rise, overlaid on a large-scale geographical background map. These analyses neither take into account the impact from storm surge, nor variations in water levels due to complex hydrodynamic effects. Coastal ocean models can more accurately simulate realistic water levels because their sophisticated numerical algorithms account for nonlinear interactions between wind/tidal forcing, bathymetric depth, land cover, and intricacies in coastline geometry. These modeling systems can more precisely identify threats from SLR, quantify their uncertainty, and provide vital information for planning and building the sustainable, hazard-resilient coastal communities of the future.

In this study, Professor Soden used the National Weather Service's Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model to simulate the impact of projected changes in sea level on inundation in South Florida. Forty-six historical tropical cyclones between the years 1900-2010 that made landfall in South Florida and 26 other storms that skirted the Florida coast were selected for simulating the maximum surface water elevation. The input wind parameters for SLOSH were extracted from the National Hurricane Center best track data for each storm. For the sea level rise simulations, initial pre-storm water levels were set to values of 0, 0.5, 1, 2,

and 3 feet to simulate current and future climate scenarios projected out to the year 2100 for South Florida by the U.S. Army Corps of Engineers.[17]

The SLOSH modeling system provides 37 localized grid basins (12 operational) for the state of Florida. The grid basin for each storm was chosen to maximize horizontal resolution and areal coverage at the landfall point and the storm tracks were adjusted in time to guarantee at least 48 hours of offshore, pre-landfall and 24 hours of inland, post-landfall wind forcing. This study presents results from 3 grid basins in South Florida, centered in Miami, the Florida Keys, and Palm Beach.

Comparison of Three Methods for Estimating the Sea Level Rise Effect on Storm Surge Flooding

Another very important report was published by Florida International University Professor, Keqi Zhang, and colleagues.[18] This study analyzed the impact of sea level rise on storm surge using several methods, including the Coastal Estuarine Storm Tide (CEST) model. Two linear methods, including the simple linear addition and linear addition by expansion, and numerical simulations, were employed to estimate storm surges and associated flooding caused by Hurricane Andrew for scenarios of sea level rise from 0.15 m to 1.05, with an interval of 0.15 m. The interaction between storm surge and sea level rise is almost linear at the open Atlantic Ocean outside Biscayne Bay, with slight reduction in peak storm surge heights as sea level rises. The nonlinear interaction between storm surges and sea level rise is weak in Biscayne Bay, leading to small differences in peak storm surge heights estimated by three methods. Therefore, it is appropriate to estimate elevated storm surges caused by sea level rise in these areas by adding the sea level rise magnitude to storm surge heights. However, the magnitude and extent of inundation at the mainland area by Biscayne Bay, estimated by numerical simulations are, respectively, 22–24 % and 16–30 % larger on average than those generated by the linear addition by expansion and the simple linear addition methods. This indicates a strong nonlinear interaction between storm surge and sea level rise. The population and property affected by the storm surge inundation estimated by numerical simulations differ up to 50–140 % from that estimated by two linear addition methods. Therefore, it is inappropriate to estimate the exacerbated magnitude and extent of storm surge flooding and affected population and property caused by sea level rise by using the linear addition methods. The strong nonlinear interaction between surge flooding and sea level rise at a specific location occurs at the initial stage of sea level rise when the water depth under an elevated sea level is less than 0.7 m, while the interaction becomes linear as the depth exceeds 0.7 m.

Estimates of Storm Surge Using the ADCIRC Model

Two research efforts described earlier are using ADCIRC to evaluate the risk of storm surge in Miami-Dade County. The first project is the remapping of the Flood Insurance Rate Maps of coastal Miami-Dade County used in the National Flood Insurance Program. The other project is

[17] U.S. Army Corps of Engineers, "Sea Level Change Curve Calculator (2014.88) User Manual" (2014) Available at http://www.corpsclimate.us/docs/SLC_Calculator_Manual_2014_88.pdf
[18] Zhang, K., Li, Y., Liu, H., *et al.,* "Comparison of three methods for estimating the sea level rise effect on storm surge flooding" Climate Change (2012) 115, No. 3-4

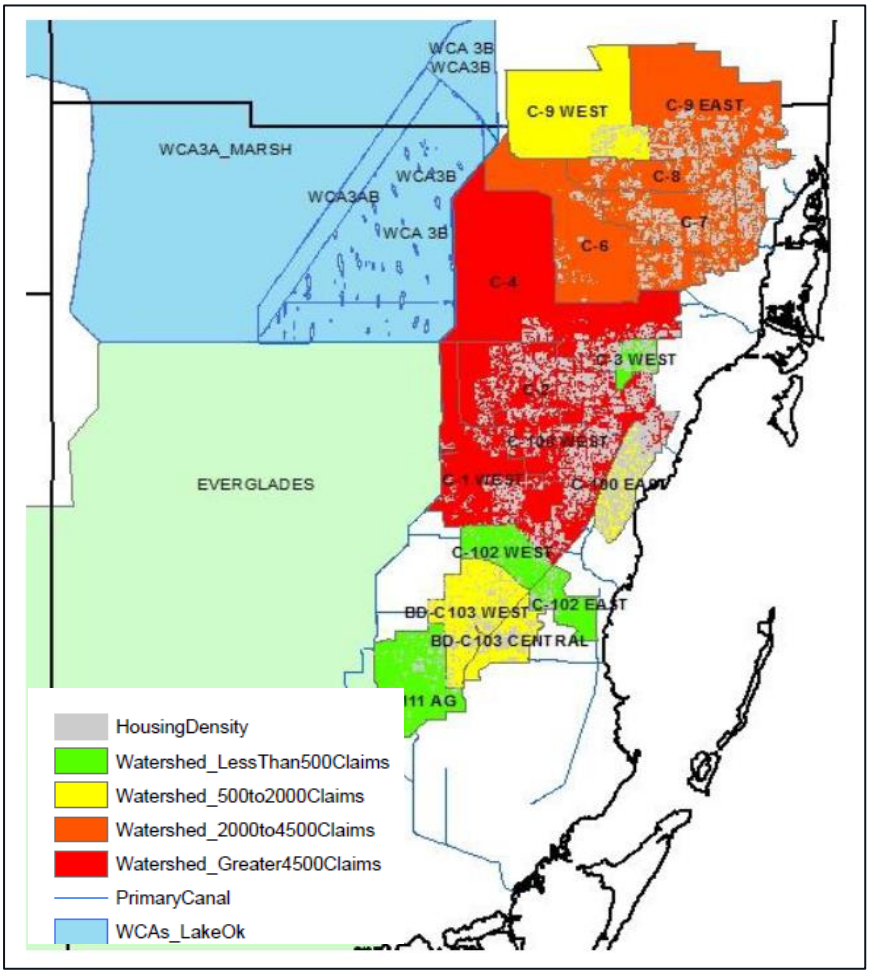
the Army Corps funded research project focused on the efficacy of non-structural flood reduction measures. ADCIRC is a system of computer programs for solving time dependent, free surface circulation and transport of fluids problems in two and three dimensions.

Studies Describing Miami-Dade County's Exposure to Flooding

The Florida Public Hurricane Loss Model

The International Hurricane Research Center at Florida International University is leading a multi-university effort with funding from the Florida Office of Insurance Regulation to develop an innovative, public hurricane loss model. In 2013 the State funded this initiative to enhance the model by adding both a storm surge and fresh water flooding component. The new components will assess storm surge and hurricane-related rain flood risk, and estimate both the insured and uninsured losses they may create. When it is completed, it will provide a state of the art innovative, transparent, combined model that can separate wind losses from flood losses and help resolve the issue of the ultimate cause of damages. It will also provide a more refined and actuarially sound method of estimating insured losses and determining fair pricing for all sources of hurricane risk. The model will also allow planners to conduct simulations and scenario analysis that can help state and local governments with disaster planning and land use planning. Additionally, results from the effort could be used to help the County and other relevant parties assess the costs and benefits of alternative mitigation strategies. This enhancement will take approximately three to four years to complete and is projected to be ready around 2017. More than two dozen professors and experts have been involved in developing the model.

Figure 14: High flood claim watersheds in Miami-Dade County



Source: Czajkowski, J., Engle, V., Martinez, C.

Economic Impacts of Urban Flooding in South Florida Due to Higher Groundwater Levels

The study "Economic Impacts of Urban Flooding in South Florida: Potential Consequences of Managing Groundwater to Prevent Salt Water Intrusion," reviewed the possible economic trade-offs associated with the competing demands to manage regional water resources to both prevent salt water intrusion and reduce

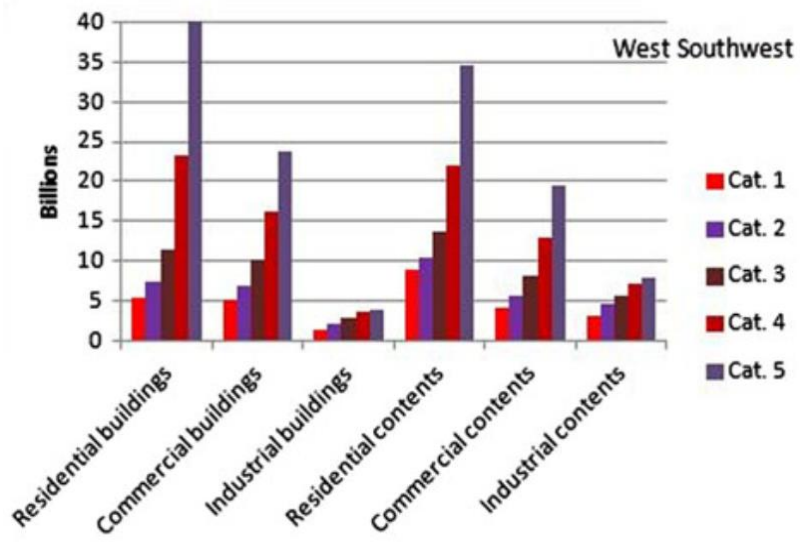
flooding risk.[19] This study provides an excellent review of the complexity of managing water resources given the region's vulnerability to salt water intrusion caused by the low topography, existing high water table, the permeable karst substrate, and sea level rise.

With higher average sea levels, canal water levels may have to be increased to prevent increased salt water intrusion. However, higher canal water levels also lead to an increased risk of inland flooding and associated economic losses, especially during the annual wet seasons. Monthly flood claims in 16 Miami-Dade watersheds (Figure 14) were collected for the timeframe of 1996 to 2010, and statistically related to corresponding watershed groundwater levels, controlling for other relevant flooding factors. This study therefore created new models that reveal the historical relationships between flood insurance claims and groundwater levels in Miami-Dade County. Utilization of the model results suggest that in a heavily developed urbanized watershed, monthly flooding losses could be as high as $8 million under current high groundwater level conditions. This is the first estimate of this kind in south Florida, thus, this study is highly relevant to future decision making related to evaluating economic trade-offs associated with different water management regimes.

Assessment of Storm Surge Damage to Coastal Settlements in Southeast Florida

The "Assessment of Storm Surge Damage to Coastal Settlements in Southeast Florida" investigated flooding risks associated with different potential hurricanes.[20] The results of this study showed that, in the absence of protections, losses from large storm surges will be very high, reaching up to tens of billions of U.S. dollars (Figure 15). This study found that, of the scenarios tested, the minimum damage to the study region would be 32 billion dollars (from a Category 1 storm from the east) and found the maximum damage would be 185 billion dollars (resulting from a Category 5 storm from the West/Southwest). The study also demonstrated how economic impacts could change if protections are built up prior to the weather event. This analysis helps illuminate the potential for different levels of protection to reduce damages. This allows for evaluation of the benefits from structural protection measures. These

Figure 15: Potential impacts from a hurricane from the west southwest



Source: Elisabeth Genovese and Colin Green, 2015

[19] Czajkowski, J., Engel, V., Martinez, C., et al. "Economic impacts of urban flooding in south Florida: Potential consequences of managing groundwater to prevent salt water intrusion" (2015) Available at: http://opim.wharton.upenn.edu/risk/library/WP201510_GWLevelsFloodClaims_Czajkowski-etal.pdf

[20] Elisabeth Genovese and Colin Green "Assessment of storm surge damage to coastal settlements in Southeast Florida" Journal of Risk Research (2015) Vol. 18, No. 4, 407-427

results could be used as inputs into a robust decision-making process to determine the future of coastal protection in South Florida.

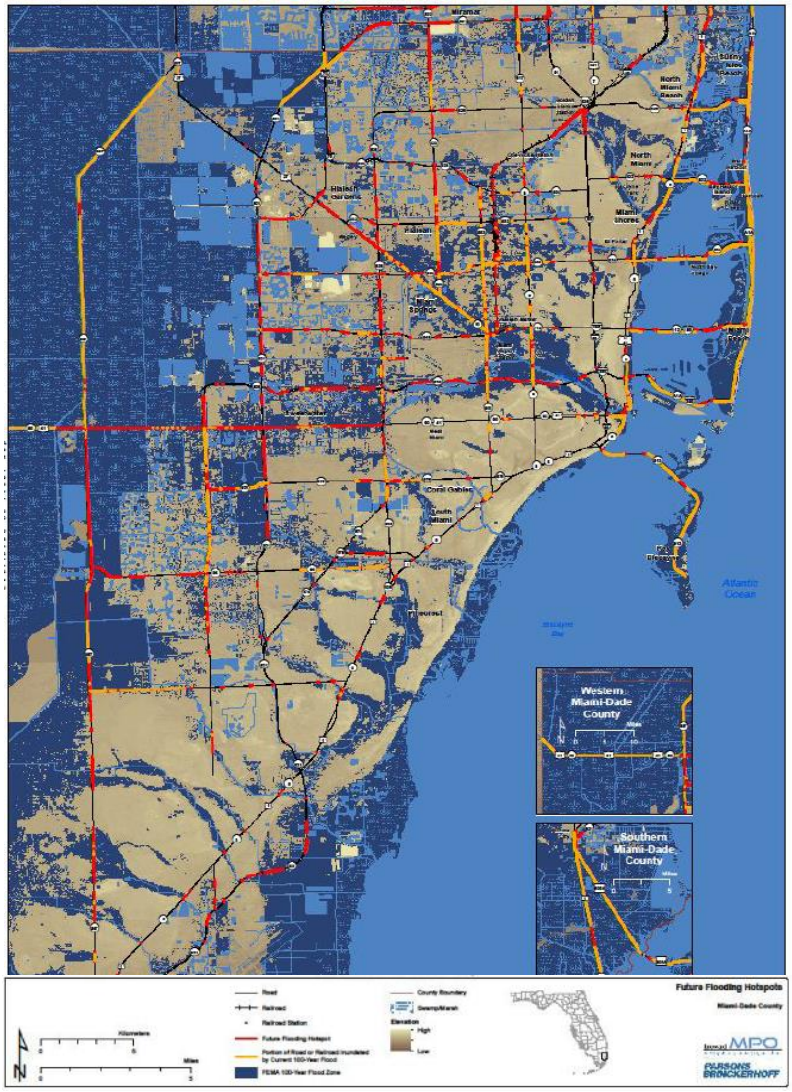
South Florida Climate Change Vulnerability Assessment and Adaptation Pilot Project

This study explored the vulnerability of certain transportation assets within Miami-Dade County (Figure 16).[21] In 2013, the Federal Highway Administration sponsored climate resilience pilot studies in selected states and metropolitan areas. These pilot studies examined approaches to conduct climate change and extreme weather vulnerability assessments of transportation infrastructure and analyzed measures to improve resiliency. The Southeast Florida four-county region was one of the chosen pilot project areas.

The study examined three climate change-related stresses: sea level rise inundation, storm surge flooding, and heavy precipitation induced flooding. Only roadway and passenger rail facilities on the designated regional transportation network were considered as part of the analysis. The overall approach to the vulnerability assessment was based on the Federal Highway Administration's Climate Change and Extreme Weather Vulnerability Assessment Framework.

The level of vulnerability for any particular asset was defined as a product of three factors, following the guidance in the agency's Vulnerability Framework: exposure, sensitivity, and adaptive capacity.

Figure 16: Future flooding hotspots along the regional transportation network, Miami-Dade County



Source: Federal Highway Administration, 2013 South Florida Climate Change Vulnerability Assessment and Adaptation Pilot Project – submitted to the Broward Metropolitan Planning Organization by Parsons Brinckerhoff, Inc. April 2015

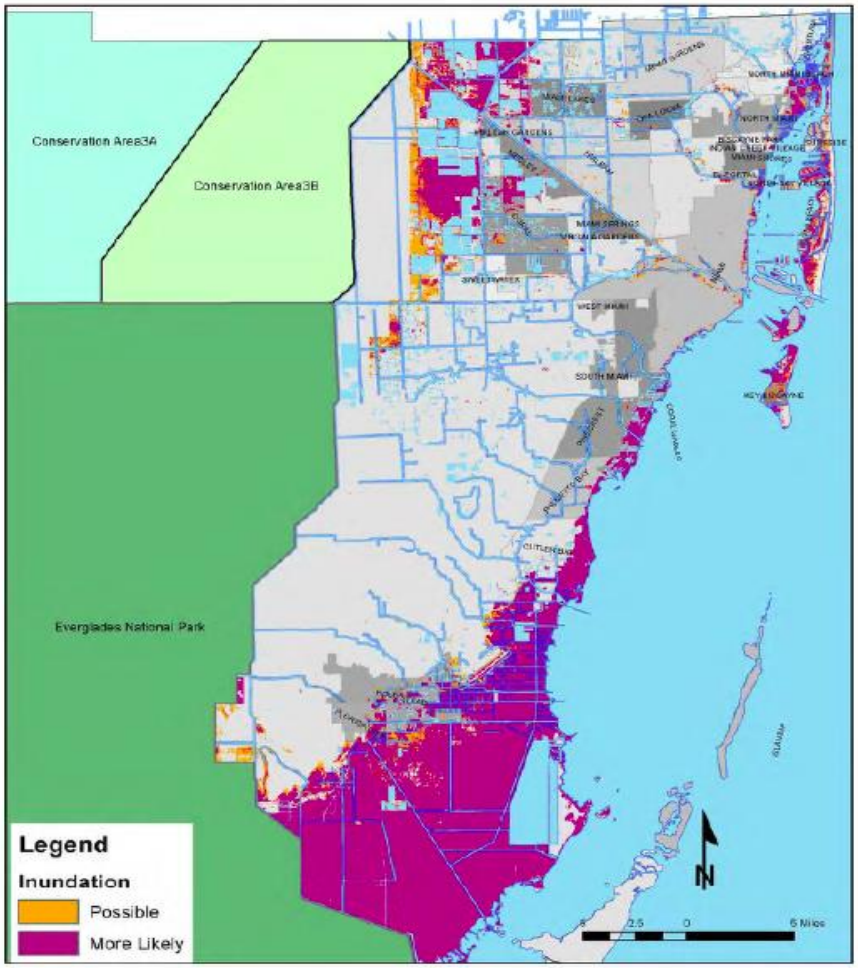
[21] South Florida Climate Change Vulnerability Assessment and Adaptation Pilot Project – submitted to the Broward Metropolitan Planning Organization by Parsons Brinckerhoff, Inc. April 2015

The initial pilot project concluded that the regional transportation network exhibited significant potential vulnerability to sea level rise and other climate change and extreme weather impacts. A follow up study is now underway to supplement the aforementioned Climate Resilience Pilot Project for Southeast Florida by contributing to a more robust understanding of potential sea level rise and storm surge impacts on mobility in the region (including general economic impacts). In doing so, a potential expanded application of the recently-adopted regional travel demand model also will be tested and help foster greater understanding of the role of critical evacuation. It will also help increase understanding of other routes in the broader network as an illustrative aid to emergency management and other planners in the region.

Analysis of the Vulnerability of South Florida to Sea Level Rise

The Southeast Florida Regional Climate Change Compact completed a regional vulnerability analysis based on projections of one, two, and three feet of sea level rise (Figure 17). This analysis was based on land and sea elevations only and did not consider flooding related to existing drainage issues associated with rain events or those caused by storm surge. It provides an overview highlighting locations that are low lying in comparison to various sea level rise scenarios. Additional analysis and more sophisticated models would be required to determine hydrologic connections and actual surface water response to rising sea levels.

Figure 17: Vulnerability analysis of Miami-Dade County to 3 feet of sea level rise



Source: Southeast Florida Regional Climate Change Compact

The analyses mapped areas that might be inundated by increased tidal elevations above current mean higher high water elevations. The study did not take into account existing ground water levels, tidal anomalies, future water management and operations, or flood mitigation practices.

This initial scoping study found that the upper estimate of taxable property value

vulnerable in Monroe, Broward, and Palm Beach Counties is greater than $4 billion.[22] In the scenario that evaluated three feet of sea level rise, these values rose to over $31 billion. At the one foot scenario, property with a current taxable value of $403-828 million was vulnerable. At three feet of sea level rise, properties valued an aggregate of $6,901-12,109 million were impacted. Under a one foot scenario, 1.3% of the County is impacted, though it was primarily conservation lands which were inundated. At the two foot scenario, 3% of the land is impacted with Electrical Generation Facilities among the top land uses impacted. At the three foot scenario, 7% of the total land mass of the County is impacted including 28% of the agricultural lands and 10% of the transit-oriented development areas. In terms of acres inundated, wetland hardwood forest and vegetated non-forested wetlands are among the major habitats impacted.

[22] Miami-Dade County did not assign a dollar value to the infrastructure at risk and was therefore not included in the estimate of value.

On-going Adaptation Efforts

Miami-Dade County Stormwater Master Plan

In 1992, Miami-Dade County began the development of a countywide stormwater management program. The Water Management Division in the Regulatory and Economic Resources Department administers the program, which is an essential component to identify and solve current and future stormwater drainage, flooding, and water quality problems in the service territory. Miami-Dade County is highly advanced in stormwater adaptation planning and implementing actionable mitigation projects. This record is demonstrated by the County's position within in The Federal Emergency Management Agency Community Rating System Program. This program recognizes communities that go above and beyond the minimum requirements for managing floodplains. The County currently has an excellent rating of five placing the County in the top 8% of all participating communities nationwide. This rating is due to the County's efforts to plan, improve, maintain, and operate the local stormwater and flood control system.

Fees collected by the stormwater utility are used to provide drainage services to the residents of the unincorporated Miami-Dade County service area. In some areas, the County's Secondary Canal System also provides drainage benefits to incorporated municipal residents. The County's Water Management Division supports numerous programs, including the County's Comprehensive Development Master Plan process, emergency preparedness and management, stormwater infrastructure maintenance, engineering evaluations and improvements to the County's' Flood Protection and Water Quality Levels of Service, as well as the County's local and regional efforts on climate change, sea level rise, and adaptation planning. The stormwater master planning process is extensive and recommends investments for flood prevention, and infrastructure improvements, as well as operations and maintenance targets. Because the stormwater master plan is integral to the Comprehensive Development Master Plan, the progress and effectiveness of the Stormwater Master Plan is monitored during the periodic "Evaluation Assessment Review" conducted by the State.

The Stormwater Master Plan already includes existing, as well as recognized, forecasts for critical engineering data such as ground water levels, critical surface water stages, storm surge, tidal elevations and anomalies, and water management operations. The County also uses the latest Federal Emergency Management Agency's risk assessment tools and risk management methodology for floodplain mapping; The Compact's most recent sea level rise projections; the latest The Federal Emergency Management Agency's Flood Insurance Rate Maps; and the latest Florida Building Code requirements for new construction and substantial improvements to existing infrastructure, both public and private.

Implementation of the Miami-Dade County Stormwater Master Plan ensures that the County continually:

- Evaluates existing and future forecasted water quantity and water quality conditions

- Develops, prioritizes, and budgets for stormwater management and engineering solutions
- Continually models, value engineers, and analyzes future impacts and mitigation scenarios to effectively address long-term strategic infrastructure planning and stormwater management decisions (including SLR adaptation)
- Develops best management practices for flood protection, reduction, and water quality improvements

Stormwater infrastructure projects, per industry engineering standards, are designed to perform for the next 30 to 50 years with the forecasted sea level rise, or best available tidal elevations forecasted for each area. The Division is continually analyzing and updating its models and regulatory framework to incorporate future changes, if any, in the hydrology, precipitation levels, ground and surface water stages, tidal elevations, and regional water management practices. This commitment to "modeling forward" is what allows the Division to study "what if" scenarios and implement future capital infrastructure and code changes to continue to provide cost effective flood control levels of service.

Miami-Dade County Local Mitigation Strategy

Miami-Dade County's Local Mitigation Strategy is a whole community initiative designed to reduce or eliminate long-term risk to human life and property from hazards, including flooding. The Local Mitigation Strategy plan is a multi-volume plan that documents the planning process and addresses mitigation measures in relation to the hazard risk and vulnerability assessment of Miami-Dade County. This is a living document that is updated semi-annually to integrate and reflect current and projected issues and track mitigation measures. The strategy includes actions that have occurred, are occurring, and are planned for or desired. This plan is a compendium of efforts of the whole community, integrating governmental and non-governmental agencies such as the non-profit and private sector, educational and faith-based organizations, as well as individual communities, families and individuals.

The plan was created by the Local Mitigation Strategy Working Group, led by the Miami-Dade County Office of Emergency Management. The Local Mitigation Strategy Working Group is made up of representatives from Miami-Dade municipalities, County departments, state and federal agencies, schools, colleges and universities, hospitals, private for-profit, and not-for-profit organizations. Because the plan is approved by The Federal Emergency Management Agency, it enables members of the working group to access available funding for mitigation such as, but not limited to, the Hazard Mitigation Grant Program, Pre-Disaster Mitigation, and Flood Mitigation Assistance. Funding from the Federal Emergency Management Agency prioritizes addressing Severe Repetitive Loss and Repetitive Flood claims.

One of the most important components of the Local Mitigation Strategy is its second section, which contains a list of mitigation projects. This list includes projects that have been completed, are being pursued, or have been identified as a need to address a known risk. Many of these projects focus on reducing the risk of flooding and will support the County's adaptation to rising sea levels. This past year alone, more than 12 major projects from the Local Mitigation Strategy

were completed (Table 1), representing more than $37 million in mitigation investments. In addition, 23 more projects are under construction representing a further investment of more than $35 million (Table 2). A study conducted by the Multi-hazard Mitigation Council shows that there is a saving of four dollar for every dollar invested into mitigation measures.

Table 1: A sample of local mitigation projects completed in 2015

Local Mitigation Strategy Project Status Reported 01/2015-12/31/2015			
Completed Projects			
Region	**Location**	**Investment**	**Funding Source**
Aventura	NE 29 Place Phase 1 drainage work	$425,000	FDEP
Cutler Bay	Caribbean Boulevard JPA project reduce flooding and increase traffic flow	$11,173,054	CITT funds
Cutler Bay	SW 212 Street Drainage Improvements from SW 87 Ave to SW 85 Ave	$850,000	TAP & FL Leg. Approp. Grant
Florida City	Generator for Underground Drainage for Friedland Manor	$904,739	State Small City CDBG and City Funds
Homestead	Land acquisition for storm water drainage	$3,000,000	Capital Improvement
Key Biscayne	Erosion Control Implementation	$10,000	Public Works General fund
Key Biscayne	Stormwater outfall rehabilitation on Harbor Drive	$150,000	Stormwater Utility and grant
Mount Sinai	Relocation of generators for energy facility into hurricane rated enclosure	$8,994,838	State DEM
Seaport	Construction of New Seawall - Area 2	$9,600,000	FDOT
Seaport	Storm Bollards	$70,115	Seaport Funds
Seaport	Concrete Panels	$619,858	Seaport Funds
Sweetwater	Stormwater Improvements Phase IIB North Project	$1,600,000	U.S, EPA, Miami Dade GOB
	Total	$37,397,604	

Table 2: Local mitigation projects under construction as of January 2016

Mitigation Projects Under Construction			
Region	**Location**	**Investment**	**Funding Source**
Cutler Bay	Reduction of Floating Debris	$60,000	Funding Secured
Cutler Bay	Flood Zone Data GIS System	$140,000	Stormwater Utility Fees
El Portal	Village of El Portal Stormwater Improvements	$10,000,000	Capital Improvement

Hialeah	Roadway/Stormwater Improvements (SE 4 ST to	$151,469	City Capital Improvement
Hialeah Gardens	Central District Drainage Improvements	$2,500,000	Capital Improvement
Homestead	Wastewater Infiltration/Inflow	$2,400,000	Capital Improvement
Homestead	Sidewalks/ Roadway Improvements	$200,000	Capital Improvement Plan
Homestead	New Sewer Mains	$2,000,000	Capital Improvement
Homestead	Sewer lines in the Northwest Neighborhood and the West Industrial	$3,300,000	Capital Improvement
Miami Beach	Venetian Islands Drainage Improvements	$9,100,000	Grant Applied For
Miami Beach	Drainage Hot Spots	**	Grant
Miami Beach	Venetian Islands – Neighborhood	**	Grant
Miami Beach	Sunset Islands 3 & 4 – Neighborhood Improvements	**	Grant
Miami Beach	Lower North Bay Road – Neighborhood Improvements	**	Grant
Miami Beach	Citywide Dune Restoration & Enhancement Project	$400,000	Grant
Miami Gardens	Create GIS Layer for Storm Sewer	$100,000	*
North Miami	Flood Prevention and Mitigation: Drainage Basin13	$500,000	Capital Improvement
North Miami	Sanitary Sewer Backup	$700,000	Capital Improvement
North Miami	Surge Resistance and Flood Mitigation at Keystone Point and Sans Souci	$500,000	Capital Improvement
North Miami	NE 172nd Drainage Improvement	$17,916	Capital Improvement
North Miami Beach	Install Additional Storm Water Basins or Increase Existing Basins	$60,000	Capital Improvement
North Miami Beach	Construct Storm Water System- may include Injection Wells in Areas Prone to Flooding	$120,000	Capital Improvement
North Miami Beach	Clean and Improve Drainage Systems	$428,400	Capital Improvement
North Miami Beach	Eastern Shores Drainage Repair/Replacement	$450,000	Capital Improvement
Palmetto Bay	Flood Zone Data Maintenance: GIS System	$100,000	Capital Improvement
Palmetto Bay	Localized Drainage Improvements	$900,000	Capital Improvement
Sweetwater	South Florida Water Management District Flood Protection Berm	$1,000,000	South Florida Water Management District
Total		$35,127,785	

Continuing to fund mitigation projects already identified in the Local Mitigation Strategy will also help reduce the County's own exposure in addition to the exposure of the community more broadly.[23] As of December 2015, the Local Mitigation Strategy contained more than 1,020 projects identified as having the potential to reduce the County's exposure to known hazards; many of these are focused specifically on addressing flooding risks.[24] Increasing funding for these projects would significantly expedite adaptation.

Miami-Dade County Beach Nourishment Program

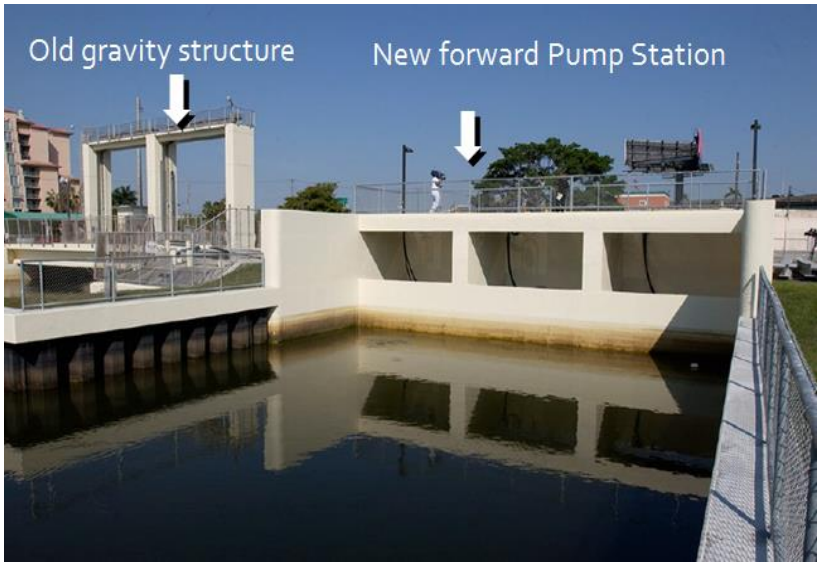
As sea levels rise they affect the beach profiles and erosion rates. Beach nourishment can help slow these changes to the County's beaches and dunes and provide important storm protection benefits. For these reasons, Miami-Dade County Environmental Resources Management and other local, Federal and State agencies work together to enhance and protect our beaches from the effects of sea and wind erosion. In an effort to improve the performance and cost-effectiveness of the Beach Erosion Control and Hurricane Surge Protection project from 1966, a number of project-wide, and site-specific, studies have been conducted to better identify these problem areas, assess the causal factors for the high erosion rates, and develop recommendations for remediating these areas. The recommendations for managing these hotspot areas of high erosion, range from no action to structural solutions such as the installation of breakwaters and groins. Tens of millions of dollars have been and will continue to be invested in these programs in order to protect our shoreline and coastal infrastructure from the effects of sea level rise.[25]

[23] More information about the Local Mitigation Strategy is available at http://www.miamidade.gov/fire/mitigation.asp
[24] The most recently published list of Local Mitigation Strategy projects is available at http://www.miamidade.gov/fire/library/OEM/local-mitigation-strategy-part-2-projects.pdf
[25] More information about the County's beach renourishment program is available at http://www.miamidade.gov/environment/beach-renourishment.asp

South Florida Water Management District Adaptation Efforts

The South Florida Water Management District continues to investigate the impacts of sea level rise on the District's mission of flood control, which could impact operations in the future. The South Florida Water Management District is working to address flooding caused by land use changes and sea level rise in Miami-Dade County. Two examples of infrastructure modifications to address flooding caused by land use changes and sea level rise in Miami-Dade County are described below.

Figure 18: Adaptation of the District's gravity-based water management infrastructure

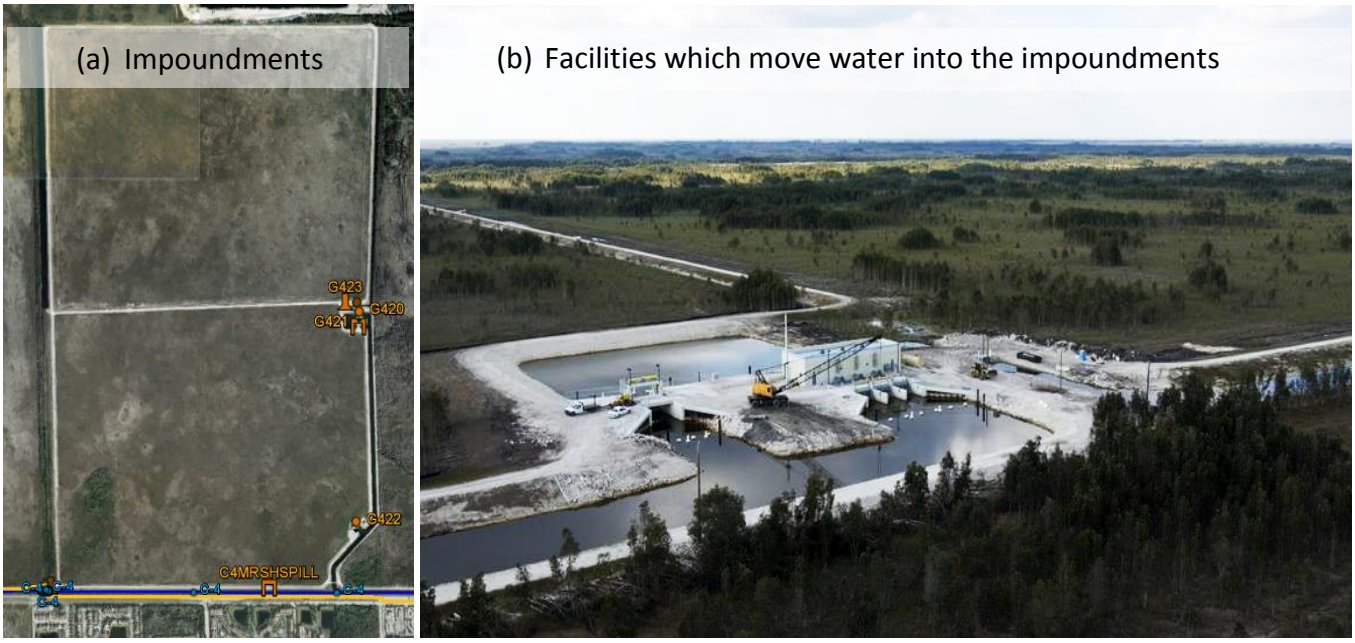


Source: South Florida Water Management District

The first example (Figure 18) shows two pumps at two coastal water control structures in Miami Dade County. The water control structures (also salinity control barriers) which discharge flood waters in the urbanized areas of Miami-Dade County were designed and built by U.S. Army Corps of Engineers during the 1950's when emphasis on sea level rise was minimal. With today's current water levels, some of the structures face higher than normal water levels during high tide, preventing the older gravity-based structures from discharging flood waters at the capacity they were designed for. In order to retrofit this condition and provide the necessary flood protection in areas around the Miami International Airport, two pumps (also called forward pumps) have been installed. These two projects were partially funded by The Federal Emergency Management Agency.

The second example of infrastructure modification in Miami-Dade County focuses on heavily urbanized areas along Tamiami Trail (south of Miami International Airport) that are subject to significant flooding during major storm events, such as tropical storms and hurricanes. Traditionally, flood waters are discharge from urban areas to the ocean. However, as explained above, the efficiency of moving water through a highly constrained canal system and water control structures is inadequate. The South Florida Water Management District has implemented a solution to this problem by moving flood waters west, for temporary storage in a newly constructed impoundment. Figure 19 shows the Western C-4 Impoundment, which was constructed to store excess flood waters. This facility improves flood protection and facilitates groundwater recharge.

Figure 19: Stormwater impoundments built in western Miami-Dade County



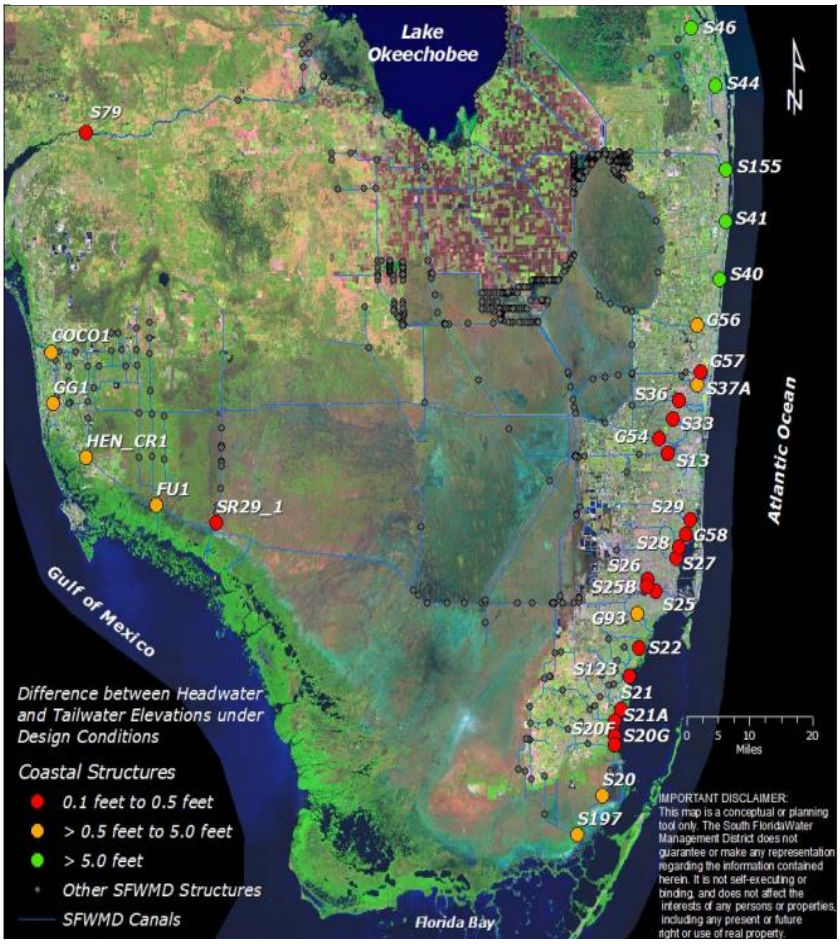
Source: South Florida Water Management District

The South Florida Water Management District also constantly monitors sea level rise data and the best available science to determine which information can be used for planning. There is a current emphasis on investment decision making under uncertainty. The South Florida Water Management District also continues to support The Southeast Florida Regional Climate Change Compact by providing technical assistance through several means: projections of SLR scenarios, providing technical data, participating in various climate change indicator subgroups, participating in the steering committee and local workshops, and supporting local government efforts to address sea level rise.

As described in the previous section, the South Florida Water Management District has a number of projects focused on adaptation to sea level rise including a pilot project to investigate the "Level of Service" for flood protection in Miami-Dade County. Because the original planning life of the Central and Southern Florida Project, created in 1948, is over, the South Florida Water Management District is beginning a long-term effort to understand the implications of current and future land use changes, sea level rise, and changes in rainfall extremes on the Districts' ability to manage the current system for flood control. The initial focus is on Miami-Dade County, as it is the area under their management that is most vulnerable to sea level rise. This is a part of long term strategy to ensure that the system is ready for the future.

A second project is being conducted in partnership with Dutch counterparts, to investigate whether Dutch technology can be used in South Florida to manage floods. Jointly with a Dutch non-profit organization, DELTARES, the South Florida Water Management District has received funding from the National Oceanographic and Atmospheric Administration to conduct a study on flood and drought risks in Miami Dade County.

Figure 20: Vulnerability assessment of the District's coastal structures to sea level rise. High, medium and low vulnerability areas are in red, orange and green, respectively.



Source: South Florida Water Management District

In a third project, the South Florida Water Management District is receiving funding from The Federal Emergency Management Agency to conduct flood studies in the C-7, C-8, and C-9 basins located in Miami-Dade County. This project will be a collaborative effort between the South Florida Water Management District and Miami-Dade County's Office of Emergency Management and the Office of Resilience. These studies are a part of the District's assistance to Miami-Dade County, which will help meet the requirements outlined in this resolution. Simultaneously, the agency is also providing technical assistance for studies in both Broward

and Palm Beach counties. As with Miami-Dade County, assistance is provided in the form of data sharing, technical input, and project review.

The South Florida Water Management District is also planning to update their 2009 white paper on climate and sea level rise. This will likely be completed by the spring of 2016. The previous document, *Climate Change and Water Management in South Florida*, provided a foundation for discussions on the effects of global climate change on water management planning and operations in the southeast Florida region.[26] The document focused on how climate change may affect South Florida's resources and outlined the mission responsibilities of the South Florida Water Management District. The paper included an initial vulnerability analysis of the potential threats of climate change and sea level rise to water supply, flood control, coastal ecosystems, and regional water management infrastructure (Figure 20). In addition to the previous efforts, the District has been working with the State of Florida Department of Environmental Protection and other Water Management Districts to develop a white paper on state-wide efforts to address the implications of sea level rise.

Miami Dade County also maintains a continuous channel of technical and institutional communication and cooperation with Dr. Jayantha Obeysekera, Chief Modeler at the South Florida Water Management District and a member of the National Climate Assessment Development & Advisory Committee, which produced the 2014 National Climate Assessment.[27] Dr. Obeysekera works very closely with Miami-Dade County staff on issues related to sea level rise and has initiated efforts to continue to communicate these adaptation efforts to the District's Governing Board.

[26] Available at www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/climate_change_and_water_management_in_sflorida_12nov2009.pdf

[27] More information on the National Climate Assessment can be found at http://nca2014.globalchange.gov/

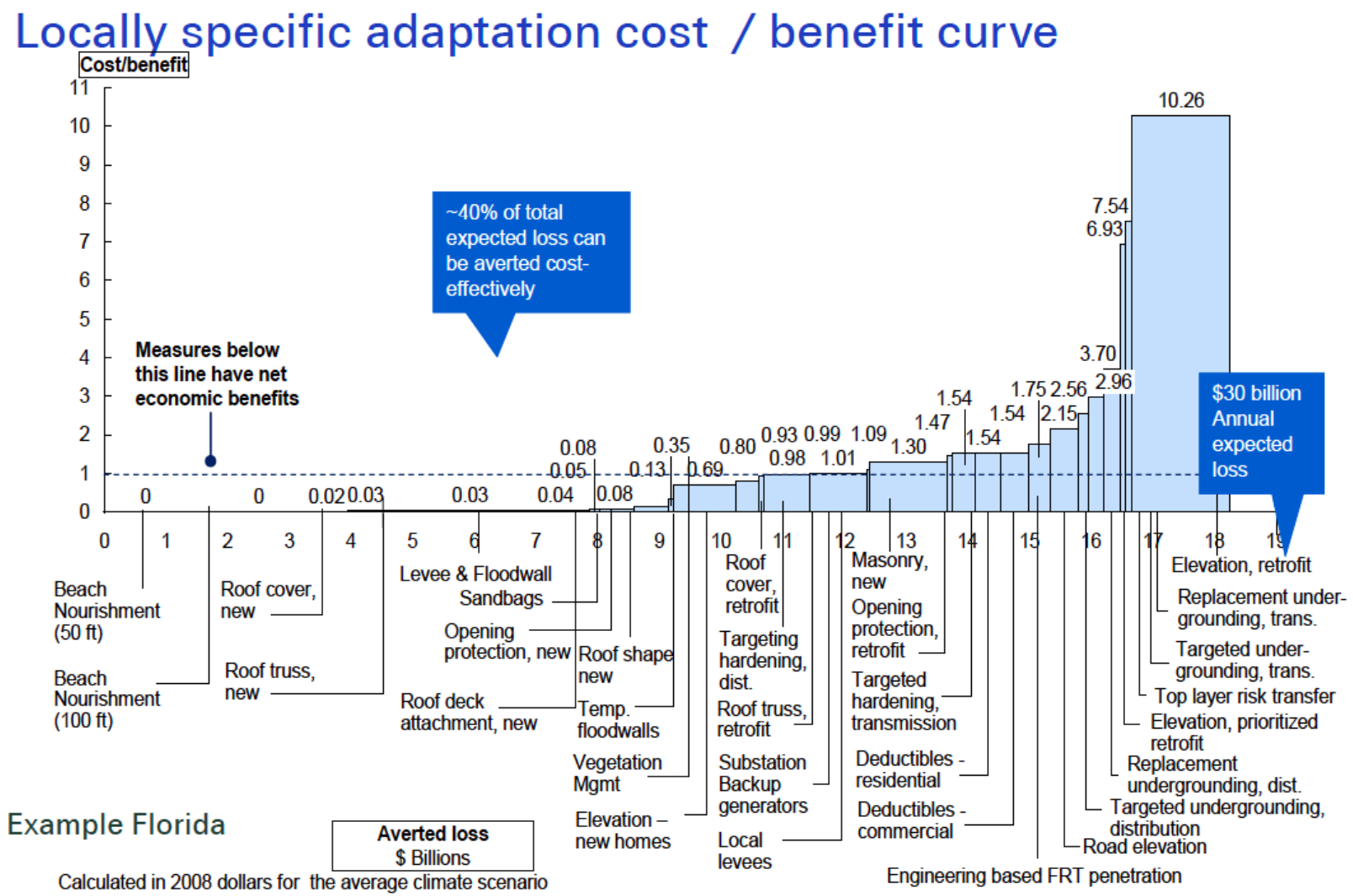
Potential Adaptation Measures

Urban expansion, sea level rise, and potential increases of extreme rainfall will stress the infrastructure in the region. Maintaining the level of service for flood protection will require a focused analysis of each major drainage basin in Miami-Dade County. Since there is a broad diversity in impacts and characteristics among basins, there is not one single solution (or even a suite of solutions) that can be applied to the entire County. For instance, two forward pumps and a western reservoir were found to be the part of a longer term solution in the C-4 basin, but such adaptation measures may not be feasible in other areas due to constraints such as land availability. Therefore, adaptation measures must be chosen on the basis of careful local analysis.

Adaptation measures should also be chosen in a way to maximize their co-benefits and cost effectiveness. As demonstrated in Figure 21 on the next page, different adaptation measure will have very different costs and benefits that are very specific to their context and design. For example, when designing a new home it may be very cost-effective to invest upfront in the marginal cost to increase the design elevation by two feet and benefit from the reduction in flood damages and insurance premiums over the lifetime of that building. In contrast, it may not be cost effective to elevate an existing building by that same amount even though it may confer the same benefits. These tradeoffs will all depend on the type of construction, value of the building, potential losses, environmental issues, and a host of other considerations. As demonstrated by the analysis conducted by SwissRe, many of the most cost effective adaptation measures include preserving and enhancing natural coastal defenses such as beaches, dunes, and mangrove forests. Similarly, it is often more cost-effective to integrate resiliency considerations into the design phase of a project as opposed to retrofitting an existing building or infrastructure.

The following tables provide a very high-level overview of some of the potential adaptation measures that may be useful in addressing some of the flooding risks in the County (Table 3). The following measures are organized by scale and the systems they primarily address; however, these distinctions are not absolute. Many measures will provide benefits at multiple scales and will provide benefits to multiple systems. It should be a priority criteria for all County projects or policies to ensure that they do confer multiple benefits across scales and systems. To reiterate, all adaptation measures must be chosen on a site-specific basis following a detailed analysis of their potential implications. What may be effective in one location may exacerbate the problem in a different context.

Figure 21: Locally-specific cost/benefit curves for a suite of adaptation measures



Source: Swiss Re

Table 3: Potential adaptation measures at different scales

Site Scale	

Buildings	• Elevate buildings
	• Flood-proof buildings
	  o Wet flood-proofing
	  o Dry flood-proofing
	  o Passive flood barriers
	  o Improvised flood protection (sand bags or moving equipment to higher elevations)
	  o Deployable flood panels
	• Elevate the height of the interior finished floor elevation
	• Elevate mechanical systems
	• Avoid below grade parking or basements
	• Augment low-lying agricultural areas affected by rising groundwater levels with additional fill

Infrastructure networks	• Construct flood barriers to protect specific infrastructure
Natural systems	• Enhance swales, rain gardens, or pervious surfaces
Drainage	• Increase the storage and infiltration of rainwater on-site with swales, rain gardens, rain barrels, increasing pervious surfaces, or other measures
Neighborhood or Block Scale	
Buildings	• Redevelop and elevate flood-prone areas
Infrastructure networks	• Abandon septic tanks and connect to the sanitary sewer networks • Elevate roadways or increase drainage to avoid saturated roadways bases which could contribute to future pavement failure and additional maintenance requirements • Elevate bulkheads • Harden critical infrastructure assets against flooding ("flood-proofing)
Natural systems	• Increase the height and width of beach and dune areas • Improve dune restoration and vegetation management • Protect or restore fringing mangrove forests • Protect or restore sea grass beds which can trap sediment and reduce erosion rates • Restore wetlands in flood-prone areas
Drainage	• Increase the area of pervious surfaces where they can effectively increase infiltration • Increase pump capacities • Increase the use of stormwater gravity or injection wells • Enhance the stormwater system by creating a collection system • Install backflow preventers to restrict the flow of seawater into the stormwater system • Increase impoundment areas to temporarily store water during times of heavy rains • Reengineer outlets of canals to prevent flooding at high tide • Retrofit drainage in areas where exfiltration systems cease to work as they become submerged • Elevate flood-prone areas on fill • Increase maintenance on sewer infrastructure to remove obstructions to maintain system capacity • Improve swale areas where they have been compacted or compromised • Increase the use of porous pavements in areas where infiltration is possible • Increase the use of green roofs and facades to reduce urban run-off

Regional Scale	
Buildings	• Strengthen building codes to require greater freeboard (or elevation above the base flood elevation) • Create incentives for buildings that exceed the minimum building requirements and provide extra flood protection • Extend certain requirements for floodplain development to areas outside of the FEMA designated Special Flood Hazard Area • Require additional flood-proofing for certain critical facilities • Limit redevelopment in high hazard areas to resilient buildings • Designate areas of targeted development that are on the least flood-prone land • Amend the Post Disaster Redevelopment Plan to encourage redevelopment in the safest areas in the County and provide a mechanism to explore other options for residents who no longer wish to live in flood-prone areas • Incentivize or require real estate disclosure of a property's vulnerability
Infrastructure networks	• Cite critical facilities such as fire stations or emergency shelters outside of the special flood hazard areas when possible • Reroute traffic or evacuation routes to reduce dependence on flood-prone roadways • Increase the required height of seawalls and bulkheads • Raise the height of the District's levees and other levees along the canals
Natural systems	• Reduce development and preserve open space or pervious areas in the floodplain • Increase beach nourishment to slow erosion and increase the width of shoreline buffer areas • Increase the protection of natural barriers, such as coral reefs and the barrier islands, which reduce flooding damage • Increase setback requirements from shorelines, particularly in areas that are expected to erode • Acquire conservation lands that will reduce the risk of "coastal squeeze" and allow protective ecosystems (such as mangrove forests) to migrate with time • Prioritize the acquisition of natural areas in the floodplain that will help reduce potential flood damage or support protective ecosystems
Drainage	• Retrofit bridges or culverts that are significantly limiting, or are expected to limit, conveyance in the future • Install additional stormwater pumps • Alter the operations or infrastructure within the canal networks • Elevate flood-prone areas on fill • Install seepage barriers to reduce the flow of groundwater • Restrict impervious lot coverage and strengthen requirements to retain stormwater on site • Remove obstructions or constrictions from the floodplain

Where Updated Information can be found

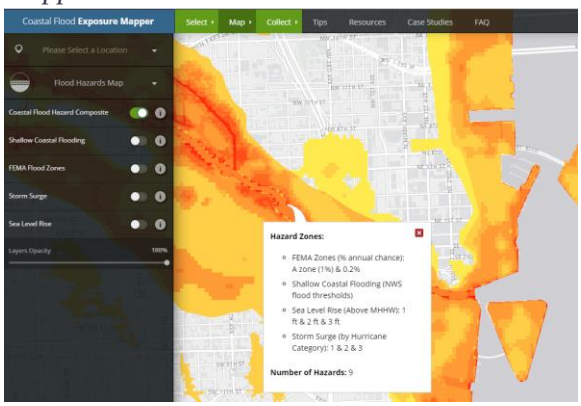
Online Viewers

A number of on-going efforts are making information about sea level rise and adaptation options publicly accessible. The following section summarizes a few of the most comprehensive "viewers" that are currently available to the public. All of the tools offer insights into the areas of the County that are low-lying and which are often, but not always, the same areas that are vulnerable to flooding. These tools are appropriate for a first examination (or "scoping analysis") to identify "hot spots" that are likely to be problematic in the future. All of the described tools use a "bathtub" inundation model, which can be helpful during preliminary studies, but cannot be used for detailed planning studies as they do not account for existing drainage infrastructure, groundwater elevation variation, erosion and other non-linear factors that influence flooding vulnerability. Despite the valuable information they can provide for a general audience, the tools are not as detailed or as accurate as the methods currently used by the County's Water Management Division and the South Florida Water Management District.

The National Oceanographic and Atmospheric Administration's Flood Exposure Mapper

The National Oceanographic and Atmospheric Association has published two user-friendly and freely accessible online viewers, allowing users to adjust the "slider" to view how different sea level rise scenarios will affect a given area.[28] The Agency has also published an online viewer that reviews coastal flooding exposure which illuminates areas of societal exposure like socially vulnerable populations, infrastructure exposure, and ecosystem exposure (Figure 22).[29] This tool includes sea level rise as one of the types of flooding it displays.

Figure 22: NOAA's Coastal Flood Exposure Mapper



Source: National Oceanographic and Atmospheric Administration

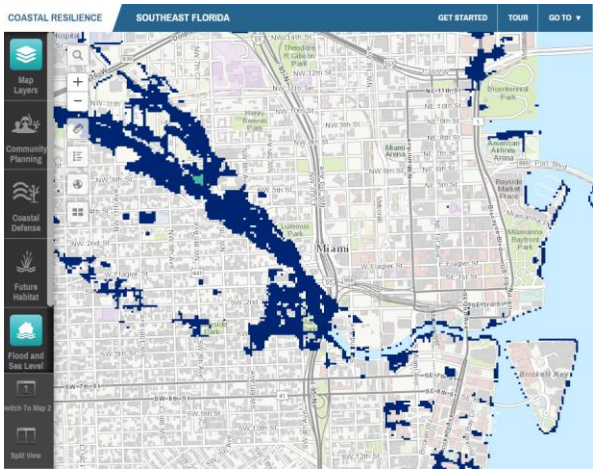
The Nature Conservancy's Coastal Resilience Tool

The Nature Conservancy has published a freely accessible, user-friendly platform to help assess the risk and vulnerability of coastal communities to the impacts of coastal hazards; identify the effectiveness of different nature-based coastal protection measures; design these nature-based solutions; and measure their effectiveness. The different tools, or applications, in this platform allow users to explore their area of interest through several filters and at different levels of detail, from a regional to a city-block level scale. For example, this platform has tools to visualize the potential impacts of sea level rise (Figure 23)[30] and to locate critical areas such as areas of erosion, areas with concentrations of repetitive loss properties, areas of on-going and

[28] Available at http://coast.noaa.gov/digitalcoast/tools/slr
[29] Available at http://coast.noaa.gov/digitalcoast/tools/flood-exposure.
[30] Available at coastalresilience.org

completed shoreline projects, and existing land use and flood zones. There are also applications to evaluate the relative effectiveness of coral reef restoration or mangrove conservation at protecting coastlines, or to identify which type of living shoreline project would be most appropriate along specific portions of the coastline. The platform is easily modified and The Nature Conservancy is prepared to add data and tools of interest to Miami-Dade County and other interested parties.

Figure 23: Nature Conservancy's Coastal Resilience Tool

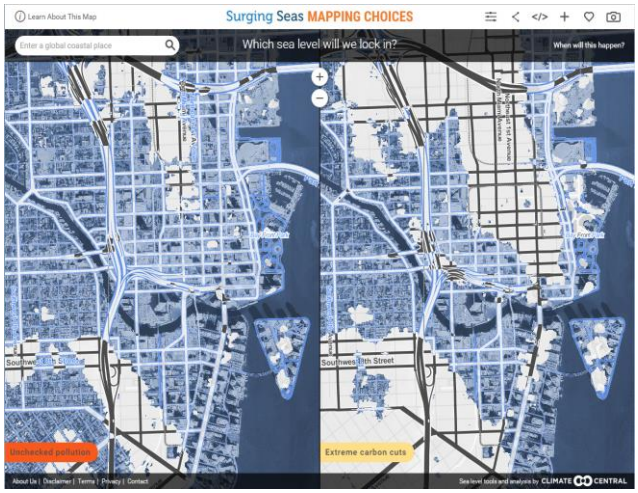


Source: The Nature Conservancy

Climate Central's Surging Seas

Climate Central has also published a similar mapping tool called the "Risk Zone Map".[31] In addition to offering a viewer showing impacts at different sea levels, the tool also offers an analysis page giving users insight into the impacted population, broken down by demographic information on race and level of social vulnerability. Their map also provides similar data about the buildings (broken down by type), infrastructure, land, and potentially contaminated sites (i.e. landfills or hazardous waste sites) that are likely to be inundated. Climate Central has also developed another mapping tool titled "Mapping Choices" which allows users to review expected amounts of sea level rise caused by different greenhouse gas scenarios (Figure 24).[32] For example, it is possible to explore the implications of continuing greenhouse gas emissions at current rates as compared to implementing extreme carbon cuts.

Figure 24: Surging Seas Mapping Choices tool by Climate Central



Source: Climate Central

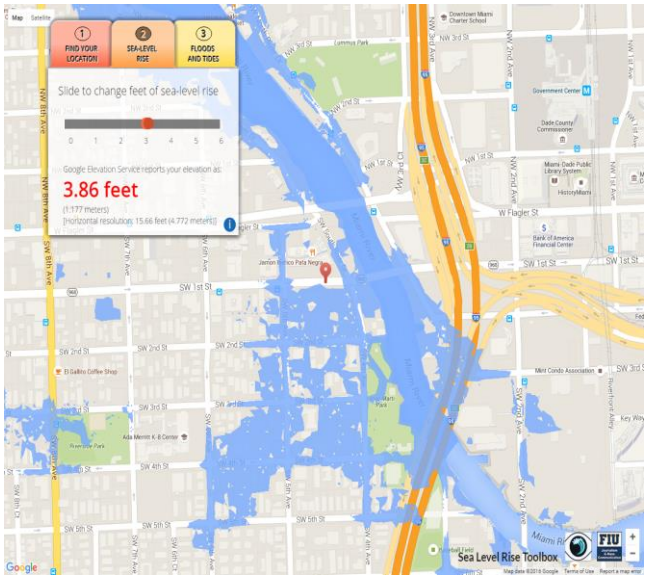
Florida International University's Eyes on the Rise

The Sea Level Rise Toolbox is part of "Eyes on the Rise", a project of Florida International University's School of Journalism and Mass Communication, led by Professors Susan Jacobson, Robert "Ted" Gutsche, Kate MacMillin, Juliet Pinto, and their students. Their map, which helps user visualize the impact of sea level rise in their neighborhood, is based upon

[31] Available at http://sealevel.climatecentral.org/ssrf/florida
[32] Available at http://choices.climatecentral.org/#12/40.7116/-74.0010?compare=temperatures&carbon-end-yr=2100&scenario-a=warming-4&scenario-b=warming-2

the State of Florida Division of Emergency Management's LiDAR (Light Detection and Ranging) Project LAS Dataset, hosted by Florida International University's International Hurricane Research Center. It is intended to project results of "static" sea level rise, not taking tidal effects in consideration. The web visualization of the "static" sea level rise map is developed by Florida International University's Geographic Information Systems Center (Figure 25). The application's main feature is an interactive sea level rise viewer where users can enter an address to visualize how a 6 foot or less increase in sea level may affect their neighborhoods in the Tri-County area of South Florida. As development on the Sea Level Rise Toolbox continues, it will also include a database of flood reports from both government and citizen sources in South Florida. Miami-Dade County recently launched an open data portal that includes flood reports, which will be included in the flood database. The flood report database will help residents identify the incidence of what the National Oceanic and Atmospheric Administration calls 'nuisance flooding,' a phenomenon that is increasingly common as coastal sea levels rise.

Figure 25: Florida International University's Eyes on the Rise mapping tool

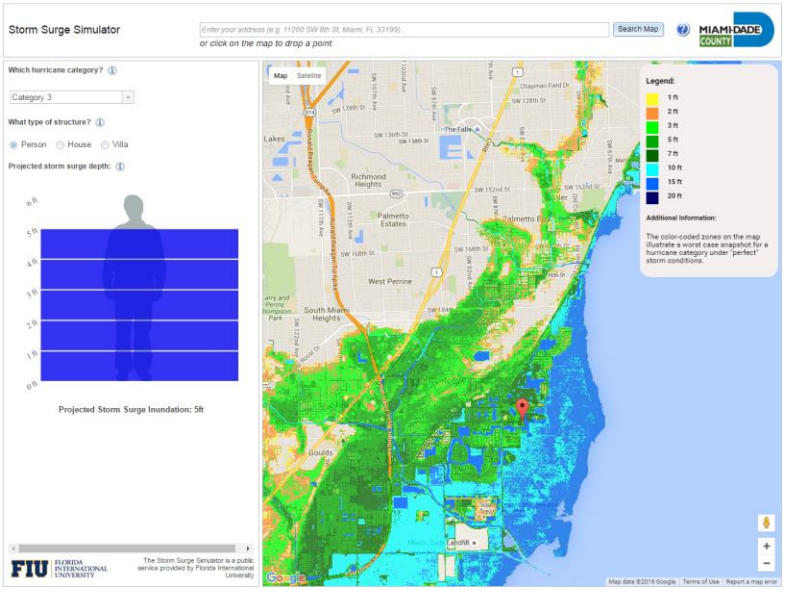


Source: Florida International University

Florida International University's Storm Surge Simulator

While it does not account for future sea level rise, another helpful online tool is Florida International University's Storm Surge Simulator, based on work of faculty experts and students at the International Hurricane Research Center and College of Engineering and Computing. This tool allows users to type in their address and see what the potential storm surge could be at their location in the event of a Category 1, 2, 3, 4, or 5 hurricane. The tool also compares the water depth to a person, house or villa in order to give users a clearer picture of what potential water depths could look like (Figure 26). While it cannot give predictive estimates of storm surge

Figure 26: Florida International University's Storm Surge Simulator Tool



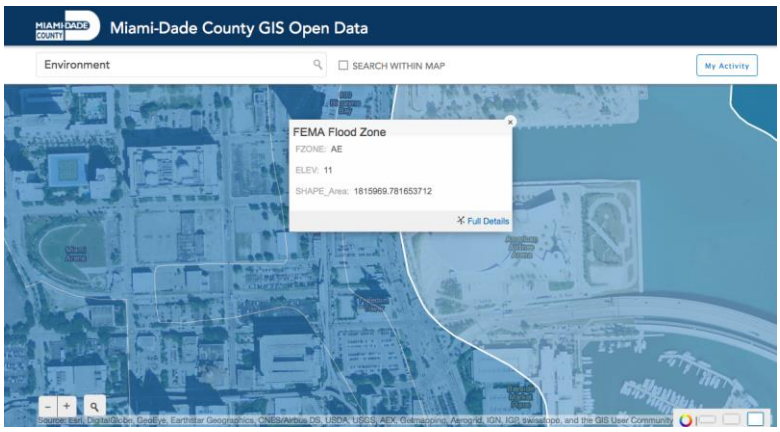
Source: Florida International University

based on an approaching storm, it is very useful tool to give users a general sense of the vulnerability of different areas to this hazard.

Miami-Dade County Open Data Portal

The County currently provides a wealth of environmental, hydrologic, planning, and public safety data through the GIS open data portal.[33] This portal allows the public to view information about existing flood zones and storm surge planning zones (Figure 27). More detailed information about emergency management, infrastructure upgrades, and other relevant is also available.[34] The County provides this website as a public service to its residents and visitors and is continually editing and updating GIS data to improve positional accuracy and information.

Figure 27: Miami-Dade County's open data portal



Source: Miami-Dade County Open Data Portal

[33] The data is available at http://gis.mdc.opendata.arcgis.com/
[34] The data is available at http://www.miamidade.gov/technology/gis-maps-and-apps.asp

Salt Water Intrusion

Overview of the Risks

Miami-Dade County's drinking water is drawn from The Biscayne Aquifer, a shallow, surficial aquifer. Because of the County's underlying geology is highly porous and transmissive (or permeable), the freshwater aquifer is not completely isolated from the brackish water at the coastal margins. There is a transitional area between fresh and brackish water that is often referred to as the "salt front", the "extent of saltwater intrusion", the "freshwater saltwater interface" or the "transition zone". The term saltwater intrusion is often used to describe the movement of saline, or brackish, water into freshwater aquifers.[35]

The interface between fresh and salty water is dynamic and can move both seasonally and over longer periods of time. As conditions change, the interface can move landward or seaward. For example, during times of extreme drought when there is less recharge of the aquifer, the salt front may move inland in places. In contrast, during the rainy season or during particularly wet years, the salt front may migrate closer to the coast in certain locations. The use (or withdrawal) of freshwater can also affect the movement of the salt front. For example, if there was significant withdrawal from coastal wellfields, this has the potential to accelerate saltwater intrusion. If there were significant aquifer recharge at that same location, it could have an opposite effect and could push the interface further toward the coast. Changes in land use may also have an effect, when they alter freshwater recharge.

The South Florida Water Management District has identified sea level rise as potentially increasing the vulnerability of the region's drinking water to salt water intrusion. The drinking water standard for chloride concentrations is below 250 mg/l. When concentrations exceed this level, drinking water must either be treated or alternative water sources must be used.

Major On-Going and Planned Studies

U.S. Geological Survey- Surface Groundwater Interface Model

To evaluate the effects of pumping groundwater on canal leakage and regional groundwater flow, the U.S. Geological Survey developed and calibrated a coupled surface-water/groundwater model of the urban areas of Miami-Dade County.[36] The development of this model is an important component to understanding the effects of sea level rise on both the risks of flooding and saltwater intrusion. The model is designed to simulate surface-water stage (water levels) and discharge (water releases) in the managed canal system and dynamic canal

[35] Additional information on saltwater intrusion is available from the USGS at http://water.usgs.gov/ogw/gwrp/saltwater/salt.html
[36] Hughes, Joseph D., and White, Jeremy T., 2014, Hydrologic conditions in urban Miami-Dade County, Florida, and the effect of groundwater pumpage and increased sea level on canal leakage and regional groundwater flow: Scientific Investigations Report.

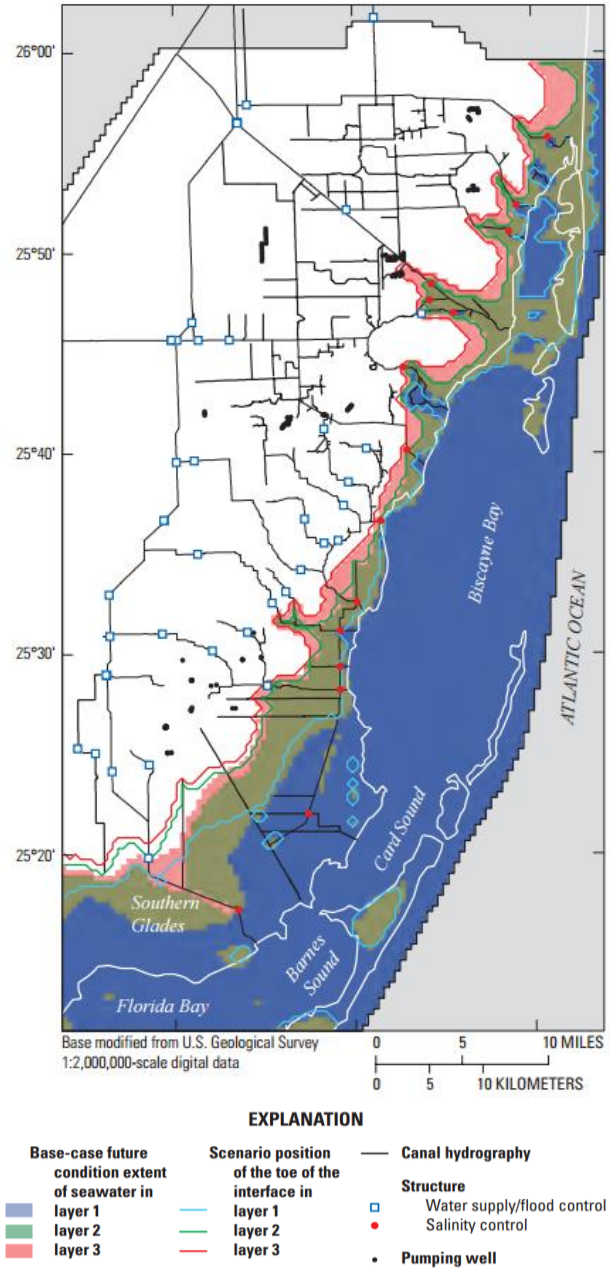
leakage to the Biscayne Aquifer, in addition to seepage to the canal from the aquifer. The model was developed using the U.S. Geological Survey's MODFLOW–NWT.[37]

The model represents the complexities of the interconnected surface-water and groundwater systems that affect how the systems respond to pumping groundwater, sea-level rise, and other hydrologic stresses. The model also quantifies the relative effects of pumping groundwater and sea level rise on the surface-water and groundwater systems. Supporting data and other information is available at the U.S. Geological Survey's publication library.[38]

The study found that analytical and simulated water budgets for the study period (1996- 2010) indicated that, on average, more of the water discharging through the salinity control structures is derived from draining of the Biscayne Aquifer within the urban parts of the study area that from controlled releases upstream . The position of the freshwater-seawater interface at the base of the Biscayne Aquifer did not change notably during the simulation period (1996–2010). This is consistent with the similar positions of the interface in 1984, 1995, and 2011, under similar hydrologic and groundwater pumping conditions. Landward movement of the freshwater-seawater interface above the base of the Aquifer is more prone to occur during relatively dry years.

The model was used to evaluate the effect of increased groundwater pumpage and (or) increased sea level on canal leakage, regional groundwater flow, and the position of the freshwater-seawater interface (Figure 28). Permitted groundwater pumping rates were used for Miami-Dade County Water and Sewer Department groundwater pumping wells in the

Figure 28: Increased sea-level and groundwater pumpage conditions



Source: U.S. Geological Survey, 2011

[37] MODFLOW-NWT is a standalone program that is intended for solving problems involving drying and rewetting nonlinearities of the unconfined groundwater-flow equation.

[38] Hughes, Joseph D., and White, Jeremy T., 2014, Hydrologic conditions in urban Miami-Dade County, Florida, and the effect of groundwater pumpage and increased sea level on canal leakage and regional groundwater flow: Scientific Investigations Report. http://pubs.usgs.gov/sir/2014/5162

base-case future scenario. These rates generally exceeded historical groundwater pumping rates. The results suggest seawater (saltwater) intrusion may occur at the Miami-Springs well field if the Miami Springs, Hialeah, and Preston well fields are operated using current permitted groundwater pumping rates in the base-case and increased pumping scenarios. Simulations also show that, in general, the canal system limits the adverse effects of proposed increased groundwater pumping on water-level changes and saltwater intrusion. In other words, when groundwater pumping rates increase, the canal system as simulated provides more recharge to the Aquifer, limiting groundwater-level declines and saltwater intrusion that might otherwise occur without additional recharge. Proposed increases in groundwater pumping do not have a notable effect on movement of the freshwater-seawater interface. Increased groundwater pumpage augmented lateral groundwater inflow into basins subject to additional groundwater pumpage; however, most of the additional groundwater extracted from pumping wells was supplied by changes in canal seepage and leakage in urban areas of the model.

Increased sea level resulted in landward migration of the freshwater-seawater interface. The largest changes in the position of the interface (or "salt front") occurred seaward of the salinity control structures with exception of parts of the model area that were inundated by increased sea level. These areas were primarily in the southeastern parts of the County in the C103, C111 basins, and in the Model Land and Southern Glades areas (Figure 28). Decreased water-table gradients reduced groundwater inflow, groundwater outflow, canal exchanges, surface-water inflow, and surface-water outflow through salinity control structures. Put another way, an increase in sea level reduces the hydraulic gradient, or the slope between surface-water and groundwater elevations onshore and coastal waters to the east. A reduction in the hydraulic gradient reduces canal flows through the salinity control structures and seaward flow of groundwater. This reduction in hydraulic gradient also reduces the rate at which water from the canal system can recharge the groundwater system.

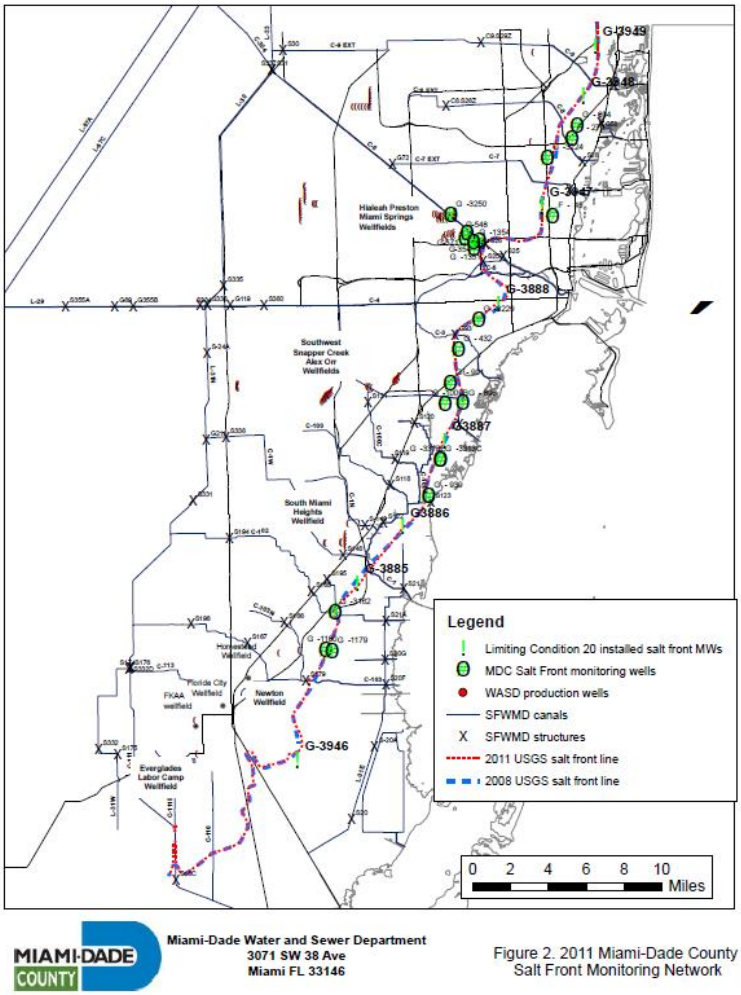
Results for the scenario that evaluated the combination of increased groundwater pumping and increased sea level did not differ substantially from the scenario that evaluated increased sea level alone. Groundwater inflow, groundwater outflow, and canal exchanges were reduced in urban areas of the study area as a result of decreased water-table gradients across the system, however, reductions were less than those in the increased sea-level scenario. The decline in groundwater levels caused by increased groundwater pumpage was lower under the increased sea-level scenario than under the increased groundwater-pumpage scenario. The largest reductions in surface-water outflow from the salinity control structures occurred with increased sea level and increased groundwater pumpage. This means that the canals are not able to drain as quickly and that there is less capacity for managing the hydrologic system. The system would be harder to drain during a rain event. There will be less ability to recharge the aquifer from the canal system, and thus less control over saltwater intrusion.

Miami-Dade County Water and Sewer Department Monitoring Network

The Miami-Dade County Water and Sewer Department is required to submit an annual Salt Front Monitoring Program summary report to the South Florida Water Management District every April 15th. The annual report summarizes hydrologic and water quality conditions ascertained from the monitoring data collected as part of the approved salt front monitoring program. This annual report includes review and analysis of the data collected and includes recommendations regarding the salt front monitoring network. The most recent report is included in Appendix 3.

Groundwater levels and chloride levels (the saltiness of the water) throughout Miami-Dade County are monitored through the joint efforts of the Miami-Dade Water and Sewer Department, the Miami-Dade Department of Regulatory and Economic Resources, and the U.S. Geological Survey. A network of small diameter wells have been drilled to the base of the Aquifer to serve as monitor wells to identify the location of the saltwater intrusion front (Figure 29).

Figure 29: Salt front monitoring network



Source: Miami-Dade County Water and Sewer Department

The salt front is identified as the location at the base of the aquifer, of the 1,000 milligrams/per liter (mg/L) isochlor. An isochlor is the line of equal chloride concentration of 1,000 mg/L. Sampling of the monitor wells is done by the U.S. Geological Survey, under a co-operative contract with the County.

Additional wells are sampled on a quarterly or yearly basis, depending on well location. Every year, the sampling schedule includes a county-wide sampling event conducted at the height of the dry season to coincide with the time when inland movement of the saltwater front would be at its peak. The data derived from that sampling is used by the U.S. Geological Survey to identify any significant movement of the salt front, and to map the location of the salt front if a significant movement is evident.

The network of monitor wells has been modified over the years, depending on the changing needs of the County and on changing hydrologic conditions. More wells have been drilled to

monitor areas where the salt front is moving and sampling has been discontinued at wells by-passed by the salt front. Other monitoring wells have been drilled around the operating wellfields to provide additional protection. The monitoring and testing program now includes annual induction logging of several wells. Through time, these electric logs may show changes in the bulk conductivity, which indicates a change in "saltiness" of the water, at specific depths. The effects of formational stratigraphy and hydraulic conductivity on the intrusion patterns can be determined from that information.

Since 2007, the Miami-Dade Water and Sewer Department has contracted with the U.S. Geological Survey to update the salt front delineation and monitoring network. The main objective of this study has been to augment an existing saltwater-intrusion monitoring network through application of surface and borehole geophysical methods and the addition of new sentinel monitoring wells. Salinity data from the new wells was integrated with existing monitoring wells and used to provide an up-to-date map showing the landward limit of the saltwater in Miami-Dade County. The U.S. Geological Survey work includes three main tasks. First, evaluate existing salt front hydrologic and geologic data and provide a draft of an updated salt line. This task was completed in October, 2008. Second, to acquire surface and/or aerial resistivity data to aid placement of new monitoring wells and construction of new monitoring wells. The installation of eight monitoring wells was completed in 2010 and their sampling was conducted in 2011. Thirdly and finally, guided by the application of surface geophysics and induction logging in existing wells, the new data was integrated with existing monitoring well data to complete a final revised position of the saltwater-freshwater interface. This task was completed in March 2011.

In 2011, the salt front line was updated again, based on additional data and sample locations. The updates were released on March 31, 2011. In general, there was no significant change between the 2008 and 2011 salt front line in the north and central areas of the County. However, the line moved further inland in the south, specifically in the C-111E canal area. WASD is currently in the process of negotiating a new joint funding agreement with USGS to update the 2011 salt front line.

The most recent report, contained in full in Appendix 3, includes review and analysis of the data collected and includes recommendations regarding the salt front monitoring network. As mentioned, groundwater levels and chloride levels throughout Miami-Dade County are monitored through the 5-year Water Resource Joint Funding Agreement (JFA) with the U.S. Geological Survey. These wells either have manual water levels taken, or have been equipped with satellite telemetry to record groundwater levels in real time.[39] Four new salt front monitoring wells were installed in 2015. Wells are monitored based on a sampling protocol developed by the U.S. Geological Survey, but every year the sampling schedule includes a county-wide sampling event conducted at the height of the dry season, to coincide with the time when inland movement of the saltwater front would be at its peak.

Results of the 2015 salt front monitoring are summarized below in Table 4. An increase in the average chloride concentration was observed for some of the wells and a slight decrease for

[39] Water level data are available from the USGS at http://www.sflorida.er.usgs.gov/ddn_data/index.html

others. However, in general, there was no significant difference between 2007 and 2015 average concentration chloride levels, with the exception of the wells located in the southeastern portion of the County, where a rapid increase in salinity has been observed in the past several years. These wells are located just east of the Newton Wellfield.

Table 4: Historic chloride data from monitoring wells from 2008-2015

Station Name	2015 Min (mg/L)	2015 Max (mg/L)	Average Chloride (mg/L) 2015	Average Chloride (mg/L) 2014	Average Chloride (mg/L) 2013	Average Chloride* (mg/L) 2012	Average Chloride (mg/L) 2011	Average Chloride (mg/L) 2010	Average Chloride (mg/L) 2009	Average Chloride (mg/L) 2008
G-3313E*	4300	5900	5100	5200	4800	4600	5600	713	1500	5400
G-3313C	4800	5400	5167	4875	4533	4350.83	4716.67	4400	4250	4200
G-3250	100	210	139	134.25	36.5	200	180.83	176	139	131
G-3229	2200	2600	2442	2250	2108.3	1883	1605.83	1217	900	807
G-3224	34	37	35	34.5	35.25	41	42.25	41	41	39
G-3162	1400	1600	1475	1541.67	1425	1267	1280	1303	1284	1208
G-1354	150	350	195	176.67	135	58	48.83	48	516	53
G-1351	390	430	406.67	399.17	436	474	491.67	503	520	530
G-1180	10	28	19	20.22	37	17	24.58	27	17	30
G-1009B	65	160	80	71.83	74	75	60.42	62	59	59
G-939	3400	4300	3767	3883.33	4108	3808	3900	3750	3333	3050
G-901	4000	5200	4650	3527.27	3058	2667	2550	2438	2550	2375
G-3611	160	160	160	165	168	165	168.75	170	172	173
G-896	260	480	347	245.83	251	258	245.33	248	235	247
G-894	14	17	15	15	17	21	22.67	22	22	21
G-571	26	28	27	26.58	28	34	35.42	34	30	32
G-548	31	34	32.58	28.58	30	31	31.5	34	36	40
G-432	5900	6800	6383	5816.67	5683	5467	5141.67	4775	4500	4150
G-354	36	44	40	40.5	42	45	46.08	49	50	53
F-279	3900	4300	4067	4116.67	3892	3675	3583.33	3475	3383	3300
F-45	120	160	143	129.5	127	118	112.92	97	97	87
G-3885	27	31	30	29.92	31	36	36.33	NA	NA	NA
G-3886	46	48	47	45.77	47	49	50.83	NA	NA	NA
G-3887	2600	2800	2692	2508.33	2442	2292	2237.50	NA	NA	NA
G-3888	5700	6300	6075	5591.67	5458	5225	5029.17	NA	NA	NA
G-3946	5100	5600	5375	5066.67	4629	4158	3716.67	NA	NA	NA
G-3947	20	23	21.27	20.67	21	25	27.92	NA	NA	NA
G-3948	4200	4500	4318.18	4275	4308	4195	3991.67	NA	NA	NA
G-3949	120	130	122	117.5	116	121	114.55	NA	NA	NA

NA=not available

*Measured only once a year

Source: Miami –Dade County Water and Sewer Department

The Water and Sewer Department, in collaboration with the U.S. Geological Survey, continued sampling 68 wells to monitor for chloride concentration and specific conductance and they are conducting a time-series electromagnetic induction log from 33 wells. Following the recommendations of the 2014 Annual report, six new wells were installed on the fresh side of the

2011 salt front line and were immediately incorporated into the monitoring network (Figure 30). Rapid salinity increase has been observed in the southeast area of the County, east of the Newton Wellfield, in Homestead. Monitoring well G-3966 was installed in 2014 between the Newton Wellfield and the Homestead Speedway. It quickly became salty, and is now on the saltwater side of the 2011 salt front line. In response, G-3976 was installed on the fresh side of the line in that area and is being monitored monthly to follow the advancement of the salt front in the area as closely as possible.

Figure 30: Additional salt front monitoring wells installed in 2015

Source: Miami-Dade County Water and Sewer Department

Additional salt front monitoring wells will be scheduled for installation in 2016, to be included in the network of wells, which provide the required data to update the saltwater encroachment along the base of the Biscayne Aquifer, as necessary. The Water and Sewer Department WASD is currently negotiating a new joint funding agreement with the U.S. Geological Survey to update the 2011 salt front line with the most current data. Additional salinity monitoring stations will be added in 2016 in south Dade in the vicinity of the advancing salt front. The Water and Sewer Department recommends that the U.S. Geological Survey update the published 2011 salt front line because monitoring has indicated that the salt front has already moved further west in part of the County since the 2011 line was published.

The issue of sea level rise may have a critical impact on Miami Dade Water and Sewer Department's operations and future water supply planning. The factors affecting salt water intrusion include wellfield withdrawal rates, climate change, rates of sea level rise, and changes to the regional water management system, including Everglades Restoration. The extent to which changing average sea levels will impact the wellfields and the Biscayne Aquifer in the coming decades is uncertain at this time due to the uncertainty surrounding these variables; however, the extensive and sophisticated monitoring network allows the County to quickly adjust operations based on changing conditions and limit the risk of saltwater intrusion.

As described in the report, *Hydrologic Conditions in Urban Miami-Dade County, Florida, and the Effect of Groundwater Pumpage and Increased Sea Level on Canal Leakage and Regional Groundwater Flow,* sea level is predicted to rise in the foreseeable future.[40] The study concludes that both increased pumping and higher sea levels may promote salt water intrusion at the

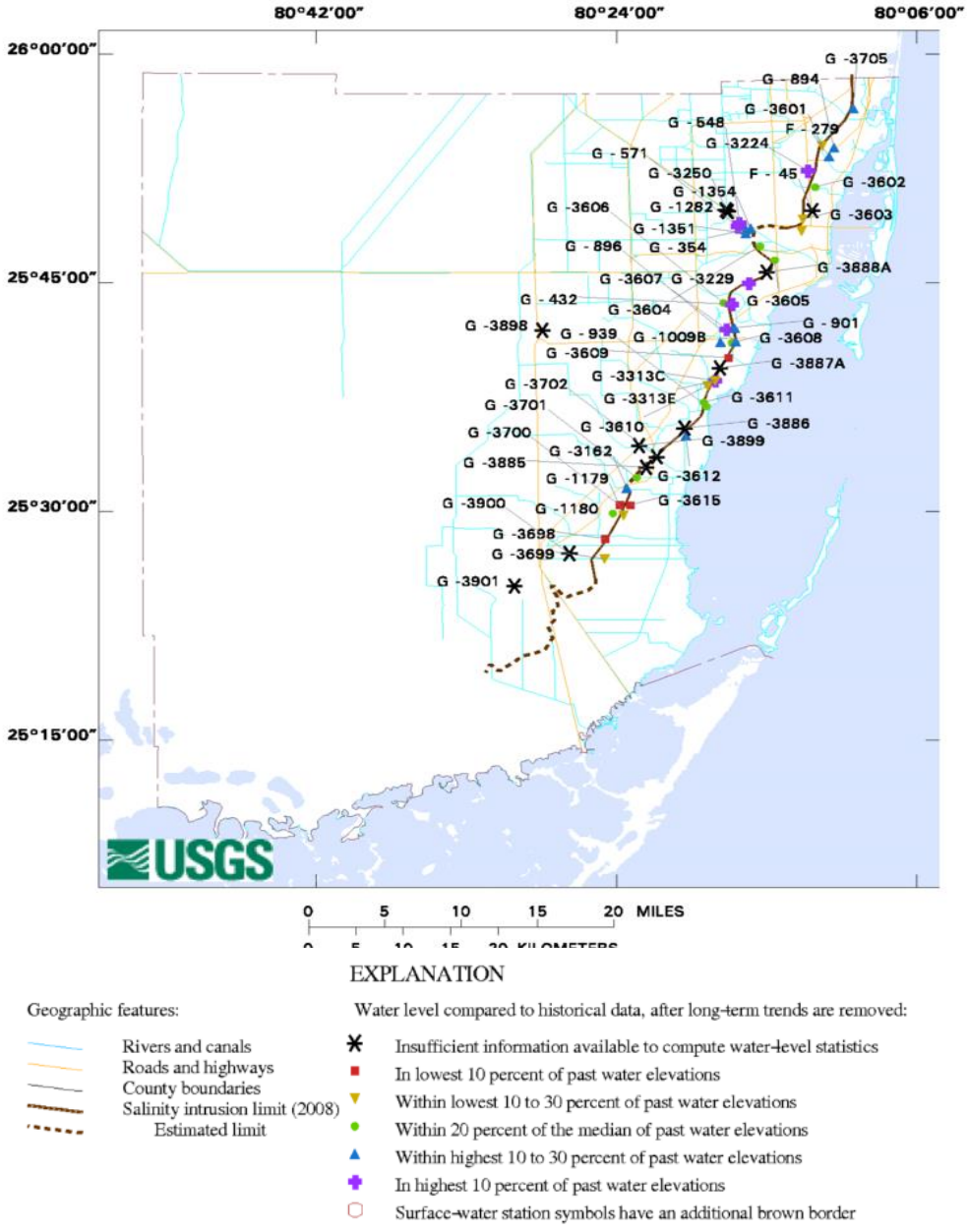
[40] "Hydrologic conditions in urban Miami-Dade County, Florida, and the effect of groundwater pumpage and increased sea level on canal leakage and regional groundwater flow "USGS 2014. Available at https://pubs.er.usgs.gov/publication/sir20145162

Miami-Spring, Hialeah, and Preston wellfields over a 30 year horizon. Miami-Dade completed an evaluation and risk assessment of Hialeah and Preston water supply which includes Miami-Springs and the evaluation recommended developing a water quality treatment plan to address this impact and Water and Sewer Department is currently working on that plan.

U.S. Geological Survey Mapping of Water Levels in Miami-Dade County

This study, described previously, is a critical component to understanding how sea level rise and groundwater pumpage will impact salt water intrusion. One figure from this comprehensive study describes how increased sea level and groundwater pumpage may affect the freshwater-seawater interface at the end of May in the 30th year of the scenario simulation period (Figure 31).

Figure 31: Water levels at selected sites, 2012

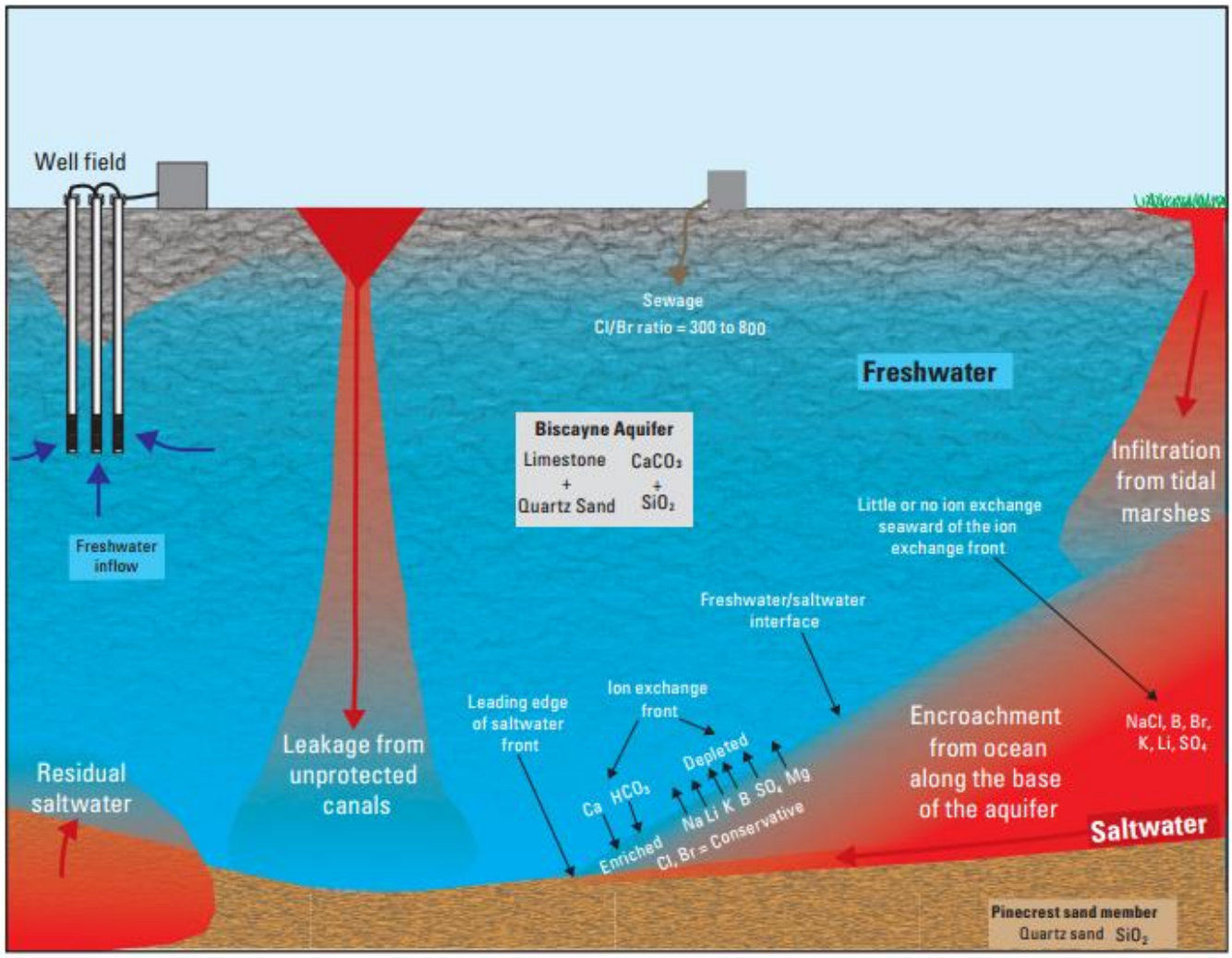


Source: U.S. Geologic Survey

U.S. Geological Survey Study on the Origins and Delineation of Saltwater Intrusion in the Biscayne Aquifer and Changes in the Distribution of Saltwater in Miami-Dade County, Florida

Saltwater intrusion of the Biscayne Aquifer began when The Everglades were drained to provide dry land for urban development and agriculture. The reduction in water levels caused by this drainage, combined with periodic droughts, allowed saltwater to flow inland along the base of the aquifer and to seep directly into the aquifer from the canals. A conceptual image of the sources and mechanisms of saltwater intrusion is shown in Figure 32.

Figure 32: Conceptual diagram of sources and mechanisms of saltwater that has intruded parts of aquifers in SE Florida



Source: U.S. Geological Survey

An examination of the inland extent of saltwater and the sources of saltwater in the aquifer was completed during 2008–2011 by using (1) all available salinity information, (2) time-series electromagnetic induction log datasets from 35 wells, (3) time-domain electromagnetic soundings collected at 79 locations, (4) a helicopter electromagnetic survey done during 2001

that was processed, calibrated, and published during the study, (5) cores and geophysical logs collected from eight sites for stratigraphic analysis, (6) eight new water-quality monitoring wells, and (7) analyses of 69 geochemical samples.

The results of the study indicate that as of 2011, approximately 1,200 square kilometers of the mainland part of the Biscayne Aquifer were intruded by saltwater. The saltwater front was mapped farther inland than it was in 1995 in eight areas, totaling about 24.1 square kilometers. In many of these areas, analyses indicated that saltwater had encroached along the base of the Aquifer. The saltwater front was mapped closer to the coast than it was in 1995 in four areas, totaling approximately 6.2 square kilometers. The changes in the extent of saltwater resulted from improved spatial information, actual movement of the saltwater front, or a combination of both.

Salinity monitoring in some of the canals between 1988 and 2010 indicated influxes of saltwater, with maximum salinities ranging from 1.4 to 32 practical salinity units upstream of the salinity control structures. Time-series electromagnetic induction log data from monitoring wells located adjacent to the Biscayne, Snapper Creek, and Black Creek Canals, and upstream of the salinity control structures, indicated shallow influxes of conductive water in the aquifer that likely resulted from leakage of brackish water or saltwater from these canals. Historical and recent salinity information from the Card Sound Road Canal indicated that saltwater may occasionally leak from this canal as far inland as 15 km. This leakage may be prevented or reduced by a salinity control structure that was installed in May 2010. Saltwater also may have leaked from the Princeton Canal.

Results of geochemical sampling and analysis indicate a close correspondence between droughts and saltwater intrusion. Comparison of average daily air temperatures in Miami, Florida, with estimates of recharge temperatures indicated that saltwater likely entered the aquifer in April or early May when water levels are typically at their lowest during the year.

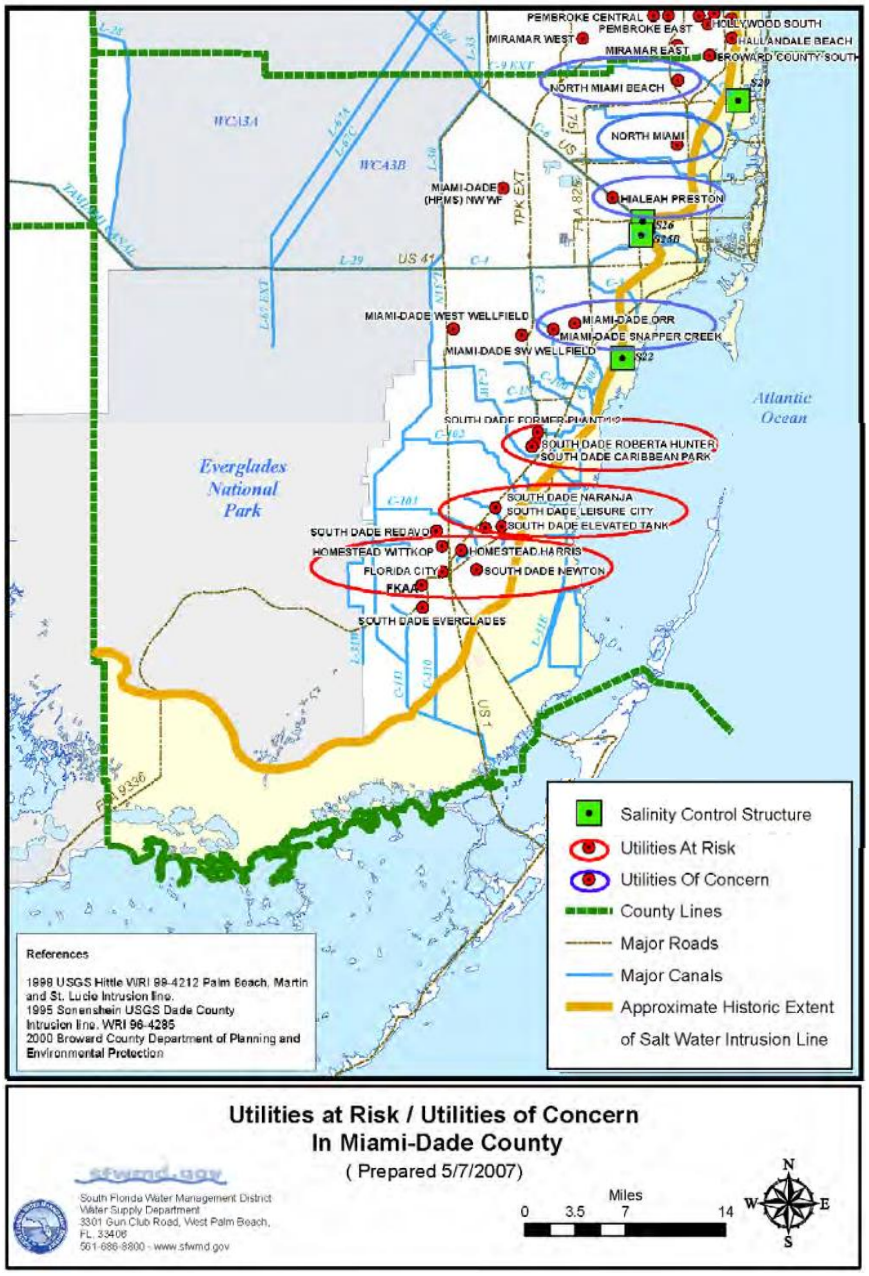
On-Going Adaptation Efforts

The South Florida Water Management District

In addition to flood control, the other three South Florida Water Management District mission elements need to be considered to develop an overall watershed management strategy: water supply, water quality, and environmental resources. Future studies will evaluate the level of service provided for these mission elements. In addition to higher risk for flooding, projected sea level rise could also cause problems with managing the water supply and natural areas of South Florida in the future as salt water intrudes into municipal wellfields and natural areas like the Everglades, likely altering habitat. To address the issue of rising sea levels causing saltwater intrusion into water supplies, the District is mapping the underground saltwater front every five years; the latest mapping was completed in 2014. The South Florida Water Management District is working with local governments that own the wellfields to incorporate the latest saltwater mapping into their water supply plans, move their wellfields, seek alternative water supplies, and emphasize water conservation

As part of the Lower East Coast Water Supply Plan Update, the District is reviewing the extent of saltwater intrusion and its potential impact on freshwater supplies throughout the region.[41] The regional canal network is operated in such a way as to minimize the risk of saltwater intrusion. The South Florida Water Management District also regulates the withdrawals from the aquifer to minimize this risk.[42] As part of that work The South Florida Water Management District has identified potential "utilities at risk" and those "of concern." Utilities were classified as "at risk" if they either did not have a western wellfield, an alternative source of water, or the ability to meet their needs through interconnection with other utilities. Additionally, other utilities were designated as "of concern" if they operated wellfields near the saltwater interface, but also had a western wellfield, or had developed an alternative source that was not threatened by saltwater intrusion.

Figure 33: Map of water utilities of concern in Miami-Dade County in 2007 relative to saltwater intrusion extent.



Source: The South Florida Water Management District

As shown in Figure 33, Miami-Dade has many facilities in the western portion of the County that have not been identified as "of concern" or "at risk." As of 2007, several facilities in the southern portion of the county were identified as "utilities at risk" and these are being closely monitored. Figure 33 also shows the approximate landward extent of the saltwater intrusion line at the time of this report.

[41] More information is available at http://www.sfwmd.gov/portal/page/portal/xweb%20-%20release%203%20water%20supply/lower%20east%20coast%20plan

[42] More information is available at http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/2013_lec_plan.pdf

Miami-Dade County Water and Sewer Department

Miami-Dade County benefits from the extensive monitoring network, which allows the Water and Sewer Department to quickly shift water sources between wellfields as conditions require. For example, if movement of the salt front is detected in the monitoring network, withdrawals can be shifted to western wellfields to reduce pressure on eastern wellfields and reduce the risk of saltwater intrusion. Similarly, the County's ability to monitor and model long-term changes with changing sea levels and precipitation patterns gives the County the capacity to anticipate changes and adjust infrastructure and water sources as needed over the longer-term.

The County can also work with others to support regional efforts that will further reduce the risk of saltwater intrusion over the long term. For example, implementing Everglades Restoration will increase the recharge of the aquifer and will help delay saltwater intrusion. Other efforts to increase recharge such as reducing impervious surfaces, increasing detention areas, or adjusting canal stages can similarly help protect the quality of the aquifer.

The County can also continue to promote successful water conservation programs to reduce demand and increase water efficiency. These programs have already successfully delayed the need for additional infrastructure to expand capacity despite recent population growth. Continuation of these efforts will help provide future flexibility for the system.

The County is also exploring the potential to increase treatment at existing facilities should saltwater intrusion occur. While there are no immediate plans to pursue this path given its increased costs and energy demand, this remains a very technologically feasible option that could be used if conditions change in the future. Currently, however, the Water and Sewer Department is focused on enhancing the existing monitoring and modeling efforts to understand how to optimize the operation of the existing system. Current modeling suggests the major water and sewer wellfields of Northwest, West, Southwest, Snapper Creek, Alexander Orr, The South Dade Utilities, and the future South Miami Heights are not expected to be impacted by saltwater intrusion through 2040. WASD is currently working on modeling scenarios through 2075 to look at longer planning horizons.

Where Updated Information can be found

Information about the landward extent of saltwater encroachment at the base of the Biscayne Aquifer is available through the U.S. Geological Survey website.[43] This page provides information about how the map was created and provides the metadata (available in FGCD and HTML formats) as well as printable Postscript and Adobe PDF versions of the map. In addition to the map, users can access more detailed information about each of the selected monitoring sites. As of January 2016, the data available is frequently updated and provides the most recent understanding of the location of the salt front. The South Florida Water Management District also collects information about the location of the salt front annually.

More information about regional efforts to address saltwater intrusion is available from the South Florida Water Management District's Lower East Coast Water Supply Plan,[44] The Southeast Florida Regional Climate Change Compact's guidance document, "Integrating Climate Change & Water Supply Management",[45] or the U.S. Geological Survey's report, "Hydrologic Conditions in Urban Miami-Dade County, Florida, and the Effect of Groundwater Pumpage and Increased Sea Level on Canal Leakage and Regional Groundwater Flow".[46]

[43] The most recent water-level reports from groundwater wells and stream gages in southern Florida can be found on the USGS website at http://www.sflorida.er.usgs.gov/edl_data/text/mad_qw.html
[44] Available at http://www.sfwmd.gov/portal/page/portal/xweb%20-%20release%203%20water%20supply/lower%20east%20coast%20plan
[45] Available at http://www.southeastfloridaclimatecompact.org//wp-content/uploads/2014/09/rcap-igd-water-supply-final-9-9.pdf
[46] Available at http://pubs.usgs.gov/sir/2014/5162/

Potential Funding Sources

Investing in climate adaptation has the potential to yield significant savings and returns; however, implementing these measures may require new financing mechanisms. One of the primary mechanisms for supporting adaptation measures will likely be grants and special assistance programs from federal, state, regional and private entities. The following pages include a preliminary list of grants that may be suitable for certain project types.

The need to update aging infrastructure is gaining attention and political momentum at a national level. The bipartisan acknowledgement of the need for timely investment in the nation's infrastructure presents the opportunity to incorporate additional resiliency measures when updating infrastructure. Initiatives like the Transportation Infrastructure Finance Innovation Act and the Railroad Rehabilitation and Improvement Financing Program are examples of potential funding options for infrastructure-based adaptation investments. At the federal level, agencies are developing climate change adaptation plans that could include funding for components of a County-wide resiliency plan. For example, the "Climate Change Adaptation Road Map" from the Department of Defense could recognize the need to protect strategic ports or other facilities. Other federal funding could be available through Environmental Protection Agency programs which support investments in water infrastructure. A closer analysis of federal opportunities could identify other funding sources from non-traditional sources.

In addition to grants and government-based funding, resiliency measures may require innovative sources of financing. Though funding opportunities explicitly for climate adaptation are relatively new, there are resources and best practices that can help guide communities as they explore new sources. One potential approach that has already been pioneered in Miami-Dade County involves the use of Public Private Partnerships (PPPs). A recent report on innovative funding to expand national infrastructure by the Treasury Department recognized Florida as an example of permissive legislation for such partnerships.[47] There are several private sector organizations dedicated to researching and exploring opportunities for the private sector involvement in adaptation strategies. Insurance and investment companies are examples of these efforts.[48] In the case of insurance, for example, it may be of mutual interest to minimize damages and mitigate risk exposure. These natural synergies can lead to opportunities to engage with the private sector. In addition to technical cooperation through data sharing and evaluation, collaboration with the insurance sector could take the form of premium adjustments to incentivize investments in mitigation.[49]

[47] The full report "Expanding Our Nation's Infrastructure through Innovative Financing" is available at www.treasury.gov/press-center/press-releases/Documents/Expanding%20our%20Nation%27s%20Infrastructure%20through%20Innovative%20Financing.pdf
[48] The Principles for Sustainable Insurance Initiative (www.unepfi.org/psi/) and Principles for Responsible Investment (http://www.unpri.org)a wealth of information on best practices and funding mechanisms.
[49] Municipal Climate Change Adaptation and the Insurance Industry, Harvard Law School, April 2012

Table 5 represents a subset of grants and other assistance programs drawn from a longer list created by the Office of Emergency Management in the Local Mitigation Strategy.[50] The table summarizes funding sources available to the County and other stakeholders, such as homeowners.[51]

Table 5: Grants and other state and federal assistance programs

Funding Source	Description
Florida Department of Community Affairs	• **Emergency Management Preparedness and Assistance Trust Fund** provides grants to implement projects that will further state and local emergency management objectives. • **Residential Construction Mitigation Program** provides technical and financial resources to homeowners for hurricane retrofitting. • **Florida Warning and Information Network** is a state-sponsored program to strengthen existing facilities against disasters events.
Florida Department of Environmental Protection	• **Revolving Fund Loan Program for Wastewater Treatment** provides funding to assist publicly-owned wastewater and stormwater treatment collection, transmission, disposal, and reclamation, re-use facilities as well as infiltration/inflow correction. • **Pollution Control Bond Program** provides loans to local governments for construction of stormwater, water, and wastewater facilities. Special districts are eligible as well as municipalities and county governments.
Florida Fish & Game Conservation Commission	• **Environment Education Projects** support actions to educate adult Floridians about population growth, habitat loss, coastal, and fresh water ecosystems.
Florida Inland Navigation District	• **Waterway Assistance Program & Cooperative Assistance Program** supports projects such as navigation channel dredging, channel markers, navigation signs or buoys, boat ramps, docking facilities, fishing and viewing piers, waterfront boardwalks, inlet management, environmental education, law enforcement equipment, boating safety programs, beach re-nourishment, dredge material management, environmental mitigation, and shoreline stabilization.
Federal Emergency Management Agency	• **Flood Mitigation Assistance Program** is a federal program administered in Florida by the Department of Community Affairs. Its goal is to fund cost-effective measures that reduce or eliminate the long-term risk of flood damage to property insurable under the National Flood Insurance Program. Both planning grants and project grants are project components. Planning grants assist state agencies and local governments in developing or updating flood mitigation plans that assess risk and propose possible mitigation actions. Project grants assist state agencies and local governments in implementing flood mitigation projects that will reduce risk of flood damage to repetitive loss properties identified in a flood mitigation plan. • **Hazard Mitigation Grant Program** provides funds to states, municipalities and certain private non-profit organizations to implement long-term hazard mitigation measures following a major disaster declaration. It provides 75% of the cost of elevation projects, land acquisition, relocation

[50] The full list of funding sources in available at http://www.miamidade.gov/fire/library/OEM/LMS-master-2012-12-Part-3-funding.pdf

[51] See The Local Mitigation Strategy (LMS) Part 3: The Funding available at: http://www.miamidade.gov/fire/library/OEM/LMS-master-2012-12-Part-3-funding.pdf

	of structures, or retrofitting of facilities. Funding is generated as a percent of the total cost to the federal government of a declared disaster event. • **Pre-Disaster Mitigation Program** provides funding on a nationally competitive basis to put mitigation initiatives in place prior to a disaster. Each project may receive 75% of project cost as the federal share not to exceed $3,000,000 for the federal share. • **Repetitive Flood Claims Program** is designed to reduce losses from severe flooding. Priority is given to acquisition of repetitive loss properties. No funding match required. • **The Mitigation Assistance Program** provides financial and technical assistance to states and territories, and their local governments, to create and maintain comprehensive state hazard mitigation capability. States and territories at risk to storm surge and hurricane force winds from tropical storms are eligible. • **Fannie Mae Pilot Loan Program** makes consumer installment loans available to Florida homeowners to make specific disaster prevention home improvements such as the installation of storm shutters or the construction of a safe room. All single-family homeowners in Florida are eligible for these loans.
Federal Highway Administration	• **Surface Transportation Program** can be used for enhancements in transportation infrastructure. Projects are generally selected competitively on a statewide basis.
Federal Transit Administration	• **Section 5309 capital funds** are available for fixed guideways (new starts, extensions, and rehabilitation), bus procurements, and acquisition or rehabilitation of major facilities. • **Section 5307 Urban Formula Grants** are designated for transit capital and operating assistance in urbanized areas.
U.S. Army Corps of Engineers (USACE)	• **Beach Erosion Control Projects** supports projects along public beaches to address shore erosion. • **Aquatic Ecosystem Restoration** provides a 65% federal match for construction of projects designed to carry out aquatic restoration that will improve the quality of the environment, are in the public interest, and are cost-effective. The program focuses on designing and implementing engineering solutions that restore degraded ecosystems to a more natural condition. Projects include restoration of canals, wetlands, and floodplains, including wildlife habitat. • **Flood Plain Management Services** provides USACE's services in planning and technical services without charge to state, tribal, and local governments for studies, including hurricane evacuation studies, comprehensive flood plain management studies, flood damage reduction studies, urbanization impact studies, stormwater management studies, and inventories of flood-prone structures. • **Planning Assistance to States** allows the USACE to assist local governments in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources with up to 50% federal match. • **Technical and planning assistance** may include wetlands evaluation studies, flood damage reduction studies, flood plain management studies, and water quality/quantity studies. • **Project Modifications for Improvement of the Environment** provides funding for ecosystem restoration by modifying the structures and/or operations of water resources projects constructed by the USACE, or by

	restoring areas where a USACE project contributed to the degradation of the area. • **Emergency Bank Protection Program** provides bank protection of highways, highway bridges, essential public works, churches, hospitals, schools, and other nonprofit public services endangered by flood-caused erosion.
U.S. Department of Agriculture	• **Emergency Watershed Protection Program** provides technical and financial assistance to local sponsors for the relief of imminent hazard and reduction of the threat to life and property in watersheds damaged by severe natural events that are either local or national in nature. Disaster area declaration is not required. The act also authorizes the purchase of rural and agricultural floodplain easements designed to retire land from frequent flooding to preclude federal disaster payments, retire land to allow levee setbacks, or limit the use of the land. • **Watershed Surveys and Planning** studies are used for appraising water and related land resources and formulating alternative plans for conservation use and development. Studies are designed to provide specific information needed for planning purposes related to non-traditional flood recovery and flood plain management strategies, including land treatment measures, nonstructural measures, and structural measures. • **Rural Utilities Service Water and Waste Disposal Program** provides grants and loans to rural communities for wastewater, drinking water, solid waste, and storm drainage projects.
U.S. Department of Commerce	• **Coastal Zone Management Program Section 306 Grants** are used for coastal hazard mitigation strategies, including the development of local hazard mitigation plans, outreach and education activities, monitoring programs, and projects to enhance program management. • **Section 308 Grants** provide emergency grants to address a wide range of unforeseen or disaster-related circumstances. • **Section 309 Grants** are competitive funds designed to enhance state programs, including planning and land regulation activities, enhancing natural features, and preventative measures. • **Economic Development Administration Business Recovery Loans** program is designed to promote long-term economic development in areas experiencing substantial economic distress. Examples of projects include port development and expansions, and construction of infrastructure necessary for economic development (water/sewer).
U.S. Environmental Protection Agency	• **Clean Water Act Section 319 Grants** are awarded to implement certain non-point source programs including wetland restoration. • **Brownfields Economic Redevelopment Grants** are intended to prevent, assess, safely clean up, and sustainable reuse of Brownfields. • **Urban Waters Program** designed to help local residents and their organizations, particularly those in underserved communities, restore their urban waters in ways that also benefit community and economic revitalization.
U.S. Department of Homeland Security	• **The Citizens Corps** mission is to bring community and government leaders together to coordinate community involvement in emergency preparedness, planning, mitigation, response, and recovery. Note: The Department has recently expressed its intention to increase interactions with local governments to "combat and adapt to climate change" as well as promote "resilient infrastructure through partnerships

	with the public and private sectors". The Department is currently supporting pilot projects focused on sea level rise in other jurisdictions.
U.S. Department of Housing and Urban Development	• **Community Development Block Grant Small Cities Program** and the **Entitlement Communities Program** provide funding to cities to improve local housing, streets, utilities, and public facilities. Disaster Recovery Initiative funds are provided for disaster relief, long-term recovery, and mitigation activities in areas affected by a presidential disaster declaration.
U.S. Department of the Interior	• **Federal Land-to-Parks Transfer Program** provides funds to identify, assess, and transfer available surplus federal real property to state and local entities for use as parks, recreation areas, and open space. • **Land Acquisition program** identifies and acquires high quality lands and waters for inclusion into the National Wildlife Refuge System. • **North American Wetland Conservation Fund** provides funds to stimulate public- private partnerships to protect, restore, and manage a diversity of wetland habitats for migratory birds and other wildlife. • **Partners for Fish and Wildlife** provides financial and technical assistance to private landowners, businesses, and local governments interested in restoring wetlands and riparian habitats on their land. • **Rivers, Trails, and Conservation Assistance Program** provides staff consultants and technical assistance for river and trail corridor planning and for open space preservation efforts.

Grant funding will likely be useful to support many individual projects, however, more sustainable mechanisms will be required for larger-scale projects. Potential funding sources for such adaptation measures have been thoroughly outlined in a recent publication *Sea-Level Rise Adaptation Financing at the Local Level in Florida.*[52] This detailed white paper outlines a myriad of potential sources, their legal basis, potential legal issues or challenges, their relative strengths and weaknesses. Most importantly, the paper reviews each funding mechanism in terms of their appropriateness for supporting adaptation investments. Because the publication is focused specifically on sea level rise adaptation and Florida, it was used as the basis for the summary table below (Table 6). Many other resources exist which summarize funding options for adaptation more generally.[53] In addition to the potential mechanisms listed in this table, there may be additional sources within the twenty-five chapters on Taxation and Finance under title XIV.

[52] Houston Endowment, Thomas Ruppert & Alex Stewart, Sea-Level Rise Adaptation Financing at the Local Level in Florida, (Sept. 2015) Available at https://www.flseagrant.org/wp-content/uploads/Local-Gov-Financing_FINAL_10.8.15.pdf

[53] For example see the U.S. Resilience Toolkit available at https://toolkit.climate.gov/content/funding-opportunities or more targeted resources such as the U.S. EPA's resource on funding for green infrastructure available at: http://www.epa.gov/sites/production/files/2015-02/documents/gi_financing_options_12-2014_4.pdf or the Johnson Foundations resource on funding water infrastructure http://www.johnsonfdn.org/sites/default/files/reports_publications/WaterInfrastructure.pdf

Table 6: Potential funding mechanisms for adaptation measures drawn from "Sea-Level Rise Adaptation Financing at the Local Level in Florida"

Funding Mechanism	Strengths	Weaknesses	Considerations
Ad Valorem Taxes and Municipal Service Taxing Units (MSTUs)	• Offers flexibility: may be used for many purposes • No requirement of specific benefit proportional to or even related to taxed properties for *ad valorem* assessments • May not require a referendum to extend beyond millage limit in certain exceptions	• May offer limited funding due to millage limitations • Could require referendum to surpass millage limits in certain cases • MSTUs may result in increased responsibility of the local government to provide the services for which property is charged	• Offers flexibility to use levied taxes on functions that offer a 'real and substantial benefit to citizenry, including adaptation measures • May be increased without referendum for certain legally provided exceptions such as need for "government responsibility to properly manage beaches" • A direct connection between taxation and services is required for MSTUs
Special Assessments and Municipal Service Benefit Units (MSBU)	• May offer flexibility in terms of how the funds can be spent so long as it provides a direct special benefit proportional to each assessed property • Can support capital improvements and services for SLR adaptation • Not subject to millage limitations • Established and recognized methods of ensuring special assessment is proportional to benefits can be adapted to SLR scenarios	• Must meet requirements of special assessments • Cannot be levied on school boards or public colleges without consent • Must carefully ensure that the assessment for each property is not greater than proportional benefits to that same property • Cannot be used for general services that do not provide special benefit to the real property assessed	• A direct, special benefit is required. Assessed properties must be "fairly and reasonably apportioned" in relation to the special benefits received • Issues may arise if SLR adaptation disbursements are (1) not directly providing special benefits to real property, (2) considered a general government service, or (3) if the assessment is in excess of proportional benefits as compared to assessments on other properties
Local Option Tourist	• May facilitate a quicker pay off	• May require a referendum	• The funding stream could require a referendum

Development Tax	of bond debts accrued through beach nourishment or other projects addressing erosion • Well suited to address issues of beach nourishment, beach erosion control, park facilities, etc. • May offer flexibility within the specific uses detailed in statutory language	• Potential scope for the use of the funding for SLR may be more narrowly defined (beach nourishment, maintenance, preservation, restoration, erosion control) • May face competition from other statutorily allowed demands for funds (advertisement, capital expenditures) • The income stream is limited (between 2-6% on short-term rental transactions) with the tax available for beach maintenance, erosion, and related beach activities limited to a 2-3% tax, depending on the county	• Once available it will allow spending for SLR adaptation that aligns with the definition in the statue and follows its strict parameters, which may be limited to beach nourishment maintenance and erosion control, and other specific actions directly linked to areas of tourism • Low risk of legal issues if clearly defined statutes are followed
Stormwater & Drainage Fees	• Well understood mechanism • Can be raised to support future capital projects for future outlays specific to stormwater management and drainage systems • Relatively flexible in terms of 'how' and 'what' fees can be raised, as statute allows for collection of "enough to meet the system's capital requirements, as well as to defray operating expenses." • May address an important aspect of SLR adaptation needs and allow fund collection for future	• Scope of uses for the funds raised will be quite limited to stormwater and drainage systems • Fees must be tied to the capital and operating requirements of stormwater and drainage systems • Some agencies of the state may assert sovereign immunity if the agency does not have a contract with the utility • Developing schedule of fees might present a challenge	• May offer appropriate source of funds with relative flexibility for investments in management of stormwater and drainage systems • Flexibility exists in regard to funding mechanisms with options to adopt stormwater utilities and stormwater fees, establish set asides to invest in stormwater management system, or create stormwater management system benefit areas • When setting up a system benefit area, local governments must comply with the process as defined in section 403.0893 (3) and special assessments in section III • Stormwater utilities that charge fees, should set a differential fee that relates use of the service to the property

	stormwater and drainage needs		
Bonds	• Fairly broad range of potential funding and use restrictions • Allow for significant funds • Liberal definition of statues allowing for capital directed at serving a public purpose	• Require an ordinance or resolution as part of issuance • Ad Valorem bonds and General Obligation Bonds require a referendum • Might be limited by credit rating of each municipality • May be subject to financing costs (interest) • Subject to challenge by property owner or interested party if issuance is not clearly established by prior use and precedent or if procedures are not followed adequately. Challenges can occur even if a court has validated the decision • Requires strong argument that home rule powers allow bonds	• Bonds provide ample and potentially adequate levels of funding for SLR adaptation because constraints are general and limited to the requirement that the investment serve a public purpose • Potential limits include importance of strict adherence to correct processes and potential for bonds to be challenged by property owners or interested parties • Other limits include a required referendum for bonds that pledge faith and credit of local governments (ad valorem and general obligation bonds)
Special Districts	• Intended to assist property owners for a specific purpose, which could include adaptation to SLR • The nature of special districts, whereby they are instituted in furtherance of a specific function are complementary to specific needs related to SLR adaptation	• Creation of special districts, whether dependent or independent, requires compliance with formation requirements as laid out by state statutes • Both dependent and independent districts are bound by millage limitations, requiring referendum prior to any increase o Dependent special districts are restricted by statutorily defined millage limitations o Millage levied by independent special districts may not exceed amount authorized by law or approved by electorate with exception of units focused on water management	• The characteristic of special districts that bind their formation to a specific public purpose that is closely related to SLR adaptation makes them a useful funding mechanism for local governments • Possible limitations include millage limitations and referendum requirements • Each type of special district (dependent and independent) or unit of local government created for a special purpose has various requirements and processes • Independent special districts must be created by legislature while dependent districts can be created by municipalities
Local Government Infrastructure Surtax	• Allows a county to levy a 0.5 or 1.0 percent tax pursuant to an ordinance of a Board of County	• Requires a referendum • Have limits of use specific to those that "finance, plan and construct infrastructure" and "acquire land for…	• Offers a substantial resource to local governments with a project proposal • A ballot must include a general description of the proposed project

	Commissioner only when there is a majority vote of the electors in a referendum • Permits fund allocation to investments relevant to adaptation	protection of natural resources."	• Even though it requires a referendum because the proposed projects will need to be described, there is an opportunity to communicate the project's benefit to the public
Charter County and Regional Transportation System Surtax	• The amount levied may be up to 1.0 percent in the form of a sales surtax, and may be used for various uses related to road and bridge infrastructure (construction and maintenance)	• Applicable to counties that meet requirements detailed in Fla. Stat. §212.055 (1)(a) and subject to approval by majority vote of the electorate in a referendum	• If a county meets the requirements, the county may levy a discretionary sales surtax that is subject to approval by majority vote of the electorate in a referendum
Other	• Electric Franchise Fee: may be collected from revenue of government owned utility or fees already charged to local electric service provider • Communications Service Tax: returns from the state mandated communications tax can be an additional source of income		

Conclusion and Next Steps

Research Gaps and Needs

The studies and initiatives highlighted throughout this report reflect the significant progress made and ongoing to understand the risks, challenges and opportunities to adapt to expected sea level rise. This understanding has been built over several years and only through extensive collaboration between agencies, universities, and many other stakeholders. In addition to leveraging local capabilities, Miami-Dade County has partnered with international experts from the Netherlands, with national scientific experts within the U.S. Geological Survey, The Army Corps of Engineers, and the Federal Emergency Management Agency, and with regional entities, including local universities recognized for their exceptional research. Close collaboration with peer governments, which has been facilitated through the Southeast Florida Regional Climate Change Compact, has helped to strengthen this network, helped articulate research needs, and has helped to attract research dollars to the region.

Because sea level rise will impact the risks of flooding and saltwater intrusion in complex and indirect ways, it is necessary to draw upon scientists from many disciplines and integrate multiple methodologies and models to understand the implications of changing sea levels. In the case of flooding risk it is essential to understand the direct impacts in the form of increased duration, depth, and extent of tidal flooding. It is arguably more important, however, to understand the secondary impacts caused by storm surge amplified by higher water levels or the effects of decreased capacity of gravity-based drainage infrastructure to drain the land after a rain event. At an even more granular level, it is important to understand the capacity of each major pump or flood control structure to function under changing conditions and to test the potential effectiveness of alternative infrastructure. Therefore, understanding the effects of changing average sea levels requires understanding how the different components of the system will respond and how they will in turn affect each other.

Many efforts are underway to integrate various efforts and synthesize their results. One of the most important of these efforts is the South Florida Water Management District's Level of Service Assessment and Miami-Dade County Water Management Division's efforts to understand the implications for Miami-Dade County's stormwater basins. While these efforts are underway, they will require additional resources to complete and will require subsequent coordination to implement their findings and integrate them into relevant policies.

This progress could be expedited by providing additional support to the Water Management Division. As was stated earlier in this report, the Water Management Division first incorporated sea level rise modeling scenarios into evaluation of future flood protection thresholds (Level of Service) in 2011. Since then, analysis has been continually adapted to incorporate new projections. To date, the Water Management Division has updated the Biscayne Bay Canal in 2014 and Arch Creek in 2015 (C-8 basin) and is working on the Snake Creek (C-9) and Oleta River basins. If current resource levels are maintained, the update cycle for the 20 basins in the system is expected to take 10 years; however, needed revisions could be completed for all basins in five years with additional resources dedicated to staff, surveying, mapping and

modeling. Increased funding would expedite cycle updates and would help maintain flood protection, forecasting and evaluation of regional water quality, implementation of engineering solutions, and evaluation of long-term strategic infrastructure investments.

As described previously, there are also multiple studies recently completed or underway that have attempted to relate the risks of flooding with different measures of exposure or vulnerability. For example, these research efforts have focused on attempting to quantify the economic impacts of urban flooding or potential damage from storm surge. Other efforts, such as the project with the Army Corps of Engineers, are focused on quantifying how certain protective assets such as dunes and mangroves can reduce that damage. While the economic consequences of sea level rise are components of the several on-going projects, including the RAND study and other collaborative efforts with insurance brokers and reinsurance companies, this is an area that will require significant further study and effort. In particular, it will be necessary to improve existing approaches to assessing the costs, benefits, and trade-offs associated with different adaptation pathways.

Despite the recent advances, there remains a need for research to increase our understanding, incorporate new information, and develop innovative, cost-effective solutions. Assumptions and modeling efforts will need to be continually revisited and updated based on new scientific information, and recalibrated in the wake of a major storm. Continuing to improve the level of cooperation with partners including our local universities, the South Florida Water Management District, The Army Corps of Engineers and the U.S. Geological Survey is a key to advancing these goals. Working through The Compact has been a critical component to connecting the County with these partners, strengthening collaboration, and bringing in new resources and experts to the region. These partnerships have proven beneficial to the County. For example, the County's partnership with the U.S. Geological Survey has greatly advanced the current saltwater intrusion monitoring work that helps protect the County's drinking water source.

In addition to research needs, the County can accelerate the implementation of adaptation efforts by supporting successful on-going initiatives such as the Local Mitigation Strategy, the beach nourishment program, and stormwater management improvements. The Local Mitigation Strategy is one example of the County's collaboration with the community to reduce long-term risk to citizens and property. As detailed in this report, the Local Mitigation Strategy is updated semi-annually and consists of a multi-volume plan to address known hazards, including flooding. The Strategy has informed investments in 23 projects currently under construction and supported the completion of 12 projects in 2015. In addition to stimulating local construction and engineering work, studies have demonstrated that four dollars are saved for every dollar invested in mitigation. Increasing the strategic investment in mitigation would not only directly reduce the community's immediate vulnerability to storms, it could also simultaneously reduce long-term vulnerabilities to sea level rise. There are currently more than 1,000 listed mitigation projects that are without an identified funding source.

Next Steps

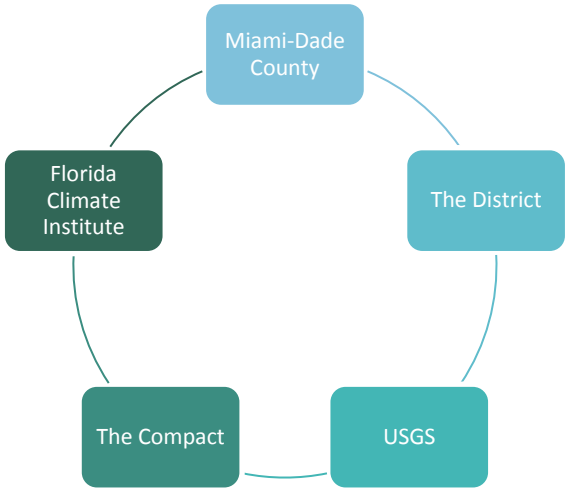
There is increasing attention by Miami-Dade County, local research institutions, and communities to invest in knowledge of the challenges and opportunities ahead. Miami-Dade County has collaborated with several partners including the South Florida Water Management District, U.S. Geological Survey, member counties in the Southeast Florida Climate Change compact, and the Army Corps of Engineers to harness existing information to improve the County's resilience to the effects of climate change. This effort has resulted in numerous collaborative efforts, which have only been briefly summarized.

This report was developed over the last year with assistance from the aforementioned partners and other collaborators who provided a general overview of the studies and efforts to address the implications of sea level rise on flooding and saltwater intrusion; however, given the extensive scope of activity, it is not possible to provide full details on all of these efforts. Collectively, this research and multiple initiatives represent millions of dollars in investments directed to better understand these issues. It is important to note that Miami-Dade County has also been fortunate to benefit from substantial outside investment from the philanthropic community and federal agencies.

While this report provides a snapshot, many of these initiatives are on-going. For example, to improve their ability to reduce the risks of flooding, the South Florida Water Management District is working to evaluate the current and future levels of flood protection to identify and prioritize long-term infrastructure needs. The agency is conducting studies to identify hazards and possible mitigation activities, and is collaborating with Dutch experts to share expertise, strategies and information (see pages 13, 14, and 39). Miami-Dade County is also partnering with the U.S. Geological Survey to analyze groundwater flows and map changes in groundwater levels (see pages 14-17 and 49-51). A partnership with the RAND Corporation is allowing the County and Compact partners to study the interactions of new infrastructure and land use changes on future water management needs and potential flooding damages (pages 17-18). The County is also assisting the Federal Emergency Management Agency in revising and updating the County's Flood Insurance Rate Maps to more accurately reflect current conditions and the most accurate mapping techniques (see pages 18-19). Some projects are bringing together several partners like the U.S. Army Corps of Engineers, the U.S. Geological Survey, and the Nature Conservancy, to study risk mitigation alternatives and assess the potential for nature-based coastal defenses (see pages 19 and 21). In addition to County-led collaborations, Miami-Dade is also working with local and national universities through research initiatives like the Sustainability Research Network-Urban Resilience to Extremes (see page 20-21). It is worth underscoring the significant contribution the Southeast Florida Regional Climate Change Compact has made to facilitating a coordinated regional approach and attracting additional resources.

Research Steering Committee

Figure 34: Sea Level Rise Research Steering Committee



As evidenced by the breadth and depth of the various research projects, there is a constant need for coordination and synthesis to translate these findings into smarter decision-making. Currently, Miami-Dade County staff drawn from the Office of Resilience, the Water and Sewer Department, Emergency Management and the Stormwater Masterplan program have been coordinating these internal and external efforts. This group coordinates very closely with the South Florida Water Management District, the U.S. Geological Survey, the Florida Climate Institute, and the Compact. This group helps coordinate these efforts by working with project managers to adjust the scope of work for new projects to align with the needs of practitioners in the region, sharing findings and data between projects, and assisting in the publication and dissemination of research findings to the public. To date, this coordination has been ad-hoc; however, through the development of this report the coordination has increased. Moving forward, this group will formalize its activities by meeting quarterly and providing an update on research efforts through the Florida Climate Institute, the Compact, and the Office of Resilience (Figure 34).

Conclusion

This report is submitted in support of Resolution R-48-15, which directs the Mayor or his designee to work in conjunction with experts and stakeholders at various levels to "conduct a comprehensive study and develop adaptation strategies to address potential flood damage reduction and saltwater intrusion associated with sea level rise and to put forth a time frame for implementation and potential funding mechanisms." It is apparent from this report that there is extensive on-going critical research that is intended to lead to a better understanding of the impact of sea level rise on flooding and salt water intrusion in Miami-Dade and the Southeast Florida region. Because of the breadth and complexity, this report is designed to provide a snapshot and summary of the extensive and interconnected work taking place. This report is also designed to provide a roadmap to resources where updated information can be found, including synthesized, user-friendly and publicly accessible tools and web pages. The Office of Resilience can provide additional information on any of the covered studies or projects and will keep abreast of new studies and updated data.

Though rising sea levels present several challenges, there is wide recognition of this and a deep network of professionals working to increase understanding of the issues in order to develop effective responses and adaptation strategies. Enhancing these efforts and collaboration with local, national and international experts continues to be of strategic importance to the County and will continue be an integral component of identifying effective adaptation strategies as the County develops its Resilience Strategy in the coming year and moves forward with implementation.

Appendix 1: Relevant Research from Local Universities

The following summary table is followed by a synopsis of research provided to the Miami-Dade County Office of Resilience from colleagues at the Florida Climate Institute and affiliated academic research centers. The research below underscores the depth of local expertise and knowledge, but represents only a small sample of the remarkable research that is happening. Many other relevant research is on-going at other institutions both within the region and at universities across the country. Furthermore, these research summaries present only a snapshot of the status of research as of the fall of 2015 and many of the initiatives highlighted below will continue to evolve quickly over the coming years.

Summary of Relevant Research from Florida Universities			
General Topic	**Title**	**Project Timeframe**	**External affiliations**
Florida Atlantic University			
Sea-level rise-adaptation	NSF Grant for Coastal SEES Collaborative Research: A cross-site comparison of salt marsh persistence in response to sea-level rise and feedbacks from social adaptations	January 1, 2015-~December 31, 2018	National Science Foundation (NSF) Funding
Water supply, sea level rise	Development of an adaptation toolbox to protect southeast Florida water supplies from climate change	October 2011	N/A
Resilience to extreme events (infrastructure)	Civil Infrastructure Systems CRISP Type 2/Collaborative Research: Probabilistic Resilience Assessment of Interdependent Systems (PRAISys)	September 1, 2015-~August 31, 2018	NSF Funding
Sustainable redevelopment	Subtropical Sustainable: A context sensitive design approach to redevelopment in Broward County	2008	N/A
Florida International University			
Saltwater intrusion, sea level rise	Biscayne Aquifer Hydraulic Conductivity	2008	N/A
Socioeconomic impacts of sea level rise	Sea Level Rise Impacts on South Florida	2011	Hurricane Research Center
Sea level rise-infrastructure & saltwater intrusion	Making Robust Infrastructure Adaptation Decisions under Uncertainty	Ongoing	N/A

Summary of Relevant Research from Florida Universities (continued)			
General Topic	**Title**	**Project Timeframe**	**External affiliations**
Ecosystem adaptation to sea level rise	Understanding mechanisms that maintain wetland elevation in south Florida coastal ecosystems	2011-ongoing	SFWMD,[54] Everglades Found. & ENP[55]
Urban resilience to extreme events	Urban Resilience to Extremes Sustainability Research Network	Ongoing	N/A
	List of 9 ongoing dissertations		
Florida State University			
Hydroclimate models	Understanding and projecting precipitation variability over Florida using high resolution climate models	Ongoing	COLA[56]
University of Central Florida			
Flood-hazard maps and analysis	Analyses for Adaptation of Drainage Infrastructure in a Coastal Urban Watershed via a Worst-Case Scenario of Storm Surge and Precipitation Variability under Climate Change and Sea-Level Rise Impacts	N/A	FL Sea Grant Program, Pinellas County
University of Florida			
Sea level rise, saltwater intrusion and human response	Sea-level rise and coastal water resources	Ongoing	NSF[57] Funding
Multi-disciplinary sea level rise adaptation plan	Science-Collaborative Resiliency Planning on Florida Atlantic and Gulf Coasts	2011-2015	FL Sea Grant & NERRS[58] Funding
Adaptation to sea level rise, land use	ReCharting Longboat Key: Toward Community, Economy and Resiliency	April 2015	N/A

[54] South Florida Water Management District
[55] Everglades National Park
[56] Center for Ocean-Land-Atmosphere Studies
[57] National Science Foundation
[58] National Estuarine Research Reserve System Science Collaborative

Summary of Relevant Research from Florida Universities (continued)			
General Topic	**Title**	**Project Timeframe**	**External affiliations**
Saltwater intrusion	Seawater Intrusion Impacts on Drinking Water Production	2014	N/A
Coastal inundation forecasting & impact	Assessing Climate Change Impacts on Hurricanes, Sea Level Rise and Coastal Inundation, and Coastal Ecosystems and Infrastructures	Ongoing	Working group
Water conservation-aquifers	Effectiveness of residential water conservation and demand management programs	Ongoing	N/A
Adaptation Strategies, reallocation	A Parameterized Climate Change Projection Model for Hurricane Flooding, Wave Action, Economic Damages and Population Dynamics – R/GOM-RP-2	2011-2012	FL Sea Grant, of Panama, FL
Facility adaptation planning	Development of Sea Level Rise Adaptation Planning Procedures and Tools Using NOAA Sea Level Rise Impacts Viewer	~2012	Mississippi-Alabama Sea Grant Consortium Funding
Evaluation of adaptive strategies	A Spatial-Temporal Econometric Model to Estimate Costs and Benefits of Sea-Level-Rise Adaptation Strategies – R/C-S-51	Ongoing	Florida Sea Grant, TBRPC[59]

Florida Atlantic University Submissions

NSF Grant for Coastal SEES Collaborative Research: A cross-site comparison of salt marsh persistence in response to sea-level rise and feedbacks from social adaptations

Researcher: Colin Polsky with Principal Investigator Karen McGlathery kjm4k@virginia.edu (Principal Investigator) and Patricia Wiberg (Co-Principal Investigator)
Institution: Florida Atlantic University
E-mail: cpolsky@fau.edu

Relevance to adaptation: Nearly half of the world's population lives within 100 kilometers of the coast, the area ranked as the most vulnerable to climate-driven sea-level rise (SLR). Projected rates of accelerated sea level rise are expected to cause massive changes that would transform both the ecological and social dynamics of low-lying coastal areas. It is thus essential to improve understanding of the sustainability of coupled coastal human-environment systems in the face

[59] Tampa Bay Regional Planning Council

of SLR. Salt marshes are intertidal habitats that provide a buffer for coastal communities to SLR and are also valued for many other ecosystem services, including wildlife habitat, nutrient cycling, carbon sequestration, aesthetics, and tourism. They are highly dynamic systems that have kept pace with changes in sea level over millennia. However, projected rates of SLR and increased human modification of coastal watersheds and shorelines may push marshes past a tipping point beyond which they are lost. Developing realistic scenarios of marsh vulnerability demands an integrated approach to understanding the feedbacks between the biophysical and social factors that influence the persistence of marshes and their supporting functions. This project will examine the comparative vulnerability of salt marshes to SLR in three U.S. Atlantic coastal sites that vary with respect to sediment supply, tidal range and human impacts. The research team will also address how feedbacks from potential adaptations influence marsh vulnerability, associated economic benefits and costs, and practical management decisions. Additional broader impacts include incorporating research results into curriculum used at local schools, an on-line cross-disciplinary graduate course, and on-going teacher-training programs, as well as training one postdoctoral researcher, four graduate students, and eight undergraduate researchers. This project is supported as part of the National Science Foundation's Coastal Science, Engineering, and Education for Sustainability program - Coastal SEES.

This project leverages the long-term data, experiments and modeling tools at three Atlantic Coast Long-Term Ecological Research sites (in MA, VA, GA), and addresses the broad interdisciplinary question "How will feedbacks between marsh response to SLR and human adaptation responses to potential marsh loss affect the overall sustainability of the combined socio-ecological systems?" The goals of the project are to understand: 1) how marsh vulnerability to current and projected SLR, with and without adaptation actions, compares across biogeographic provinces and a range of biophysical and social drivers; and 2) which marsh protection actions local stakeholder groups favor, and the broader sustainability and economic value implications of feasible adaptation options. The biophysical research uses historical trends, "point" and spatial models to determine threshold and long-term responses of marshes to SLR. Social responses to marsh vulnerability are integrated with biophysical models through future scenario planning with stakeholders, economic valuation of marsh adaptation options, and focus groups that place the combined project results within a concrete policy planning context to assess how marshes fit into the larger view of coastal socio-ecological sustainability. This integrated approach at multiple sites along gradients of both environmental and human drivers will allow for general conclusions to be made about human-natural system interactions and sustainability that can be broadly applicable to other coastal systems.

Start date: January 1, 2015. Estimated end date: December 31, 2018
NSF Grant: http://www.nsf.gov/awardsearch/showAward?AWD_ID=1427282

Development of an Adaptation Toolbox to Protect Southeast Florida Water Supplies from Climate Change

Researcher: Frederick Bloetscher
Institution: Florida Atlantic University
E-mail: fbloetsc@fau.edu

Relevance to adaptation: Sea level rise and changes in precipitation patterns due to climate change present a challenge to water resources engineers and planners in southeast Florida with regard to sustainable water supplies and Everglades restoration. Because over half of the urban areas of Miami–Dade and Broward counties, as well as portions of Palm Beach County (home to 5 million people), are at an elevation below 5 feet national geodetic vertical datum (NGVD), protection against sea level rise and coastal migration presents a challenge. Current approaches to water supply will not protect the resilience and prolong the sustainability of the region's water resources. In this paper, the authors outline the potential effects of sea level rise scenarios for coastal southeast Florida and develop a toolbox of options for adaptation for water, wastewater, and stormwater utilities to apply. Any given option may not be appropriate for all utilities, and any given utility may deem there to be benefits to pursuing multiple strategies on a timeline in keeping with the latest estimates of sea level rise. The authors also developed milestones to trigger infrastructure investments, as climate changes may occur more rapidly or more slowly than currently projected.

Table 2. Summary of water supply benefits and climate change benefits from various tools in toolbox (after Heimlich et al. 2009).

Tool	Benefit to water supply	Climate change benefit
Install local pumping stations	None – reduces aquifer levels	Reduce flooding in low lying areas
Water conservation	Lowers per capita use, stretched current supplies	Reduces stress on vulnerable water supplies
Armoring the sewer system	Protects water quality and supply	Protect reclaimed water option but protecting water quality
Wastewater reclamation	Replaces use of fresh water for irrigation and industrial use	Replaces vulnerable water supplies
Aquifer recharge	Reduces raw water requirements	Recycles existing water to increase available fresh water
Protection of existing water sources	Protects water quality and supply	Reduces stress on vulnerable water supplies
Strategic well relocation	Reduce impact of coastal supplies	Increased fresh water available for countering impacts
Horizontal wells	Skims fresh water	Increased fresh water available for countering impacts
Re-engineering canal systems	Controlling water tables and protecting against contamination	Flood control
Hydrodynamic barriers	Controlling water tables and protecting against contamination	Reduce saltwater intrusion
Capture and surface storage of excess runoff	Storage mechanism for existing	Increased fresh water available for countering impacts
Septic tank closure	Protect groundwater quality	Increased fresh water availability
Close private wells	Protect groundwater quality	Increased fresh water availability
Desalination	New water source	Replaces vulnerable water supplies
Aquifer storage and recovery	Storage mechanism for existing	Increased fresh water available for countering impacts
Regionalization of alternative water supplies	Shared risks of water supply options	Economies of scale for wastewater and stormwater recovery and reuse

Full article available at:
http://research.fit.edu/sealevelriselibrary/documents/doc_mgr/449/Bloetscher%20et%20al.%202012.%20SE%20Florida%20Adaptation%20Toolbox.pdf

NSF Funding Awarded for Civil Infrastructure Systems CRISP Type 2/Collaborative Research: Probabilistic Resilience Assessment of Interdependent Systems

Researcher: Diana Mitsova-Boneva
Institution: Florida Atlantic University
E-mail: dmitsova@fau.edu

Relevance to adaptation: After a disruptive extreme event, such as an earthquake or severe storm, the socio-economic recovery of the affected region depends on the recovery of its infrastructure systems. Lifelines, such as power and water distribution systems, transportation networks, communication systems, and critical buildings have a primary role in disaster response,

management, and long-term recovery. The failure to rapidly restore the services required for personal, social, and commercial activities leads to continued socio-economic losses and progressive depopulation. This collaborative project brings together scholars in Civil Engineering, Systems Engineering, Computer Science, Economics, Urban Planning, and Policy Making. Its purpose is to establish and demonstrate a comprehensive framework that combines models of individual infrastructure systems with models of their interdependencies for the assessment of interdependent infrastructure system resilience for extreme events under uncertainty. The "PRAISys" platform (Probabilistic Resilience Assessment of Interdependent Systems) will emphasize a probabilistic approach that permeates all aspects of the models, including the interdependencies. Some types of uncertainties that were not considered before (e.g., the possibility of using contingency plans that provide services without functioning infrastructure) will be classified; while mathematical and computational tools will be devised to capture their characteristics. PRAISys will enable better management and design of next generation infrastructure, more resilient to extreme events and to component failures under normal conditions. This will reduce the likelihood of extreme events becoming catastrophic in terms of casualties and injuries, long-lasting socio-economic losses, and environmental impact. The results of the research will be disseminated to the public in various forms: through series of seminars for professionals and administrators; by participating in Lehigh University's STAR academy program for disadvantaged middle and high school students; through scientific publications and presentation; and by curriculum development.

The development, calibration, and validation of PRAISys will enable research on stochastic interdependencies among infrastructure systems in the wake of an extreme event. This requires advancements in several disciplines. For instance, a new hybrid reliability model, which combines graph theory for network analysis and classic system reliability to model the probabilistic dependencies among infrastructures will be studied. The new concept of "uncertain dependencies," which are rigorously modeled and include "contingency plans" will be introduced. Advancements in stochastic network optimization will be sought, to predict the optimal strategies and to inform the disaster management. Social network data will be used as an additional source of information on the recovery of a region, in real time, mining public posts. A comprehensive decision framework will combine the results of the simulation platform with expert opinions and surveys to identify the importance of various aspects of recovery. Finally, new techniques for the collection of large sets of data from utility companies, local government and other authorities will be studied.

September 1, 2015- ~August 31 2018

Subtropical Sustainable

Researcher: Anthony Abbate
Institution: Florida Atlantic University
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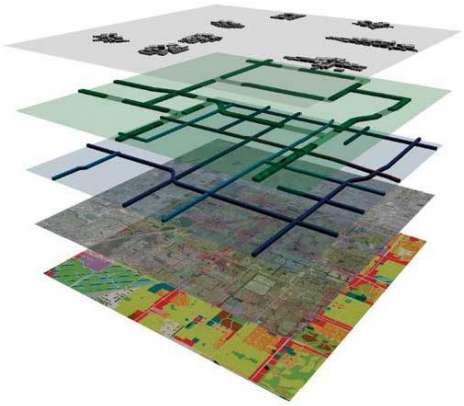
Relevance to adaptation: Broward County's Transit | Housing Oriented Redevelopment (THOR) Pilot Study project brought various government, transportation, planning, and transit agencies together with the community and the FAU College of Architecture, Urban and Public Affairs to develop strategies for linking land use to transportation and to establish a process for context

sensitive design. The initial Pilot Study involved communities situated along segments of Broward Boulevard and State Road 7 in central Broward County, Florida. Both areas were originally developed in the middle of the 20th century. The initial overriding theme of context sensitive solutions hence carried a subtheme that resonated across professions, specializations, and interests: subtropical sustainability.

The core redevelopment strategy of the Community Design Guidebook is the idea of the Quilt-Net: a network of transit and multimodal transportation corridors, greenways, and blueways, connecting new walkable urban centers that are superimposed on the existing patterns of development throughout the county. This superimposition creates a new organizing scheme for redevelopment that is more sustainable and sensitive to the environmental context. It maintains the integrity of existing single family land uses, while it transforms commercial and light industrial sites and regional activity centers into transit-oriented, mixed-use, sub-tropical, urban places accessible without the need for an automobile, from any other part of the county.



The general concept of the Quilt-Net provides a reference for examining possibilities for situating higher density development along existing county corridors that are newly designated for transit. Previous elements of the county transportation plan addressed only the efficiencies and effectiveness of moving traffic. The THOR Pilot Study introduces the possibility of new elements that address the qualitative aspects of subtropical context and design for a new transportation infrastructure suggesting new forms for sustainable redevelopment. To achieve this, the key challenge is to develop a community design process that is inclusive, multidisciplinary, and multi-jurisdictional.

Full report available at:
https://www.broward.org/PlanningAndRedevelopment/Redevelopment/Documents/subtropical_sustainable.pdf

Florida International University Submissions

Biscayne Aquifer Hydraulic Conductivity

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Relevance to adaptation: There is a critical need to better quantify the hydraulic conductivity in the Biscayne Aquifer because the hydraulic conductivity has been shown to strongly affect the extent of seawater intrusion in response to sea level rise (Figure 1, Werner and Simmons, 2009) and because the very high hydraulic conductivity of the Biscayne Aquifer has not been adequately determined. All existing modeling efforts rely on inconclusive hydraulic conductivity data.

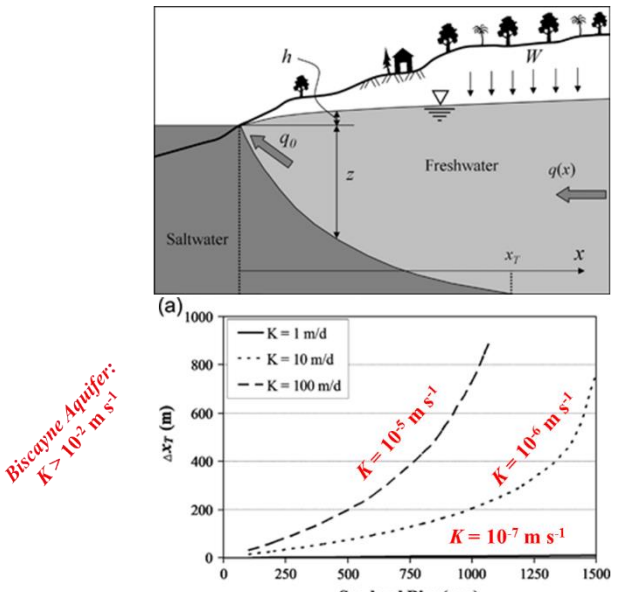

Figure 1. Landward movement of the saltwater intrusion toe as a function of the amount of sea level rise and aquifer hydraulic conductivity (Werner and Simmons, 2009). The Biscayne Aquifer is known to have a conductivity at least 3 orders of magnitude higher than the highest values considered in the analysis and its response to sea level rise could be substantially greater.

Work by Werner and Simmons (2009) has shown that the extent of seawater intrusion depends strongly on the hydraulic conductivity for head-controlled aquifers such as the Biscayne Aquifer. Figure 1 shows for example that 1 meter of sea level rise should result in about 200 meters of inland movement of the saltwater intrusion toe when the hydraulic conductivity is 10^{-6} m s^{-1}. If the hydraulic conductivity is one order of magnitude higher at 10^{-5} m s^{-1} however, the inland movement of the saltwater intrusion toe is 800 meters. The Biscayne Aquifer has thick and laterally extensive zones of touching-vug porosity with vugs commonly about 2 centimeters in diameter and porosity of 50% or more. These connected vugs can impart an exceptionally high hydraulic conductivity (*K*), commonly exceeding 10^{-2} m s^{-1}, to the aquifer. Thus the inland movement of the seawater intrusion toe in response to sea level rise is likely to be much greater than it is for lower *K*.

Despite the likelihood that this is the best-studied aquifer of such high *K*, reliable values of its *K* have been challenging to establish due to the inapplicability or inconclusiveness of various test methods for extreme *K*.

Multiple methods over a broad range of scales have been used to estimate *K* values for the Biscayne Aquifer, including:

- detailed Lattice Boltzmann modeling at pore scale;
- Lattice Boltzmann modeling and laboratory measurements at core scale;
- high-resolution borehole scale geostatistical and flow modeling based on borehole images;
- borehole scale slug testing; and
- aquifer test meta-analysis.

Results indicate that maximum *K* values from these methods vary over 5 orders of magnitude from 10^{-4} to 10^{1} m s^{-1}. Some variations in *K* are due to disparities in the physical samples and aquifer reconstructions tested, but most are intrinsic to the methods. For example, limitations of standard laboratory *K* measurements of core samples truncate the distribution of Biscayne Aquifer core *K* values at about 10^{-4} m s^{-1}. Slug tests in appropriately-constructed wells in the Biscayne Aquifer are generally underdamped and appear to underestimate *K* (returning maximum values of 10^{-2} m s^{-1} comparable to a sand aquifer), possibly due to the Darcian flow assumption that underlies analysis methods for such tests. Aquifer tests are difficult to conduct in the Biscayne Aquifer and are commonly inconclusive for a variety of reasons.

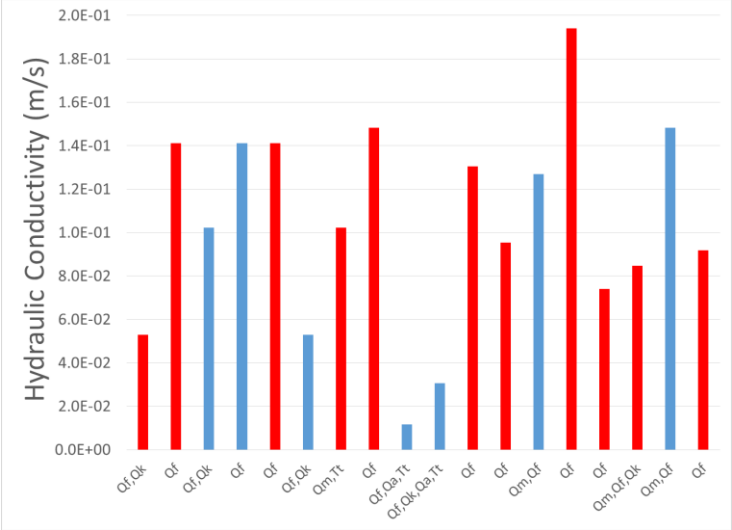

Figure2. Aquifer test database of Fish and Stewart (1991). Red bars show inconclusive results reported as 'greater than' the values shown and represent 11 out of 18 results.

LBM applied at numerous scales yields *K* values that tend to converge and agree with pipe flow expectations and specialized lab measurements on a 0.1 m diameter core model. The *K* values from LBM at core scale are consistent with LBM *K* values from 2.72 m^3-volume scale explicit pore/solid aquifer models based on novel geostatistical extrapolation of borehole optical images.

Sea Level Rise Impacts on South Florida

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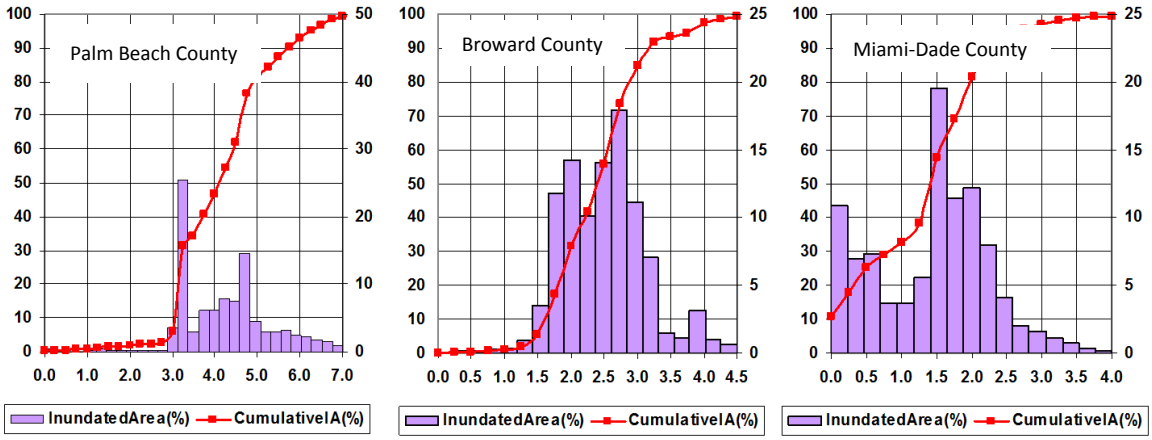
Relevance to adaptation: Combining land surface elevation data with socio-economic data allows estimation of the submerged land area, the number of people affected, and the value of submerged property with different sea level rise amounts. Consideration of different scenarios of sea level rise with time permits the estimation of submerged land area, affected population, and value of submerged property as a function of time.

High-resolution land surface elevation data can be evaluated to assess the fractional submergence of South Florida land area for a given amount of sea level rise based on simple 'bathtub' models that assume submergence when the sea level exceeds the land surface elevation. More refined models can be used in this analysis as they become available. Calculations have been made for Palm Beach, Broward, and Miami-Dade counties. Figure 1 shows the percentage of the area inundated for increments of sea level rise in meters on the x

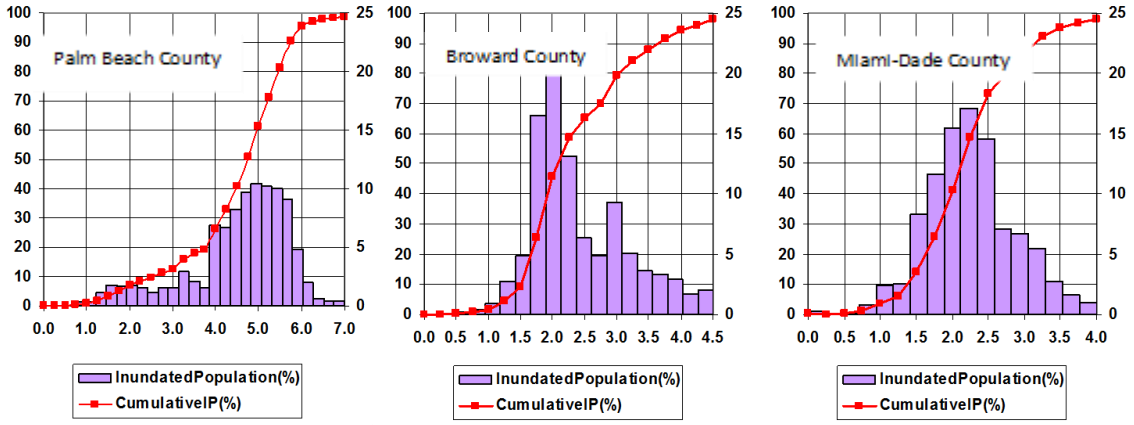
axis. The purple bars give the percentage inundated for each increment of sea level rise as read on the right-hand side axis. For example, 1.5 meters of sea level rise inundates an additional 20% of the land area of Miami-Dade County beyond the area inundated by the next smallest increment at roughly 1.25 meters. The red curves show the cumulative inundation through 100% of each county's land area and are read on the left-hand axis. Four meters of sea level rise is enough to submerge all of Miami-Dade County's land, while 7 meters are needed to submerge all of Palm Beach County. These curves are useful because they show that even if the rate of sea level rise is steady (linear) the amount of land submerged is not expected to be a linear function; little effect may be observed until the sea reaches a critical level and large areas may be inundated soon after the critical level is reached. For exqample, Palm Beach County is expected to retain more than 95% of its land area until 3 meters of sea level rise occur; just beyond 3 meters, only 70% of the land area will remain.

Figure 9: Cumulative (left axis) and incremental (right axis) percentages of inundated land areas of Palm Beach, Broward, and Miami-Dade counties as a function of sea level rise in meters (x-axis). Based on 'bathtub' model.



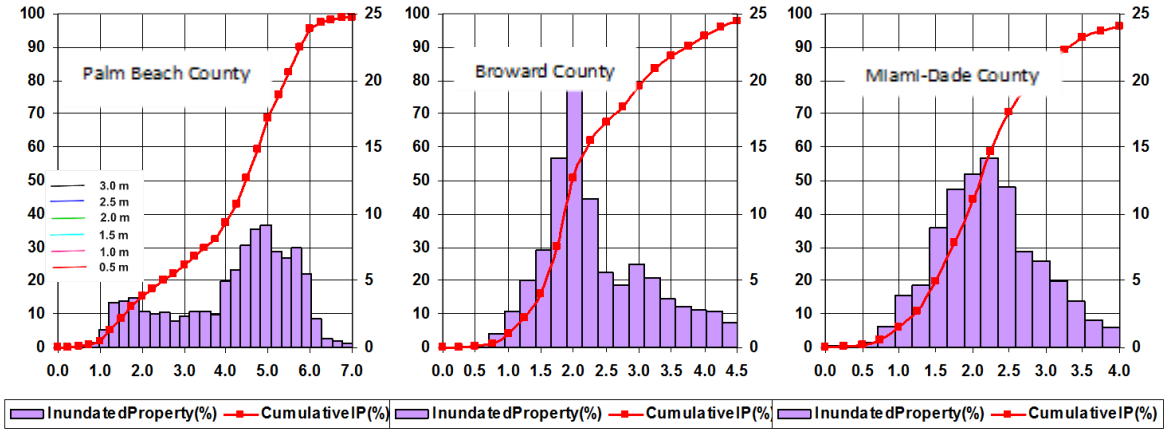
Combining the land elevation-based submergence with available socio-economic data permits other views of the information. For example, Figure 2 show the percentatges of the population affected by various increases in sea level in each of the counties.

Figure 210. Cumulative (left axis) and incremental (right axis) percentages of population affected by inundation of Palm Beach, Broward, and Miami-Dade counties as a function of sea level rise in meters (x-axis). Based on 'bathtub' model.



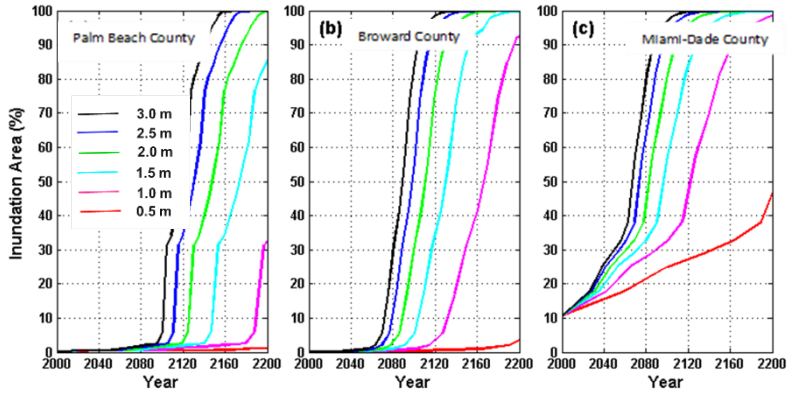
Similarly, the value of inundated property can be considered as a function of sea level rise. Figure 3 shows the cumulative and incremental percentages of property value affected by inundation for Palm Beach, Broward, and Miami-Dade counties as a function of sea level rise in meters (x-axis) based on a 'bathtub' model approach.

Figure 3:11 Cumulative (left axis) and incremental (right axis) percentages of property value affected by inundation of Palm Beach, Broward, and Miami-Dade counties as a function of sea level rise in meters (x-axis). Based on 'bathtub' model.



Finally, various sea level rise scenarios can be combined with the results above to estimate the amounts of land area loss or other factors as a function of time.

Figure 4: Cumulative inundation areas as a function of time for sea level rise amounts from 0.5 to 3 meters by 2100 as shown by legend for Palm Beach, Broward, and Miami-Dade counties.



Making Robust Infrastructure Adaptation Decisions under Uncertainty

Researcher: Ali Mostafavi
Institution: College of Engineering and Computing, Florida International University
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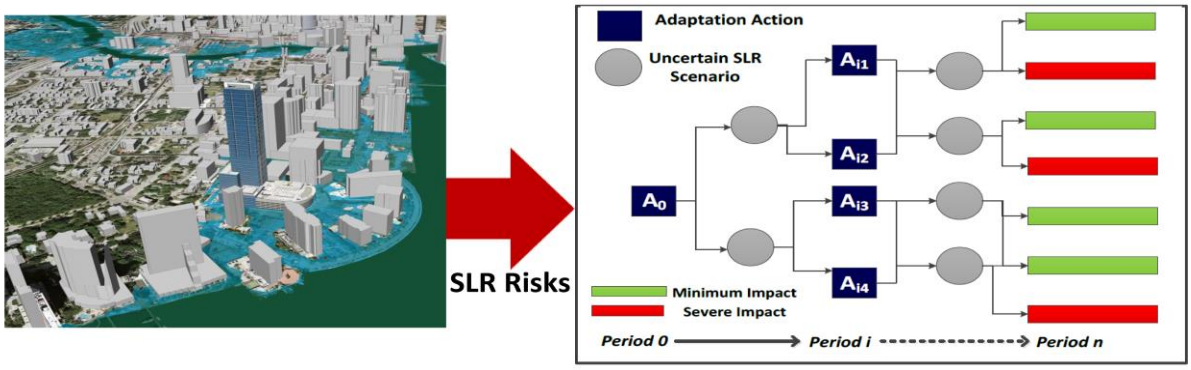
Relevance to adaptation: The objective of this ongoing research study is to identify robust strategies for adaptation of infrastructure systems under sea-level rise. Evaluation of the effectiveness of adaptation actions is critical to avoid maladaptation. Maladaptation is failure to change behaviors and undertake timely actions such that the infrastructure systems on which a society is depended becomes unable to provide the required level of service. Maladaptation may occur due to failure to take timely actions and anticipate uncertainty. Anticipation of uncertainty is particularly important to identify flexible adaptation pathways (Fig. 1) that enable re-evaluation of plans when new information becomes available.

Figure 1: Robust adaptation decision-making under uncertainty



The problem of SLR adaptation is characterized by "deep uncertainty" that makes it almost impossible and economically impractical to design "fail-safe" systems under future uncertain scenarios. In this project, advanced simulation models are created and tested to investigate the long-term impacts of sea-level rise on infrastructure systems in order to evaluate the

effectiveness of various adaptation strategies based on a cost-benefit analysis. To this end, the long-term performance of infrastructure systems under various scenarios of sea-level rise and adaptation strategies is modeled using stochastic mathematical simulation. Then, the impacts of sea-level rise are determined in terms of the life cycle costs of infrastructure networks. These estimated costs are used for evaluation of the feasibility of various adaptation strategies under future uncertain scenarios. Currently, data related to water, wastewater, and roadway infrastructure from Miami-Dade and Broward Counties are being collected in order to model the long-term impacts of sea-level rise scenarios and conduct cost-benefit analysis for evaluation of adaptation strategies. At the same time, a preliminary numerical case study has been conducted to test the proof of concept for the simulation methodology. Using the data related to a sub-set of a road network, a model was created to evaluate the effectiveness of adaptation strategies in mitigating the impact of flooding induced by sea-level rise. Adaptation strategies considered include base protection through the use of well-point systems and storm-water drainage as well as raising roads elevations. Then, the projected sea-level rise data was used in order to determine the likelihood and depth of floods within a 40-year analysis horizon (Figure 2). The impact of flooding on roadways was determined based on the damages to the structural number and pavement condition. Accordingly, the annual life cycle cost of the network was determined in two scenarios: (1) no adaptation; and (2) adaptation to cope with 2ft inundation under slow sea-level rise (Fig. 3) and fast sea-level rise scenarios (Fig. 4). The difference between the annual life-cycle costs was used to determine the incremental annual value of adaptation (Figure 5), and using economic analysis, the present value of adaptation solution was determined.

Figure 12:-Sea-level rise scenarios and likelihood of flood risk

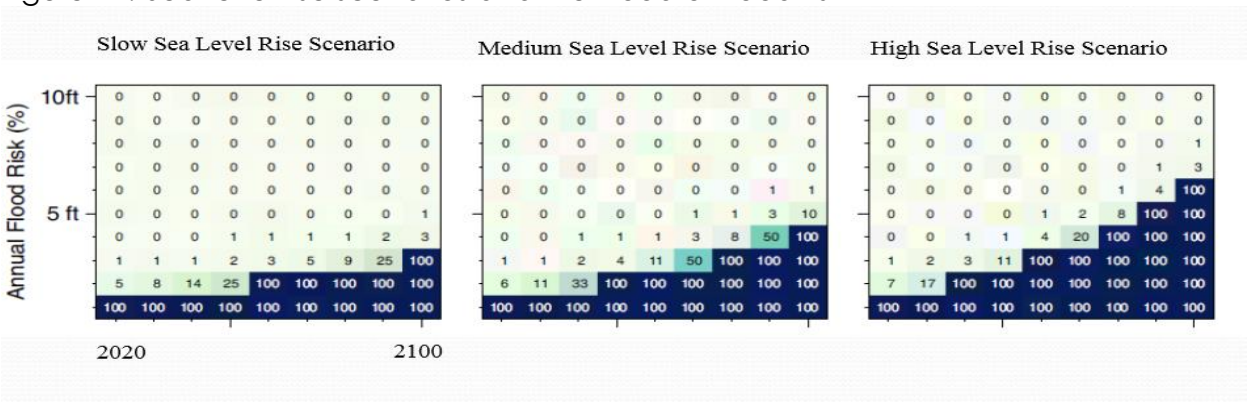


Figure 3- Annual life cycle cost of the network under slow sea-level rise

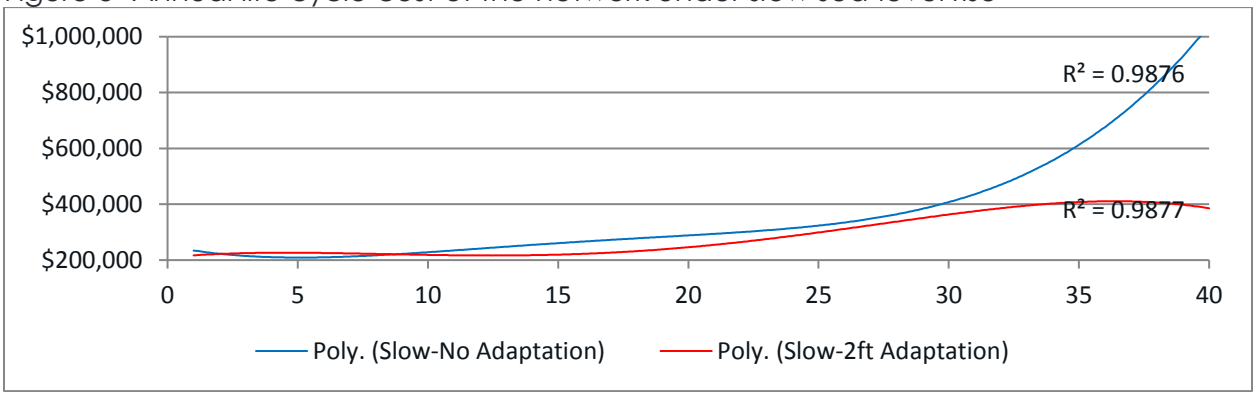


Figure 4- Annual life cycle cost of the network under fast sea-level rise

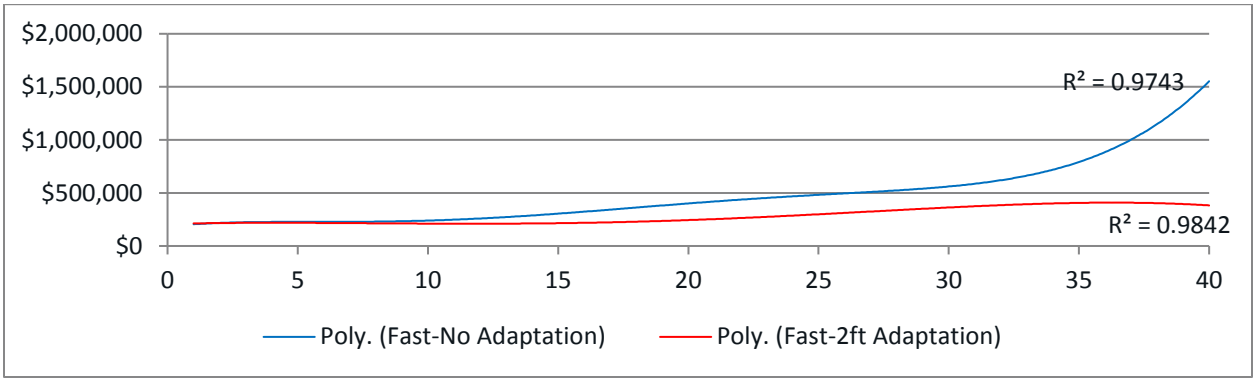
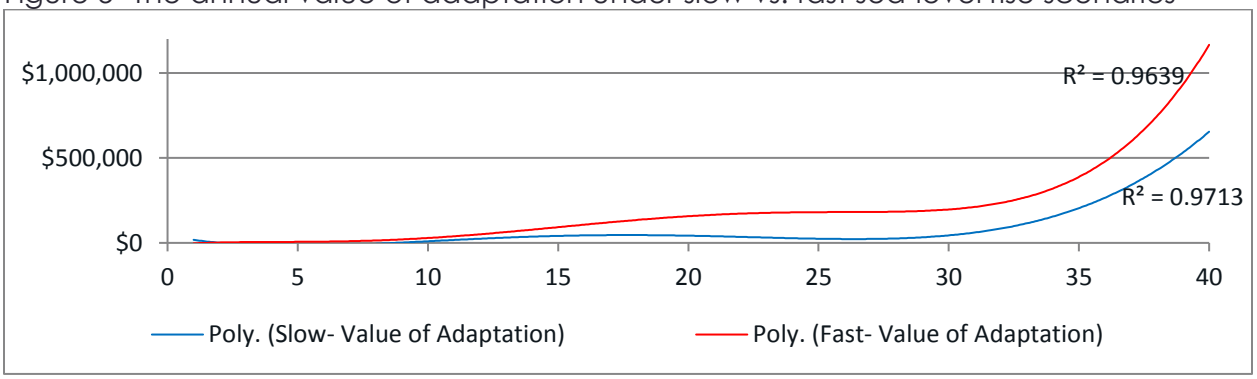


Figure 5- The annual value of adaptation under slow vs. fast sea-level rise scenarios



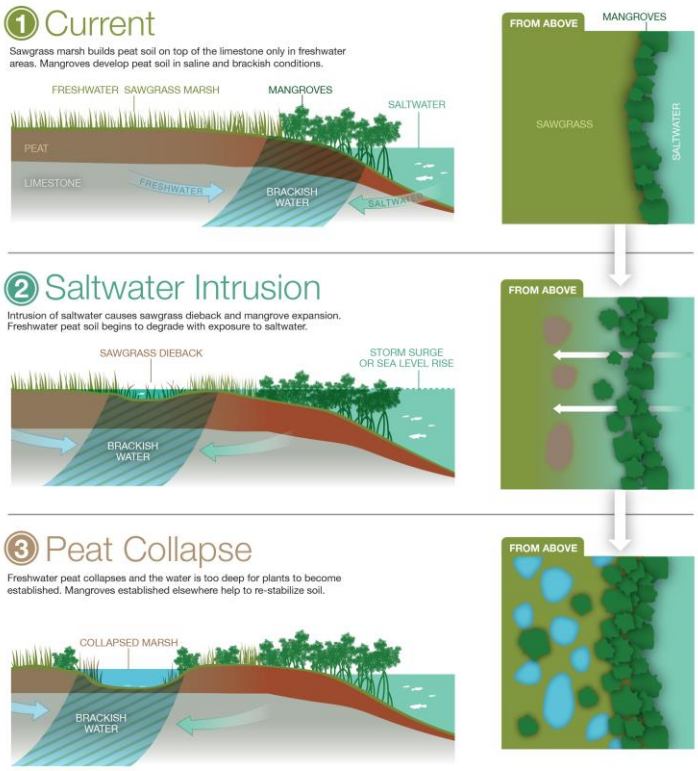
In an ongoing study, the adaptation of water infrastructure is being evaluated in order to identify robust strategies to cope with saltwater intrusion. Possible adaptation action alternatives for coping with salt water intrusion include exploitation of aquifers in non-affected areas, building desalination capacity in treatment plants, and building additional reclaimed water production facilities. The effectiveness of these adaptation actions are being evaluated through the use of dynamic models to simulate the impacts of sea-level rise on water infrastructure under uncertain future scenarios.

Understanding Mechanisms that Maintain Wetland Elevation in South Florida Coastal Ecosystems

Researcher: Tiffany Troxler, Evelyn Gaiser, John Kominoski (in collaboration with scientists from South Florida Water Management District, Everglades Foundation and Everglades National Park
Institution: Southeast Environmental Research Center, Florida International University with funding by the Florida Sea Grant with cost sharing by the South Florida Water Management District
E-mail: troxlert@fiu.edu

Relevance to adaptation: Sea levels in south Florida are conservatively predicted to rise 0.6 m by 2060 (Zhang et al. 2011) and this estimate now defines the upper range for the sea-level rise (SLR) planning horizon for south Florida (SFRCCC 2011, Obeysekera et al. 2015). South Florida is particularly vulnerable to SLR given the low topographic incline, shallow and highly permeable karst aquifer and large-scale hydrologic diversions that have amplified coastal transgression (Ross et al. 2000). Extensive areas of low lying land inland and along the coast increase risk of salinity intrusion. For example, about 60% of Everglades National Park (ENP) is at or under 0.9 m in elevation relative to mean sea level (Pearlstine et al. 2010). This rate of sea-level change (~1 cm yr^{-1}) and low elevation of much of ENP and other low lying areas put significant areas at greater risk of increased saltwater inundation. Subsequently, this puts south Florida's coastline at risk and consequently the ecosystem services that coastal wetlands provide. Inland transgression of mangroves has been suggested as a means by which sub-tropical and tropical coastal landscapes will "adapt" to increasing sea-level rise – mangroves will replace inland marshes as sea-level rises (citation), stabilizing soils as they transgress. Historically, rates of soil accretion of mangroves and salt marsh wetlands have kept pace with rates of SLR by accreting vertically (e.g. McKee et al., 2011). However, as inland freshwater wetlands are and will continue to be exposed to increased duration and spatial extent of inundation and salinity from seawater, the risk to soil carbon (C) balance that maintains coastal elevation increases. This is attributed to impacts that can affect soil C balance through soil oxidation-reduction potential, soil respiration, and the intensity of osmotic stress to vegetation. The term "peat collapse" has been used to describe a relatively dramatic shift in soil C balance, leading to a rapid loss of soil elevation, and culminating in a conversion of vegetated freshwater marsh to open water (Fig. 1). In this project, we are using coupled field and experimental outdoor mesocosm experiments to quantify biological, chemical and physical responses to increased salinity due to saltwater intrusion and inundation in south Florida wetland ecosystems.

Figure 1. Conceptual diagram illustrating conversion of inland wetlands to open water as a function of saltwater intrusion (H2H graphics and Davis)

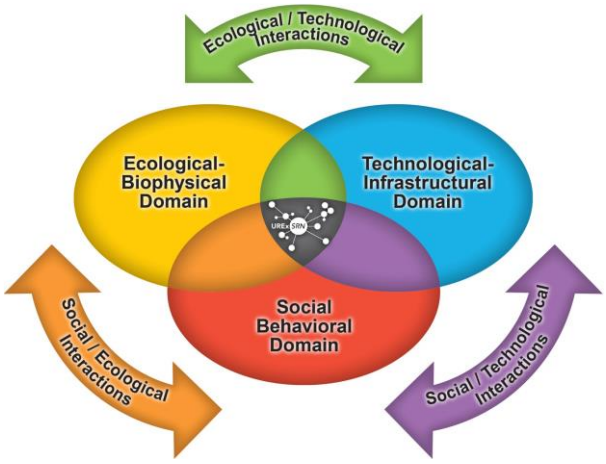


Urban Resilience to Extremes Sustainability Research Network

Researcher: Evelyn Gaiser, Tiffany Troxler, John Kominoski (in collaboration with scientists from multiple institutions, with lead institution Arizona State University)
Institution: Southeast Environmental Research Center, Florida International University

E-mail: gaisere@fiu.edu; troxlert@fiu.edu

Relevance to adaptation: Climate change is widely considered to be one of the greatest challenges to global sustainability, with extreme events being the most immediate way that people experience this phenomenon. Urban areas are particularly vulnerable to these events given their location, high concentration of people, and increasingly complex and interdependent infrastructure. Impacts of Hurricane Katrina, Superstorm Sandy, and other disasters demonstrate not just failures in built infrastructure, they highlight the inadequacy of institutions, resources, and information systems to prepare for and respond to events of this magnitude.



The highly interdisciplinary and geographically dispersed Urban Resilience to Extremes Sustainability Research Network team will develop a diverse suite of new methods and tools to assess how infrastructure can be more resilient, provide ecosystem services, improve social well-being, and exploit new technologies in ways that benefit all segments of urban populations. The Urban Resilience to Extremes Sustainability Research Network focuses on integrating social, ecological, and technical systems to devise, analyze, and support urban infrastructure decisions in the face of climate uncertainty (Figure 1). The central question of the project is:
How do Social Ecological Technological Systems (SETS) domains interact to generate vulnerability or resilience to climate-related extreme events, and how can urban SETS dynamics be guided along more resilient, equitable, and sustainable trajectories? We will use a (1) network of diverse cities, (2) a network of experts in Working Groups, (3) a holistic conceptual framework, (4) an inclusive, participatory approach, and (5) a workflow, education program, and evaluation plan that produces results and continually learns to address this question. A primary activity within the project will be to assemble and collate ecological, social, infrastructure, hydrology, and other data to address the question, working with ecologists, social scientists, engineers, planners, designers, climatologists, physical scientists to develop downscaled climate extreme projections, developing a geodatabase, and conducting computation and visualizations to conduct transitions work to achieve and implement strategies. Infrastructure that is flexible, adaptable, safe-to-fail, socially equitable, and ecologically based will enhance urban resilience in the face of a higher incidence of extreme events, more culturally diverse communities, and continued urbanization pressures. Ultimately, the Urban Resilience to Extremes Sustainability Research Network will help accelerate knowledge generation and application to encourage innovative strategies towards urban sustainability. More information on the Urban Resilience to Extremes Sustainability Research Network research initiative is available at the following link: https://sustainability.asu.edu/urbanresilience/

Dissertation and Theses at Florida International University

Chatterjee, Chiradip
Four essays of environmental risk-mitigation

Cui, Zheng
A generalized adaptive mathematical morphological filter for LIDAR data

Eisenhauer, Emily
Socio-ecological vulnerability to climate change in South Florida

Mozumder, Pallab
Coping with a natural disaster: Understanding household and social responses

Nodine, Emily
Evidence of climate variability and tropical cyclone activity from diatom assemblage dynamics in coastal southwest Florida

Stalker, Jeremy
Hydrological dynamics between a coastal aquifer and the adjacent estuarine system, Biscayne Bay, South Florida

Twigg, David
The winds of change? Exploring political effects of Hurricane Andrew

Zhang, Keqi
Twentieth century storm activity and sea level rise along the United States coast and their impact on shoreline position

Zhu, Zhenduo
Mechanisms governing the eyewall replacement cycle in numerical simulations of tropical cyclones

Florida State University Submission

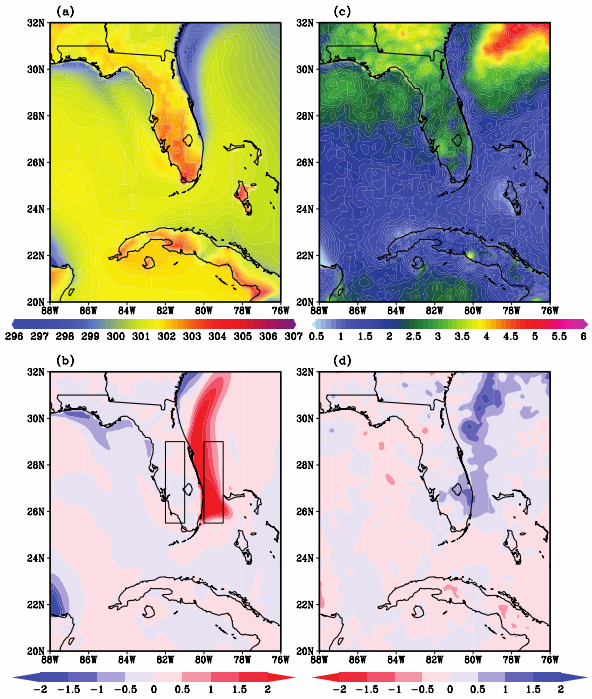
Understanding and Projecting Precipitation Variability over Florida Using High Resolution Climate Models

Researcher: Vasu Misra
Institution: Center for Ocean-Land-Atmosphere Studies/Florida State University
E-mail: vmisra@fsu.edu

Relevance to adaptation: Florida is one of the regions in the continental U.S. that receives a significant amount of annual rainfall. It has distinct seasonality and is a primary source of fresh water both for groundwater recharge and consumptive use. And yet understanding its variability and projected change is a challenge for a variety of reasons including Florida's unique geography. Peninsular Florida, with close proximity to strong mesoscale surface ocean currents among other factors, warrants the use of relatively high resolution climate models to simulate its hydroclimate. In the absence of such high resolution climate models, we highlight the uncertainty in the simulation of the warm western boundary current (the Gulf Stream) in two relatively coarse spatial resolution CMIP5 (global) models used in IPCC AR5.

But before we highlight the uncertainty in the global models, we will demonstrate (Fig. 1) that differences in terrestrial rainfall over Florida during the wet season can be influenced by changes in the Gulf Stream by simple changes to ocean bathymetry in a high resolution regional coupled ocean-atmosphere model (RCM). It is very clearly seen that the rainfall over peninsular Florida is strongly influenced by the strength of the Gulf Stream in the model (not shown), with stronger Gulf Stream producing more rainfall over Florida. The RCM experiments with different bathymetry clearly suggest that large changes in western Atlantic coastal Sea Surface Temperature (SST) can be affected. This affects the gradient between local SST and surface temperature over peninsular Florida. This modulation of surface temperature gradient has a consequence on the moisture flux convergence and surface evaporation that are primary sources of moisture for rainfall over peninsular Florida (not shown).

A well-known fact is that the grid size resolution of global models in the global models are rather inadequate to resolve the rich mesoscale oceanic features in the region, and even in some instances, inadequate to properly represent the coastlines of peninsular Florida. Besides this issue of model grid resolution, we also find that there are significant differences in the prescribed bathymetry of these global models (Figs. 2a and b). The depths of the channels (e.g. Florida Straits, Yucatan Channel), the extent of the continental shelf (e.g., along the eastern coast of Florida) is significantly different in the two models (Fig. 2). The mean ocean heat transports through these channels are also significantly different. However, one needs to be careful in not attributing all of these differences in the ocean heat transport to differences in the bathymetry, as other differences in the models (e.g. systematic errors, local and remote air-sea feedback) also can potentially play a role. We, however, observe that colder SST's along the eastern coast of Florida are associated with weaker surface currents between the two CMIP5 models (Figs. 2c and d), suggesting the potential subtle role of ocean bathymetry. For example, the coastal SST along the western Atlantic in The Geophysical Fluid Dynamics Laboratory model (GFDL) (Fig. 2c) is lower than that in the Community Climate System Model 4.0 (CCSM4) (Fig. 2d) simulation. This also corresponds with weaker surface currents (Fig. 2a) and ocean heat transport (Fig. 2c) in the GFDL relative to the corresponding CCSM4 simulation in Figs. 2b and d respectively. Further along this line of argument, we find that the mean June-July-August (JJA) rainfall over peninsular Florida is much lower in the GFDL (Fig. 2e) than in the CCSM4 (Fig. 2f) simulation. The two global models are, however, significantly different in their structure, design, parameterizations, dynamical core, with very different systematic errors, ENSO characteristics and other natural variations that could all influence the SST simulation along the western coastal Atlantic. But qualitatively, the difference in surface meteorology over peninsular Florida and the difference of SST over the Gulf Stream alongside the differences in ocean heat transport between the two global models as shown in Fig. 2 is similar to the regional climate model (RCM) experiments, which is compelling.



For a region like Florida, the sustained influence of the coastal SST on the terrestrial hydroclimate needs to be taken advantage of in simulating the terrestrial regional hydroclimate when extreme weather events, like land-falling tropical cyclones that also contribute to the hydroclimate, are inherently difficult to simulate in climate models.

Figure 1: a) The climatological seasonal mean JJA SST and land surface temperature from a) RCM1 integration (K; fine bathymetry) and b) the corresponding differences from RCM2 (coarse bathymetry) integration (RCM1-RCM2; °C). Similarly, the climatological seasonal mean JJA

precipitation (mm day^{-1}) from c) RCM1 integration and b) the corresponding differences from RCM2 integration (RCM1-RCM2).

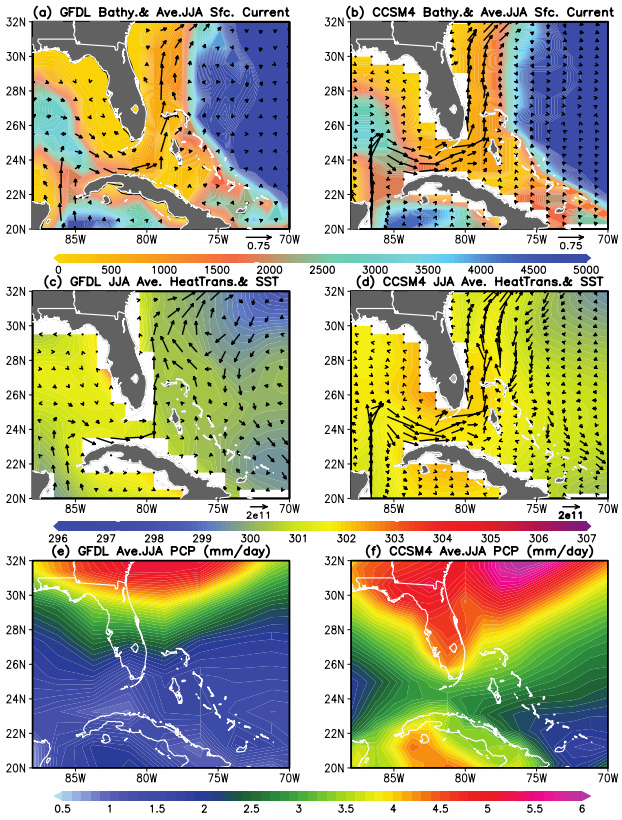


Figure 2: The bathymetry (meters) around Florida coast overlaid with the climatological JJA surface ocean currents (ms^{-1}) in a) CCSM4, and b) GFDL-ESM2G used in the 20th century simulations for CMIP5. Similarly, the climatological mean JJA SST (°C) and ocean heat transport vectors (Wm^{-1}) in c) CCSM4, and d) GFDL-ESM2G. Likewise, the climatological mean JJA precipitation (mm day^{-1}) from e) CCSM4, and f) GFDL-ESM2G.

University of Central Florida Submission

Analyses for Adaptation of Drainage Infrastructure in a Coastal Urban Watershed via a Worst-Case Scenario of Storm Surge and Precipitation Variability under Climate Change and Sea-Level Rise Impacts

Researcher: Ni-Bin Chang, Justin Joice, Rahim Harji, and Thomas Ruppert
Institution: University of Central Florida, Pinellas County Government, Florida Sea Grant Program
E-mail: nchang@ucf.edu

Relevance to adaptation: This study analyzes the impact of storm tide and long term precipitation variability on coastal inundation in the Tampa Bay Region under a worst case scenario of climate variability and sea-level rise. The study generates flood hazard maps of the impact of storm tide and precipitation to test the response of the Cross Bayou watershed to the worst case storm conditions combined with scenarios of precipitation variability, hurricane landfall, and sea-level rise using 2030 as a period of concern. In particular two considerations were evaluated: (1) response of watershed drainage to storm tide, precipitation, and sea-level rise with current infrastructure in place and (2) response of watershed to storm tide, precipitation,

and sea-level rise with changes in infrastructure such as the expansion of the Cross Bayou Canal and the promotion of low impact development.

An innovative feature of this study is that it integrates several existing models and elements to create a more holistic view of the potential interaction of various factors on existing stormwater infrastructure, thus allowing for an integrated understanding of risk that permits better design of long-lasting, costly infrastructure critical to protecting people and property in the future.

The study includes a coupled hydrodynamic circulation (ADCIRC) and wave driven model ("SWaN" or Simulated Waves Nearshore model) to simulate the propagation of wind-driven waves, tides, and storm surge from deep water to nearshore. In addition, a comprehensive hydrodynamic stormwater and hydrologic model ("ICPR 4" or Interconnected Pond Routing Model 4) is utilized to route output from the coupled hydrodynamic and wave driven model such as storm tide heights over the Tampa Bay region, in particular the Cross Bayou Watershed. The hydrodynamic stormwater and hydrologic model also takes into account hydrologic processes such as precipitation and runoff which can contribute to significant flooding in the region. Thus, the impacts of different scenarios of sea levels on drainage efficiency as well as different possible scenarios of future rainfall can be considered together for future mitigation actions.

Finally, due to the number of scenario-dependent variables in this work, including storm size, strength, direction, and speed, precipitation, and sea level, the study will utilize new, innovative statistical analysis techniques that can provide an overall measure of risk in light of so many variables.

University of Florida Submissions

Sea-Level Rise and Coastal Water Resources

Researcher: Andrea Dutton
(in collaboration with Jon Martin, Arnoldo Valle-Levinson, Andy Ogram, Zhong-Ren Peng—all at UF)
Institution: University of Florida
E-mail: adutton@ufl.edu

Relevance to adaptation: Though many people think of sea-level rise solely as a problem of flooding and coastal inundation, the accompanying transformation to freshwater resources as well as coastal brackish to saltwater resources may well approach irreversible tipping points in terms of sustainability of human populations along the coastlines long before flooding does. In the face of rising sea-levels, there is an acute need to understand the thresholds and interplay between salt-water intrusion to groundwater aquifers, microbial response, nutrient supply and alterations to water chemistry, and the physical dynamics of fresh and salt water mixing and migration of water bodies.

Our interdisciplinary team links these diverse aspects associated with sea-level rise across a range of spatial and temporal scales (Fig. 1). In particular, we seek to compare and contrast

systems with fundamentally different physical bedrock and water permeability properties (karstic carbonate bedrock with open conduits vs. siliciclastic sediment with pore spaces). This range of physical properties can presently be found along the Florida coastline, and we are using sites along the coast of Florida for some of our field studies (e.g., Indian River Lagoon and the Florida Keys).

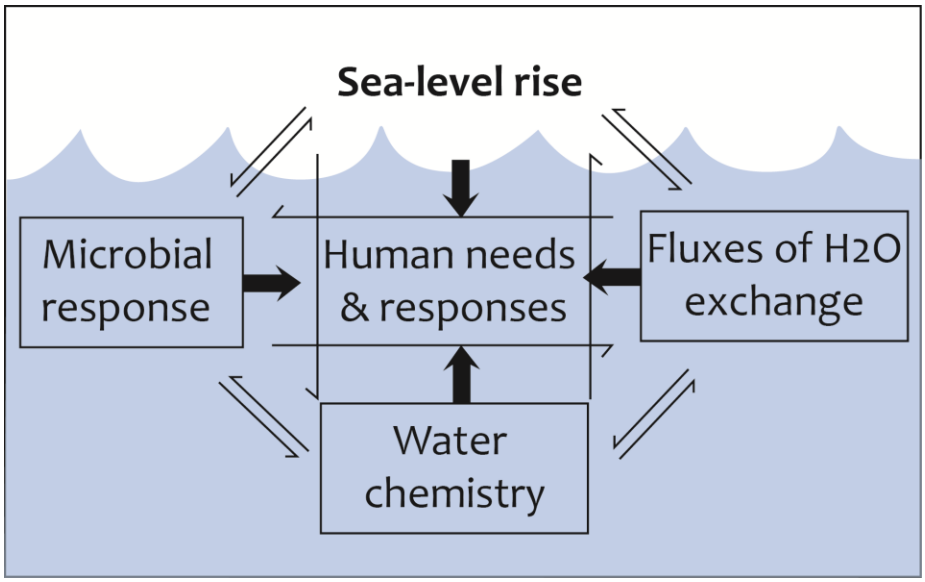


Figure 1. Conceptual diagram demonstrating links between all of the variables in the outer circle that ultimately impact the sustainability of coastal human populations. Our team of 5 PIs is constructed such that each variable in this diagram is associated with the expertise of one of the PIs.

To adequately adapt to the changes that will occur in this complex system, it is critical to define the relevant thresholds (tipping points) that cause a system to shift into an unsustainable territory. Part of our group has been working under the umbrella of an NSF-funded project on this topic and the entire team is presently applying for a larger grant from the same NSF program to expand this research.

Relevant results that will factor into adaptation strategies include the observation of changes in the rate of sea-level rise that directly impact the rate of salt-water intrusion and associated changes in water chemistry and microbial balance. Key to our assessment is the determination of whether these thresholds are the gatekeeper to reversible processes or whether they represent uni-directional changes that result in a more permanent change of state. This aspect is relevant, for example, to the dynamics of storm surges that may induce ephemeral extremes in the system. Once the storm surge has passed, the pressing question is how long will the effects persist? By studying these processes over a range of timescales, we aim to define the timescales of response for each element in the system.

In conjunction with studying the scientific aspects of the natural system, we are also incorporating an analysis of the response of coastal human communities to the threat of rising sea level. This is being accomplished by developing GIS applications to evaluate populations that may be impacted by coastal flooding and corresponding economic damages based on probabilistic different sea-level rise scenarios and time periods. A dynamic economic model will be developed based on surveys of local communities and human activity theories. Results of our salt water intrusion work include a parameterized physical response model that will be

coupled with models of projected long-term sea level change and linked to our assessments of potential rates of sea-level change. Economic impacts of sea-level rise on coastal human communities will also be expressed through changes in tourist attitudes. Tourist attitudes will be evaluated through traditional surveys and data mining via social media to develop a regional tourism variation model. This model will be used to predict potential economic impacts of various sea level rise scenarios and the impacts of sea-level rise on water resources. The results will be useful to local community managers setting policy regarding human community responses to loss of coastal resources.

Research Topic: Science-Collaborative Resiliency Planning on Florida Atlantic and Gulf Coasts

Lead Researcher: Kathryn Frank
Associate Researchers: Thomas Hoctor, Michael Volk, Paul Zwick, Greg Kiker, Thomas Ruppert, Joseli Macedo, Jeff Wade
Institution: University of Florida
Email: kifrank@ufl.edu

Relevance to adaptation: Coastal communities, land managers, and local governments have critical roles to play in sea level rise adaptation planning and implementation. Local adaptation planning should be both scientifically sound and collaborative in order to be successful. Additionally, to support resiliency and sustainability principles, adaptation planning should integrate concerns for the built and natural environments, as well as social and economic aspects.

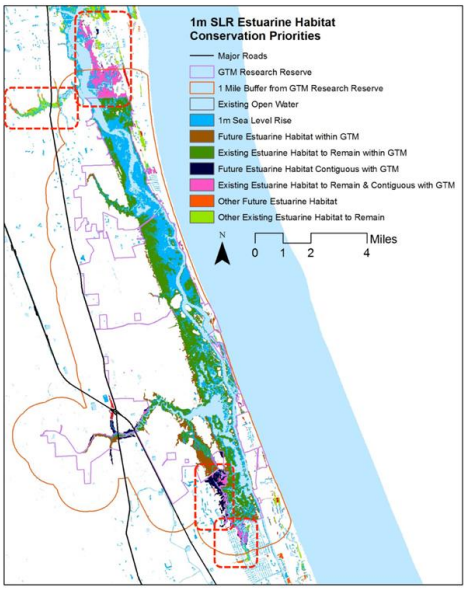
This research has piloted community and regional scale adaptation planning techniques for scientific analyses, stakeholder collaboration and public engagement, policy and governance analyses, and strategy design. The three applied planning projects were conducted from 2011 to 2015 in St. Johns and Flagler counties on the northeast Florida Atlantic coast (with local partner the Guana Tolomato Matanzas National Estuarine Research Reserve and including St. Augustine and Palm Coast), and in Levy County on the Florida Gulf coast (working with the County, and cities of Cedar Key, Yankeetown, and Inglis). Funding for the projects was provided by Florida Sea Grant and the National Estuarine Research Reserve System Science Collaborative.

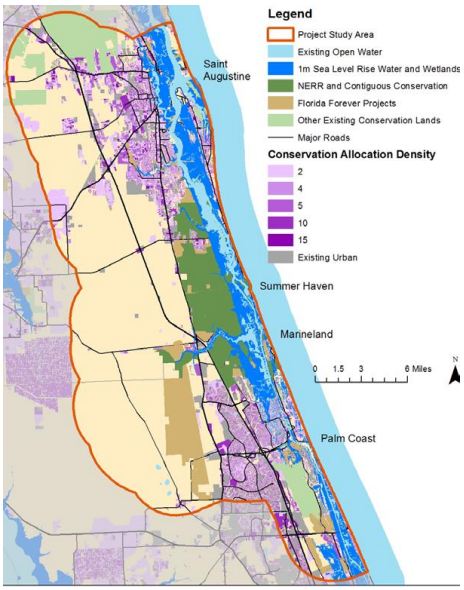
In each location, the research generated comprehensive, community-based and spatially explicit sea level rise vulnerability and adaptive capacity information, and recommended a wide variety of integrated adaptation strategies. Additionally, the relationships formed during the studies have led to new UF-local stakeholder initiatives being proposed. Information about the projects is available at http://planningmatanzas.org and http://changinglevycoast.org. Example recommended strategies are below:

Matanzas Basin

The Matanzas Basin project modeled land cover changes for sea level rise up to 2.5 meters by 2100, future development scenarios to year 2060, and impacts to ecological resources; and it identified future conservation priorities and resilient designs of the built environment. The figures

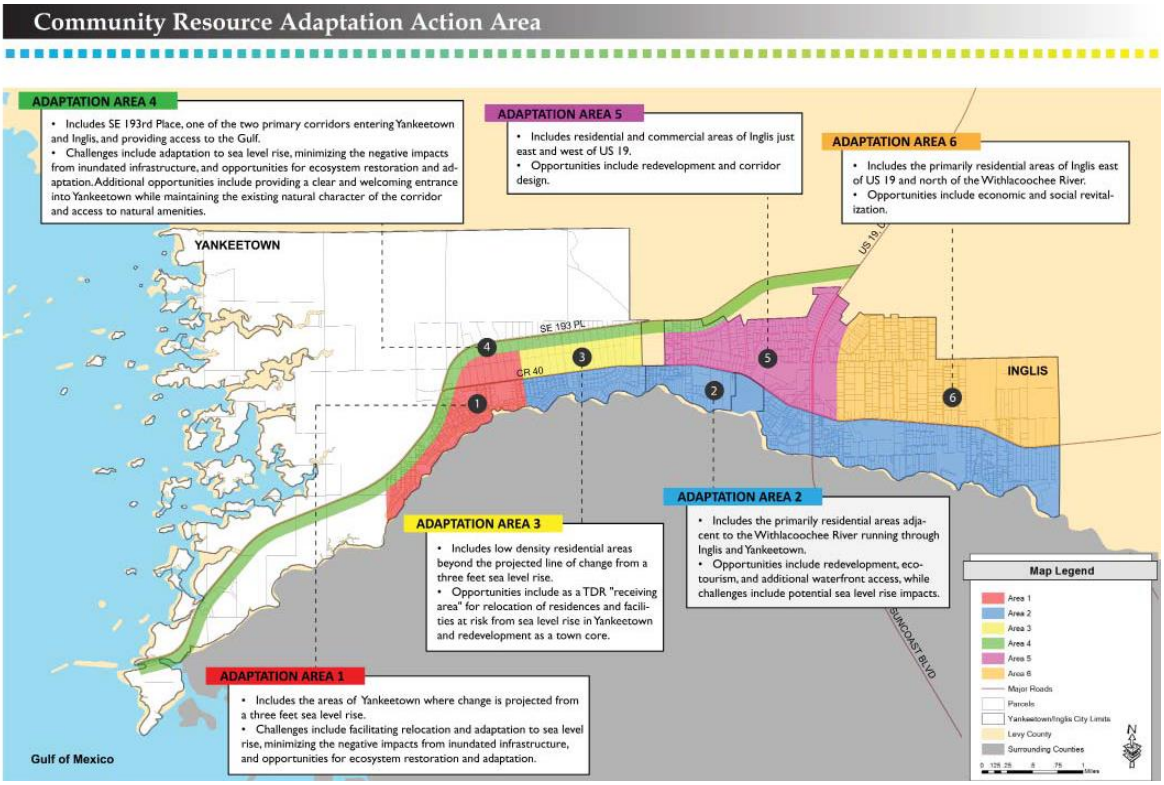
below show (1) resulting estuarine habitat conservation priorities adjacent to the GTM Research Reserve for a 1 meter sea level rise scenario, and (2) a future development scenario including adaptation of vulnerable development and avoidance of aggregated conservation priorities.





Yankeetown-Inglis

In the small towns of Yankeetown and Inglis in the Florida Big Bend region, the project addressed the significant flooding vulnerabilities, and recognized the capacities for adaptation. The project proposed six adaptation areas within which different sets of strategies would apply. The adaptation areas were designed to coordinate "sending and receiving areas" for adaptation, and align with social and economic goals.



Predicting and Mitigating the Effects of Sea-Level Rise and Land Use Changes on Imperiled Species and Natural Communities in Florida

Principal Investigator: Tom Hoctor, University of Florida Center for Landscape Conservation Planning; Project Manager: Michael Volk, University of Florida Center for Landscape Conservation Planning; Partners: Reed Noss, University of Central Florida; Jon Oetting, Florida Natural Areas Inventory; Paul Zwick, University of Florida; Joshua Reece, University of Central Florida
Project Period: 1/1/2011-2/15/2014

Relevance to adaptation: The goal of this project was to create a detailed assessment of the combined impacts of sea-level rise and land-use shifts on imperiled species and habitat throughout the State. This assessment was used to develop spatially explicit, science-based adaptive strategy recommendations to assist policy decisions. This work is a starting point for future assessments of the impacts of sea-level rise and adaptation options, and will form an essential foundation for future research and funding that builds on the results and methodology of this project. Of particular importance is the integration of strategies for adaptation of human communities with those that focus on adaptation of natural communities and species, so that they are harmonious and complementary rather than conflicting.

Project Goal: The overall goal of this project was to conduct an assessment of the potential impacts of sea-level rise and land-use change in Florida on high priority natural communities and species identified in Florida's Comprehensive Wildlife Conservation Strategy. Such an assessment is necessary for developing conservation strategies, including identification and

protection of functional connectivity, that will avoid, minimize, and mitigate anticipated impacts. This work formed the foundation for revising conservation land acquisition priorities, land-use planning and management strategies, and adaptation measures for at-risk species and natural communities to promote resistance and resilience to climate change. The specific objectives included:

Objective 1 Data Collection and Development: Collect and develop critical foundational data for assessing the combined impacts of sea-level rise and land-use changes on imperiled species in coastal areas. This objective includes development of a range of sea-level rise projection models, collection of future land-use projections, development of updated habitat models for imperiled species, and a literature review on the habitat characteristics, autecology, and risk factors for particular species.

Objective 2 Impacts Assessment: Based on the updated habitat models and literature review, assess the potential impacts of sea-level and land-use projections on imperiled taxa, natural communities, and habitat corridors as a basis for defining specific adaptive strategies.

Objective 3 Strategy Recommendations: Based on projected impacts to imperiled species and communities, identify specific strategies for mitigating the effects of climate change and facilitating species and habitat adaptation, which will provide a spatially explicit, scientific basis for future conservation policy decisions.

The full project report is at this link: http://conservation.dcp.ufl.edu/Project-Downloads.html and is titled
"Adaptation to Sea-level Rise in Florida: Biological Conservation Priorities". Outcomes from this project that are relevant to the Miami-Dade area include any of the findings related to future development patterns in the area, impacts from development and sea level rise on important species and ecosystems in the southeast Florida, as well as the potential adaptation strategies that we have outlined for specific species.

ReCharting Longboat Key: Toward Community, Economy and Resiliency

Lead Researchers: Martin Gold, Martha Kohen, Jerry Murphy
Institution: University of Florida: Resilient Communities Initiative
E-mail: murphyge@frci.dcp.ufl.edu

Relevance to adaptation: Army Corps of Engineers and National Oceanic and Atmospheric Administration data suggest that sea levels at Longboat Key, an incorporated barrier island on the west coast of Florida in Sarasota and Manatee Counties, may rise as much as five (5) to six (6) feet by the year 2100. Utilizing an Urban Design Studio (UDS) comprised of UF College of Design, Construction and Planning (DCP) faculty, graduate architecture students—in conjunction with PhD candidates in architecture and planning—the research examined the natural conditions, the infrastructural concerns, the activities, and the developed land potential. The Sea Level Rise (SLR) issues for the Barrier Island condition became an underlying consideration in the wake of future impact into existing investments and lifestyles present within the island community.

Possible futures: Four teams were formed, involving multiple DCP faculty and students. The teams were tasked with examining the barrier island condition in the context of the Gulf of Mexico and Sarasota Bay and the adjoining mainland influence on the Key. The team's diagnoses were unique in their considerations and emphases but, as a coordinated group, they were able to identify the main aspects and underlying conditions. Their individual visions, and the discussion and presentation of their ideas, contributed to raising and completing the group consciousness of the breadth of the necessary considerations, bringing depth to certain aspects selected by the teams as determining factors. Their diagnostic findings identifying strengths, threats, vulnerabilities, and weaknesses—as well as opportunities—were briefly described in text next to their team proposal graphics. The larger group provided insight, as well as technical support, for this analytical stage—in particular regarding SLR predictions at the individual parcel level.

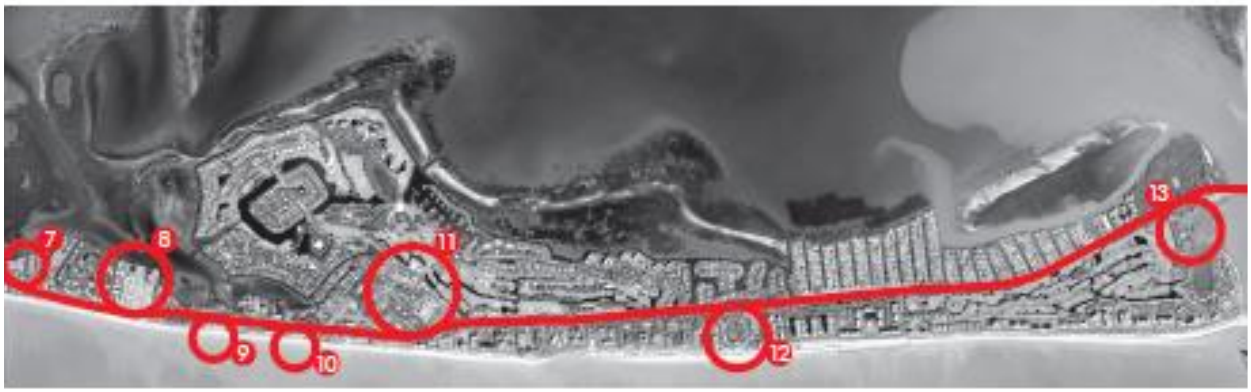
In light of their selected aspects diagnostics, and incorporating the other teams' analyses, the four teams developed, at territorial scale, their master plan proposals that were presented to the groups and the public. The master plans include identification of design exploration sites that are representative of more generalized strategies that exemplify and support changes in natural assets, density, economic development, infrastructure, land use, mobility, public space, and residential typologies. The identified exploration sites support projects that could serve as testing grounds for proposed land use planning and land development code modifications. The projects also included the development of innovative programmatic opportunities, later exemplified by individual student redevelopment intervention project proposals.
Finally, the group's proposals were combined in a composite master plan strategy—developed after extensive group discussion and examination, inclusive of the individual plans, but selective towards the main proposals that the group prioritized. The combined master plan displays the identified universe of possibilities that introduce phasing aspects of the 21st Century priorities and feasibilities.

Recommendations:
The resulting Report outlines and details Objectives, Strategies, and Suggested Regulations that could be empowered through three (3) means of implementation:

1. Establishing incentives for private development;
2. Revising/replacing the land development regulations to remove barriers to proactive redevelopment; and
3. Direct action by the Town of Longboat Key.

Recommendations include positive steps forward to address the immediate redevelopment concerns in concert with ecological enhancement and medium to long-term challenges and threats to the Longboat Key community. The takeaway section, *Longboat Key 2101*, introduces the concept of making near-term decisions that are influenced by, and also begin to address, futures that are both fairly clear and carry forward into the next century.

4 Locations of Opportunity



Seawater Intrusion Impacts on Drinking Water Production

Researcher: Treavor Boyer
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Relevance to adaptation: As the seawater or salt content of groundwater and surface water increases, the treatment processes required to produce potable water change, and in many cases become less effective. For example, fresh groundwater typically requires minimal treatment such as chlorine addition for disinfection, and fresh surface water is typically treated by coagulation/flocculation to remove particulate and organic material followed by chlorine disinfection. The efficacy of chlorine disinfection, which is the most widely used disinfectant in drinking water treatment, is greatly altered by the presence of increasing seawater content in freshwater. Although seawater is dominated by sodium and chloride ions (i.e., common table salt), it also contains bromide ions. During chlorine disinfection the bromide ions are transformed to halogenated organic disinfection byproducts (DBPs), such as trihalomethanes (THMs) and haloacetic acids (HAAs), which are considered possible human carcinogens and regulated by the U.S. Environmental Protection Agency as primary drinking water contaminants.

Ged and Boyer (2014) and Boyer (unpublished) simulated seawater intrusion into fresh groundwater by mixing Gulf of Mexico seawater with Floridan Aquifer groundwater and Atlantic Ocean seawater with Biscayne Aquifer groundwater (see Figure 1). The most striking result is the increased formation of disinfection byproducts with increasing seawater content at a typical chlorine dose. For a very low fraction of seawater intrusion, e.g., 0.2 to 0.4% seawater by volume, the total formation of disinfection byproducts measured as trihalomethanes exceeded its maximum contaminant level of 80 µg/L. This is a critical result for water supply planning and treatment because the maximum contaminant level for trihalomethane formation is exceeded, which is based on adverse human health effects, whereas the bulk seawater content is low and does not require desalination.

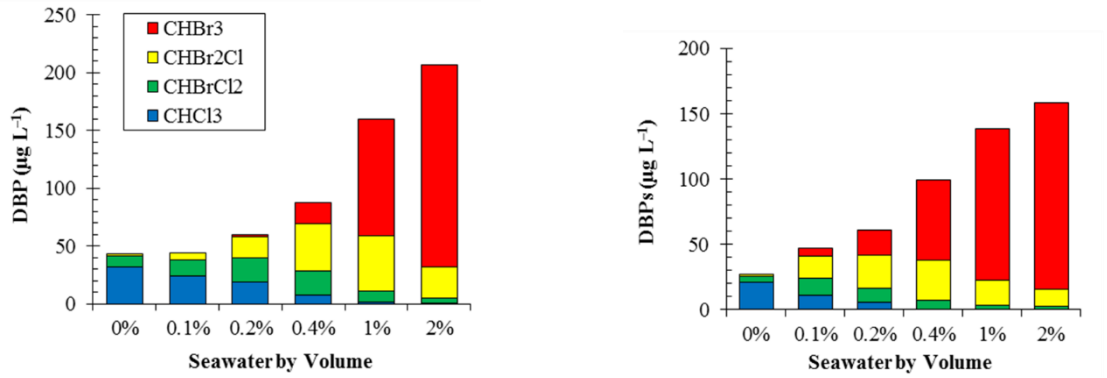

Figure 1. Formation of trihalomethanes during chlorine addition to groundwater–seawater mixtures. Gulf of Mexico (left) and Atlantic Ocean (right) seawater.

Assessing Climate Change Impacts on Hurricanes, Sea Level Rise and Coastal Inundation, and Coastal Ecosystems and Infrastructures

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Relevance to adaptation: Climate adaptation requires knowing accurate information of coastal inundation during current and future climates and their impacts on coastal ecosystems and infrastructures. Recent researches have shown that climate change can not only cause slowly varying sea level rise (SLR), but also may increase the intensity and even frequency of tropical cyclones in the future. Therefore, climate adaptation must consider the coastal inundation in future climate due to tropical cyclones and sea level rise. The Advanced Coastal Environment Systems (ACES) group at the University of Florida has used dynamic climate and coastal models to produce probabilistic coastal inundation maps in current and future climates due to the combined effects of sea level rise and increased future cyclone activities. Using the probabilistic coastal inundation maps, the ACES Group, along with the interdisciplinary faculty at ESSIE, has been and continues to be engaged in the following activities: (1) real-time forecasting the water level, currents, and salinity around the Florida Coasts; (2) predicting coastal inundation impact on population and property; (3) predicting coastal inundation impact on coastal wetlands and estuaries; (4) predicting coastal inundation impact on transportation and water systems; (5) assessing the role of coastal wetlands (marshes and mangroves) in reducing future coastal inundation risk; (6) assessing the impact of coastal inundation on inland flooding through coastal canals; and (7) assessing the impact of future coastal inundation on groundwater system and the role of groundwater in affecting future coastal inundation.

Most of the above mentioned activities are focused on the Southeast Florida region, including Miami-Dade, Broward, and Palm Beach Counties. Currently, ACES is funded by the National Oceanographic and Atmospheric Administration Climate Program Office, Florida Sea Grant, and South Eastern Coastal Ocean Observing Regional Association to conduct some of the activities mentioned above. ACES has been engaged with the Miami-Dade, Broward, and Palm Beach Counties as well as the South Eastern Florida Regional Climate Change Compact on some of the above topics, both as research partners and participants at numerous outreach activities including the Climate Change Summits and the Resilience Redesigns.

ACES develops and applies integrative multidisciplinary approaches to address the various research topics listed above. For example, some are studying the impact of various sea level rise scenarios on coastal inundation using the "bathtub" approach, which applies a single sea level rise value throughout a coastal area, e.g., Miami-Dade County. Using dynamic models, we have found that the "bathtub" approach generally over-estimates the extent and elevation of coastal inundation due to sea level rise, because the "bathtub" approach ignores the effect of land dissipation on coastal inundation. Other "bathtub" studies have combined the effect of sea level rise and future storms by adding a SLR value with a peak storm surge value calculated by statistical analysis of water level data, then applying the added inundation value throughout the coastal area. This approach, again, over-estimates the coastal inundation because it ignores the land dissipation and the interaction between the slowly varying SLR and the storm induced coastal inundation. Moreover, such maps are not true risk maps because they do not have any probabilistic information.

We have used dynamic global and regional climate models to predict the future storms expected in the Miami-Dade and Broward Counties, then using an integrated coastal storm surge and inundation modeling system (CH3D-SSMS, Sheng et al. 2010a and b, Sheng and Liu 2011) to produce future coastal inundation maps in the region (Sheng et al. 2012b, 2015; Sheng and Paramygin 2014). As an example, in Figure 1, we show two coastal inundation maps in the Miami-Dade County due to 1 m and 2 m SLR, as well as a 1% annual chance coastal inundation map in 2010 which includes 1m SLR and future storms. As shown in Figure 1, significant inundation levels of 4-9 ft are found in the south Miami-Dade. With higher SLR, the 1% coastal inundation level will increase further, thereby affecting more population and properties. Using the method described in Condon and Sheng (2012), we can estimate the affected population and property in the Miami-Dade in 2100. We can also assess the relative impact of SLR and future storms on future coastal inundation.

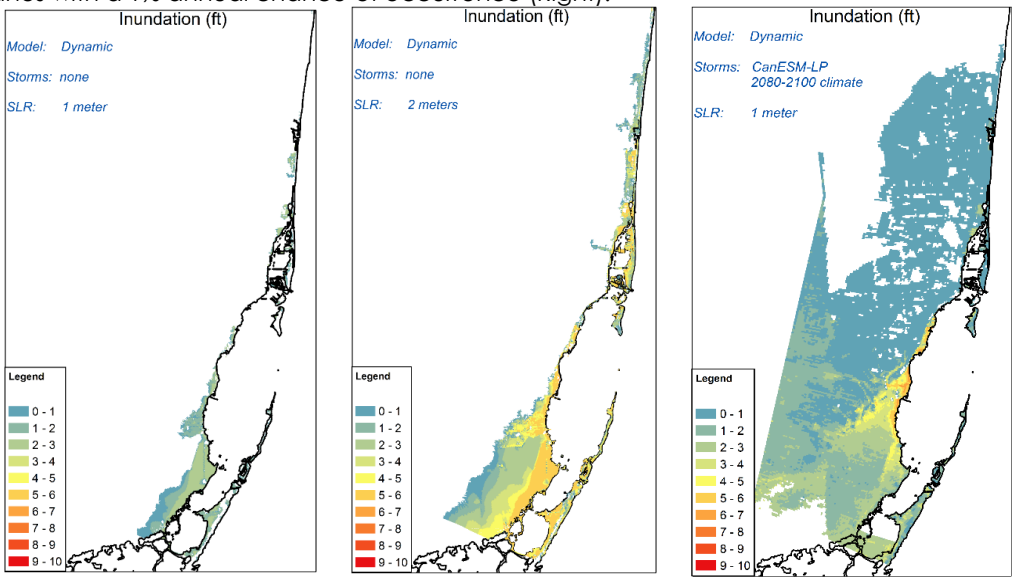
To make these future inundation projections more useful to Miami-Dade, we plan to add a groundwater model SEAWAT (Langevin and Zygnerski 2013; Sukop 2015) to the coastal inundation modeling system to allow interaction between surface water and groundwater, and to enable more accurate prediction of climate change impact on

the coastal area. Motz (2014) has simulated the sea level rise impact on groundwater salinity in Broward County. If needed, surface storm water model can be added to the coupled surface water and groundwater modeling system.

Moreover, we plan to add coastal canals to our coastal model domain so we can assess the impact of future coastal inundation on inland canal systems which are maintained by the South Florida Water Management District.

Sheng et al. (2012a) developed a robust three-dimensional wetland-resolving surge-wave modeling system to simulate the effect of marshes and mangroves in reducing coastal surge and inundation. Lapetina and Sheng (2014, 2015) showed that the modeling system allows accurate simulation of surge and flood reduction by wetlands without resorting to ad-hoc tuning of bottom friction coefficients.

Figure 1. Coastal Inundation in Miami-Dade County due to 1 m Sea Level Rise (Left), 2 m SLR (Middle), and 1 m SLR plus future hurricanes with a 1% annual chance of occurrence (Right).



Effectiveness of Residential Water Conservation and Demand Management Programs

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Relevance to adaptation: Water conservation and reduction in per capita water demand in urban areas is one strategy to address reductions in aquifer levels and salt water intrusion issues. FRED faculty have been examining effectiveness of various water conservation programs implemented by water utilities, local government, and Extension service. Specifically, we examined residential water conservation extension workshops (in Osceola county), residential irrigation inspections (in Alachua county), and changes

in water price structure (high water use properties in Orange county). The analysis was conducted using property-level water use data provided by water utilities. The results show that all three programs are effective in changing property owners' water use; however, the effectiveness varies among programs. Local governments need to select the conservation program or a combination of program to achieve specific water conservation goals.

A Parameterized Climate Change Projection Model for Hurricane Flooding, Wave Action, Economic Damages and Population Dynamics – R/GOM-RP-2

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Relevance to adaptation: Historical tidal gauges data and satellite observation have demonstrated sea level has been rising over the last 100 years and will continue to rise or even accelerate into the future (IPCC, 2014a; National Research Council, 2012; and Hsu, 2014). The key question is how coastal communities would respond if their primary residences are permanently inundated due to sea level rise (SLR). There are several adaptation strategies, including building sea walls and relocation. Building sea walls are obviously expensive (Yang, 2014); additionally, structural protection is not a feasible option for some coastal areas. Therefore, relocation may be a viable alternative. While previous studies focus on evaluating the impacts of SLR and the pros and cons of different adaptation strategies, few studies quantitatively model and assess land use changes and population relocation. This research contributes to the body of planning literature by filling this void. From the public point of view, people are not highly aware of sea level rise; according to our survey study, only half of the respondents agree that sea level is rising. Accordingly, this research establishes a channel to offer the public with scientific findings and raise the public awareness towards changing sea level, intensified flooding, and inundation.

Response: First, we identified coastal residents' perceptions regarding sea level rise and responses and attitudes towards inundation due to changing sea level and intensified storm surge. We fulfill this goal by conducting a field survey study in the City of Panama, Florida, with the collaboration from the city's Planning Department.
Second, we are building a residential-relocation on the basis of sea level rise and flooding results from our project partners of Texas A&M University. Specifically, we are fulfilling the following goals:

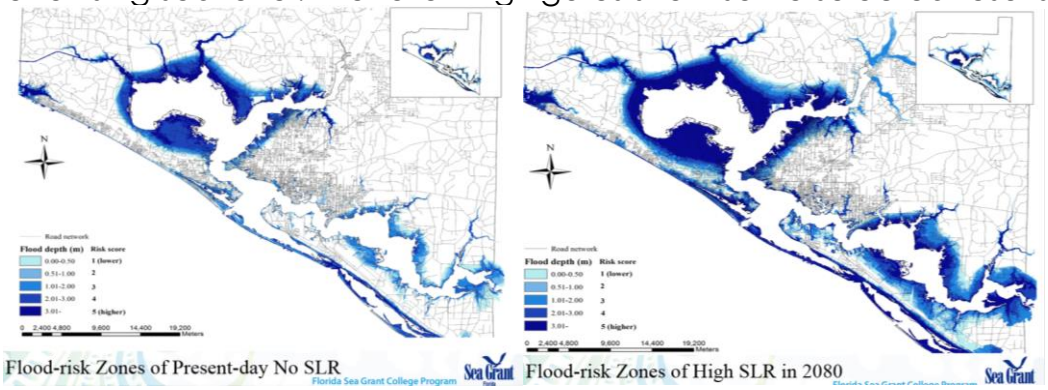
- Using Bay County, Florida as a case study, determined affected population whose primary residences would be permanently inundated due to sea level rise.
- Using Bay County, Florida as a case study, to simulate population dynamics in response to sea level rise in 2030 and 2080.

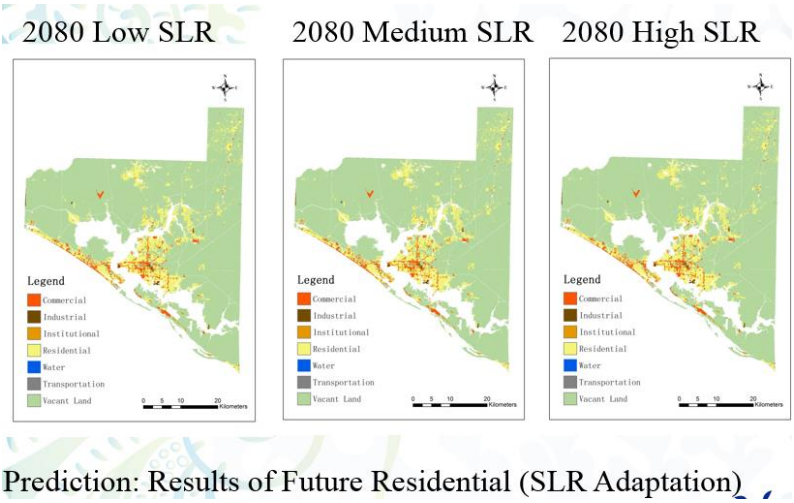
- To develop a generalized model framework that could be applied into other coastal regions which are susceptible to rising sea level.
- To provide local governments and planning agencies with guidelines and recommendations regarding population-retreat strategies and long-range land use planning that takes into account the impacts of sea level rise.

Results: One of the achievements of this project is to understand the public perception and attitudes towards sea level rise and hurricanes. Public support or opposition to sea level rise adaptation policies will be greatly influenced by public perceptions of the risks and dangers of sea-level rise. This study has conducted a survey to collect information on coastal residents' attitude toward future adaptation strategies, including preference to residential relocation. The results show that 74% of respondents would move if their primary residences are permanently inundated, and most of them prefer to move to other part of the same county.

Second, the proposed project contributes to the literature by integrating modeling, urban and regional planning, and climate change literature and to the public policy by providing a decision support tool for local governments to make scientifically sound public policies.

Another achievement of this project is to identify future available lands for residents whose primary residences would be permanently inundated due to sea level rise. Therefore, the proposed model could help local planning agencies better develop long-range land use planning under different SLR scenarios. Most importantly, the generalized model framework could be applied into other coastal regions that are susceptible to rising sea level. The following figures show some selected results.





Prediction: Results of Future Residential (SLR Adaptation)

Development of Sea Level Rise Adaptation Planning Procedures and Tools Using NOAA Sea Level Rise Impacts Viewer, funded by Mississippi-Alabama Sea Grant Consortium

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Relevance to adaptation: In this study, we have conducted surveys to better understand what professionals need in the adaptation planning and how they prioritize the different facilities. The vulnerability analysis based on the survey results can therefore significantly facilitate understanding of vulnerability and adaptation planning. It directly shows where the most vulnerable area is and how the vulnerability index changes under different sea level rise scenarios. This visualization tool will be provided to planners, city managers, council members, and planning and engineering professionals within Tampa Bay Region through Tampa Bay Region Planning Council. By using this visualization tool, the scientific community, researchers and planners can better understand how sea level rise will affect Tampa Bay Region, what will be the most influential aspects of the integrated vulnerability at the census block group level, and how to prepare for sea level rise to best reduce the inundation vulnerability. It provides useful information for the local adaptation planning council to make adaptation planning more efficient and intuitive.

Response: The visualization tool will be mainly provided to different agencies, including 7 municipal planning agencies, four county agencies, state and regional environmental protection agency and department of transportation, private planning and engineering companies, and water supply authority. And we will also invite coastal community representatives to use this visualization tool in order to understand the effect of this tool on non-professional people.

Results: This tool provides a good visualization of inundated infrastructures and regional vulnerability for local agencies to improve adaptation planning efficiency through: showing vulnerable facilities and vulnerable areas under different situations and scenarios (inundated infrastructures and low-lying infrastructures under 1ft, 2ft and 5ft sea levels) providing infrastructure vulnerability index and integrated vulnerability (including economic vulnerability score, social vulnerability score, and infrastructure vulnerability score) for users to check how vulnerable a specific area is under different sea level rise scenarios from multiple aspects using users preferred interface design (Google map): http://plaza.ufl.edu/dengyujun11/SLR7.0.html

Recap: The vulnerability analysis and the tool developed provides a guidance for local planners to identify the most vulnerable infrastructures and area from different perspectives, to understand the primary causes of overall vulnerability in a region, and therefore help them to prioritize their adaptation planning focus area and sections (e.g. economic, infrastructure, socially constructed adaptive capacity).

A Spatial-Temporal Econometric Model to Estimate Costs and Benefits of Sea-Level-Rise Adaptation Strategies – R/C-S-51

Researcher: Zhong-Ren Peng
Institution: Department of Urban and Regional Planning, University of Florida; Funded by Florida Sea Grant
Email: zpeng@dcp.ufl.edu

Relevance to adaptation: Sea level is expected to rise steadily though slowly in the foreseeable future. A direct consequence of sea level rise is the inundation and flooding, inflicting considerable economic and ecological damages. A challenge for all coastal area governments and state and national politicians is to decide on an appropriate adaptation strategy to mitigate the damages and when to implement it, and more importantly on how to rally public support for the new adaptation strategy. A growing body of current research has been devoted to sea level rise impact analysis and adaptation planning. However, despite these research efforts and various existing sea level rise adaptive planning tools, decision makers and residents at coastal areas are not making significant progress to prepare for future sea level rise. One of the major reasons for this slow reaction is that people are unaware of the costs of doing nothing or postponed actions, and the benefits of taking adaptation actions. To meet this challenge, this research project has an interdisciplinary team from economics, climate change, and urban and regional planning areas who have worked together to formulate an interdisciplinary opinion so that policy makers can make scientifically sound policy decisions. Therefore, this research provides a better understanding of the economic impacts of different adaptation strategies in response to sea-level rise in the adaptation decision-making process

Response: In cooperation with Tampa Bay Regional Planning Council (TBRPC), this research project develops a temporal-spatial econometric model to evaluate the costs and benefits of various adaptive strategies. This project also provides a decision support tool that local planners and decision makers can generate and visualize such information on their own. Furthermore, this project integrates both direct and indirect economic impacts of sea level rise into the cost-benefit analysis framework, which is applied to evaluate the most commonly adopted adaptation strategies.
The economic loss has been estimated on land values, business revenue, coastal wetland ecosystem services, building damages and value of travel time delay at different time points. These economic losses are considered as benefits of adaptation strategies. Additionally, the cost of adopting these strategies are quantified at different time points which are consistent with benefit analysis. Finally, all the benefits and costs are put together to analyze the cost efficiency and best time to take actions. It also proposes an adaptation plan that assigns each strategy to its appropriate locations as a guide for local communities. An uncertainty analysis is also conducted to evaluate the cost efficiency of adaptation strategies as well as the proposed adaptation plan under different uncertainty levels.

Results and contributions: The results reveal that different strategies have very different cost efficiency. Generally speaking, the strategies that target to protect built environment have higher cost efficiency than the ones that focus more on preserving ecosystems. Furthermore, cost benefit analysis at different action time points help to decide the best action time for each strategy as well as the adaptation plan. Although current sea level rise projection is associated with high uncertainty, the uncertainty analysis shows that even under the highest uncertainty level, most adaptation strategies and the adaptation plans are more cost efficient than doing nothing.

The key benefits of this project is that it provides a tool for adaptation planning. Policy makers may have several adaptation strategies to choose from. Using this research's results, they are able to choose the one that yields the highest benefits. The project also provides a model to quantify and forecast the economic costs and benefits for each adaptation strategy.

Appendix 2: Quarterly Reports

First Quarter Update (January 31, 2015 – April 30, 2015)

On January 21, 2015, the Board of County Commissioners (Board) passed seven (7) resolutions, each supporting the implementation of one of the seven recommendations included in the "Miami-Dade Sea Level Rise Task Force Report and Recommendations." Resolution R-48-15, which requires a quarterly status report and a final report within 364 days, directs the Mayor or Mayor's designee to work in conjunction with the Office of Intergovernmental Affairs (OIA), the South Florida Water Management District, the United States Geological Survey, and other member Counties of the Southeast Florida Regional Climate Change Compact (Compact) to conduct a comprehensive study and develop adaptation strategies to address potential flood damage reduction and salt water intrusion associated with sea level rise. Pursuant to R-48-15, this status report is submitted for your review.

Background

In July 2013, the Board created the Miami-Dade Sea Level Rise Task Force (Task Force) for the purpose of reviewing current and relevant data, science and reports, and to assess the likely and potential impacts of sea level rise and storm surge on Miami-Dade County over time. On July 1, 2014, the Task Force presented a report to the Board entitled, "Miami-Dade Sea Level Rise Task Force Report and Recommendations," providing the requested assessment along with recommendations of how Miami-Dade County may can begin planning and preparing for projected sea level rise impacts. In addition, Resolution R-451-14 and Ordinance 14-79 were adopted in 2014, requiring that planning, design and construction of County infrastructure consider potential sea level rise impacts.

In February 2008, Miami-Dade County entered into Joint Funding Agreement 08E0FL20817 with the U.S. Geological Survey to develop an integrated surface/groundwater numerical flow model, with one of the objectives of the project being to evaluate if sea level rise will cause salt water intrusion into coastal wellfields. Technical staff from the Miami-Dade Water and Sewer Department has worked with the U.S. Geological Survey on this project since then, and the numerical model was formally published by the U.S. Geological Survey in September 2014. The model is designed to evaluate if the current surface-water structure control operational criteria effectively control saltwater intrusion and flooding with projected population increase and sea level rise, among other uses.

This enhanced modelling capability is extremely important to all forthcoming adaptation planning for sea level rise in Miami-Dade County and the Southeast Florida region because it is a significant improvement upon former models used to generate "bathtub" sea level rise inundation maps. It will provide critical information about the effects of sea level rise and precipitation events on the groundwater table, and how

this may affect water resource management, including water supply, wastewater disposal, and canal operations. This will facilitate a more accurate understanding of areas and infrastructure more vulnerable to flooding in Miami-Dade County. The Water and Sewer Department and the U.S. Geological Survey used the modified guidance developed by the U.S. Army Corps of Engineers (USACE, 2011) and a planning scenario of 9 to 24 inches additional rise by 2060, consistent with projections presented in the 2014 National Climate Assessment, and formally adopted by the partner counties in the Compact for the modelling effort. Future efforts include updating the model to include the revised sea level rise projection, which is expected to be published in August 2015, by the Compact's Sea Level Rise Consensus Workgroup.

The South Florida Water Management District is the primary water management agency for Southeast Florida. As a result, their primary infrastructure and water management strategies are critical to good water supply, water quality, and flood control in the region, and consequently determines Miami-Dade's water management strategies and operation of secondary structures. The South Florida Water Management District and Miami-Dade County have a long history of close collaboration on water management and supply, as well as Everglades restoration, and this continued collaboration will be critical in effectively facing the additional challenges of climate change and sea level rise.

In 2009, the South Florida Water Management District's Interdepartmental Climate Change Group published a report entitled, "Climate Change and Water Management in South Florida." This report provided a good overview of the potential impacts of climate change to South Florida with regards to sea level rise, temperature, and evapotranspiration, rainfall, floods, drought, and tropical storms and hurricanes. In this report, the South Florida Water Management District stated that flood protection in Southeast Florida may be impacted by sea level rise and they identified several existing South Florida Water Management District coastal structures in Miami-Dade County that could be potentially impacted. Retrofitting of more structures with forward pumps will be considered as a feature of adaptation plans being developed to address sea level rise and rainfall changes in Miami-Dade County. The South Florida Water Management District has initiated a new pilot project to determine the current level of flood protection in the C-4 basin, to consider future changes that may impact flood protection, and to develop adaptation strategies to address such impacts. The South Florida Water Management District will also initiate similar efforts in the C-7, C-8, and C-9 Canal basins in Miami-Dade County with funding from the Federal Emergency Management Agency.

In addition to working with state and regional partners, the South Florida Water Management District is also engaging international expertise in addressing these issues. In April of 2014, the South Florida Water Management District signed a three year Memorandum of Agreement (MOA) with the Ministry of Infrastructure and the Environment of the Netherlands, and the Delfland Water Board, to work cooperatively

and share information, expertise and strategies in flood control, water supply, spatial development, environmental ecosystem restoration, crisis management, modelling, service level practices, sea level rise, climate adaptation strategies and salt water intrusion impacts. Because there are many similarities in the water management systems of South Florida and the Netherlands, these two (2) organizations agreed to work towards a comprehensive thematic annual work program on information and best practices exchange, and to evaluate and update the work program annually. Therefore, the additional expertise of these Dutch partners will contribute to the regional efforts of the South Florida Water Management District, the U.S. Geological Survey, Miami-Dade County and the Compact to better understand potential flood damage and saltwater intrusion and begin to develop adaptation strategies.

Quarter 1 Progress (January 31, 2015 – April 30, 2015)

- The South Florida Water Management District has recently initiated a two year grant project that is funded by the National Oceanographic and Atmospheric Administration's Sectoral Applications Research Program. It was awarded to the South Florida Water Management District and their partner, Deltares, for their project entitled, "Flood and Drought Risk Management Under Climate Change: Methods for Strategy Evaluation and Cost Optimization." Deltares is an independent research institute which focuses on applied research in the field of water, subsurface, and infrastructure. Deltares is based in Delft and Utrecht in the Netherlands, with a USA branch (Deltares USA) based in Silver Springs, Maryland.

- This project is anticipated to contribute significantly to the directives required by R-48-15 because the project team has chosen Miami-Dade County as a pilot area to implement concepts of flood and drought risk management to: (1) determine the current level of flood protection in the C-4 basin, (2) consider future changes that may impact flood protection, and (3) develop adaptation strategies to address such impacts. Furthermore, the South Florida Water Management District will also initiate similar efforts in the C-7, C-8, and C-9 Canal basins in Miami-Dade County with funding from The Federal Emergency Management Agency. This project aims to accomplish several relevant objectives:

    - Further analyze the impacts of climate change on the occurrence of floods and droughts in the South Florida Water Management District;
    - Gain more insight into the intended and unintended effects of flood and drought risk reduction measures;
    - Develop and apply a method to evaluate the capability of the water management system to effectively address extreme events (floods and droughts), and use the outcomes for the assessment of comprehensive adaptation strategies aimed at flood and drought risk reduction under climate change;
    - Apply an economic optimization method for determining the optimal investment in flood risk reduction. With this application, the project will

document the process of moving the method from the Netherlands to Florida, and identify what is required to apply the optimization method to other regions;
    - Assess and communicate the usefulness of applying this optimization method for decision making in water resource management; and
    - Publish the general outcomes on the methods and the specific outcomes for the case study area, through two stakeholder and expert workshops and scientific (journal) publications.

- The South Florida Water Management District and its Deltares partners held a project kick-off meeting and site tour on March 23-25, 2015, where local and regional partners and contributors were formally introduced to the project and encouraged to provide suggestions for data gathering and project implementation. The Miami-Dade Office of Sustainability and the Water and Sewer Department hosted the meetings on the first two (2) days, and appropriate County technical staff participated to provide input and suggestions. Staff from the Water and Sewer Department and Public Works and Waste Management's Stormwater Master Planning Program will be integral contributors to the project.

- Staff of the Miami-Dade Regulatory and Economic Department (RER) and the Water and Sewer Department are working to establish an internal working group comprised of technical staff from key departments to begin evaluating the engineering and other expertise needed to conduct a thorough analysis and develop cost estimates to acquire the expertise and begin formulating a capital plan. One of the first tasks for the technical workgroup is to develop criteria and parameters for use in the groundwater/surface water integrated model, which will then be utilized to help determine areas and infrastructure more at risk for flooding and inundation.

- The Compact's Sea Level Rise Consensus Workgroup is currently finalizing a revised Sea Level Rise Projection for Southeast Florida. This projection, which is expected to differ to some degree from the original sea level rise projection developed in 2011, will be utilized by the partners of the Compact, including Miami-Dade County, for planning purposes. This revised projection and accompanying document are expected to be finalized and released in August 2015.

- The South Florida Water Management District hosted a meeting on April 30, 2015, with their Netherlands MOA partners, the Ministry of Infrastructure and the Environment of the Netherlands, and the Delfland Water Board, to discuss a variety of climate change and sea level rise related topics, including saltwater intrusion and "science based adaptation strategies" for water and climate. County staff participated to see how the work associated with this MOA can contribute to accomplishing the tasks required in Resolution R-48-15.

In accordance with Ordinance 14-65, this memorandum and report will be placed on the next available Board of County Commissioners meeting agenda.

If you have questions concerning the above, please contact Mark R. Woerner, AICP, Assistant Director for Planning, Department of Regulatory and Economic Resources, at (305) 375-2835 or mwoerner@miamidade.gov.

Second Quarter Update (May 1, 2015- July 30, 2015)

The following steps have been taken during the Second Quarter to address the comprehensive study referenced in this resolution:

- The Water and Sewer Department is currently evaluating the potential impact of salt water intrusion by monitoring a series of groundwater wells which indicate the fluctuating location of the salt water front line. Several projects such as earthen plugs and salinity control structures are helping to mitigate the potential impact of salt water intrusion on Miami Dade County's water supply. The resources needed to continue to protect freshwater resources are currently being re-evaluated and a final report will be available by the conclusion of 2015, indicating where additional resources are needed. This report will also assess the potential to slow or limit salt water intrusion in the future.

- On July 27, 2015, a full-day workshop was held at the South Florida Water Management District headquarters with representatives from the Miami Dade County Department of Regulatory and Economic Resources, Public Works and Waste Management, and Water and Sewer Department, and the South Florida Water Management District, U.S. Geological Survey, the Army Corps of Engineers, Deltares, Florida Climate Institute and the Compact. This workshop brought together practitioners and researchers to review all of the on-going and planned research efforts which are examining flooding risk, salt water intrusion, and adaptation approaches in the region. Participants discussed where informational and analytical gaps exist, as well as other studies or methodologies used in other regions and countries that could be drawn upon to address those gaps. The group also reviewed potential funding for adaptation measures. The on-going monitoring, modelling, and adaptation measures being taken by Public Works and Waste Management, Water and Sewer Department and the South Florida Water Management District were the focus of the afternoon workshop. RER staff is currently reviewing and revising the proposed timeline and draft outline developed from this workshop, which will be used for the final report to be presented to the Board at in January 2016. The group that participated in the July 27th workshop will continue to contribute to the development of that report and will continue to provide expertise on how this analysis can be completed with existing resources, and where additional expertise and resources will be needed.

- RER staff also contacted the Army Corps of Engineers staff members who recently completed the North Atlantic Coast Comprehensive Study. This two-year study was requested by the Obama Administration in the wake of Hurricane Sandy to systematically review and evaluate the coastal flooding risks for the Sandy affected area. The Comprehensive Study detailed coastal storm and flood risks to vulnerable populations, property, ecosystems, and infrastructure in the region. The study was intended to help local communities better prepare for future flood risks and make the latest scientific information

available to local planners. While the geographic scope of the study was much larger than what is needed for Miami-Dade County, there are potential lessons that could be learned and methods for modelling coastal storm surge that could be replicated for a local assessment.

- On June 24, 2015, Florida International University hosted the kick-off event for the Compact's regional project with the RAND Corporation, known as "Water Management and Adaptation Planning to Address Sea Level Rise and Climate Change in Southeast Florida". At this meeting, members of the Compact, the U.S. Geological Survey, South Florida Water Management District, the Water and Sewer Department, the South Florida Regional Planning Council (SFRPC), The Nature Conservancy (TNC), and other academic partners developed the scope of work, schedule, and action plan for the study. Participants reviewed the region's most pressing water management decisions, completed a gap analysis identifying which key decisions currently lack sufficient analytical support, and worked through a prioritization exercise to address those gaps. RAND has previous experience helping policy makers work though complex problems and decision-making processes and has provided research and facilitation support to stakeholders in the Mississippi Delta region. RAND will be able to provide support to the Compact by helping to analyze and connect several existing models. The exact scope of the project is still being determined. It is anticipated that within the next 12-16 months this project will provide a decision support tool to help the region evaluate the economic implications of various water management regimes and infrastructure investments, as well as different land use patterns. A focus of this research will be integrating economic models to identify ways that the economic exposure of regional assets to storms and flooding risks can be minimized.

- One of the most significant factors in determining our regional flooding risk will be future precipitation patterns. Early model runs with the newly developed U.S. Geological Survey model used current precipitation patterns, but these patterns may shift in the future. A change in either direction toward drier or wetter conditions would have significant implications of regional water management strategies. On June 22 and 23, 2015, the U.S. Geological Survey and the Florida Center for Environmental Studies hosted a two day event at Florida Atlantic University to review the latest science on future precipitation patterns. The event provided a good opportunity for climate modelers and climatologists to interface directly with decision-makers and Compact members. The scientific review of the latest dynamical and statistical climate downscaling techniques revealed the importance of continuing to advance this line of research, particularly given the current uncertainty surrounding future wet and dry season conditions and their potentially significant implications for drinking water resources, agriculture, and ecosystems.

- The South Florida Water Management District continued to work on its two year National Oceanic Atmospheric Administration funded grant project "Flood and Drought Risk Management under Climate Change: Methods for Strategy Evaluation and Cost Optimization." As mentioned in the First Quarter update report, this work is being conducted jointly with Deltares, an independent research institute which focuses on applied research in the field of water, subsurface, and infrastructure. Deltares is based in Delft and Utrecht in the Netherlands, with a USA branch (Deltares USA) based in Silver Springs, Maryland.

- During this quarter, PWWM continued to advance their flood risk analysis within the C-8 and C-9 basins. The preliminary model runs for the C-8 and C-9 basins have been completed, using the previous Compact sea level rise projections (2012), current land use (2013) and future land use (2030). Inundation limits, and a new floodplain map have been prepared using the 2012 projections and an estimate for the end of wet season groundwater table. Staff are now in the process of preparing the model runs for the updated Compact sea level rise projections (2015), and a new floodplain map will be prepared using the new projections, considering future groundwater table and future land use.

Third Quarter Update (July 31, 2015- October 31, 2015)

- The following steps have been taken during the third quarter to address the comprehensive study referenced in this resolution:

- The Water and Sewer Department continues to monitor changing environmental conditions and evaluate the potential impact of saltwater intrusion. The resources needed to continue to protect freshwater resources are currently being re-evaluated and a final report will be available by January 2016, indicating where additional resources may be needed. This report will also assess the potential to slow or limit saltwater intrusion.

- The Stormwater Utility Planning Division continues to advance their flooding studies within the C-8 and C-9 basins. The division had previously developed inundation limits and new floodplain maps and an estimate for the end-of-wet season groundwater table. The division is in the process of converting the C-9 model to the appropriate vertical datum (NAVD88), in order to create a new floodplain map which will use the Compact's new unified sea level projections (2015), considering future groundwater table and future land use. The completion schedule for this first modeling work is approximately six (6) weeks after receipt of the future groundwater table from WASD, based on the new U.S. Geological Survey groundwater/surface water interface model. After this modelling phase is complete and the floodplain maps are produced, the Planning Division of RER will analyze potential land use impacts.

- In addition, the model runs for Arch Creek basin have been completed using the current Compact sea level rise projections (2015). Maps of inundation depths and new floodplain maps are being prepared using the 2015 Compact projections. Since this is a coastal basin, only the tide projections are necessary for the first round of modeling. The Planning Division of RER, will review the results for potential land use impacts.

- The model runs for Oleta River basin are being prepared, using the current Compact sea level rise projections (2015). Inundation depths maps and new floodplain maps are being prepared using the 2015 Compact projections. Since this is a coastal basin, only the tide projections are necessary for the first round of modeling. The Planning Division of RER, will review the results for potential land use impacts.

- The Florida Climate Institute (FCI) is a consortium of Florida universities with programs focused on climate change and sea level rise related research, and currently includes the University of Miami, Florida International University, Florida Atlantic University, and University of Florida, amongst other Florida universities. RER staff are working with several of the South

Florida FCI universities to assemble and summarize the best available science relevant to Miami-Dade County's vulnerability to sea level rise and saltwater intrusion, as well as research on potential adaptation options. A first draft of the submissions from the Florida Climate Institute has been drafted and will be incorporated into the final report which will be submitted to the board in January 2016. The scientific research spans the breadth of disciplines from studying social adaptation to sea level rise, to changing precipitation patterns, to modeling of the interdependencies of various infrastructural systems, to modeling the resilience of wetland ecosystems to changing sea levels.

- Work also continues on the RAND Corporation study "Adaptation Planning for Sea Level Rise and Climate Change in Southeast Florida: Understanding the Interactions of New Infrastructure, Land Use Changes, and Water Management". The technical experts working on this project are world-renowned experts in complex decision-making and are bringing a wealth of expertise to our regional adaptation challenges. While the final scope is not finalized and may still change, the intended outcome is to develop an integrated system of simulation models for the region that will provide a transparent, interactive tool, and a level analytical playing field to assess potential interactions among water management, transportation, and land use decisions under a range of scenarios. The project's ultimate goal is to provide tools to help decision-makers and stakeholders in the region gain a better understanding of the costs of both action, and inaction, across a wide range of scenarios. In collaboration with RER staff and with technical experts and partners within the region, RAND's engagement will help to support: rigorous evaluation of vulnerabilities of land-based assets, application of models to support economic loss and benefit-cost evaluations, assessment of alternative funding and financing strategies, and identification of preferred and phased risk-reduction strategies. RAND will also seek to test several hypotheses including one which proposes that more compact development will reduce the costs of providing selected public services.

- Work is also beginning on a Pre-disaster Mitigation project in the C-7, C-8, and C-9 basins. This project, funded by the Federal Emergency Management Agency and awarded to the South Florida Water Management District and State of Florida's Office of Emergency Management, will identify the most vulnerable coastal flood control structures within the pilot basins. The project will use storm surge modeling to analyze surge predictions at the downstream locations of the flood control structures, which will then be used to drive watershed simulation models for the selected basins. The project will also collect higher-resolution elevation data, canal cross sections, and land use, to develop realistic flood simulation models for two watersheds. These simulations will also incorporate a range of sea level rise projections to identify changes in the level of service over the next 25 to 50 years. This project will also include the development of various communication tools which will help local, regional, state, and federal agencies visualize the potential impacts of flooding events. This project is expected to be completed before September, 2017.

- On August 11 and 12, 2015, RER and the Stormwater Utility Planning Division staff members participated in a two day GIS-based training provided by the National Oceanographic and Atmospheric Administration. This training taught staff several techniques including: (1) how to map coastal inundation, including how to map water levels using GIS techniques; (2) how to determine the differences among various inundation products; and (3) how to access and manipulate water level, topography, bathymetry and base layer data. This

includes mapping storm surge, inland flooding, shallow coastal flooding, and sea level rise. This training was integral to broadening the technical expertise and the number of full-time staff with the technical capability to support future vulnerability analyses for the County. Additionally this training is now available to all staff interested in taking advantage of it.

- On August 17, 2015, RER staff met with the director and several staff members of the University of Miami's School of Architecture's Center for Urban and Community Design. This Center, directed by Professor Sonia Chao, has extensive experience with sustainable and environmental design, and with assisting local governments to develop innovative solutions to community design challenges. This meeting focused on the precedent projects that could be useful models for Miami-Dade County to consider when framing potential adaptation options for Miami Dade County. Professor Chao also reviewed how design guidelines could be useful tools for the County as it moves forward and encourages more resilient forms of development. The discussion also focused on how to effectively integrate community participation into future adaptation planning.

- On August 20, 2015, Planning staff and Environmental Resources Management staff of RER met with The Nature Conservancy to discuss how future adaptation options can enhance ecological restoration and further The Nature Conservancy's goals to increase equity and access to safe, attractive, and healthy public spaces.

- On September 1, 2015, RER staff held a conference call with New York City Department of City Planning staff who developed NYC's "Urban Waterfront Adaptive Strategies". This guidance document identifies resilience strategies and a framework for analysis specific to different urban coastal communities. The guide also outlines the type and approximate costs and benefits associated with each different adaptation approach. It also outlines a clear framework wherein each coastal community can evaluate the appropriateness of different adaptation approaches to their particular coastal geomorphology and urban condition. This reference serves as an excellent model which could be readily replicated in Miami-Dade County to provide a similar framework for approaching adaptation.

Appendix 3: Salt Front Monitoring Program 2016 Annual Submittal

Miami-Dade
Water and Sewer Department

Miami-Dade Consolidated PWS
Water Use Permit No. 13-00017-W

Salt Front Monitoring Program
Annual Submittal
Special Permit Condition #37

Submittal date:

April 15, 2016

Miami-Dade

Water and Sewer Department

P.O. Box 33-0316, Miami, FL 33233-0316

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1. Introduction

The South Florida Water Management District (SFWMD) issued Water Use Permit # 13-0007-W (WUP) to Miami-Dade Water & Sewer Department (WASD) November 15, 2007. At the request of WASD, this permit was first modified and re-issued by the SFWMD on November 1st, 2010 and subsequently on July 16, 2012 and on February 9th, 2015. Per Special Permit Condition (SPC) #37 the Permittee is required to submit an annual Salt Front Monitoring Program summary report. The annual report summarizes hydrologic and water quality conditions ascertained from the monitoring data collected as part of the approved salt front monitoring program described in Exhibit 28 of the 2015 modified WUP. This annual report includes review and analysis of the data collected and includes recommendations regarding the salt front monitoring network. The annual submittal is due to the SFWMD on April 15, 2016. Therefore, this report is intended to comply with the SPC #37 annual report requirement. Please refer to **Appendix A** for copy of the SPC #37 of the WUP, re-issued on February 9th, 2015. This report summarizes the data collected during 2015 and previously submitted to the SFWMD in quarterly reports in April 2015, July 2015, October 2015 and January 2016, and includes the progress made on the salt front update project.

1.1 Special Permit Condition #37

As per SPC #37, WASD is required to continue submitting monitoring data in accordance with the approved comprehensive water quality/water level monitor network to assess the salt front in Miami-Dade County. This monitoring network was designed to meet the criteria SFWMD Basis of Review (BOR) for Water Use Permit Applications in the South Florida Water Management District amended April 23, 2007, Section 4.0 Monitoring Requirements; Section 4.2 Saline Water Monitoring. WASD public wellfields locations are found in **Figure 1, Appendix B**. As part of this submittal all monitoring network site names and IDs, locations (latitude and longitude), program, and well construction details are summarized in **Table C-1, Appendix C.** Groundwater levels and chloride levels throughout Miami-Dade County are monitored through the 5-year Water Resource Joint Funding Agreement (JFA) with the USGS (currently JFA 14GGESMC0000109). A copy of this JFA is included in **Appendix D**. These wells either have manual water levels taken, or have been equipped with satellite telemetry to record groundwater levels in realtime. Water level data are available from the

USGS website http://www.sflorida.er.usgs.gov/ddn_data/index.html. Wells are sampled according to the schedule for chlorides by USGS personnel following USGS sampling protocols.

1.2 Background

Saltwater intrusion in Miami-Dade County is monitored through a joint effort of the Miami-Dade Water and Sewer Department (WASD), the Division of Environmental Resources Management (DERM) of Miami-Dade Department of Regulatory and Economic Resources (RER), and the U.S. Geological Survey (USGS). A network of small diameter wells have been drilled to the base of the aquifer to serve as monitor wells to identify the location of the saltwater intrusion front. The salt front is identified as the location, at the base of the aquifer, of the 1,000 milligrams/per liter (mg/L) isochlor, or line of equal chloride concentration of 1,000 mg/L). Sampling of the monitor wells is done by the USGS, under a cooperative contract with Miami-Dade County for wells currently included in the salt front monitoring program on the schedule indicated on **Table C-1 Appendix C**. Additional wells are sampled quarterly or yearly basis depending on well location, but every year the sampling schedule includes a county-wide sampling event conducted at the height of the dry season to coincide with the time when inland movement of the saltwater front would be at its peak. The data derived from that sampling is used by the USGS to identify any significant movement of the salt front, and to map the location of the salt front if a significant movement is evident. WASD reports the data to the South Florida Water Management District (SFWMD) quarterly, as part of the WUP #13-00017-W requirements.

The USGS published an update of the salt front line was in 1995 (Sonenshein, 1997; please refer to **Figure 2, Appendix B**) and in 2011 (Scott Prinos et al). The network of monitor wells has been modified over the years, depending on the changing needs of the county and on changing hydrologic conditions. More wells have been drilled to monitor areas where the salt front is moving, and sampling of those wells already by-passed by the salt front has been discontinued. Four new salt front monitoring wells were installed in 2015 (**Figure 3, Appendix B**). Other wells have been drilled around the operating wellfields to provide additional protection. The monitoring and testing program now includes annual induction logging of several wells. These electric logs show the variations in the bulk conductivity of the well water with changes in well depth, and from that information the effects of formational stratigraphy and hydraulic conductivity on the intrusion patterns can be determined. The existing salt water front monitoring network is included as **Table C-1, Appendix C**, which includes well IDs, construction details, type of monitoring, sampling frequency, and the 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014 and 2015 chloride data currently used in the salt front delineation program.

2. Chloride Data – 2015

Results of the 2015 salt front monitoring are plotted and included as **Appendix E**, and summarized below in Table 1. An increase in the average chloride concentration was observed for some of the wells and a slight decrease for others, but in general, there was no significant difference between 2007 and 2015 average concentrations chloride levels, excepting the wells located in the southeastern portion of the County, where a rapid increase in salinity has been observed in the several past years. These wells are located just east of the Newton Wellfield (refer to **Figure 1, Appendix B** for wellfield location). Please refer to **Appendix E** for graphs summarizing the 2003 – 2015 chloride data, and the past 25 year's historical data.

Station Name	*2015 Min (mg/L)*	*2015 Max (mg/L)*	*Average Chloride (mg/L) 2015*	*Average Chloride (mg/L) 2014*	*Average Chloride (mg/L) 2013*	*Average Chloride* (mg/L) 2012*	*Average Chloride (mg/L) 2011*	*Average Chloride (mg/L) 2010*	*Average Chloride (mg/L) 2009*	*Average Chloride (mg/L) 2008*
*G-3313E**	*4300*	*5900*	*5100*	*5200*	*4800*	*4600*	*5600*	*713*	*1500*	*5400*
G-3313C	*4800*	*5400*	*5167*	*4875*	*4533*	*4350.83*	*4716.67*	*4400*	*4250*	*4200*
G-3250	*100*	*210*	*139*	*134.25*	*36.5*	*200*	*180.83*	*176*	*139*	*131*
G-3229	*2200*	*2600*	*2442*	*2250*	*2108.3*	*1883*	*1605.83*	*1217*	*900*	*807*
G-3224	*34*	*37*	*35*	*34.5*	*35.25*	*41*	*42.25*	*41*	*41*	*39*
G-3162	*1400*	*1600*	*1475*	*1541.67*	*1425*	*1267*	*1280*	*1303*	*1284*	*1208*
G-1354	*150*	*350*	*195*	*176.67*	*135*	*58*	*48.83*	*48*	*516*	*53*
G-1351	*390*	*430*	*406.67*	*399.17*	*436*	*474*	*491.67*	*503*	*520*	*530*
G-1180	*10*	*28*	*19*	*20.22*	*37*	*17*	*24.58*	*27*	*17*	*30*
G-1009B	*65*	*160*	*80*	*71.83*	*74*	*75*	*60.42*	*62*	*59*	*59*
G-939	*3400*	*4300*	*3767*	*3883.33*	*4108*	*3808*	*3900*	*3750*	*3333*	*3050*
G-901	*4000*	*5200*	*4650*	*3527.27*	*3058*	*2667*	*2550*	*2438*	*2550*	*2375*
G-3611	*160*	*160*	*160*	*165*	*168*	*165*	*168.75*	*170*	*172*	*173*
G-896	*260*	*480*	*347*	*245.83*	*251*	*258*	*245.33*	*248*	*235*	*247*
G-894	*14*	*17*	*15*	*15*	*17*	*21*	*22.67*	*22*	*22*	*21*
G-571	*26*	*28*	*27*	*26.58*	*28*	*34*	*35.42*	*34*	*30*	*32*
G-548	*31*	*34*	*32.58*	*28.58*	*30*	*31*	*31.5*	*34*	*36*	*40*
G-432	*5900*	*6800*	*6383*	*5816.67*	*5683*	*5467*	*5141.67*	*4775*	*4500*	*4150*
G-354	*36*	*44*	*40*	*40.5*	*42*	*45*	*46.08*	*49*	*50*	*53*
F-279	*3900*	*4300*	*4067*	*4116.67*	*3892*	*3675*	*3583.33*	*3475*	*3383*	*3300*
F-45	*120*	*160*	*143*	*129.5*	*127*	*118*	*112.92*	*97*	*97*	*87*
G-3885	*27*	*31*	*30*	*29.92*	*31*	*36*	*36.33*	*NA*	*NA*	*NA*
G-3886	*46*	*48*	*47*	*45.77*	*47*	*49*	*50.83*	*NA*	*NA*	*NA*

Station Name	*2015 Min (mg/L)*	*2015 Max (mg/L)*	*Average Chloride (mg/L) 2015*	*Average Chloride (mg/L) 2014*	*Average Chloride (mg/L) 2013*	*Average Chloride* (mg/L) 2012*	*Average Chloride (mg/L) 2011*	*Average Chloride (mg/L) 2010*	*Average Chloride (mg/L) 2009*	*Average Chloride (mg/L) 2008*
G-3887	*2600*	*2800*	*2692*	*2508.33*	*2442*	*2292*	*2237.50*	*NA*	*NA*	*NA*
G-3888	*5700*	*6300*	*6075*	*5591.67*	*5458*	*5225*	*5029.17*	*NA*	*NA*	*NA*
G-3946	*5100*	*5600*	*5375*	*5066.67*	*4629*	*4158*	*3716.67*	*NA*	*NA*	*NA*
G-3947	*20*	*23*	*21.27*	*20.67*	*21*	*25*	*27.92*	*NA*	*NA*	*NA*
G-3948	*4200*	*4500*	*4318.18*	*4275*	*4308*	*4195*	*3991.67*	*NA*	*NA*	*NA*
G-3949	*120*	*130*	*122*	*117.5*	*116*	*121*	*114.55*	*NA*	*NA*	*NA*

NA=not available

*Measured only once a year

3. Salt Front Update

In 2007 WASD contracted the USGS to update the salt front delineation and monitoring network. The main objective of this study was to augment an existing saltwater-intrusion monitoring network through application of surface and borehole geophysical methods and the addition of new sentinel monitoring wells. Salinity data from the new wells was integrated with existing monitoring wells, and used to provide an up-to-date map showing the landward limit of the saltwater in Miami-Dade County. The USGS work includes three main tasks. The first was to evaluate existing salt front hydrologic and geologic data, and to provide a draft of an updated salt line. This task was completed in October, 2008. The second was to acquire surface and/or aerial resistivity data to aid placement of new monitoring wells, and construction of the new monitoring wells. The installation of eight monitoring wells was completed in 2010 and their sampling was conducted in 2011. Finally, guided by the application of surface geophysics and induction logging in existing wells, the new data was integrated with existing monitoring well data to complete a final revised position of the saltwater-freshwater interface. This task was completed in March 2011.

3.1 Salt Front Update Line – 2008 and 2011

The USGS was contracted as part of JFA 08EOFL208004 to prepare a draft update of the 1995 salt front line with existing chloride data. This task was completed on October 30, 2008, as scheduled. In addition to analyzing chloride data, the USGS collected and interpreted 30 Time Domain Electromagnetic (TEM) measurements in 2008. These measurements combined with additional USGS data and data collected by other organizations were used to help evaluate the landward extent of encroachment at the base of the Biscayne aquifer. The information collected was used to create

a preliminary GIS layer estimating the landward extent of seawater encroachment at the base of the Biscayne aquifer. The primary avenue for public distribution of this GIS layer is the IMS website which was also created as part of this project. This website was completed and submitted to the District in October 2009 (http://www.sflorida.er.usgs.gov/edl_data/text/mad_gw.html). The 2008 line was estimated (dotted line) in several areas. The largest area was in south Miami-Dade County where the Helicopter Electromagnetic (HEM) survey was flown but where little data existed to ground truth it. Please refer to **Figure 2, Appendix B**, for a map of the 2008 salt front line. The 1995 line is also included on **Figure 2a** for comparison. There was a minimal change in the 2008 line in north and central Miami-Dade County, however, based on the TEM/HEM measurements the 2008 line in south Miami-Dade County appears to have moved inland from the 1995 line.

USGS personnel completed in March 2009 the collection of additional 36 TEM measurements to aid in interpretation of the line particularly in south Miami-Dade County. In addition to these soundings several electromagnetic induction logs were collected from wells, and water conductivity profiles were collected in 2009. The results of the TEM investigations are published by the USGS in "Results of Time-Domain Electromagnetic Soundings in Miami-Dade and Southern Broward Counties, Florida", Fitterman, D.V., and Prinos, S.T., 2011 (accessed at http://pubs.usgs.gov/of/2011/1299/).

Based on the mapping work conducted, 8 sites were selected where additional long term monitoring was determined to be needed to continually evaluate the landward extent of saltwater encroachment. The wells have been installed, and all geophysical logging and drilling results were included in the final USGS publication. In 2011, the salt front line was again updated based on additional data and sample locations, and was released on March 31, 2011 (Origins and Delineation of Saltwater Intrusion in the Biscayne Aquifer and Changes in the Distribution of Saltwater in Miami-Dade County, Florida, Prinos et Al, 2014 (found at http://pubs.usgs.gov/sir/2014/5025/). In general, there was no significant change between the 2008 and 2011 salt front line in the north and central areas of the County. , However, the line moved further inland in the south, specifically in the C-111E canal area. Please refer to **Figure 2a, Appendix B** for a location map of the 2011 salt front line.

3.2 IMS Website

The website was completed and submitted to the District in October 2009 (http://www.sflorida.er.usgs.gov/edl_data/text/mad_gw.html). On February 9, 2011 the USGS formally released to the public the website, "Saline Intrusion Monitoring, Miami Dade County, Florida", (http://www.envirobase.usgs.gov/FLIMS/SaltFront/). This website provides easy access to salinity monitoring data to the public.

3.3 Salt Front monitoring in 2015

To comply with the WUP requirement, WASD in collaboration with the USGS continued sampling 68 wells to monitor for chloride concentration and specific conductance and conducting time-series electromagnetic induction log (TSEMIL) from 33 wells. Following the recommendations of the 2014 Annual report, six new wells were installed on the fresh side of the 2011 salt front line and were immediately incorporated into the monitoring network. These wells are following and their locations are shown in **Figure 3, Appendix B**:

- G-3601 intermediate (1" casing with screen at 105-115ft) and shallow (2" casing with screen at 70-75 ft), both located on the east bank of the Biscayne canal on Memorial Highway and NE 135th St.
- G-3976, in the City of Homestead, a 2" casing with screen at 82.2-87.2 ft.
- G-3977-S and G-3877-D (Shallow and Deep), located in the City of Miami; G-3977-D: 2" casing with screen at 118.5-123.5, G-3977-S: 1" casing with screen at 46.5-51.5 ft.
- G-3978, located in North Miami Beach, 2" casing with screen interval at 125-135 ft.

Rapid salinity increased has been observed in the southeast area of the County, east of the Newton Wellfield, in Homestead (refer to Wellfield Location Map, **Figure 1, Appendix B**). Monitoring well G-3966 was installed in 2014 between the Newton Wellfield and the Homestead Speedway, quickly became salty, and is now on the saltwater side of the 2011 salt front line. In response, G-3976 was installed in the fresh side of the line in that area and is being monitored monthly to follow the advancement of the salt front in the area as closely as possible (**Figure 3, Appendix B**).

4. Recommendations

As required by the WUP #13-0007-W, the USGS in cooperation with WASD and RER continues to monitor the saltwater intrusion in the Biscayne Aquifer in Miami Dade County. The USGS monitors a total of 68 chloride stations (four more chloride stations are being built and one rebuilt) and 33 time-series electromagnetic induction log stations (and 2 more stations will be added when the new wells are completed) as part of the cooperation with Miami Dade County. Additional salt front monitoring wells will be scheduled to be installed in 2016, to be included in the network of wells, which provide the required data to update the saltwater encroachment along the base of the Biscayne Aquifer as necessary.

WASD recommends continuing the salt front monitoring program as approved in WUP #13-0007-W. Additional salinity monitoring stations should be added in 2016 in south Dade in the vicinity of the advancing salt front. WASD recommends that the USGS update the published 2011 salt front line as monitoring has indicated the salt front has already moved further west in part of the County since the 2011 line was published.

References

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APPENDIX A

SFWMD WUP #13-00017-W Special Permit Conditions And Exhibit 28

Table C-1. Reporting Miami-Dade County Salt Front Monitoring Wells

USGS ID	STATION NAME	LATITUDE	LONGITUDE	SITE USE	HOLE DEPTH (ft)[B]	WELL DEPTH (ft)[B]	CASING DEPTH (ft)[B]	Current GWL measurement Freq.	Current Cl Sampling Freq	Induction Log Done	2007 Chloride (mg/l)	2008 Chloride (mg/l)	2009 Chloride (mg/l)	2010 Chloride (mg/l)	2011 Chloride (mg/l)	2012 Chloride (mg/l)	2013 Chloride (mg/l)	2014 Chloride (mg/l)
253831080180204	G -3313E	25 38 34.4	-080 18 04.7	observation/monitoring	114	114	32	quarterly	quarterly	No	5100	5400	1500	713	5600	4600	4800	5200
253831080180204	G -3313C	25 38 35.1	-080 18 04.8	observation/monitoring	110	110	open hole	quarterly	quarterly	No	4000	4200	4250	4400	4717	4351	4533	4872
254946080172601	G -3250	25 49 46	-080 17 26	observation/monitoring	116	116	106	Monthly	Monthly	Yes	68	131	139	176	181	200	37	134
254457080160301	G -3229	25 44 57	-080 16 03	observation/monitoring	85	85	A	Monthly	Monthly	No	700	807	900	1217	1606	1883	2108	2250
255222080123001	G -3224	25 52 22	-080 12 30	observation/monitoring	95.5	95.5	94	Monthly	Monthly	No	44	39	41	41	42	41	35	34
253202080232601	G -3162	25 31 32	-080 23 25	observation/monitoring	92	92	82	quarterly	quarterly	No	1140	1208	1284	1303	1280	1267	1425	1542
254833080155801	G -1354	25 48 33	-080 15 58	observation/monitoring	104	104	91	Monthly	quarterly	No	56	53	516	48	49	58	135	177
254813080161501	G -1351	25 48 13	-080 16 15	observation/monitoring	103	103	100	Monthly	Monthly	No	540	530	520	503	492	474	436	399
252947080235301	G -1180	25 29 47	-080 23 53	observation/monitoring	67	67	open hole	Monthly	Monthly	No	32	30	17	27	25	17	37	20
252944080233401	G-1179	25 29 44.9	-80 23 33	observation/monitoring	80	80	open hole	twice a year	twice a year	Yes	3175	2950	2450	2350	2898	2800	Burried under construction debris	
254106080174601	G -1009B	25 41 06	-080 17 46	observation/monitoring	100	100	NA	Monthly	Monthly	No	50	59	59	62	60	75	74	72
253652080183701	G-939	25 36 53.8	-080 18 35.4	observation/monitoring	61	61	NA	twice a year	twice a year	No	3100	3050	3333	3750	3900	3808	4108	3883
254201080173001	G-901	25 42 03.0	-080 16 54.4	observation/monitoring	96	96	95	twice a year	twice a year	No	2325	2375	2550	2438	2550	2667	3058	3527
253710080184701	G -3611	25 37 10.4	-080 18 45.4	observation/monitoring	100	100	95	quarterly	quarterly	Yes	200	173	172	170	169	165	168	129
254107080165201	G - 896	25 41 07	-080 16 52	observation/monitoring	74	74	60	Monthly	Monthly	No	245	247	235	248	245	258	251	238
255350080105801	G - 894	25 53 51.7	-080 10 57.2	observation/monitoring	76	76	75	Monthly	Monthly	No	24	21	21	22	23	21	17	15
254841080164401	G - 571	25 48 41	-080 16 44	observation/monitoring	94.5	94.5	95	Monthly	Monthly	No	32	32	30	34	35	34	28	27
254855080163701	G-548	25 48 55.9	-080 16 36.4	observation/monitoring	97	97	91	Monthly	twice a year	No	41	40	36	34	32	31	30	29
254335080170501	G-432	25 43 35.9	-080 17 03.3	observation/monitoring	100	100	98	Monthly	twice a year	No	4000	4150	4500	4775	5142	5467	5683	5800
254828080161501	G - 354	25 48 28	-080 16 15	observation/monitoring	90	90.2	89	quarterly	quarterly	No	54	53	50	49	46	45	42	41
255315080111501	F-279	25 53 17.8	-080 11 14.6	observation/monitoring	117	117	NA	Monthly	quarterly	No	3150	3300	3383	3475	3583	3675	3892	4117
254943080121501	F - 45	25 49 43	-080 12 15	observation/monitoring	84.9	84.9	84	Monthly	Monthly	No	104	87	97	97	113	118	127	130
253253080221201	G-3885	25 32 53.1	-080 22 12.7	observation/monitoring	91	86	86	Monthly	Monthly	No	NA	NA	NA	NA	36	36	31	30
2535270801195400	G-3886	25 35 27.9	-080 19 54.2	observation/monitoring	109	101	101	Monthly	Monthly	No	NA	NA	NA	NA	51	49	47	46
253924080174601	G-3887	25 39 24.7	-080 17 46.8	observation/monitoring	134	130	130	Monthly	Monthly	No	NA	NA	NA	NA	2238	2292	2442	2508
254542080145901	G-3888	25 39 2407	-080 14 5908	observation/monitoring	149	144	144	Monthly	Monthly	No	NA	NA	NA	NA	5029	5225	5458	5592
252431080261001	G-3946	25 24 30.7	-080 26 09.7	observation/monitoring	99	98	87	Monthly	Monthly	No	NA	NA	NA	Under cor	3717	4158	4629	5067
255011080124501	G-3947	25 50 11.3	-080 12 45.4	observation/monitoring	229	227	200	Monthly	Monthly	No	NA	NA	NA	Under cor	28	25	21	21
255515080103601	G-3948	25 55 14.9	-080 10 36.2	observation/monitoring	279	277	273	Monthly	Monthly	No	NA	NA	NA	Under cor	3992		4308	4282
255733080195601	G-3949	25 57 33.6	-080 09 56.5	observation/monitoring	349	349	325	Monthly	Monthly	No	NA	NA	NA	Under cor	115	121	116	117

A. Per USGS, depth of the casing is not precisely known.
B. Feet Below Land Surface (bls)
GWL: groundwater level
Cl: chloride

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WATER USE INDIVIDUAL PERMIT

APPLICATION NO: 140627-12 **PERMIT NUMBER:** 13-00017-W

DATE ISSUED: February 9, 2015 **EXPIRATION DATE:** February 9, 2035

PERMITTEE: MIAMI-DADE WATER AND SEWER DEPARTMENT
P O BOX 330316
MIAMI, FL 33233-0316

PROJECT NAME: MIAMI-DADE CONSOLIDATED PWS

PROJECT LOCATION: Miami-Dade County, SEE ATTACHED FOR SECTIONS, TOWNSHIPS AND RANGES

PROJECT DESCRIPTION/AUTHORIZING:

The continued use of groundwater from the Upper Floridan aquifer and Biscayne aquifer for Public water supply for the MDWASD Service Area serving 2,642,929 persons in the year 2033 with an average finished water per capita use rate of 137.2 gallons per day per person and a maximum monthly to average monthly pumping ration of 1.05:1 with an annual allocation of 140,915.50 million gallons.

This is to notify you of South Florida Water Management District's (District) agency action concerning Permit Application Number 140627-12, received June 27, 2014. This action is taken pursuant to Chapter 373, Part II, Florida Statutes (F.S.), Rule 40E-1.603 and Chapter 40E-2, Florida Administrative Code (F.A.C). Based on the information provided, District rules have been adhered to and a Water Use Individual Permit is in effect for this project subject to:

1. Not receiving a filed request for an administrative hearing pursuant to Section 120.57 and Section 120.569 (F.S.), or request a judicial review pursuant Section 120.68, F.S.; and
2. The attached 57 permit conditions.
3. The attached 37 exhibits.

By acceptance and utilization of the water authorized under this permit, the Permittee agrees to hold and save the District and its successors harmless from any and all damages, claims or liabilities that may arise by reason of the construction, maintenance or use of activities authorized by this permit. Should you object to the permit, please refer to the attached "Notice of Rights" that addresses the procedures to be followed if you desire a public hearing or other review of the proposed agency action. Should you wish to object to the proposed agency action or file a petition or request, please provide written objections, petitions, requests and/or waivers to the District, attention of Office of the District Clerk, South Florida Water Management District, Post Office Box 24680, West Palm Beach, FL 33416-4680.

CERTIFICATION OF SERVICE

I HEREBY CERTIFY THAT this written notice has been mailed or electronically transmitted to the Permittee (and the persons listed in the attached distribution list) this 10th day of February, 2015, in accordance with Section 120.60(3), F.S. Notice was also electronically posted on this date through a link on the home page of the District's website (my.sfwmd.gov/ePermitting).

BY: _____
JUANITA BOZEMAN
DEPUTY CLERK, SOUTH FLORIDA WATER MANAGEMENT DISTRICT

SPECIAL PERMIT CONDITIONS

1. This permit is issued to:
   MIAMI-DADE WATER AND SEWER DEPARTMENT
   P O BOX 330316
   MIAMI, FL 33233-0316

2. This permit shall expire on February 9, 2035.

3. Use classification is:

   Public Water Supply
   Aquifer Storage And Recovery

4. Source classification is:

   Groundwater from:
   Biscayne Aquifer
   Upper Floridan Aquifer

5. Allocation:

   Total annual allocation is 140,915.50 million gallons (MG). (386.07 MGD)

   Total maximum monthly allocation is 12,330.11 million gallons (MG).

   Allocation from a specific source (aquifer, waterbody, facility, or facility group):

   Maximum annual allocation from Upper Floridan Aquifer shall not exceed 13,348.05 million gallons (MG). (36.60 MGD).

   Maximum annual allocation from Biscayne Aquifer shall not exceed 127,567.50 million gallons (MG). (349.50 MGD).

   Maximum monthly allocation from Upper Floridan Aquifer shall not exceed 1,167.95 million gallons (MG).

   Maximum monthly allocation from Biscayne Aquifer shall not exceed 11,162.16 million gallons (MG).

   These allocations represent the amount of water required to meet the water demands as a result of a rainfall deficit during a drought with the probability of recurring one year in ten. The Permittee shall not exceed these allocations in hydrologic conditions less than a 1-in-10 year drought event. Compliance with the annual allocation is based on the quantity withdrawn over a 12-month time period. Compliance with the maximum monthly allocation is based on the greatest quantity withdrawn in any single month. The annual allocation expressed in GPD or MGD is for

informational purposes only.

If the rainfall deficit is more severe than that expected to recur once every ten years, the withdrawals shall not exceed that amount necessary to continue to meet the reasonable-beneficial demands under such conditions, provided no harm to the water resources occur and:

1. All other conditions of the permit are met; and

2. The withdrawal is otherwise consistent with applicable declared Water Shortage Orders in effect pursuant to Chapter 40E-21, F.A.C.

6. Withdrawal facilities:

Groundwater - Proposed:

1 - 24" X 50' X 2800 GPM Well Cased To 45 Feet
7 - 24" X 1200' X 2430 GPM Wells Cased To 1100 Feet
1 - 24" X 50' X 1400 GPM Well Cased To 45 Feet
3 - 24" X 72' X 1400 GPM Wells Cased To 45 Feet
8 - 17" X 1490' X 1400 GPM Wells Cased To 1080 Feet

Groundwater - Existing:

2 - 24" X 100' X 7500 GPM Wells Cased To 50 Feet
3 - 48" X 88' X 7500 GPM Wells Cased To 33 Feet
5 - 17" X 1490' X 1400 GPM Wells Cased To 1080 Feet
1 - 4" X 74' X 0 GPM Well Cased To 63.5 Feet
1 - 18" X 65' X 1500 GPM Well Cased To 50 Feet
20 - 14" X 115' X 2500 GPM Wells Cased To 80 Feet
4 - 24" X 100' X 4900 GPM Wells Cased To 35 Feet
10 - 48" X 80' X 10420 GPM Wells Cased To 46 Feet
1 - 12" X 40' X 800 GPM Well Cased To 35 Feet
1 - 42" X 68' X 10000 GPM Well Cased To 54 Feet
1 - 6" X 30' X 400 GPM Well Cased To 25 Feet
1 - 16" X 50' X 1600 GPM Well Cased To 40 Feet
1 - 30" X 115' X 4170 GPM Well Cased To 80 Feet
1 - 18" X 66' X 1500 GPM Well Cased To 53 Feet
1 - 14" X 115' X 3800 GPM Well Cased To 80 Feet
1 - 30" X 1250' X 3500 GPM Well Cased To 845 Feet
6 - 42" X 107' X 7000 GPM Wells Cased To 66 Feet
1 - 24" X 70' X 3470 GPM Well Cased To 35 Feet
7 - 16" X 100' X 4170 GPM Wells Cased To 40 Feet
2 - 24" X 70' X 6945 GPM Wells Cased To 35 Feet
1 - 42" X 68' X 8500 GPM Well Cased To 60 Feet
1 - 17" X 1490' X 1400 GPM Well Cased To 1150 Feet

4 - 40" X 100' X 10420 GPM Wells Cased To 57 Feet
1 - 30" X 1210' X 3500 GPM Well Cased To 835 Feet
1 - 42" X 68' X 8500 GPM Well Cased To 54 Feet
1 - 18" X 55' X 1500 GPM Well Cased To 45 Feet
1 - 42" X 107' X 7000 GPM Well Cased To 69 Feet
4 - 24" X 108' X 8300 GPM Wells Cased To 50 Feet
2 - 12" X 40' X 1600 GPM Wells Cased To 35 Feet
4 - 24" X 104' X 6940 GPM Wells Cased To 54 Feet
1 - 12" X 35' X 1200 GPM Well Cased To 30 Feet
1 - 48" X 80' X 10416.67 GPM Well Cased To 46 Feet
1 - 12" X 35' X 800 GPM Well Cased To 30 Feet
1 - 30" X 115' X 2500 GPM Well Cased To 80 Feet
1 - 42" X 68' X 10000 GPM Well Cased To 60 Feet
1 - 18" X 55' X 1500 GPM Well Cased To 42 Feet
6 - 20" X 100' X 4900 GPM Wells Cased To 40 Feet
1 - 16" X 100' X 7500 GPM Well Cased To 40 Feet
1 - 18" X 50' X 500 GPM Well Cased To 40 Feet
1 - 30" X 1200' X 3500 GPM Well Cased To 765 Feet
1 - " X 60' X 0 GPM Well Cased To 55 Feet
1 - 30" X 1300' X 3500 GPM Well Cased To 850 Feet
1 - 30" X 1200' X 3500 GPM Well Cased To 760 Feet

7. The Permittee shall submit all data as required by the implementation schedule for each of the permit conditions to: SFWMD at www.sfwmd.gov/ePermitting, or Regulatory Support, MSC 9611, P.O. Box 24680, West Palm Beach, FL 33416-4680.

8. The Permittee must submit the appropriate application form incorporated by reference in Rule 40E-2.101, F.A.C., to the District prior to the permit expiration date in order to continue the use of water.

9. The Permittee shall secure a well construction permit prior to construction, repair, or abandonment of all wells, as described in Chapter 40E-3, F.A.C.

10. Permittees, who are dependent on other sources of water supply such as reclaimed water or water sale agreements to meet a portion of their demands, shall include the monthly volumes from all other sources in the report to the District, unless the use of those sources is reported to another state agency, in which case the District will obtain the water use information from said agency. The water accounting method and means of calibration shall be stated on each report.

11. Prior to any withdrawals at the project, the Permittee shall provide the results of the calibration testing of the identified water accounting method(s) and equip all existing and proposed withdrawal facilities with approved water use accounting method(s) pursuant to Subsection 4.1.1 of the Applicant's Handbook for Water Use Permit Applications.

12. Every five years from the date of last calibration, the Permittee shall submit re-calibration data for each withdrawal facility.

13. Monthly withdrawals for each withdrawal facility shall be reported to the District semi-annually. The water accounting method and means of calibration shall be stated on each report.

14. The Permittee shall notify the District within 30 days of any change in service area boundary that results in a change in demand that affects its permitted allocation. The allocation shall be modified to effectuate such change.

15. If at any time there is an indication that the well casing, valves, or controls leak or have become inoperative, repairs or replacement shall be made to restore the system to an operating condition. Failure to make such repairs shall be cause for filling and abandoning the well, in accordance with procedures outlined in Chapter 40E-3, F.A.C.

16. The Permittee shall maintain an accurate flow meter at the intake of the water treatment plant for the purpose of measuring daily inflow of water.

    Permittee shall maintain a calibrated flow meter(s) at the intake (raw water) and discharge (treated water) points within the Hialeah/Preston, Alexander Orr, and proposed Hialeah RO and South Miami Heights water treatment plants for the purpose of measuring treatment losses and shall submit monthly data semi-annually as required pursuant to Special Condition 13.

17. The Standard Water Conservation Plan described in Subsection 2.3.2.F.1.a of the Applicant's Handbook for Water Use Permit Applications within the South Florida Water Management District and the Staff Report, must be implemented in accordance with the approved implementation schedule described in the following exhibit:

    The Water Conservation Plan is contained in Exhibit 18. The permittee shall submit an annual report covering water conservation activities during the prior calendar year by April 15 of each year describing water conservation activities for the year including expenditures, projects undertaken and estimated water savings.

18. The Permittee shall notify the District within 30 days of entering into an inter-local agreement, contract, or other similar instrument to deliver or receive water outside of its service area or to serve a demand not identified to determine the allocation described in this permit. A copy of such agreement shall be provided to the District. The monthly volume of water delivered and/or received via each inter-local agreement, contract, or other similar instrument shall be submitted to the District at the same reporting frequency as the withdrawals for each withdrawal facility required in this permit.

19. The Permittee shall implement the wellfield operating plan submitted in support of the permit application, as described in the District staff report.

See Exhibit 10

20. The Permittee shall determine unaccounted-for distribution system losses. Losses shall be determined for the entire distribution system on a monthly basis. Permittee shall define the manner in which unaccounted-for losses are calculated. Reports shall be submitted to the District on a yearly basis and are due by April 30th of each year.

    In the event that the annual unaccounted-for distribution system losses, as defined by Section 2.3.2.F.2.c, of the Applicants Handbook for Water Use Permit Applications [AH], exceeds 10 percent, the permittee shall include in the annual report a description of additional actions which will be implemented the following year(s) to reduce the losses to less than ten percent.

21. Public water utilities that control, either directly or indirectly, a wastewater treatment plant, and which have determined pursuant to Section 403.064, F.S., that use of reclaimed water is feasible, must provide the District with annual updates of the following information: 1) the status of distribution system construction, including location and capacity of lines; 2) a summary of uncommitted supplies for the next year; 3) copies of any new or amended local mandatory reclaimed water reuse zone ordinances; and 4) a list of end-users who have contracted to receive reclaimed water and the agreed upon quantity of water to be delivered.

22. The Permittee shall maintain an accurate flow meter at the point of discharge from the treatment plant for the purpose of measuring the daily flow of water.

    Permittee shall maintain a calibrated flow meter(s) at the intake (raw water) and discharge (treated water) points within the Hialeah/Preston, Alexander Orr, and proposed Hialeah RO and South Miami Heights water treatment plants for the purpose of measuring treatment losses and shall submit monthly data semi-annually as required pursuant to Special Condition 13.

23. Pursuant to Section 373.236(4), F.S., every ten years from the date of permit issuance, the Permittee shall submit a water use compliance report for review and approval by District Staff to SFWMD at www.sfwmd.gov/ePermitting, or Regulatory Support, MSC 9611, P.O. Box 24680, West Palm Beach, FL 33416-4680.
    (A) The results of a water conservation audit that documents the efficiency of water use on the project site using data produced from an onsite evaluation conducted. In the event that the audit indicates additional water conservation is appropriate or the per capita use rate authorized in the permit is exceeded, the permittee shall propose and implement specific actions to reduce the water use to acceptable levels within timeframes proposed by the permittee and approved by the District.

    (B) A comparison of the permitted allocation and the allocation that would apply to the project based on current District allocation rules and updated population and per capita use rates. In the event the permit allocation is greater than the allocation provided for under District rule, the permittee shall apply for a letter modification to reduce the allocation consistent with District rules and the updated population and per capita use rates to the extent they are considered by the

District to be indicative of long term trends in the population and per capita use rates over the permit duration. In the event that the permit allocation is less than allowable under District rule, the permittee shall apply for a modification of the permit to increase the allocation if the permittee intends to utilize an additional allocation, or modify its operation to comply with the existing conditions of the permit.

3. Summary of the current and previous nine years progress reports for implementation of the Alternative Water Supply Plan and any modifications necessary to continue to meet the Plan requirements and conditions for issuance.

4. Information demonstrating that the conditions for issuance of the permit are being complied with, pursuant to Special Condition 45 and Section 373.236, F.S.

5. Updates or amendments to the County's reuse plan.

24. The Permittee shall provide annual status reports to the District that summarizes the Aquifer Storage and Recovery cycle testing activities. Reports shall be submitted to the District on a yearly basis and are due by April 30th of each year.

25. The Permittee shall submit to the District an updated "Summary of Groundwater (Well) Facilities" table ("Section IV - Sources of Water", Water Use Permit Application Form 1379) within 90 days of completion of the proposed wells identifying the actual total and cased depths, pump manufacturer and model numbers, pump types, intake depths and type of meters.

26. The permittee shall operate surface water control structure known as the Mid-canal structure and bridge in accordance with the approved operational plan included in Exhibit 22. In addition, whenever this structure is opened for the purpose of raising water in the Wellfield Protection Canal down stream of the structure, the upstream structure that delivers water from the L-30 canal shall be opened in a manner to deliver equal volumes to those passed through the Mid-canal structure and bridge. The permittee shall submit operation and flow data logs regarding both structures to the District semi-annually.

27. The Permittee is authorized to exercise the emergency wells at the Medley Wellfield for a total of two hours per month as needed for bacterial clearance and pump maintenance. Operation of the emergency wells at the Medley Wellfield for more than this amount shall require prior approval from SFWMD. Pumpage data shall be collected and report in accordance with Special Condition 13.

28. No more than 15 MGD shall be withdrawn from the West Biscayne aquifer Wellfield on any given day.

29. No more than 25,550 MGY shall be withdrawn during any 12 month consecutive period from the combined Hialeah, Preston, Medley and Miami Springs Biscayne aquifer wellfields.

30. No more than 7,993 MGY shall be withdrawn during any 12 month consecutive period from the Snapper Creek Wellfield.

31. No more than 39,931 MGY shall be withdrawn during any 12 month consecutive period from the Southwest Biscayne aquifer Wellfield.

32. No more than 67,999 MGY shall be withdrawn during any 12 month consecutive period from the combined West, Southwest Snapper Creek and Alexander Orr Biscayne aquifer wellfields.

33. No more than 1,095 MGY shall be withdrawn during any 12 month consecutive period from the South Miami Heights Wellfield.

34. No more than 1,752 MGY shall be withdrawn during any 12 month consecutive period from the combined Everglades Labor Camp and Newton wellfields.

35. No more than 1,571 MGY shall be withdrawn during any 12 month consecutive period from the combined Elevated Tank, Leisure City and Naranja wellfields.

36. The Permittee shall continue to submit monitoring data in accordance with the approved water level monitoring program for this project. The existing monitoring program is described in Exhibits 30 and 32B.

37. The Permittee shall continue to submit monitoring data in accordance with the approved saline water intrusion monitoring program for this project.
See exhibits 28A and 32B for a list of monitor wells and required sampling schedule.

    The permittee shall submit annual Monitoring Program summary reports. The annual report will summarize the status of the project to update the salt front and install new monitor wells.

38. Within six months of permit issuance, an executed large user water agreement with the City of Hialeah shall be submitted to the District. In the event that the final agreement is for volumes less than those used in the formulation of the allocations in this permit, the allocations shall be reduced through a letter modification.

39. The permittee shall update the District on the status of reuse projects in Exhibit 14 on an annual basis.

40. The permittee will develop alternative water supplies in accordance with the schedules described in Exhibit 13.

    The permittee will provide annual updates of the status of all alternative water supply projects (per

the timeframes contained in Special Condition 44). The status report shall include work completed to date, expenditures and any anticipated changes in the timelines.

41. In the event that a milestone specified in the alternative water supply schedule and plan contained in Exhibit 13 is going to be missed, the permittee shall notify the Executive Director of the District in writing explaining the nature of the delay, actions taken to bring the project back on schedule and an assessment of the impact the delay would have on the rates of withdrawals from the Everglades water bodies and associated canals as defined in SFWMD consumptive use permitting rules. The District will evaluate the situation and take actions as appropriate which could include: a.) granting an extension of time to complete the project (if the delay is minor and doesn't affect the Everglades Waterbodies or otherwise violates permit conditions), b.) take enforcement actions including consent orders and penalties, c.) modify allocations contained in this permit from the Biscayne aquifer including capping withdrawal rates until the alternative water supply project(s) are completed (in cases where the delay would result in violations of permit conditions) or d.) working with the Department of Community Affairs to limit increase demands for water until the alternative water supply project is completed.

42. For rehydration of Biscayne Coastal Wetlands, in consultation with the District, the FDEP and Biscayne Bay National Park, upon completion of the pilot testing program, the parties shall agree on the water quality treatment required and the feasibility, as defined in Section 2.2.4 of the Applicants Handbook for Water Use Permit Applications, of this project on or before April 15, 2015. Extension of this deadline may be issued in writing by the District upon demonstration of good cause such as events beyond the control of the permittee or after consideration of the results/data collected, the District determines that additional testing is necessary. In determining the water quality needed, the parties will consider State and Federal water quality discharge standards, the volume and timing of water to be delivered to Biscayne Bay and the location of delivery. In the event the parties do not reach agreement on the feasibility by April 15, 2015, the Permittee shall begin development of an alternate reuse project from the South District wastewater facility and shall provide the District with a proposal for an alternate project including a conceptual design and schedule for implementation on or before March 15, 2016.

43. The permittee may request temporary authorization from the District to capture and store stormwater via withdrawals from the permitted Biscayne aquifer production wells, for storage within the Floridan aquifer system consistent with their FDEP issued Underground Injection Control permits.The District will consider the availability of stormwater that is not otherwise needed for environmental protection or enhancement and is in no way bound to authorize such requests. All such requests shall be made in writing to the Director of Water Use Regulation.

44. All annual reports required in these Special Conditions shall address activities that occurred during a calendar year and shall be submitted to Water Use Compliance on or before April 15th of the following year.

45. If it is determined that the conditions for permit issuance are no longer met for the 20 year permit duration, the permittee shall obtain a modification of the Permit from the District as necessary to

come into compliance with the conditions for permit issuance. Such conditions for permit issuance include minimum flows and levels, water reservations, and other conditions ensuring the use does not cause water resource harm and is consistent with the objectives of the District, including implementation of the Comprehensive Everglades Restoration Plan.

46. The permittee shall operate the West Wellfield in accordance with the Memorandum of Understanding between the U.S. Department of the Interior, the Governor of the State of Florida, Miami Dade County and the District incorporated in Exhibit 35.

STANDARD PERMIT CONDITIONS

1. All water uses authorized by this permit shall be implemented as conditioned by this permit, including any documents incorporated by reference in a permit condition. The District may revoke this permit, in whole or in part, or take enforcement action, pursuant to Section 373.136 or 373.243, F.S., unless a permit modification has been obtained to address the noncompliance.

   The Permittee shall immediately notify the District in writing of any previously submitted material information that is later discovered to be inaccurate.

2. The Permittee is advised that this permit does not relieve any person from the requirement to obtain all necessary federal, state, local and special district authorizations.

3. The Permittee shall notify the District in writing within 30 days of any sale, transfer, or conveyance of ownership or any other loss of permitted legal control of the Project and/or related facilities from which the permitted consumptive use is made. Where Permittee's control of the land subject to the permit was demonstrated through a lease, the Permittee must either submit a new or modified lease showing that it continues to have legal control or documentation showing a transfer in control of the permitted system/project to the new landowner or new lessee. All transfers of ownership are subject to the requirements of Rule 40E-1.6107, F.A.C. Alternatively, the Permittee may surrender the consumptive use permit to the District, thereby relinquishing the right to conduct any activities under the permit.

4. Nothing in this permit should be construed to limit the authority of the District to declare a water shortage and issue orders pursuant to Chapter 373, F.S. In the event of a declared water shortage, the Permittee must adhere to the water shortage restrictions, as specified by the District. The Permittee is advised that during a water shortage, reports shall be submitted as required by District rule or order. The Permittee is advised that during a water shortage, pumpage, water levels, and water quality data shall be collected and submitted as required by District orders issued pursuant to Chapter 40E-21, F.A.C.

5. This permit does not convey to the Permittee any property rights or privileges other than those specified herein, nor relieve the permittee from complying with any applicable local government, state, or federal law, rule, or ordinance.

6. With advance notice to the Permittee, District staff with proper identification shall have permission to enter, inspect, observe, collect samples, and take measurements of permitted facilities to determine compliance with the permit conditions and permitted plans and specifications. The Permittee shall either accompany District staff onto the property or make provision for access onto the property.

7. A. The Permittee may seek modification of any term of an unexpired permit. The Permittee is advised that Section 373.239, F.S., and Rule 40E-2.331, F.A.C., are applicable to permit modifications.

   B. The Permittee shall notify the District in writing 30 days prior to any changes to the project that

could potentially alter the reasonable demand reflected in the permitted allocation. Such changes include, but are not limited to, change in irrigated acreage, crop type, irrigation system, large users agreements, or water treatment method. Permittee will be required to apply for a modification of the permit for any changes in permitted allocation.

8. If any condition of the permit is violated, the permit shall be subject to review and modification, enforcement action, or revocation pursuant to Chapter 373, F.S.

9. The Permittee shall mitigate interference with existing legal uses that was caused in whole or in part by the Permittee's withdrawals, consistent with the approved mitigation plan. As necessary to offset the interference, mitigation will include pumpage reduction, replacement of the impacted individual's equipment, relocation of wells, change in withdrawal source, or other means.

   Interference to an existing legal use is defined as an impact that occurs under hydrologic conditions equal to or less severe than a 1-in-10 year drought event that results in the:

   A. Inability to withdraw water consistent with provisions of the permit, such as when remedial structural or operational actions not materially authorized by existing permits must be taken to address the interference; or

   B. Change in the quality of water pursuant to primary State Drinking Water Standards to the extent that the water can no longer be used for its authorized purpose, or such change is imminent.

10. The Permittee shall mitigate harm to the natural resources caused by the Permittee's withdrawals, as determined through reference to the conditions for permit issuance. When harm occurs, or is imminent, the District will require the Permittee to modify withdrawal rates or mitigate the harm. Harm, as determined through reference to the conditions for permit issuance includes:

    A. Reduction in ground or surface water levels that results in harmful lateral movement of the fresh water/salt water interface,

    B. Reduction in water levels that harm the hydroperiod of wetlands,

    C. Significant reduction in water levels or hydroperiod in a naturally occurring water body such as a lake or pond,

    D. Harmful movement of contaminants in violation of state water quality standards, or

    E. Harm to the natural system including damage to habitat for rare or endangered species.

11. The Permittee shall mitigate harm to existing off-site land uses caused by the Permittee's withdrawals, as determined through reference to the conditions for permit issuance. When harm occurs, or is imminent, the District will require the Permittee to modify withdrawal rates or mitigate the harm. Harm as determined through reference to the conditions for permit issuance, includes:

A. Significant reduction in water levels on the property to the extent that the designed function of the water body and related surface water management improvements are damaged, not including aesthetic values. The designed function of a water body is identified in the original permit or other governmental authorization issued for the construction of the water body. In cases where a permit was not required, the designed function shall be determined based on the purpose for the original construction of the water body (e.g. fill for construction, mining, drainage canal, etc.)

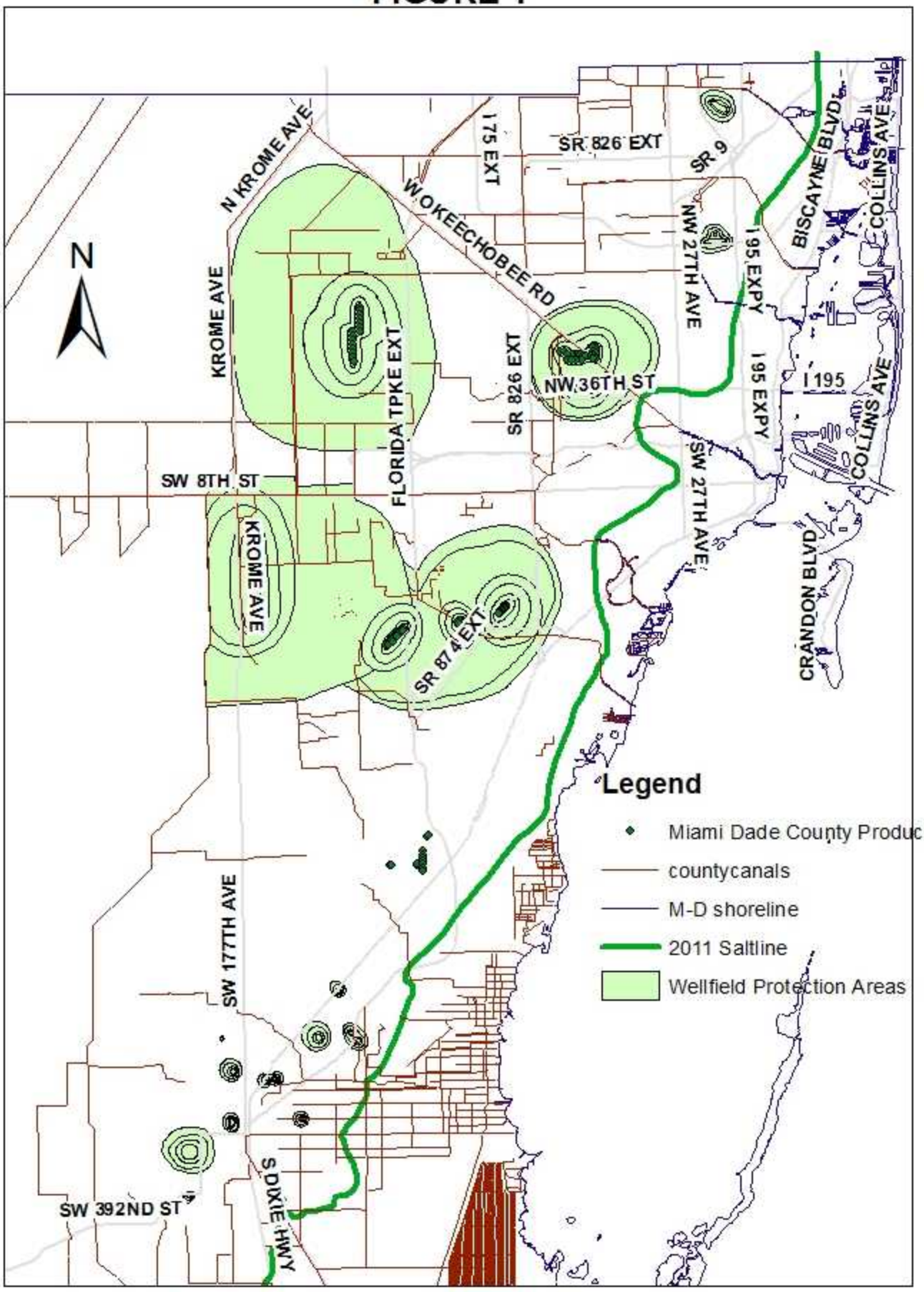
B. Damage to agriculture, including damage resulting from reduction in soil moisture resulting from consumptive use; or,

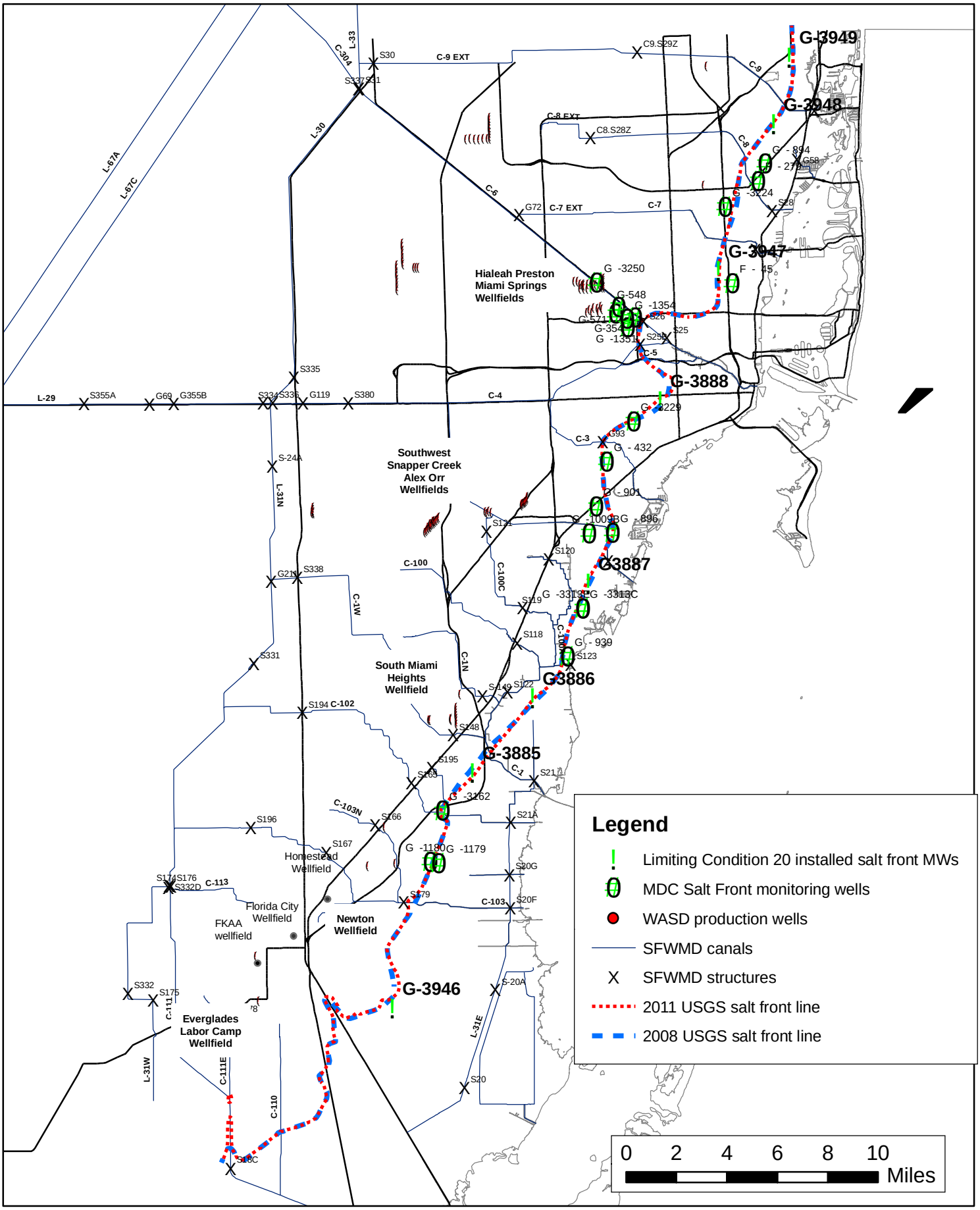
C. Land collapse or subsidence caused by reduction in water levels associated with consumptive use.

APPENDIX B

FIGURES

ADDITIONAL SALTFRONT MONITORING WELL LOCATION MAP
FIGURE 1

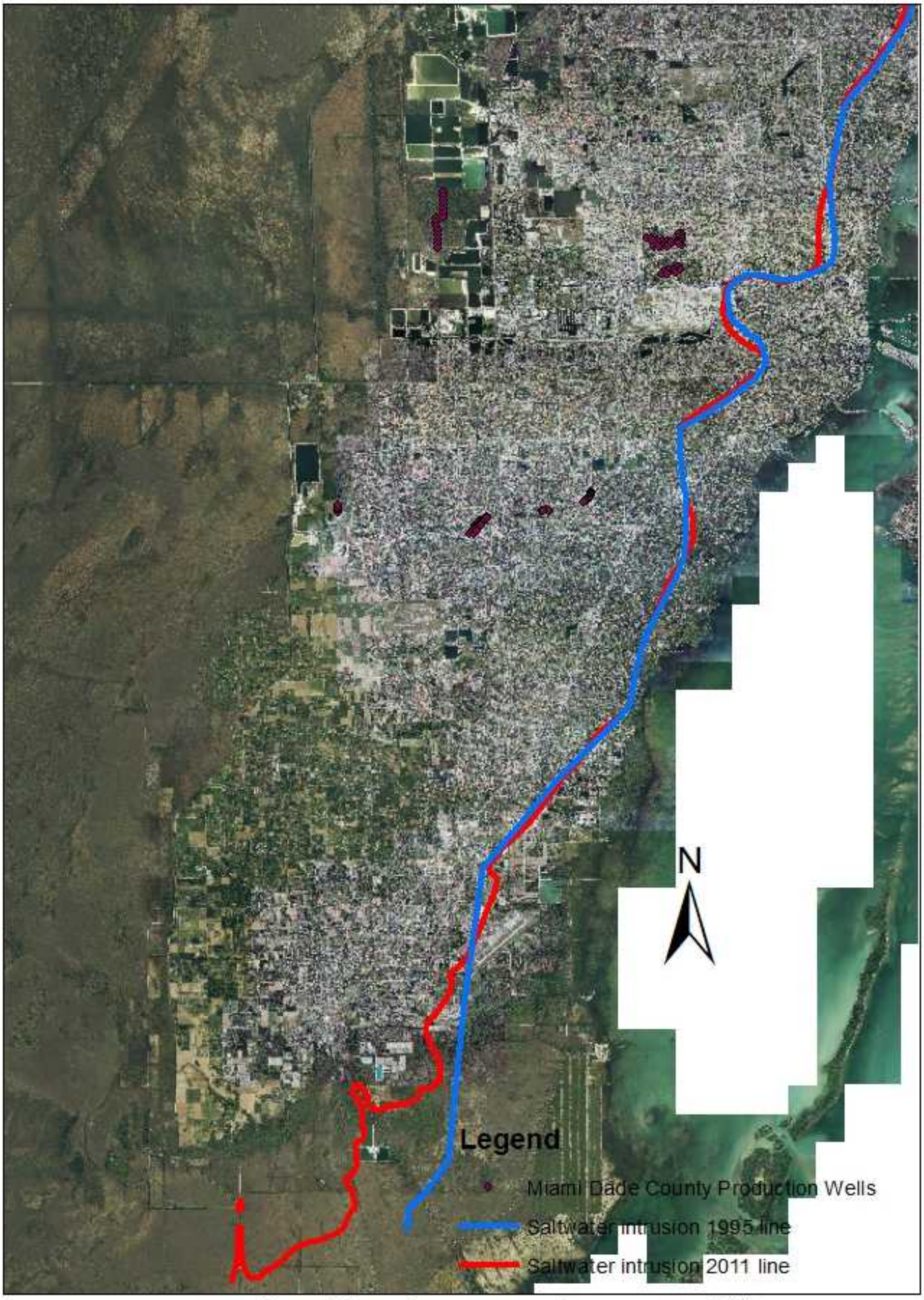




Miami-Dade Water and Sewer Department
3071 SW 38 Ave
Miami FL 33146

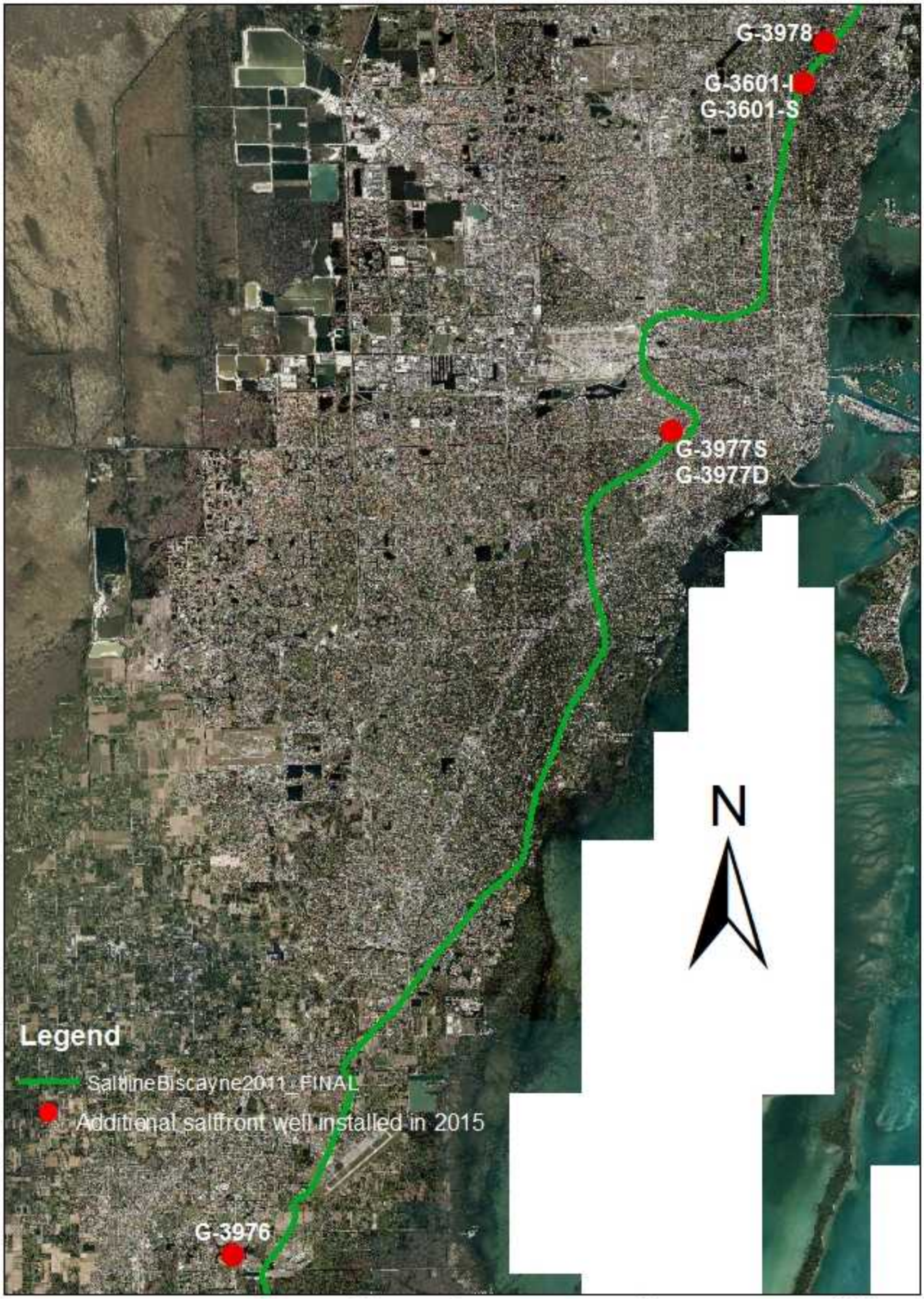
Figure 2. 2011 Miami-Dade County Salt Front Monitoring Network

1995 AND 2011 SALTFRONT LINES
LOCATION MAP
FIGURE 2a



MIAMI-DADE COUNTY

ADDITIONAL SALTFRONT MONITORING WELL LOCATION MAP
FIGURE 3



MIAMI-DADE COUNTY

APPENDIX C

TABLES

Table C-1. Existing Miami-Dade County Salt Front Monitoring Wells

USGS ID	STATION NAME	LATITUDE	LONGITUDE	SITE USE	HOLE DEPTH (ft)[B]	WELL DEPTH (ft)[B]	CASING DEPTH (ft)[B]	Current GWL measurement Freq.	Current Cl Sampling Freq	Induction Log Done	2007 Chloride (mg/l)	2008 Chloride (mg/l)	2009 Chloride (mg/l)	2010 Chloride (mg/l)	2011 Chloride (mg/l)	2012 Chloride (mg/l)	2013 Chloride (mg/l)	2014 Chloride (mg/l)	2015 Chloride (mg/l)
253831080180204	G -3313E	25 38 34.4	-080 18 04.7	observation/monitoring	114	114	32	quarterly	quarterly	No	5100	5400	1500	713	5600	4600	4800	5200	5100
253831080180204	G -3313C	25 38 35.1	-080 18 04.8	observation/monitoring	110	110	open hole	quarterly	quarterly	No	4000	4200	4250	4400	4717	4351	4533	4875	5167
254946080172601	G -3250	25 49 46	-080 17 26	observation/monitoring	116	116	106	Monthly	Monthly	Yes	68	131	139	176	181	200	37	134	139
254457080160301	G -3229	25 44 57	-080 16 03	observation/monitoring	85	85	A	Monthly	Monthly	No	700	807	900	1217	1606	1883	2108	2250	2442
255222080123001	G -3224	25 52 22	-080 12 30	observation/monitoring	95.5	95.5	94	Monthly	Monthly	No	44	39	41	41	42	41	35	35	35
253202080232601	G -3162	25 31 32	-080 23 25	observation/monitoring	92	92	82	quarterly	quarterly	No	1140	1208	1284	1303	1280	1267	1425	1542	1475
254833080155801	G -1354	25 48 33	-080 15 58	observation/monitoring	104	104	91	Monthly	quarterly	No	56	53	516	48	49	58	135	177	195
254813080161501	G -1351	25 48 13	-080 16 15	observation/monitoring	103	103	100	Monthly	Monthly	No	540	530	520	503	492	474	436	399	407
252947080235301	G -1180	25 29 47	-080 23 53	observation/monitoring	67	67	open hole	Monthly	Monthly	No	32	30	17	27	25	17	37	20	19
252944080233401	G-1179	25 29 44.9	-80 23 33	observation/monitoring	80	80	open hole	twice a year	twice a year	Yes	3175	2950	2450	2350	2898	2800	Destroid	Destroid	
254106080174601	G -1009B	25 41 06	-080 17 46	observation/monitoring	100	100	NA	Monthly	Monthly	No	50	59	59	62	60	75	74	72	80
253652080183701	G-939	25 36 53.8	-080 18 35.4	observation/monitoring	61	61	NA	twice a year	twice a year	No	3100	3050	3333	3750	3900	3808	4108	3883	3767
254201080173001	G-901	25 42 03.0	-080 16 54.4	observation/monitoring	96	96	95	twice a year	twice a year	No	2325	2375	2550	2438	2550	2667	3058	3527	4650
253710080184701	G -3611	25 37 10.4	-080 18 45.4	observation/monitoring	100	100	95	quarterly	quarterly	Yes	200	173	172	170	169	165	168	165	160
254107080165201	G - 896	25 41 07	-080 16 52	observation/monitoring	74	74	60	Monthly	Monthly	No	245	247	235	248	245	258	251	246	347
255350080105801	G - 894	25 53 51.7	-080 10 57.2	observation/monitoring	76	76	75	Monthly	Monthly	No	24	21	21	22	23	21	17	15	15
254841080164401	G - 571	25 48 41	-080 16 44	observation/monitoring	94.5	94.5	95	Monthly	Monthly	No	32	32	30	34	35	34	28	27	27
254855080163701	G-548	25 48 55.9	-080 16 36.4	observation/monitoring	97	97	91	Monthly	twice a year	No	41	40	36	34	32	31	30	29	33
254335080170501	G-432	25 43 35.9	-080 17 03.3	observation/monitoring	100	100	98	Monthly	twice a year	No	4000	4150	4500	4775	5142	5467	5683	5817	6383
254828080161501	G - 354	25 48 28	-080 16 15	observation/monitoring	90	90.2	89	quarterly	quarterly	No	54	53	50	49	46	45	42	41	40
255315080111501	F-279	25 53 17.8	-080 11 14.6	observation/monitoring	117	117	NA	Monthly	quarterly	No	3150	3300	3383	3475	3583	3675	3892	4117	4067
254943080121501	F - 45	25 49 43	-080 12 15	observation/monitoring	84.9	84.9	84	Monthly	Monthly	No	104	87	97	97	113	118	127	130	143
253253080221201	G-3885	25 32 53.1	-080 22 12.7	observation/monitoring	91	86	86	Monthly	Monthly	No	NA	NA	NA	NA	36	36	31	30	30
2535270801195400	G-3886	25 35 27.9	-080 19 54.2	observation/monitoring	109	101	101	Monthly	Monthly	No	NA	NA	NA	NA	51	49	47	46	47
253924080174601	G-3887	25 39 24.7	-080 17 46.8	observation/monitoring	134	130	130	Monthly	Monthly	No	NA	NA	NA	NA	2238	2292	2442	2508	2692
254542080145901	G-3888	25 39 2407	-080 14 5908	observation/monitoring	149	144	144	Monthly	Monthly	No	NA	NA	NA	NA	5029	5225	5458	5592	6075
252431080261001	G-3946	25 24 30.7	-080 26 09.7	observation/monitoring	99	98	87	Monthly	Monthly	No	NA	NA	NA	Under cor	3717	4158	4629	5067	5375
255011080124501	G-3947	25 50 11.3	-080 12 45.4	observation/monitoring	229	227	200	Monthly	Monthly	No	NA	NA	NA	Under cor	28	25	21	21	21
255515080103601	G-3948	25 55 14.9	-080 10 36.2	observation/monitoring	279	277	273	Monthly	Monthly	No	NA	NA	NA	Under cor	3992		4308	4275	4318
255733080195601	G-3949	25 57 33.6	-080 09 56.5	observation/monitoring	349	349	325	Monthly	Monthly	No	NA	NA	NA	Under cor	115	121	116	118	122

A. Per USGS, depth of the casing is not precisely known.
B. Feet Below Land Surface (bls)
GWL: groundwater level
Cl: chloride

APPENDIX D

US GEOLOGICAL SURVEY PROJECT WATER RESOURCES JOINT FUNDING AGREEMENT

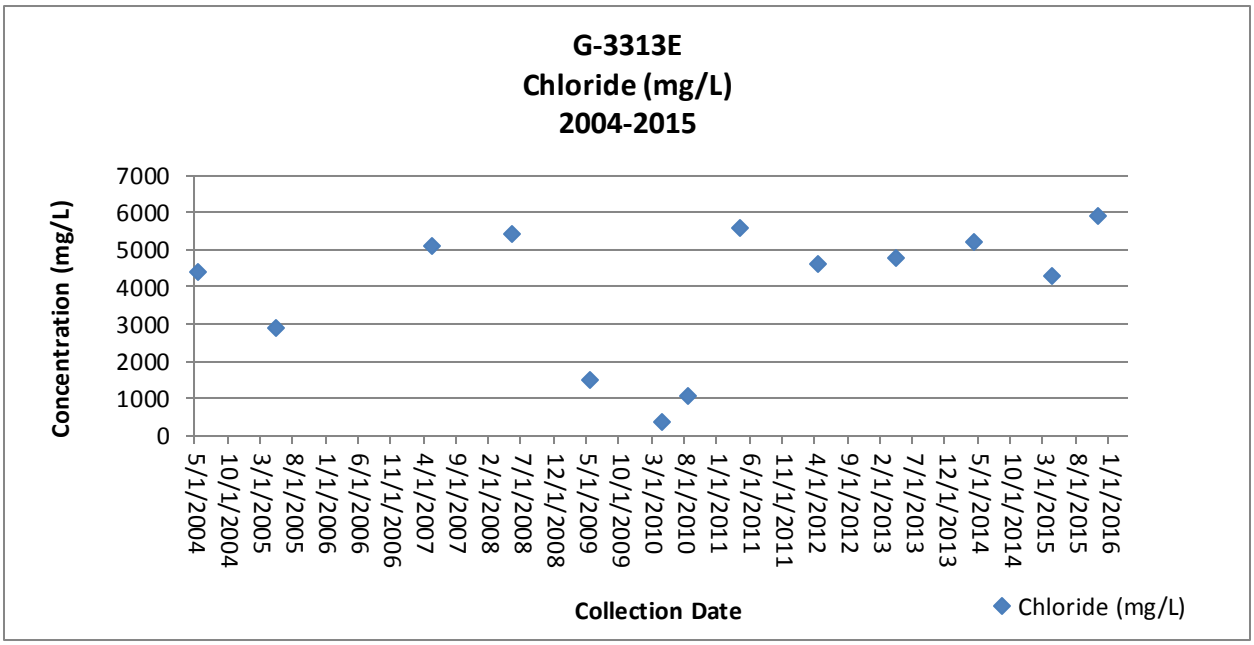
Table C-1. Existing Miami-Dade County Salt Front Monitoring Wells

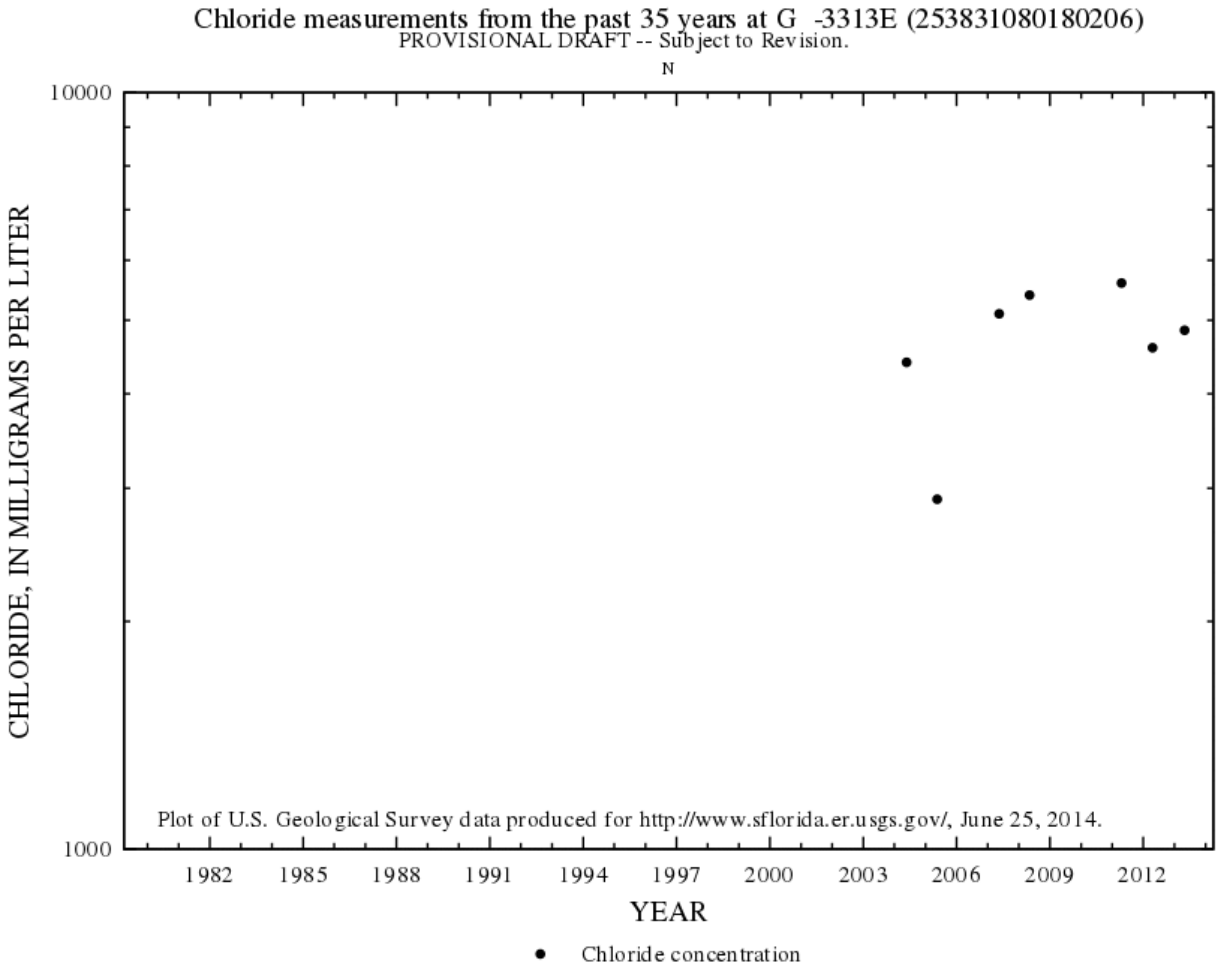
USGS ID	STATION NAME	LATITUDE	LONGITUDE	SITE USE	HOLE DEPTH (ft)[B]	WELL DEPTH (ft)[B]	CASING DEPTH (ft)[B]	Current GWL measurement Freq.	Current Cl Sampling Freq	Induction Log Done	2007 Chloride (mg/l)	2008 Chloride (mg/l)	2009 Chloride (mg/l)	2010 Chloride (mg/l)	2011 Chloride (mg/l)	2012 Chloride (mg/l)	2013 Chloride (mg/l)	2014 Chloride (mg/l)	2015 Chloride (mg/l)
253831080180204	G -3313E	25 38 34.4	-080 18 04.7	observation/monitoring	114	114	32	quarterly	quarterly	No	5100	5400	1500	713	5600	4600	4800	5200	5100
253831080180204	G -3313C	25 38 35.1	-080 18 04.8	observation/monitoring	110	110	open hole	quarterly	quarterly	No	4000	4200	4250	4400	4717	4351	4533	4875	5167
254946080172601	G -3250	25 49 46	-080 17 26	observation/monitoring	116	116	106	Monthly	Monthly	Yes	68	131	139	176	181	200	37	134	139
254457080160301	G -3229	25 44 57	-080 16 03	observation/monitoring	85	85	A	Monthly	Monthly	No	700	807	900	1217	1606	1883	2108	2250	2442
255222080123001	G -3224	25 52 22	-080 12 30	observation/monitoring	95.5	95.5	94	Monthly	Monthly	No	44	39	41	41	42	41	35	35	35
253202080232601	G -3162	25 31 32	-080 23 25	observation/monitoring	92	92	82	quarterly	quarterly	No	1140	1208	1284	1303	1280	1267	1425	1542	1475
254833080155801	G -1354	25 48 33	-080 15 58	observation/monitoring	104	104	91	Monthly	quarterly	No	56	53	516	48	49	58	135	177	195
254813080161501	G -1351	25 48 13	-080 16 15	observation/monitoring	103	103	100	Monthly	Monthly	No	540	530	520	503	492	474	436	399	407
252947080235301	G -1180	25 29 47	-080 23 53	observation/monitoring	67	67	open hole	Monthly	Monthly	No	32	30	17	27	25	17	37	20	19
252944080233401	G-1179	25 29 44.9	-80 23 33	observation/monitoring	80	80	open hole	twice a year	twice a year	Yes	3175	2950	2450	2350	2898	2800	Destroid	Destroid	
254106080174601	G -1009B	25 41 06	-080 17 46	observation/monitoring	100	100	NA	Monthly	Monthly	No	50	59	59	62	60	75	74	72	80
253652080183701	G-939	25 36 53.8	-080 18 35.4	observation/monitoring	61	61	NA	twice a year	twice a year	No	3100	3050	3333	3750	3900	3808	4108	3883	3767
254201080173001	G-901	25 42 03.0	-080 16 54.4	observation/monitoring	96	96	95	twice a year	twice a year	No	2325	2375	2550	2438	2550	2667	3058	3527	4650
253710080184701	G -3611	25 37 10.4	-080 18 45.4	observation/monitoring	100	100	95	quarterly	quarterly	Yes	200	173	172	170	169	165	168	165	160
254107080165201	G - 896	25 41 07	-080 16 52	observation/monitoring	74	74	60	Monthly	Monthly	No	245	247	235	248	245	258	251	246	347
255350080105801	G - 894	25 53 51.7	-080 10 57.2	observation/monitoring	76	76	75	Monthly	Monthly	No	24	21	21	22	23	21	17	15	15
254841080164401	G - 571	25 48 41	-080 16 44	observation/monitoring	94.5	94.5	95	Monthly	Monthly	No	32	32	30	34	35	34	28	27	27
254855080163701	G-548	25 48 55.9	-080 16 36.4	observation/monitoring	97	97	91	Monthly	twice a year	No	41	40	36	34	32	31	30	29	33
254335080170501	G-432	25 43 35.9	-080 17 03.3	observation/monitoring	100	100	98	Monthly	twice a year	No	4000	4150	4500	4775	5142	5467	5683	5817	6383
254828080161501	G - 354	25 48 28	-080 16 15	observation/monitoring	90	90.2	89	quarterly	quarterly	No	54	53	50	49	46	45	42	41	40
255315080111501	F-279	25 53 17.8	-080 11 14.6	observation/monitoring	117	117	NA	Monthly	quarterly	No	3150	3300	3383	3475	3583	3675	3892	4117	4067
254943080121501	F - 45	25 49 43	-080 12 15	observation/monitoring	84.9	84.9	84	Monthly	Monthly	No	104	87	97	97	113	118	127	130	143
253253080221201	G-3885	25 32 53.1	-080 22 12.7	observation/monitoring	91	86	86	Monthly	Monthly	No	NA	NA	NA	NA	36	36	31	30	30
2535270801195400	G-3886	25 35 27.9	-080 19 54.2	observation/monitoring	109	101	101	Monthly	Monthly	No	NA	NA	NA	NA	51	49	47	46	47
253924080174601	G-3887	25 39 24.7	-080 17 46.8	observation/monitoring	134	130	130	Monthly	Monthly	No	NA	NA	NA	NA	2238	2292	2442	2508	2692
254542080145901	G-3888	25 39 2407	-080 14 5908	observation/monitoring	149	144	144	Monthly	Monthly	No	NA	NA	NA	NA	5029	5225	5458	5592	6075
252431080261001	G-3946	25 24 30.7	-080 26 09.7	observation/monitoring	99	98	87	Monthly	Monthly	No	NA	NA	NA	Under cor	3717	4158	4629	5067	5375
255011080124501	G-3947	25 50 11.3	-080 12 45.4	observation/monitoring	229	227	200	Monthly	Monthly	No	NA	NA	NA	Under cor	28	25	21	21	21
255515080103601	G-3948	25 55 14.9	-080 10 36.2	observation/monitoring	279	277	273	Monthly	Monthly	No	NA	NA	NA	Under cor	3992		4308	4275	4318
255733080195601	G-3949	25 57 33.6	-080 09 56.5	observation/monitoring	349	349	325	Monthly	Monthly	No	NA	NA	NA	Under cor	115	121	116	118	122

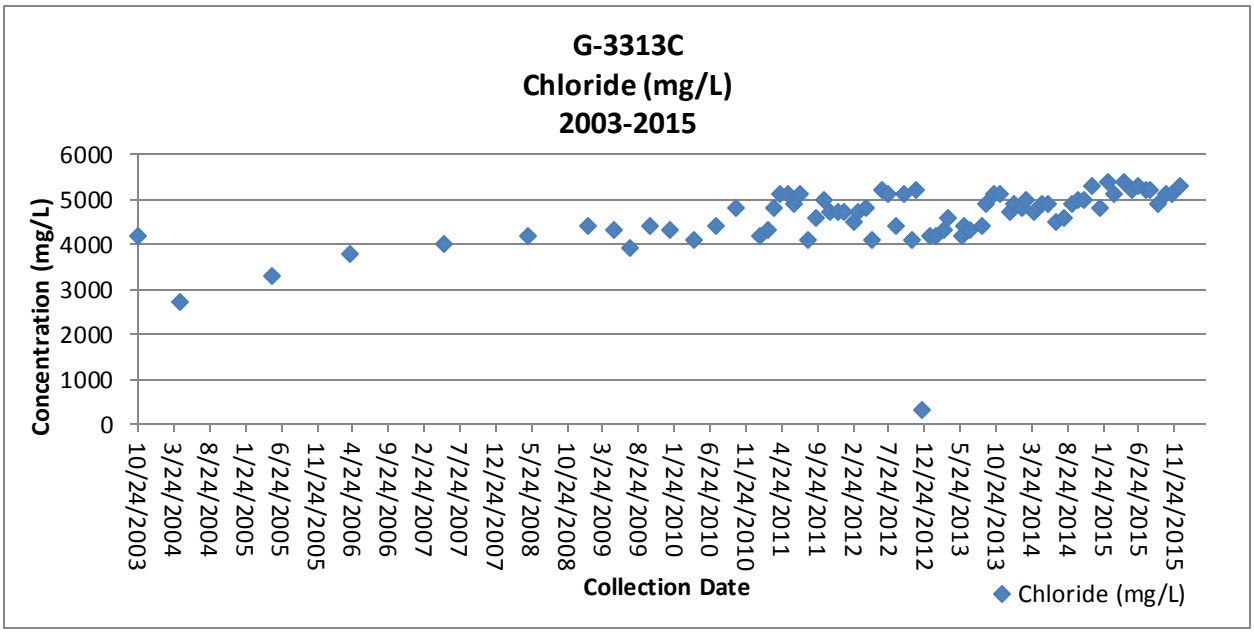
A. Per USGS, depth of the casing is not precisely known.
B. Feet Below Land Surface (bls)
GWL: groundwater level
Cl: chloride

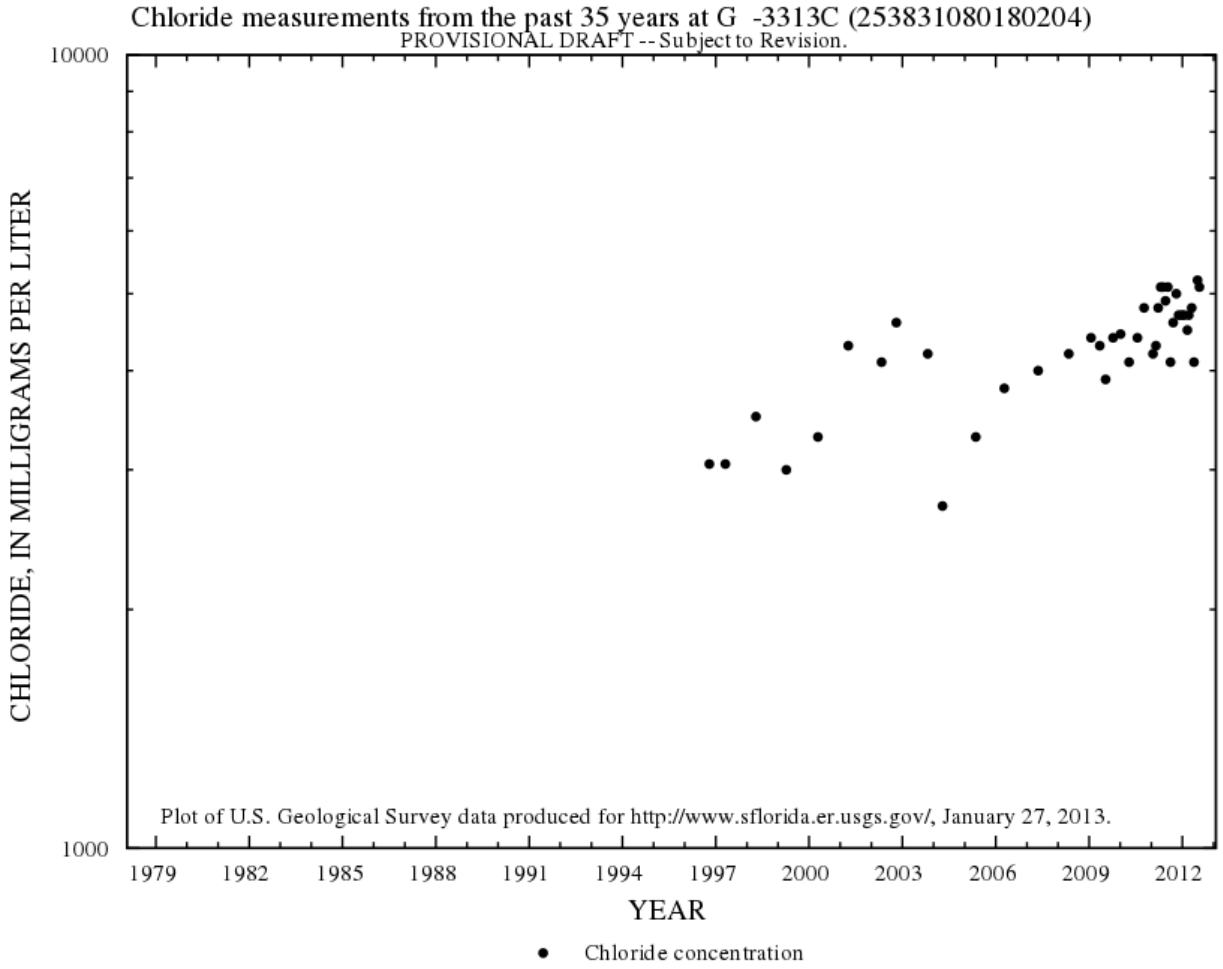
APPENDIX E

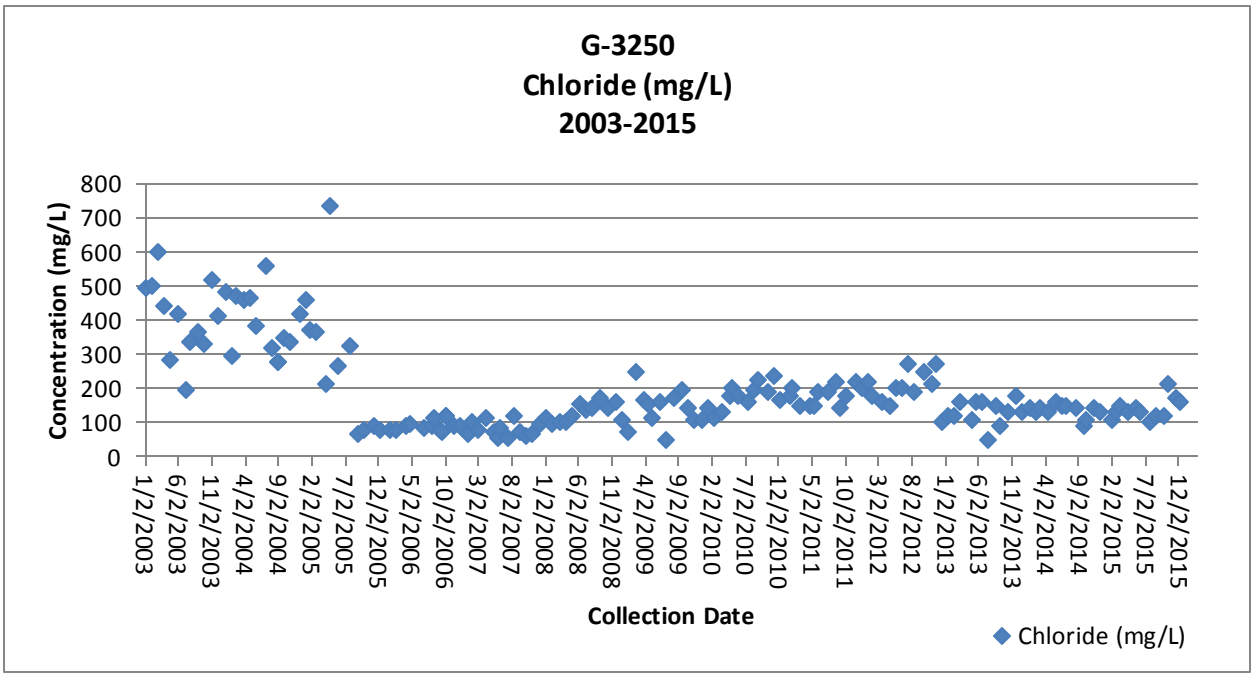
CHLORIDE HISTORICAL GRAPHS

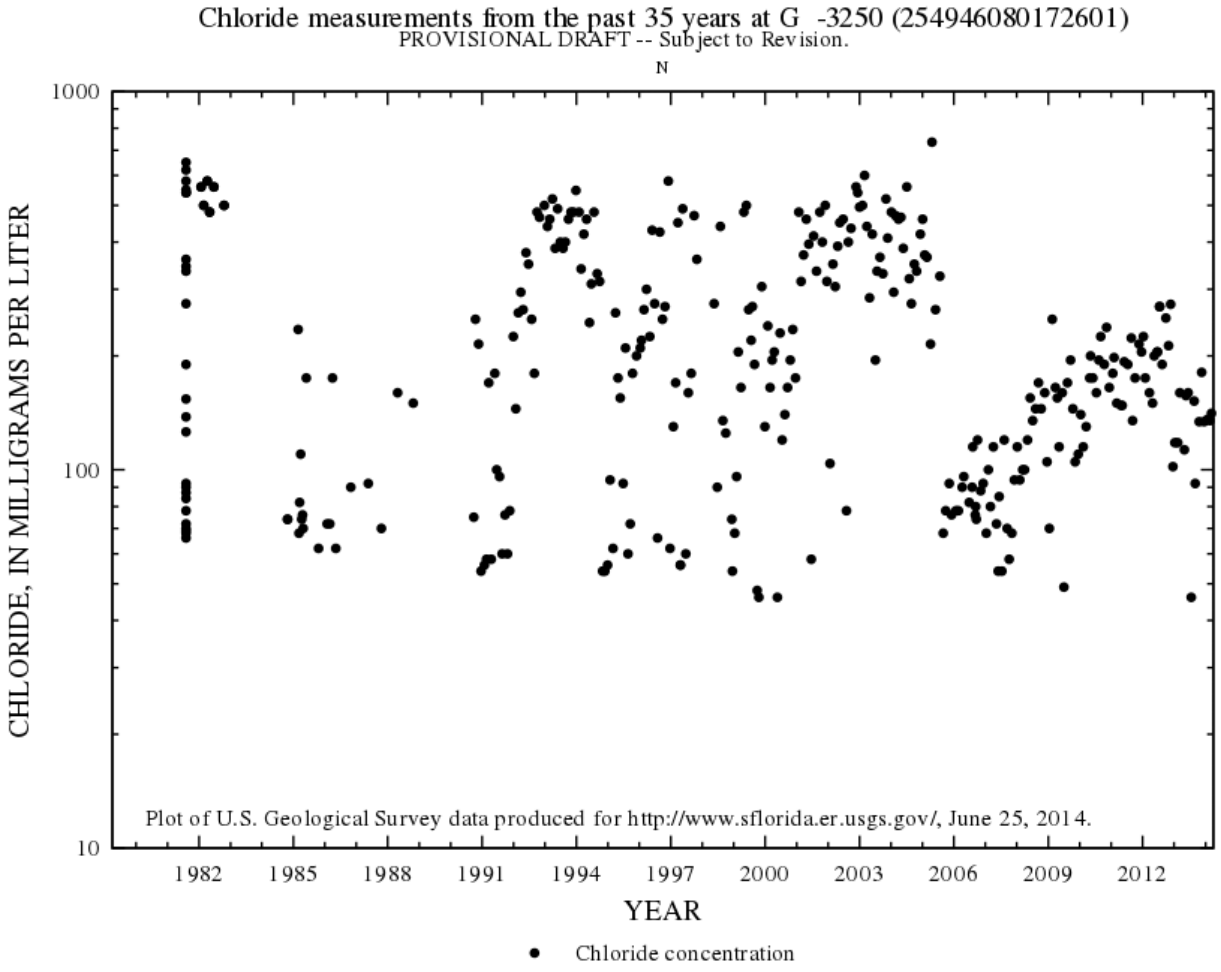

G-3313E
Chloride (mg/L)
2004-2015
Concentration (mg/L)
7000
6000
5000
4000
3000
2000
1000
0
5/1/2004
10/1/2004
3/1/2005
8/1/2005
1/1/2006
6/1/2006
11/1/2006
4/1/2007
9/1/2007
2/1/2008
7/1/2008
12/1/2008
5/1/2009
10/1/2009
3/1/2010
8/1/2010
1/1/2011
6/1/2011
11/1/2011
4/1/2012
9/1/2012
2/1/2013
7/1/2013
12/1/2013
5/1/2014
10/1/2014
3/1/2015
8/1/2015
1/1/2016
Collection Date
Chloride (mg/L)

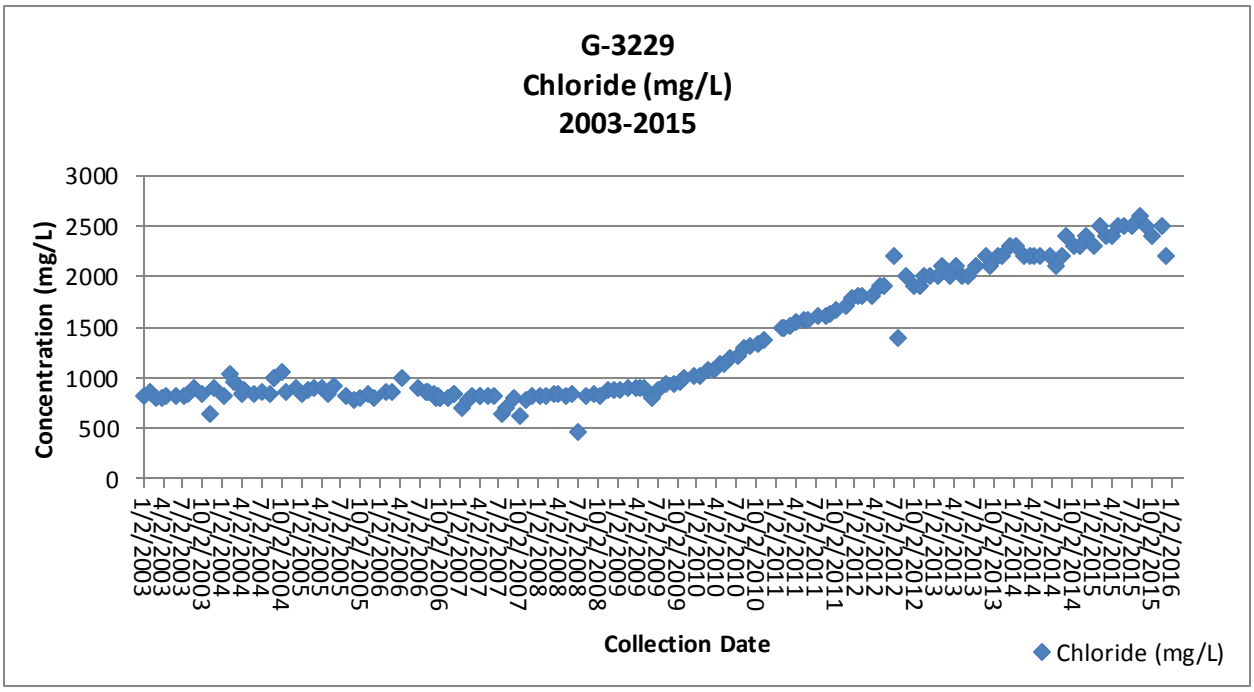

Chloride measurements from the past 35 years at G -3313E (253831080180206)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 25, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

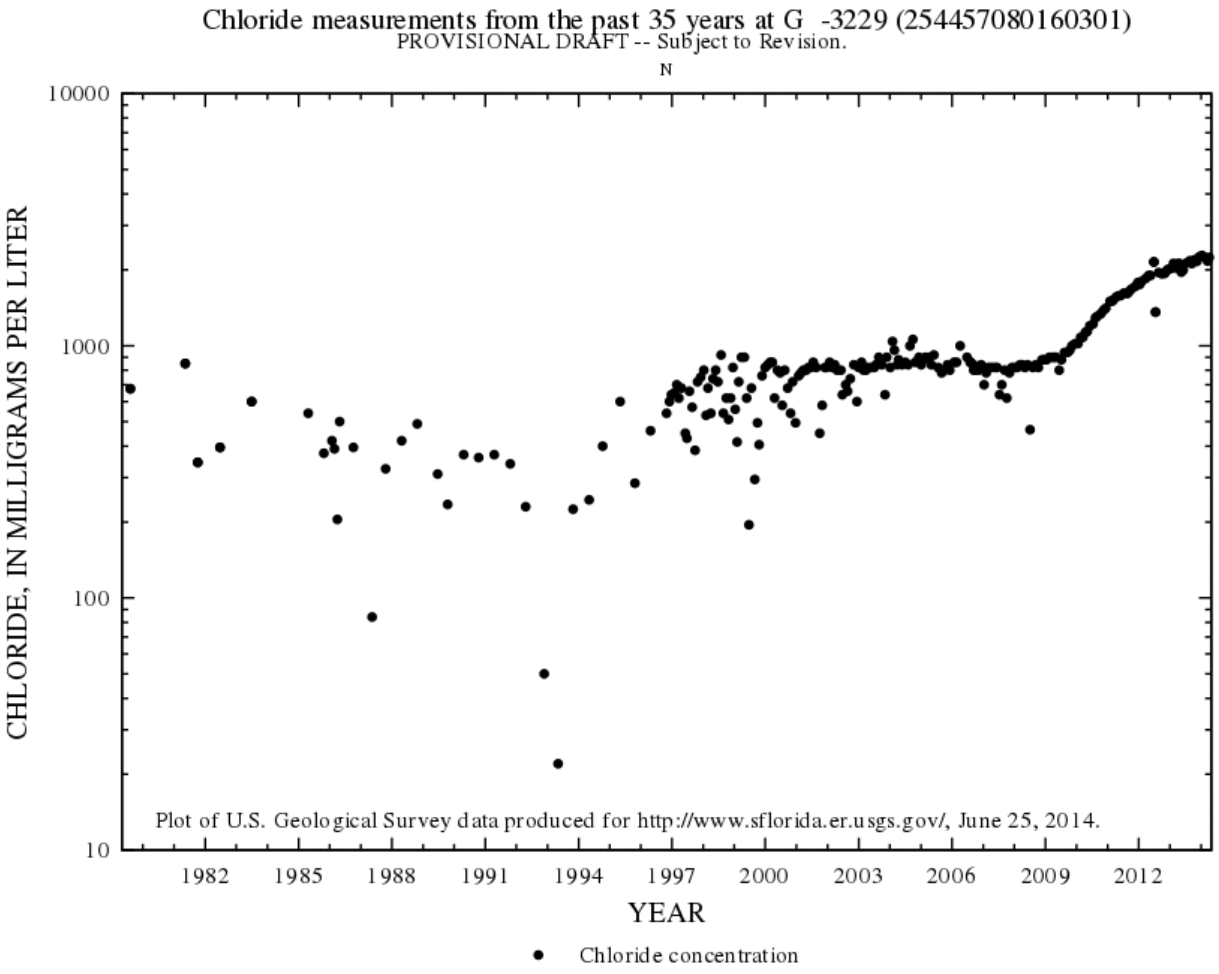

G-3313C
Chloride (mg/L)
2003-2015
Concentration (mg/L)
6000
5000
4000
3000
2000
1000
0
10/24/2003
3/24/2004
8/24/2004
1/24/2005
6/24/2005
11/24/2005
4/24/2006
9/24/2006
2/24/2007
7/24/2007
12/24/2007
5/24/2008
10/24/2008
3/24/2009
8/24/2009
1/24/2010
6/24/2010
11/24/2010
4/24/2011
9/24/2011
2/24/2012
7/24/2012
12/24/2012
5/24/2013
10/24/2013
3/24/2014
8/24/2014
1/24/2015
6/24/2015
11/24/2015
Collection Date
Chloride (mg/L)

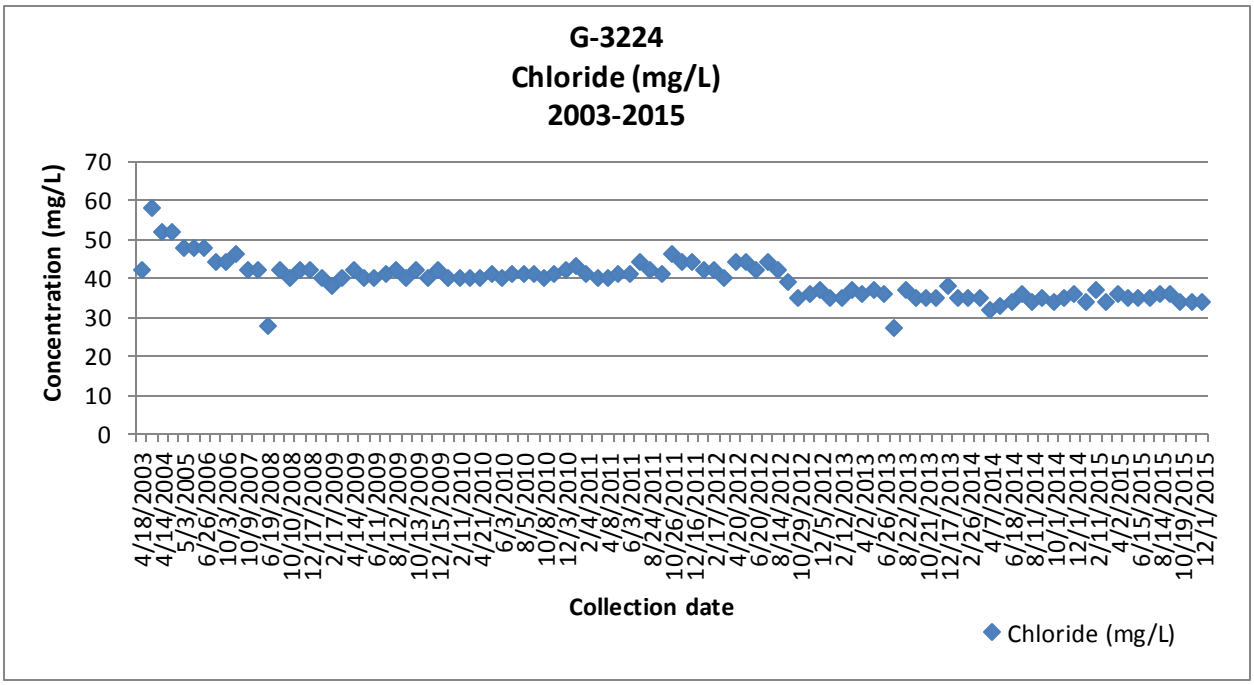

Chloride measurements from the past 35 years at G -3313C (253831080180204)
PROVISIONAL DRAFT -- Subject to Revision.
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, January 27, 2013.
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

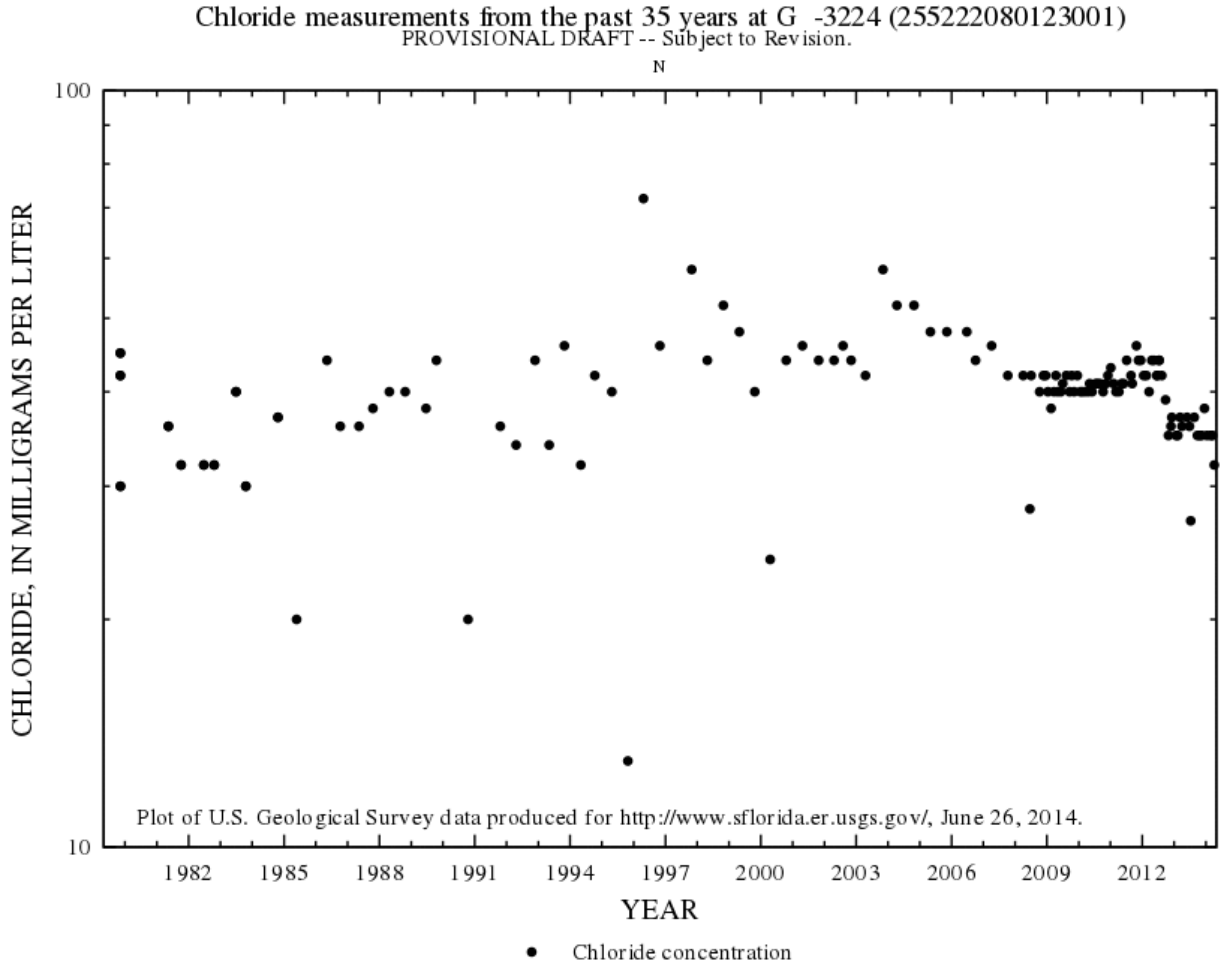

G-3250
Chloride (mg/L)
2003-2015
Concentration (mg/L)
800
700
600
500
400
300
200
100
0
1/2/2003
6/2/2003
11/2/2003
4/2/2004
9/2/2004
2/2/2005
7/2/2005
12/2/2005
5/2/2006
10/2/2006
3/2/2007
8/2/2007
1/2/2008
6/2/2008
11/2/2008
4/2/2009
9/2/2009
2/2/2010
7/2/2010
12/2/2010
5/2/2011
10/2/2011
3/2/2012
8/2/2012
1/2/2013
6/2/2013
11/2/2013
4/2/2014
9/2/2014
2/2/2015
7/2/2015
12/2/2015
Collection Date
Chloride (mg/L)

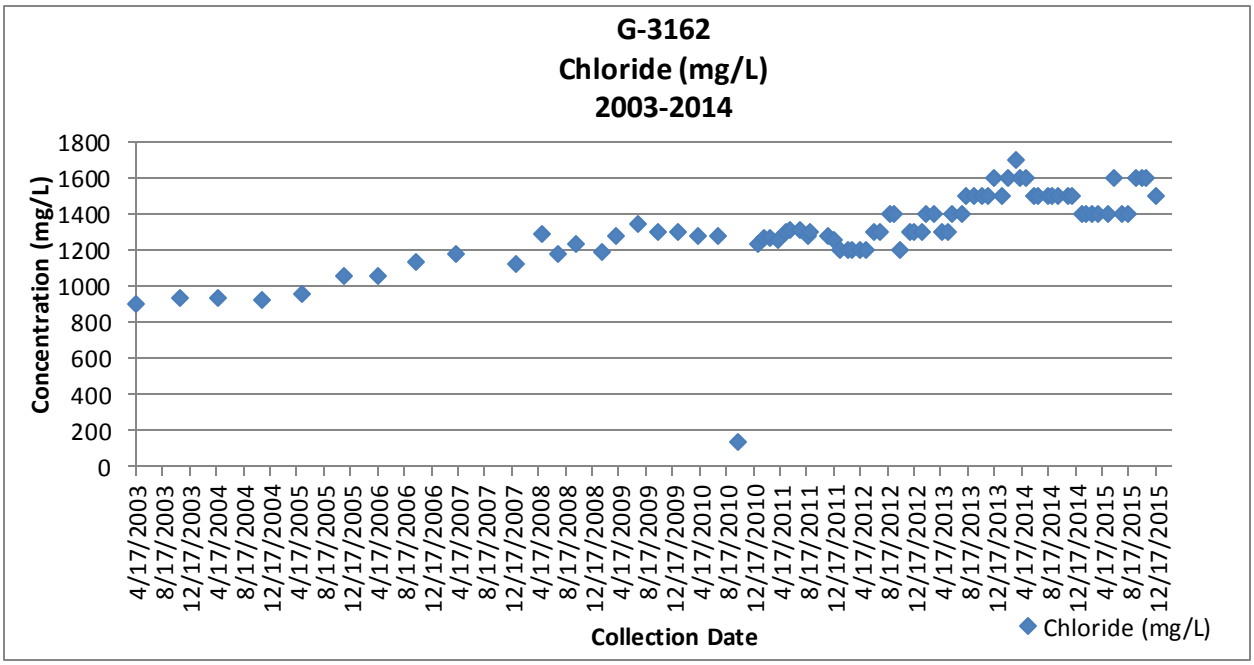

Chloride measurements from the past 35 years at G -3250 (254946080172601)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
1000
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 25, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

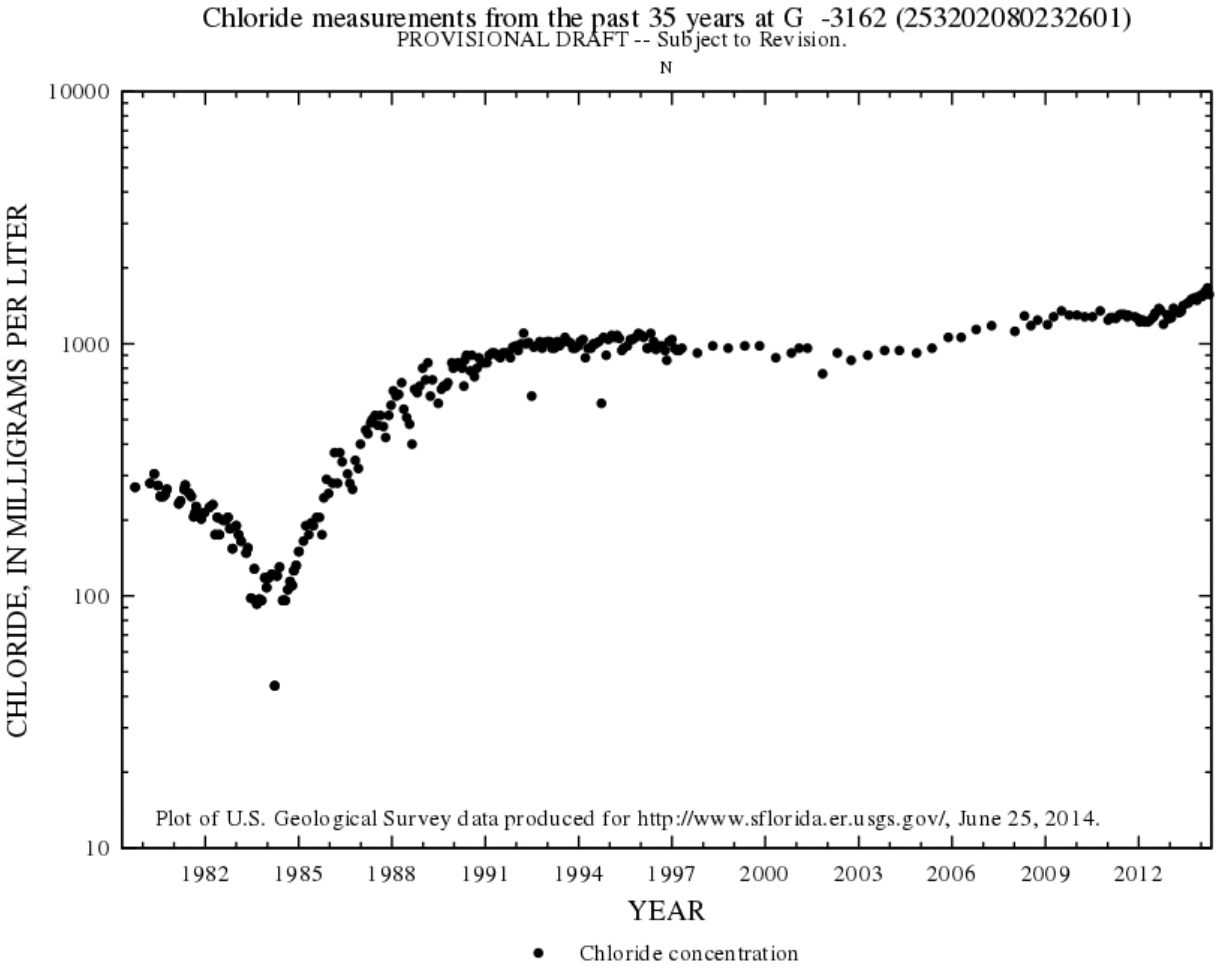

G-3229
Chloride (mg/L)
2003-2015
Concentration (mg/L)
3000
2500
2000
1500
1000
500
0
Collection Date
Chloride (mg/L)

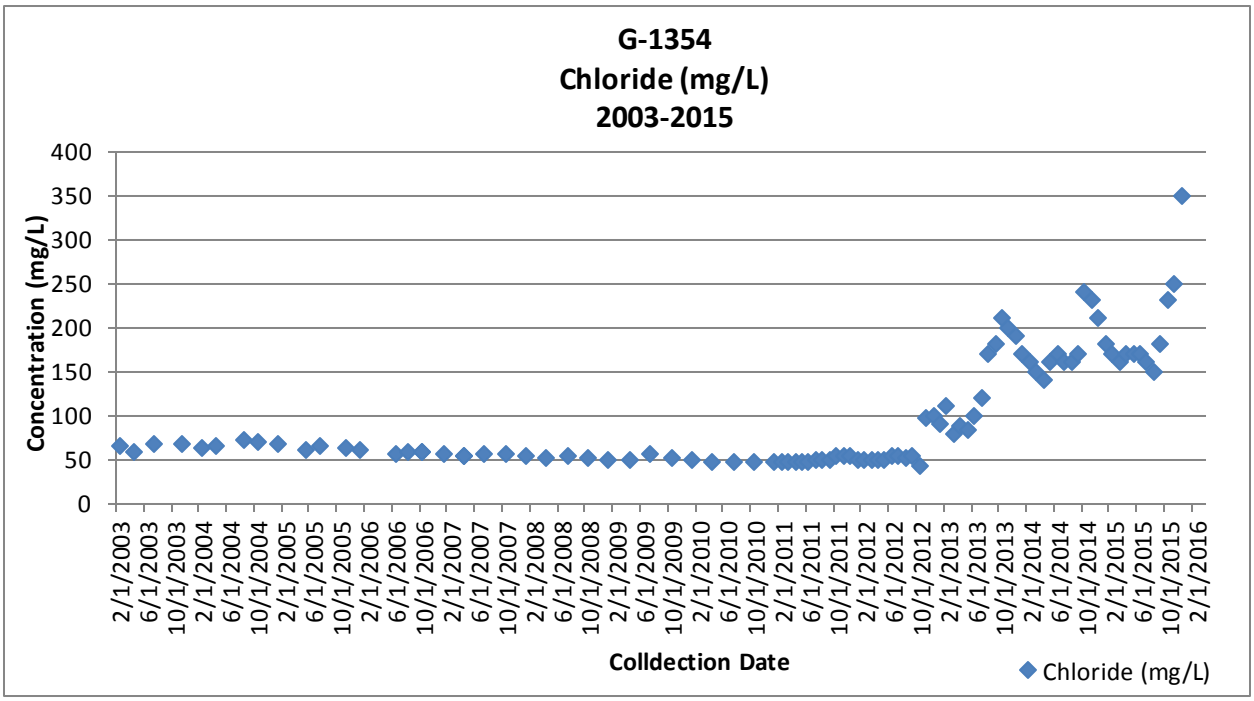

Chloride measurements from the past 35 years at G -3229 (254457080160301)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 25, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

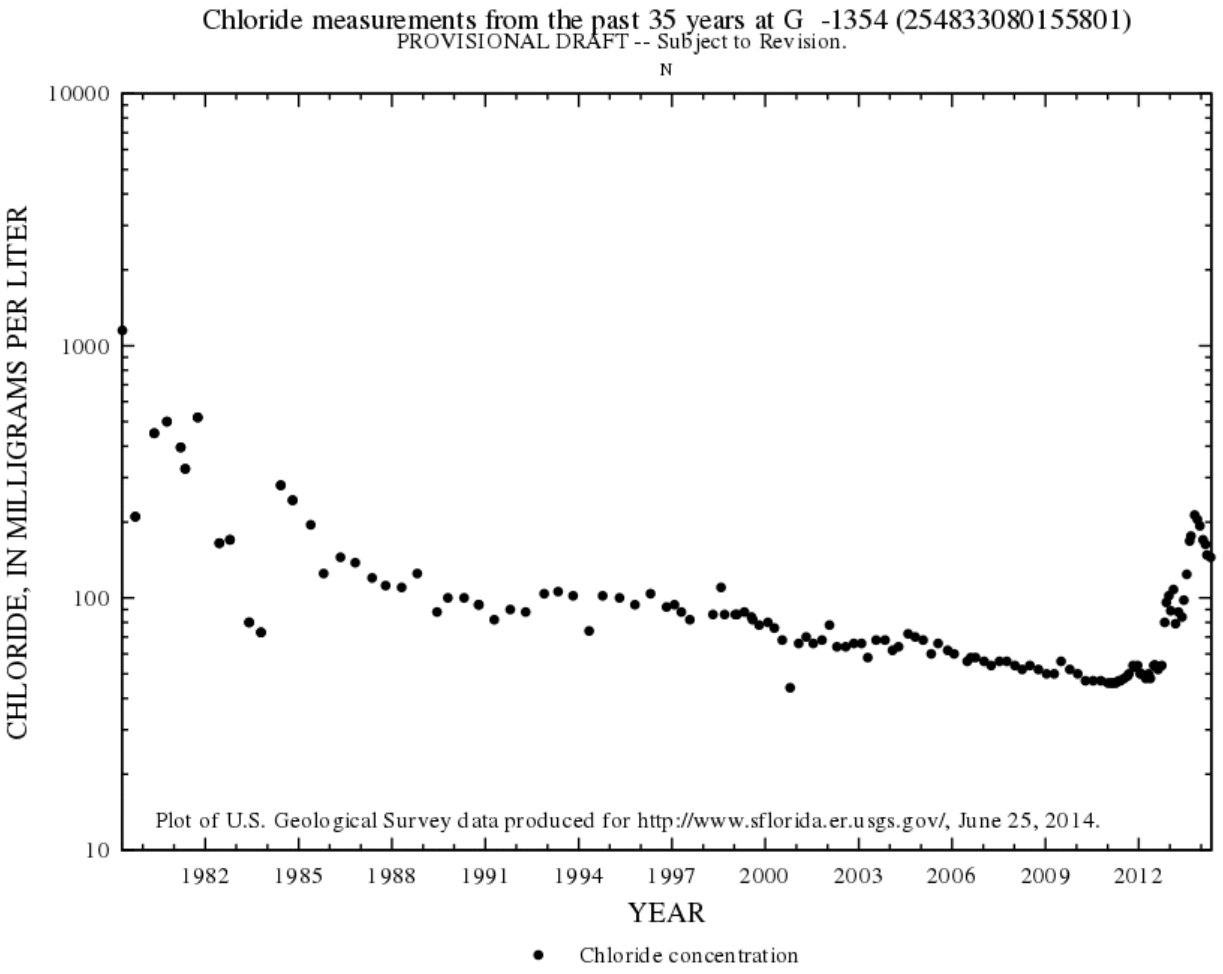

G-3224
Chloride (mg/L)
2003-2015
Concentration (mg/L)
70
60
50
40
30
20
10
0
4/18/2003
4/14/2004
5/3/2005
6/26/2006
10/3/2006
10/9/2007
6/19/2008
10/10/2008
12/17/2008
2/17/2009
4/14/2009
6/11/2009
8/12/2009
10/13/2009
12/15/2009
2/11/2010
4/21/2010
6/3/2010
8/5/2010
10/8/2010
12/3/2010
2/4/2011
4/8/2011
6/3/2011
8/24/2011
10/26/2011
12/16/2011
2/17/2012
4/20/2012
6/20/2012
8/14/2012
10/29/2012
12/5/2012
2/12/2013
4/2/2013
6/26/2013
8/22/2013
10/21/2013
12/17/2013
2/26/2014
4/7/2014
6/18/2014
8/11/2014
10/1/2014
12/1/2014
2/11/2015
4/2/2015
6/15/2015
8/14/2015
10/19/2015
12/1/2015
Collection date
Chloride (mg/L)

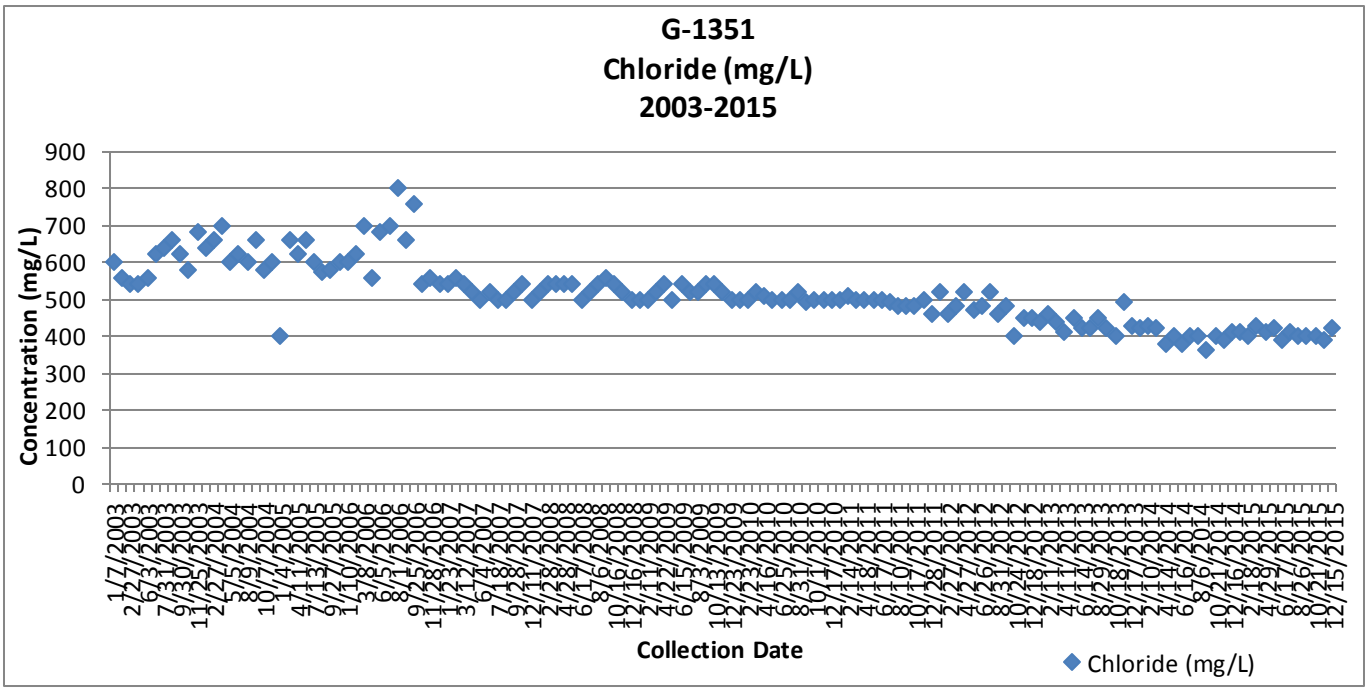

Chloride measurements from the past 35 years at G -3224 (255222080123001)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 26, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

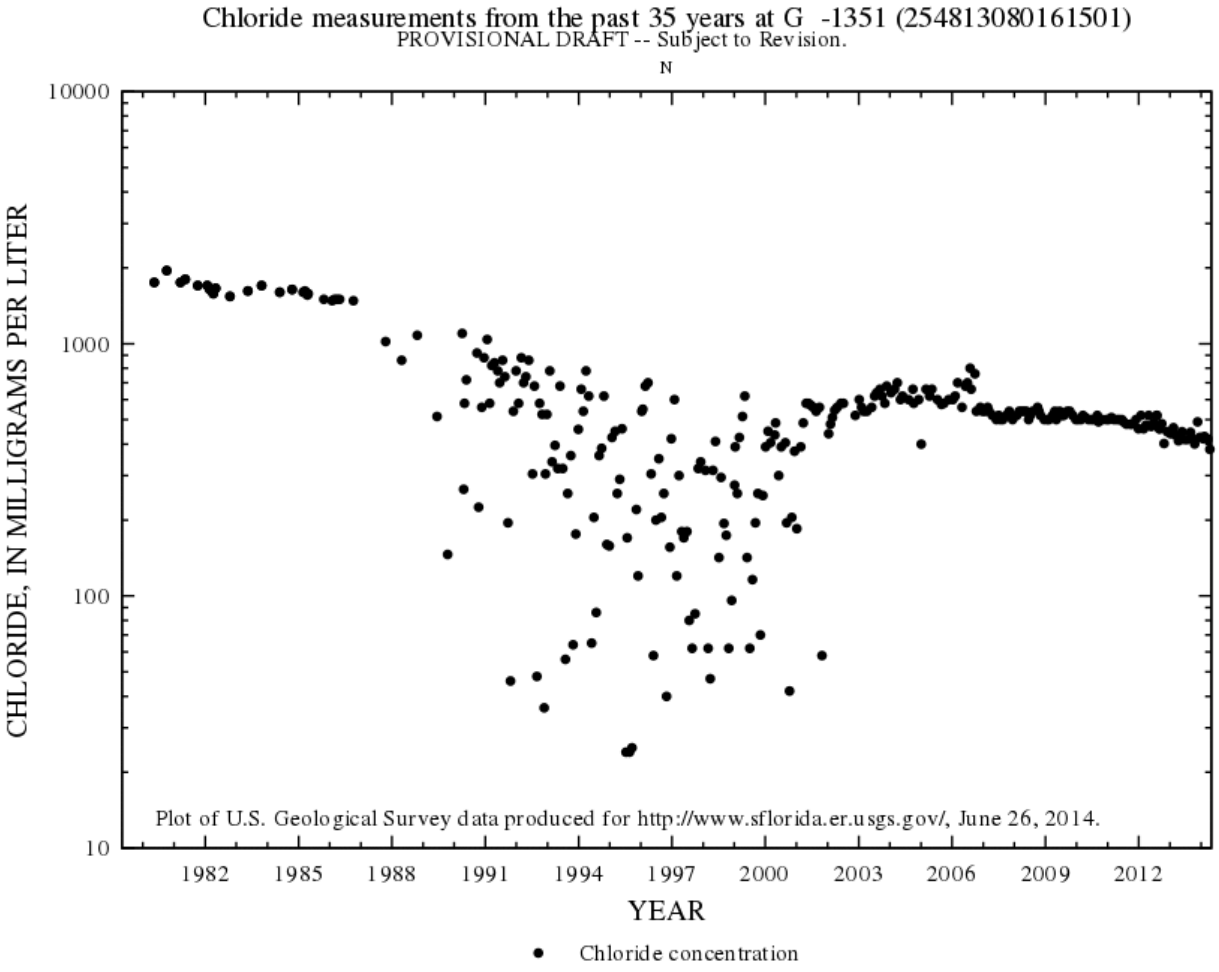

G-3162
Chloride (mg/L)
2003-2014
Concentration (mg/L)
1800
1600
1400
1200
1000
800
600
400
200
0
4/17/2003
8/17/2003
12/17/2003
4/17/2004
8/17/2004
12/17/2004
4/17/2005
8/17/2005
12/17/2005
4/17/2006
8/17/2006
12/17/2006
4/17/2007
8/17/2007
12/17/2007
4/17/2008
8/17/2008
12/17/2008
4/17/2009
8/17/2009
12/17/2009
4/17/2010
8/17/2010
12/17/2010
4/17/2011
8/17/2011
12/17/2011
4/17/2012
8/17/2012
12/17/2012
4/17/2013
8/17/2013
12/17/2013
4/17/2014
8/17/2014
12/17/2014
4/17/2015
8/17/2015
12/17/2015
Collection Date
Chloride (mg/L)

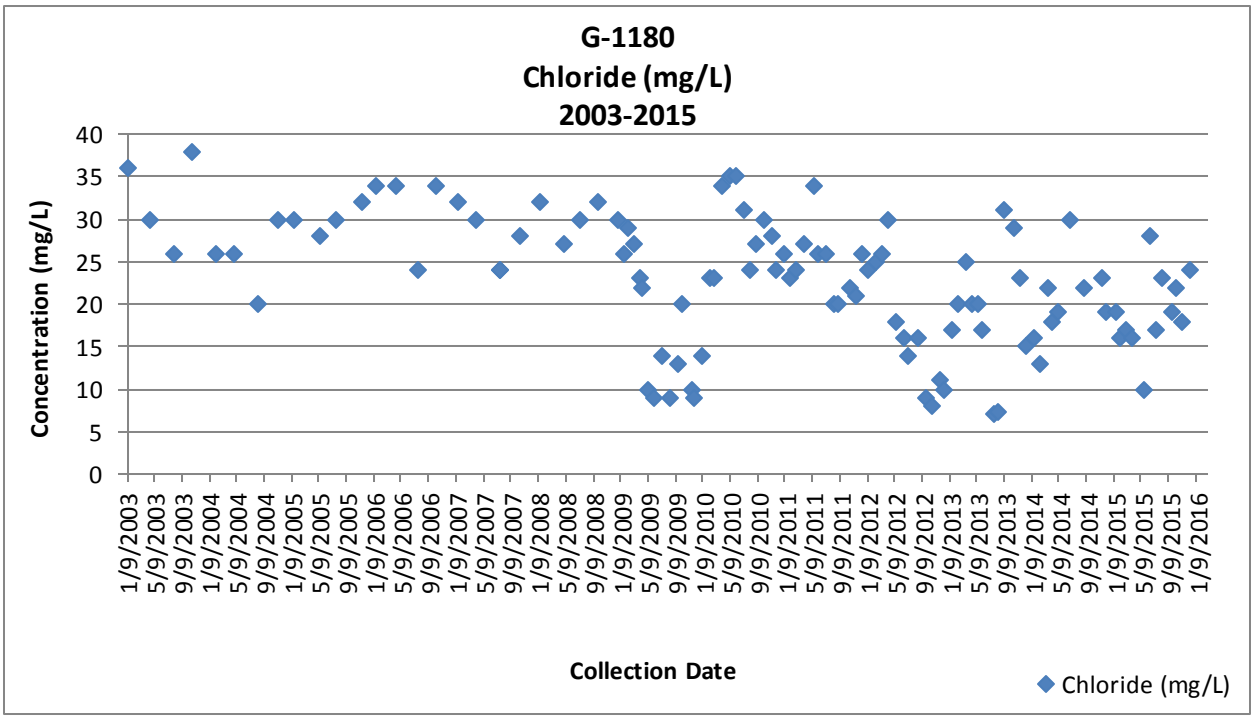

Chloride measurements from the past 35 years at G -3162 (253202080232601)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 25, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

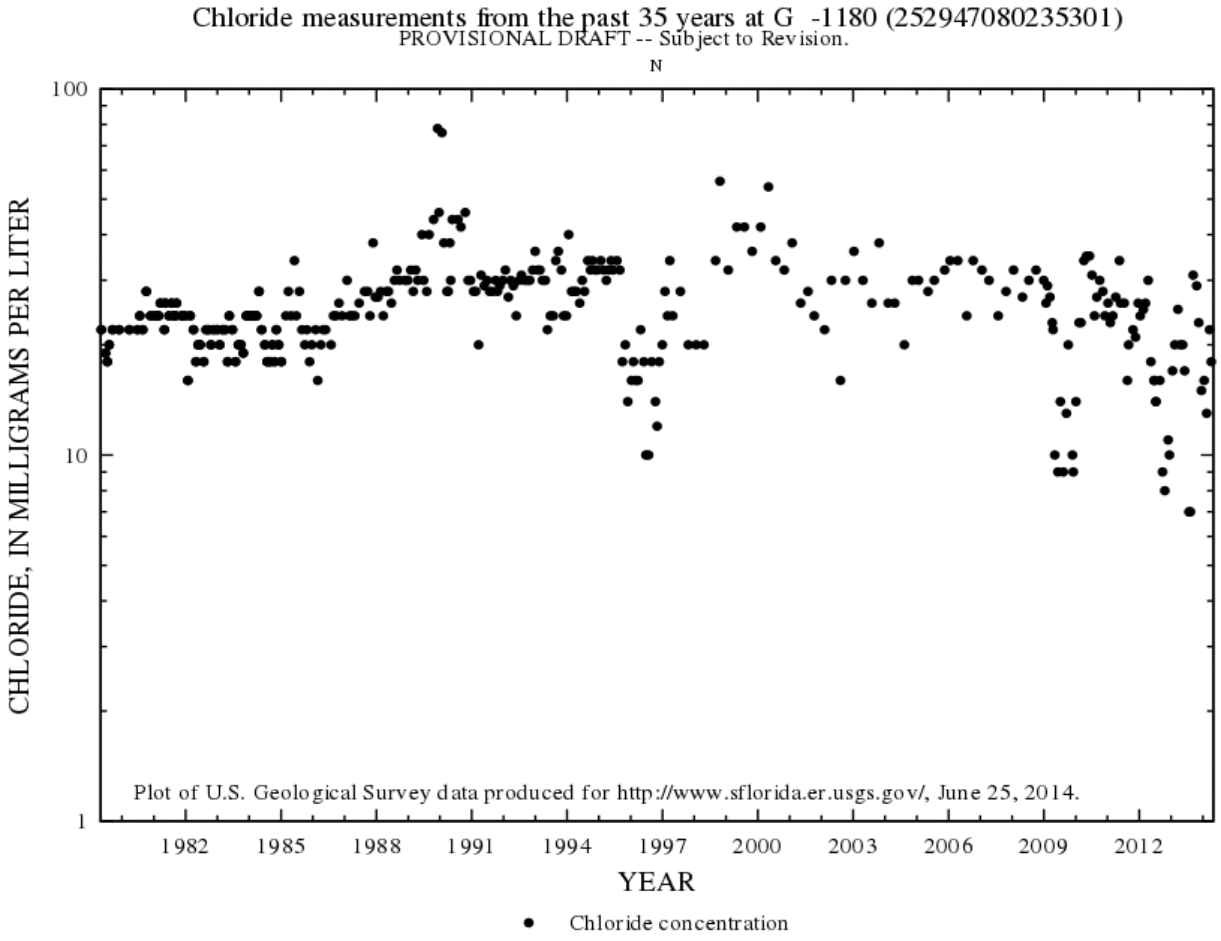

G-1354
Chloride (mg/L)
2003-2015
Concentration (mg/L)
400
350
300
250
200
150
100
50
0
2/1/2003
6/1/2003
10/1/2003
2/1/2004
6/1/2004
10/1/2004
2/1/2005
6/1/2005
10/1/2005
2/1/2006
6/1/2006
10/1/2006
2/1/2007
6/1/2007
10/1/2007
2/1/2008
6/1/2008
10/1/2008
2/1/2009
6/1/2009
10/1/2009
2/1/2010
6/1/2010
10/1/2010
2/1/2011
6/1/2011
10/1/2011
2/1/2012
6/1/2012
10/1/2012
2/1/2013
6/1/2013
10/1/2013
2/1/2014
6/1/2014
10/1/2014
2/1/2015
6/1/2015
10/1/2015
2/1/2016
Colldection Date
Chloride (mg/L)

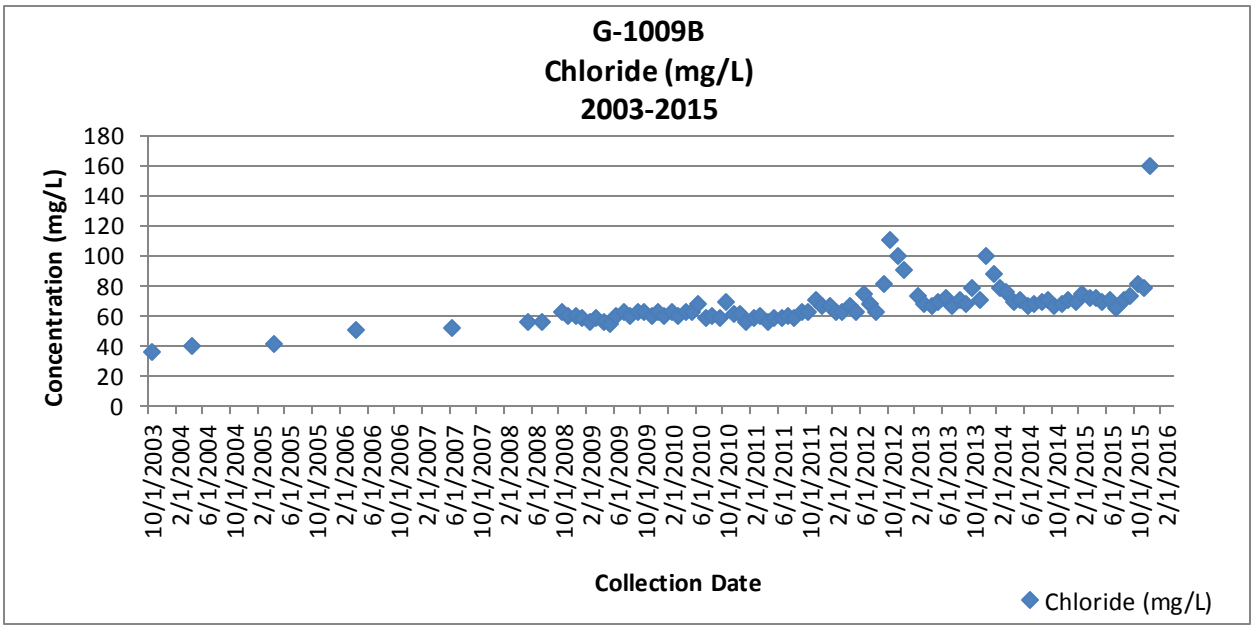

Chloride measurements from the past 35 years at G -1354 (254833080155801)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 25, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

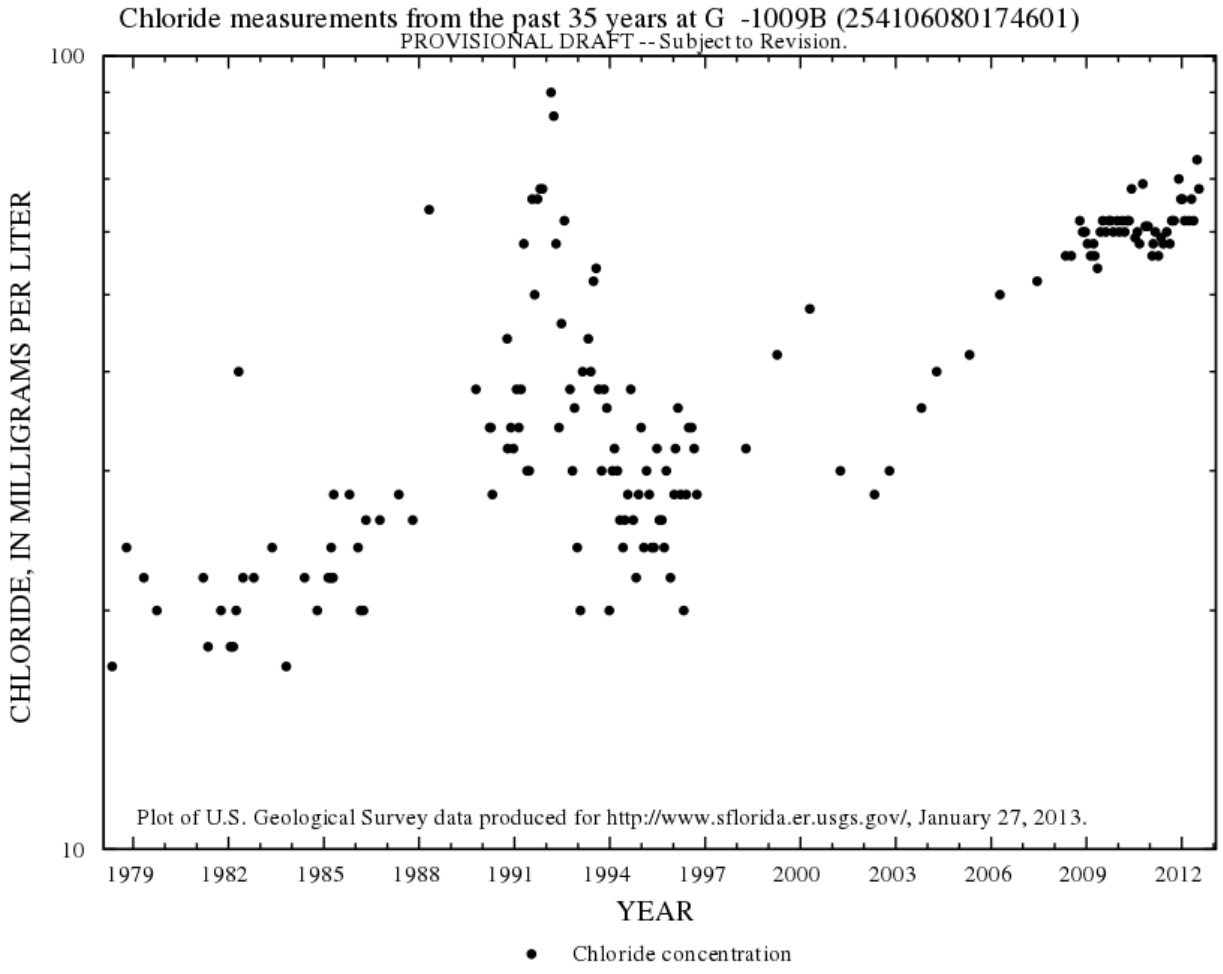

G-1351
Chloride (mg/L)
2003-2015
Concentration (mg/L)
900
800
700
600
500
400
300
200
100
0
Collection Date
Chloride (mg/L)

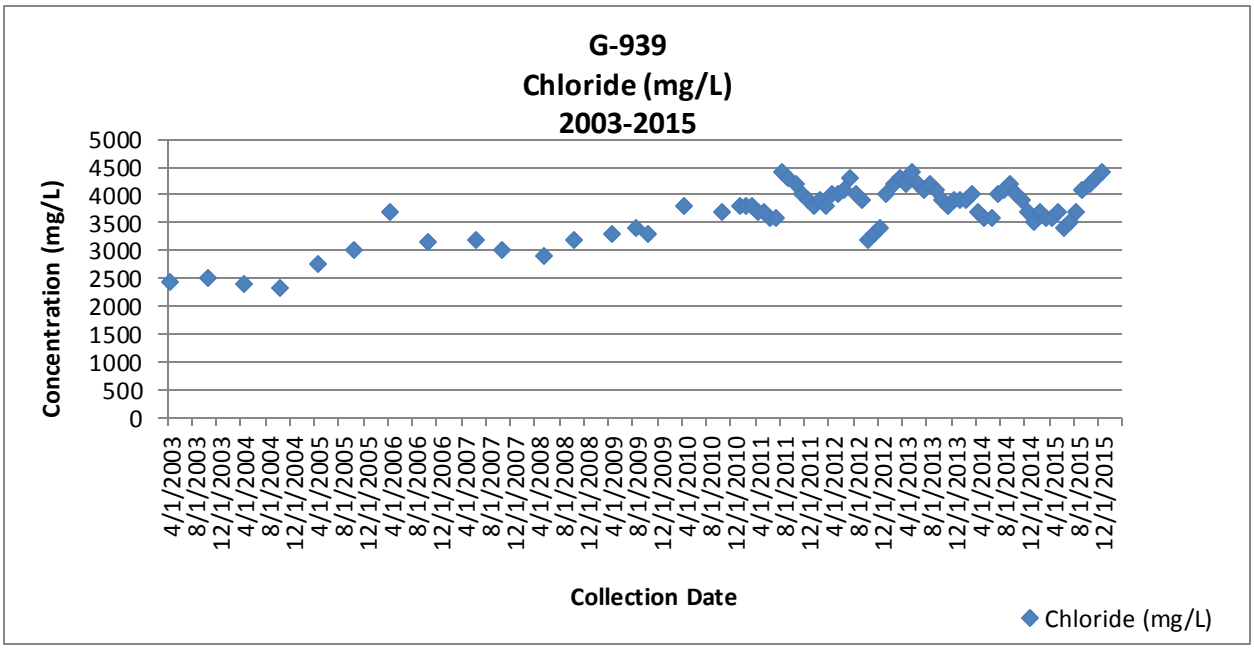

Chloride measurements from the past 35 years at G -1351 (254813080161501)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 26, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

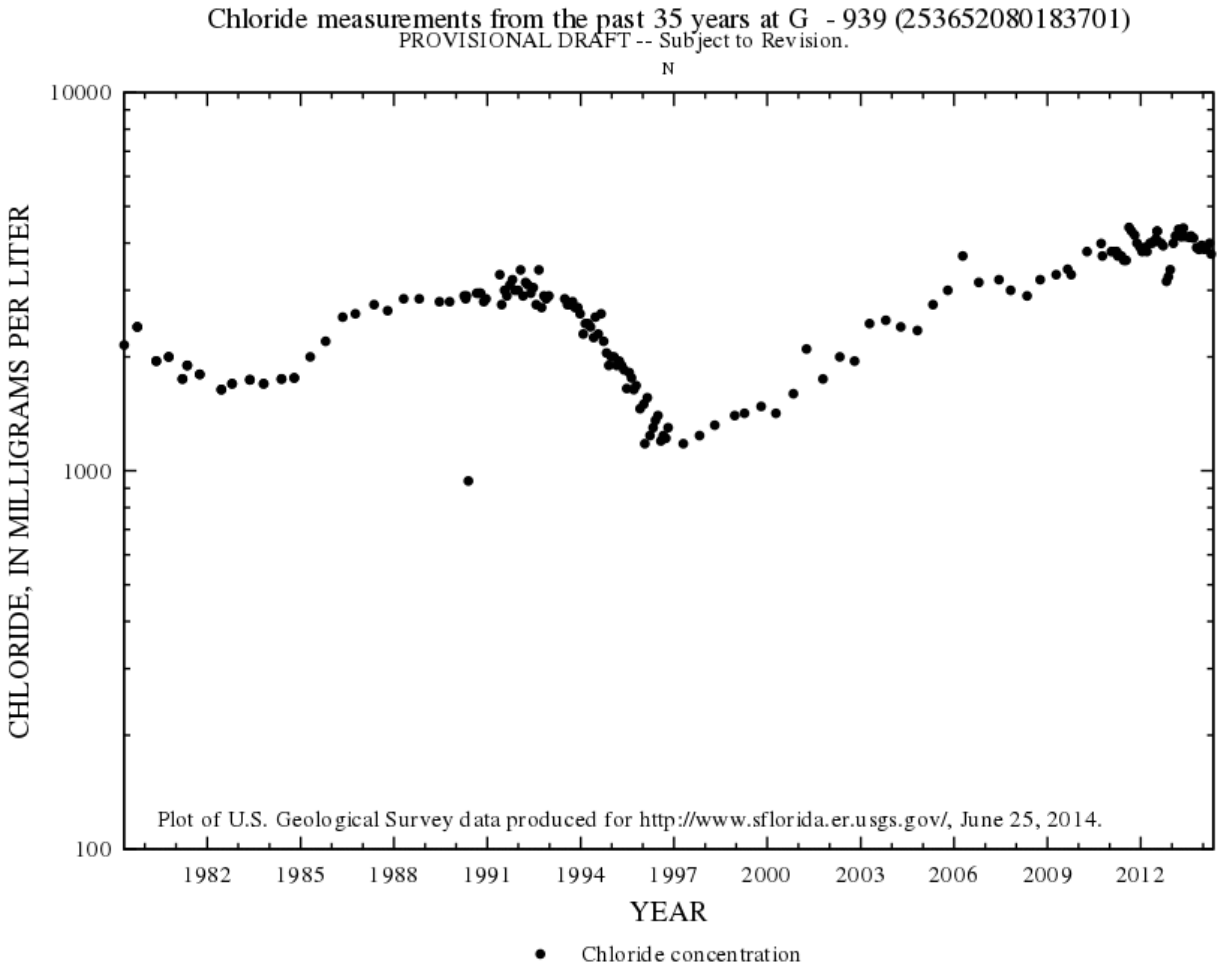

G-1180
Chloride (mg/L)
2003-2015
Concentration (mg/L)
40
35
30
25
20
15
10
5
0
1/9/2003
5/9/2003
9/9/2003
1/9/2004
5/9/2004
9/9/2004
1/9/2005
5/9/2005
9/9/2005
1/9/2006
5/9/2006
9/9/2006
1/9/2007
5/9/2007
9/9/2007
1/9/2008
5/9/2008
9/9/2008
1/9/2009
5/9/2009
9/9/2009
1/9/2010
5/9/2010
9/9/2010
1/9/2011
5/9/2011
9/9/2011
1/9/2012
5/9/2012
9/9/2012
1/9/2013
5/9/2013
9/9/2013
1/9/2014
5/9/2014
9/9/2014
1/9/2015
5/9/2015
9/9/2015
1/9/2016
Collection Date
Chloride (mg/L)

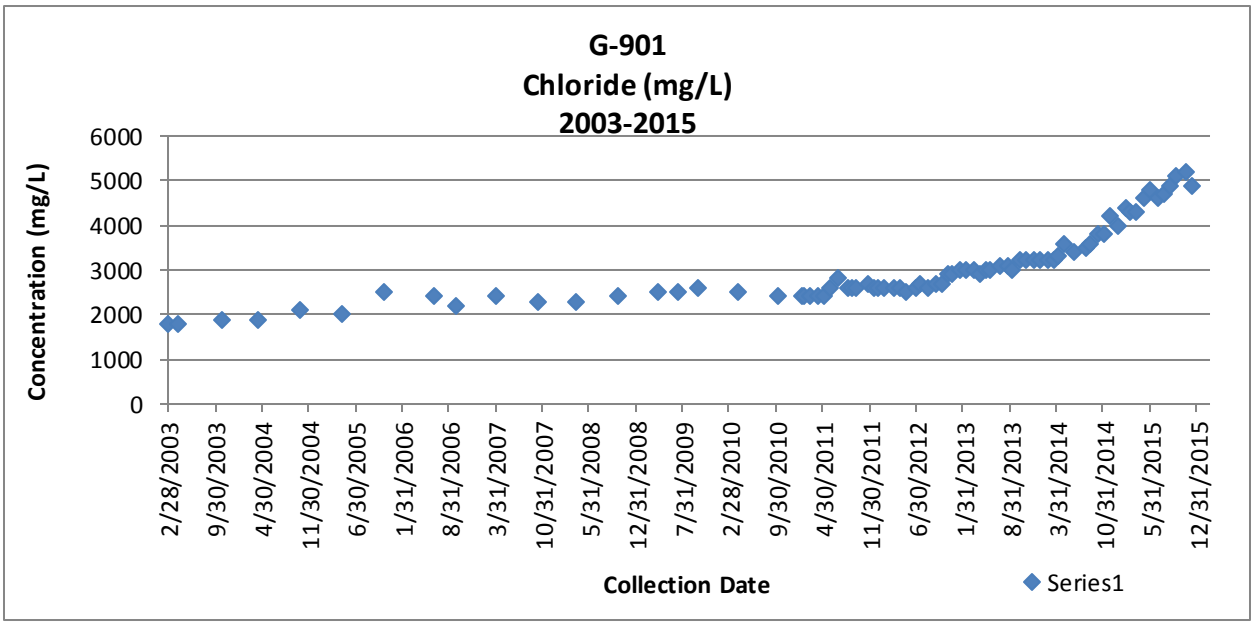

Chloride measurements from the past 35 years at G -1180 (252947080235301)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
100
10
1
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 25, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

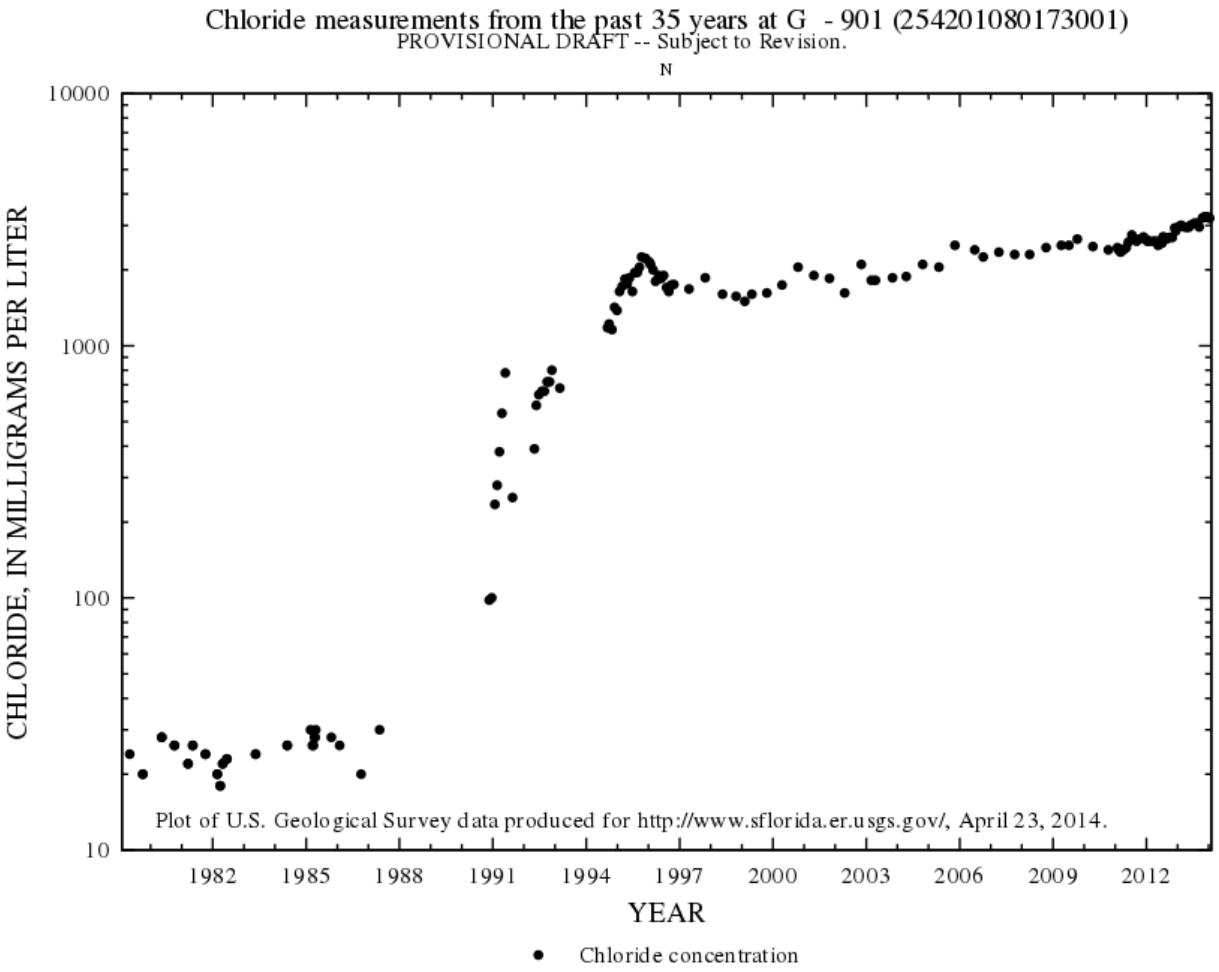

G-1009B
Chloride (mg/L)
2003-2015
Concentration (mg/L)
180
160
140
120
100
80
60
40
20
0
10/1/2003
2/1/2004
6/1/2004
10/1/2004
2/1/2005
6/1/2005
10/1/2005
2/1/2006
6/1/2006
10/1/2006
2/1/2007
6/1/2007
10/1/2007
2/1/2008
6/1/2008
10/1/2008
2/1/2009
6/1/2009
10/1/2009
2/1/2010
6/1/2010
10/1/2010
2/1/2011
6/1/2011
10/1/2011
2/1/2012
6/1/2012
10/1/2012
2/1/2013
6/1/2013
10/1/2013
2/1/2014
6/1/2014
10/1/2014
2/1/2015
6/1/2015
10/1/2015
2/1/2016
Collection Date
Chloride (mg/L)

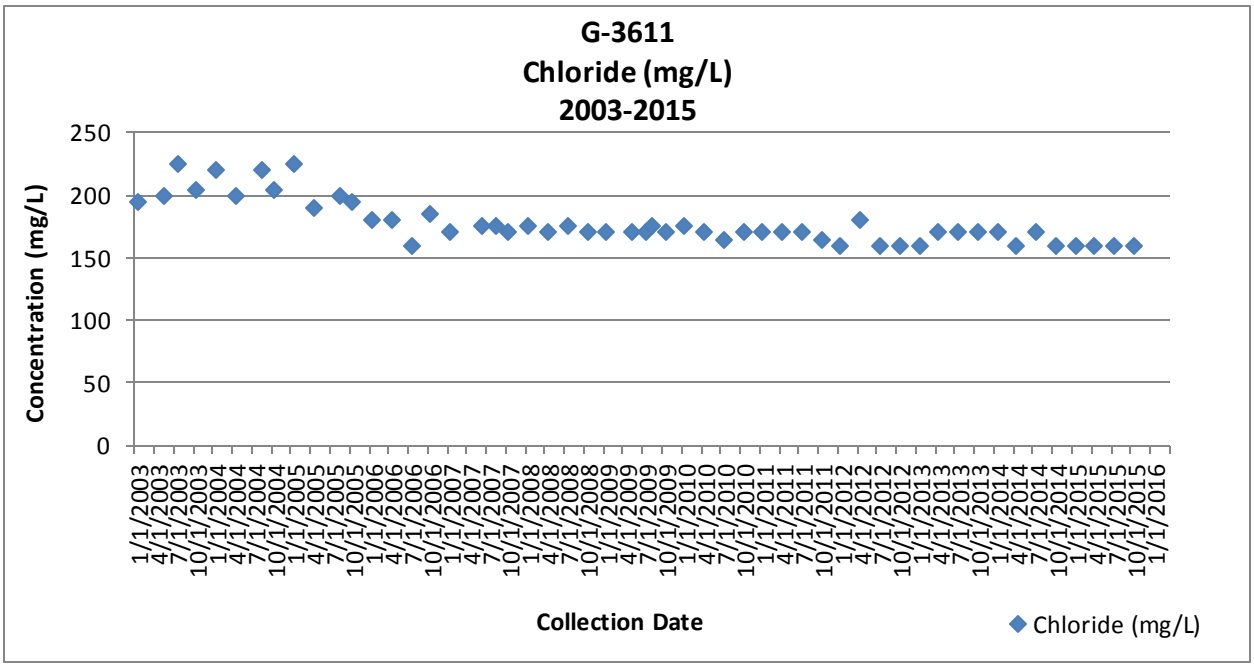

Chloride measurements from the past 35 years at G -1009B (254106080174601)
PROVISIONAL DRAFT -- Subject to Revision.
CHLORIDE, IN MILLIGRAMS PER LITER
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, January 27, 2013.
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

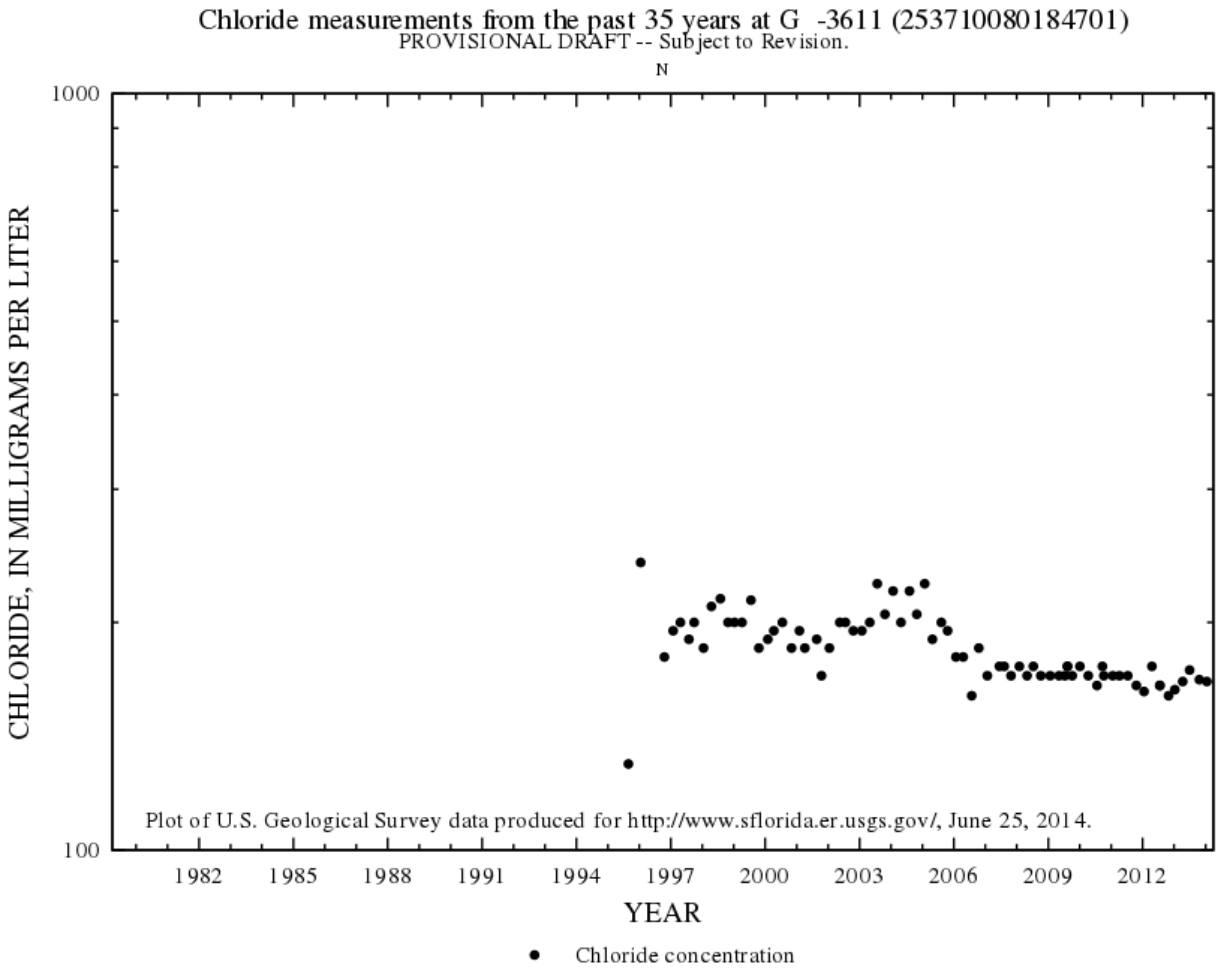

G-939
Chloride (mg/L)
2003-2015
Concentration (mg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
4/1/2003
8/1/2003
12/1/2003
4/1/2004
8/1/2004
12/1/2004
4/1/2005
8/1/2005
12/1/2005
4/1/2006
8/1/2006
12/1/2006
4/1/2007
8/1/2007
12/1/2007
4/1/2008
8/1/2008
12/1/2008
4/1/2009
8/1/2009
12/1/2009
4/1/2010
8/1/2010
12/1/2010
4/1/2011
8/1/2011
12/1/2011
4/1/2012
8/1/2012
12/1/2012
4/1/2013
8/1/2013
12/1/2013
4/1/2014
8/1/2014
12/1/2014
4/1/2015
8/1/2015
12/1/2015
Collection Date
Chloride (mg/L)

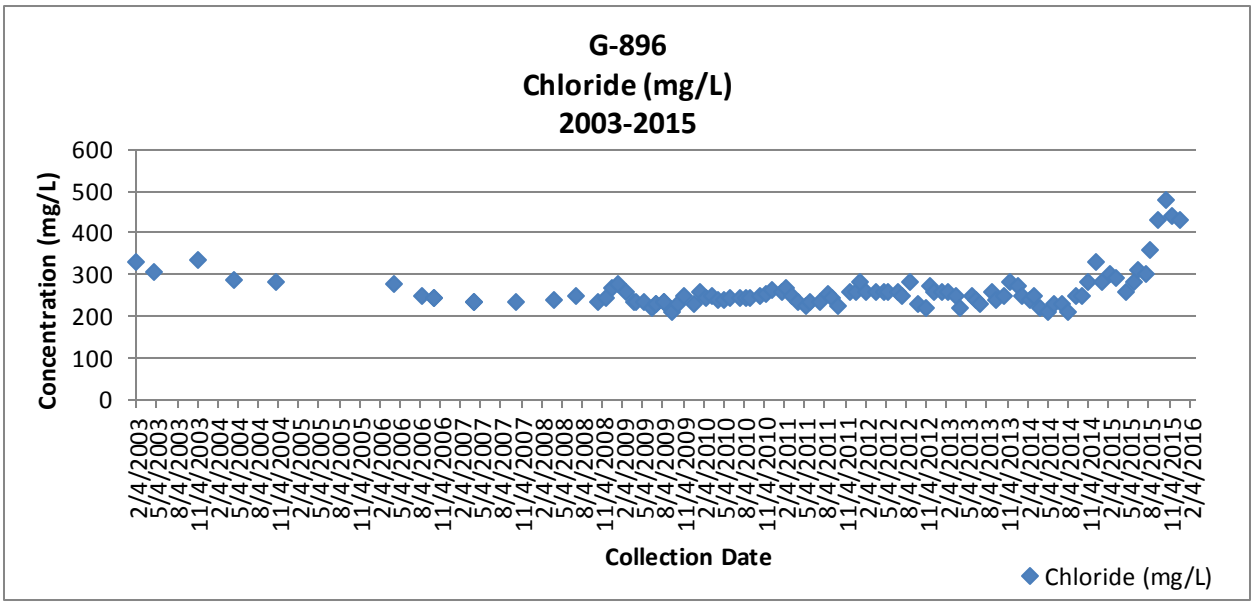

Chloride measurements from the past 35 years at G - 939 (253652080183701)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
100
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 25, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

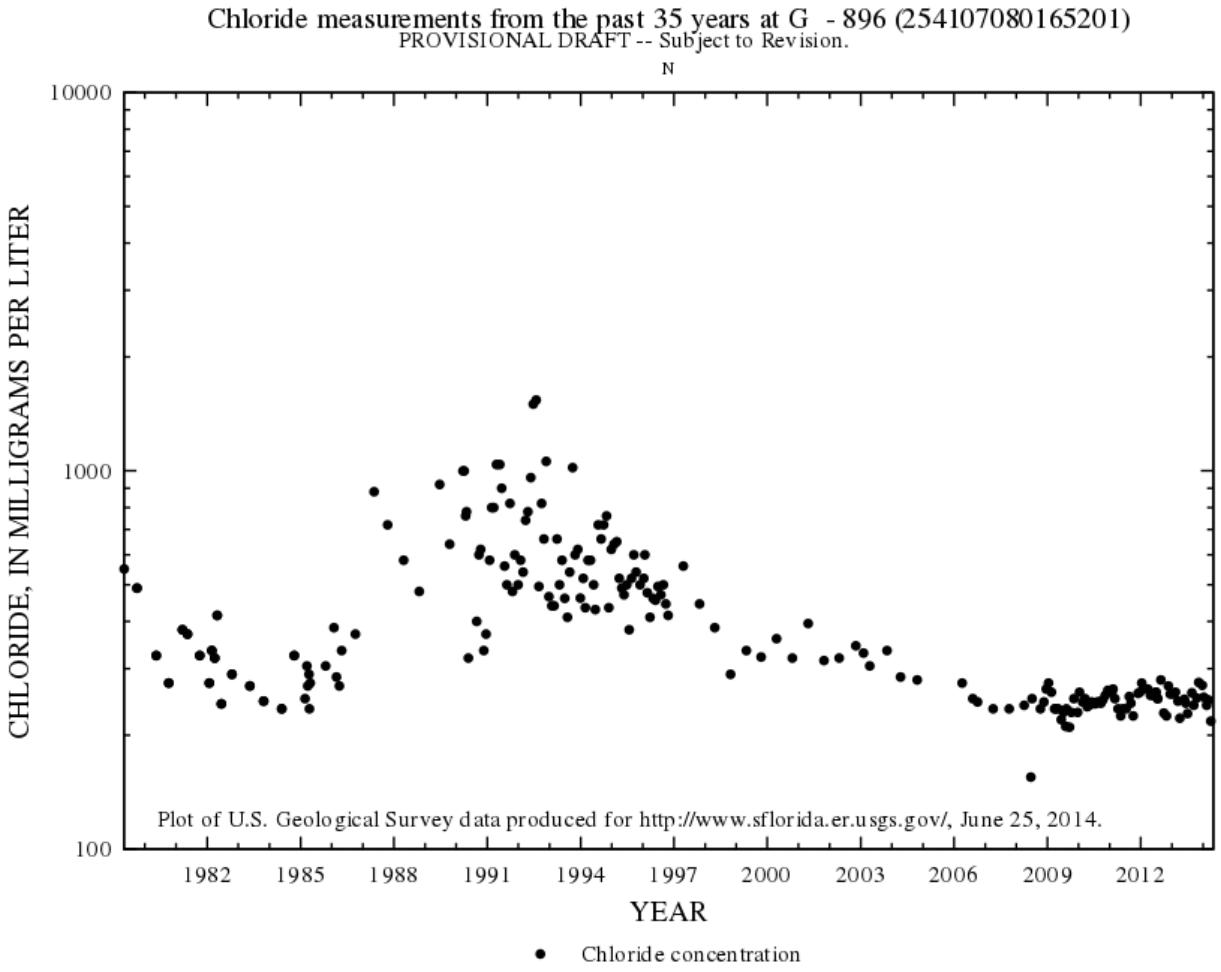

G-901
Chloride (mg/L)
2003-2015
Concentration (mg/L)
6000
5000
4000
3000
2000
1000
0
2/28/2003
9/30/2003
4/30/2004
11/30/2004
6/30/2005
1/31/2006
8/31/2006
3/31/2007
10/31/2007
5/31/2008
12/31/2008
7/31/2009
2/28/2010
9/30/2010
4/30/2011
11/30/2011
6/30/2012
1/31/2013
8/31/2013
3/31/2014
10/31/2014
5/31/2015
12/31/2015
Collection Date
Series1

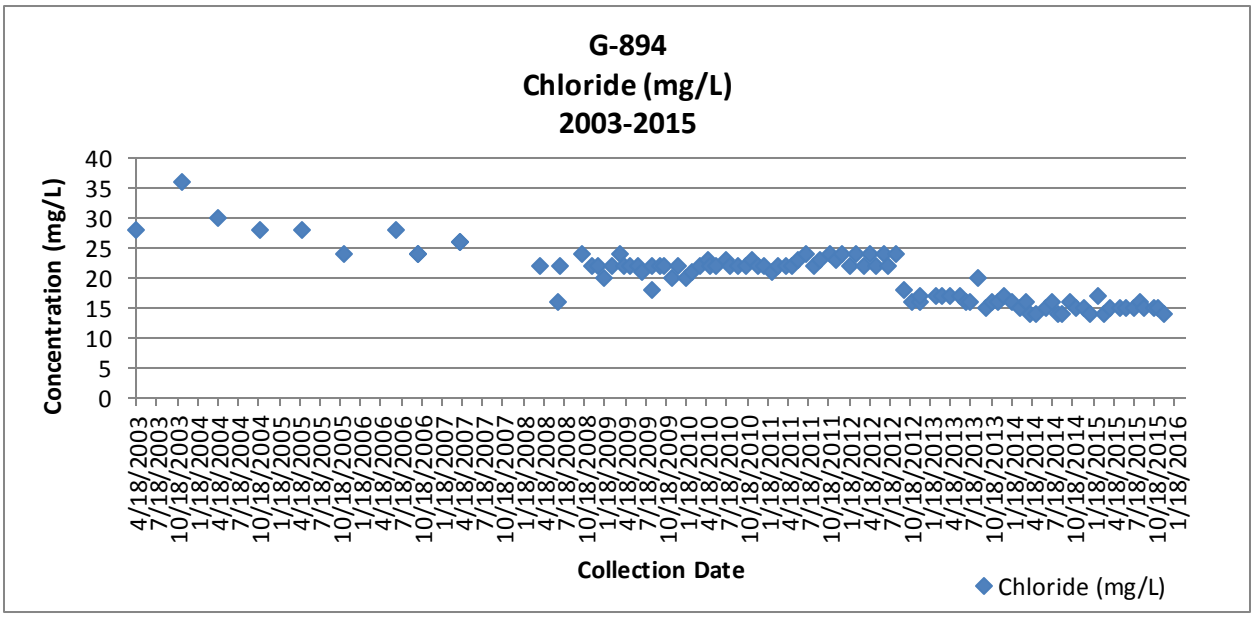

Chloride measurements from the past 35 years at G - 901 (254201080173001)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, April 23, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

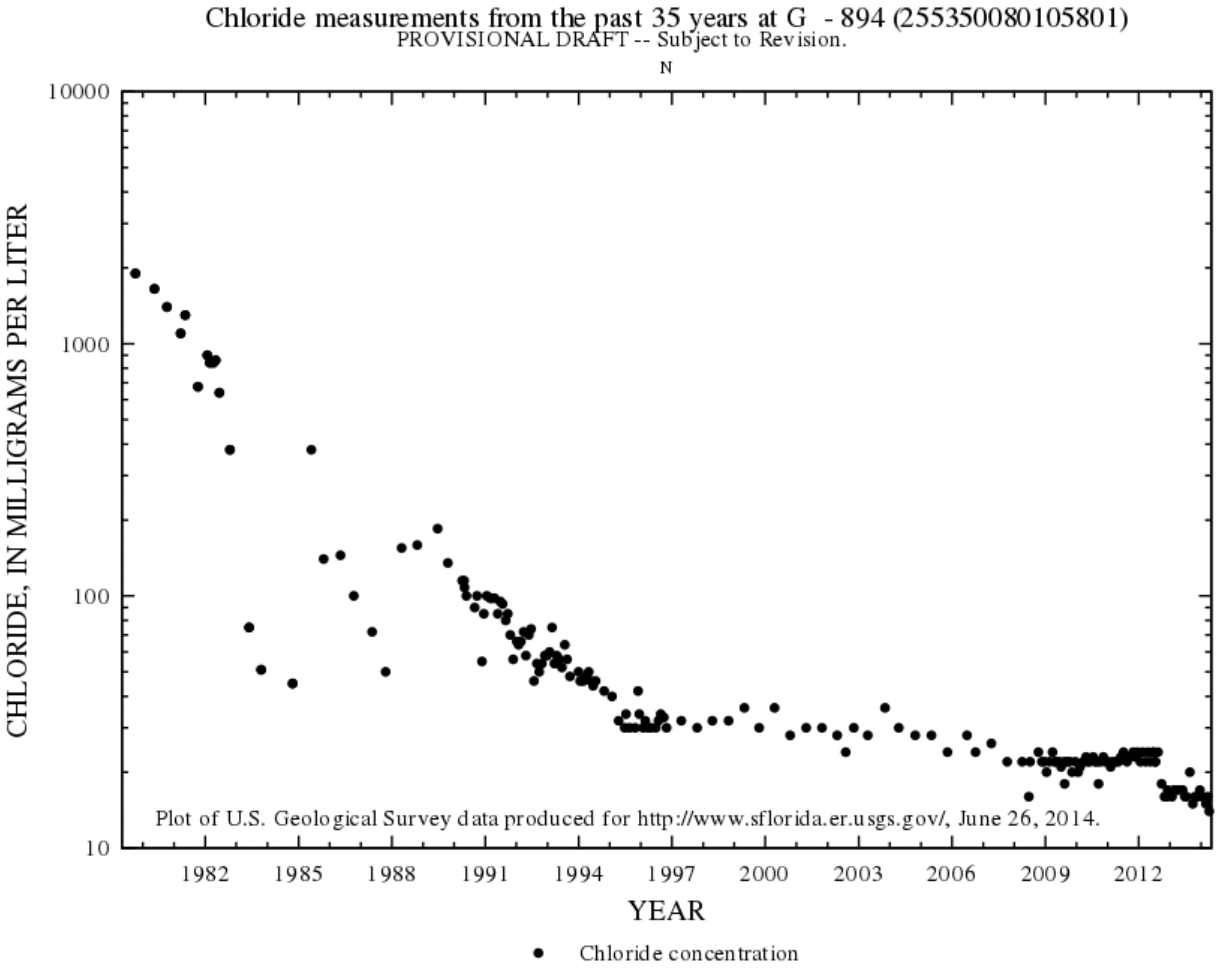

G-3611
Chloride (mg/L)
2003-2015
Concentration (mg/L)
250
200
150
100
50
0
1/1/2003
4/1/2003
7/1/2003
10/1/2003
1/1/2004
4/1/2004
7/1/2004
10/1/2004
1/1/2005
4/1/2005
7/1/2005
10/1/2005
1/1/2006
4/1/2006
7/1/2006
10/1/2006
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013
4/1/2013
7/1/2013
10/1/2013
1/1/2014
4/1/2014
7/1/2014
10/1/2014
1/1/2015
4/1/2015
7/1/2015
10/1/2015
1/1/2016
Collection Date
Chloride (mg/L)

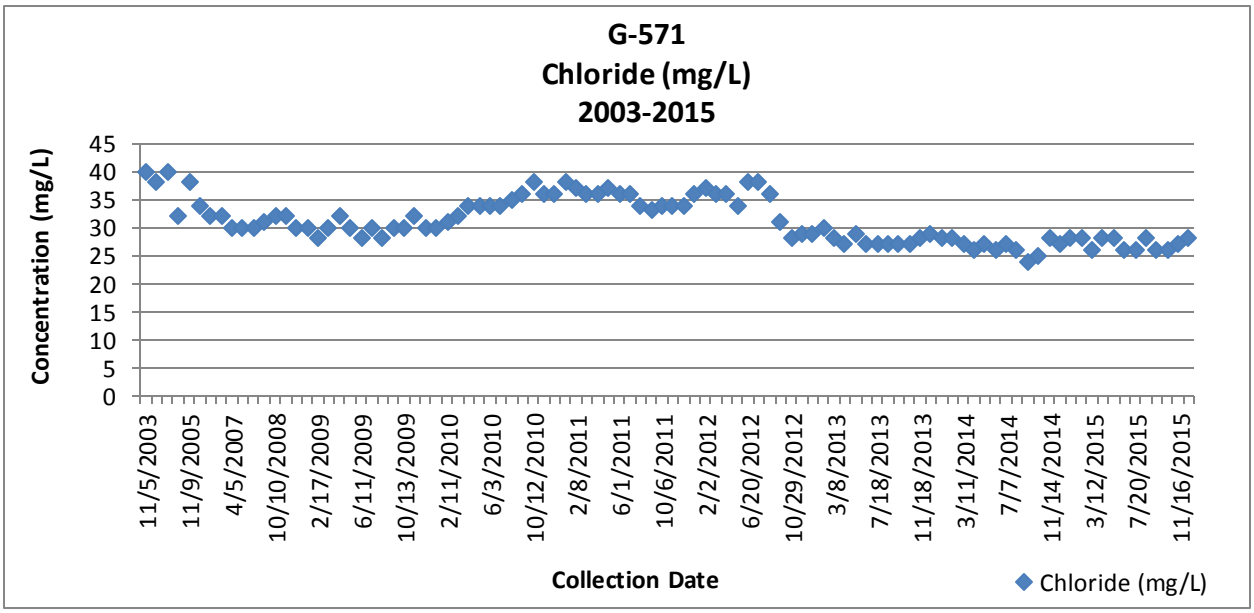

Chloride measurements from the past 35 years at G -3611 (253710080184701)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
1000
100
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 25, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

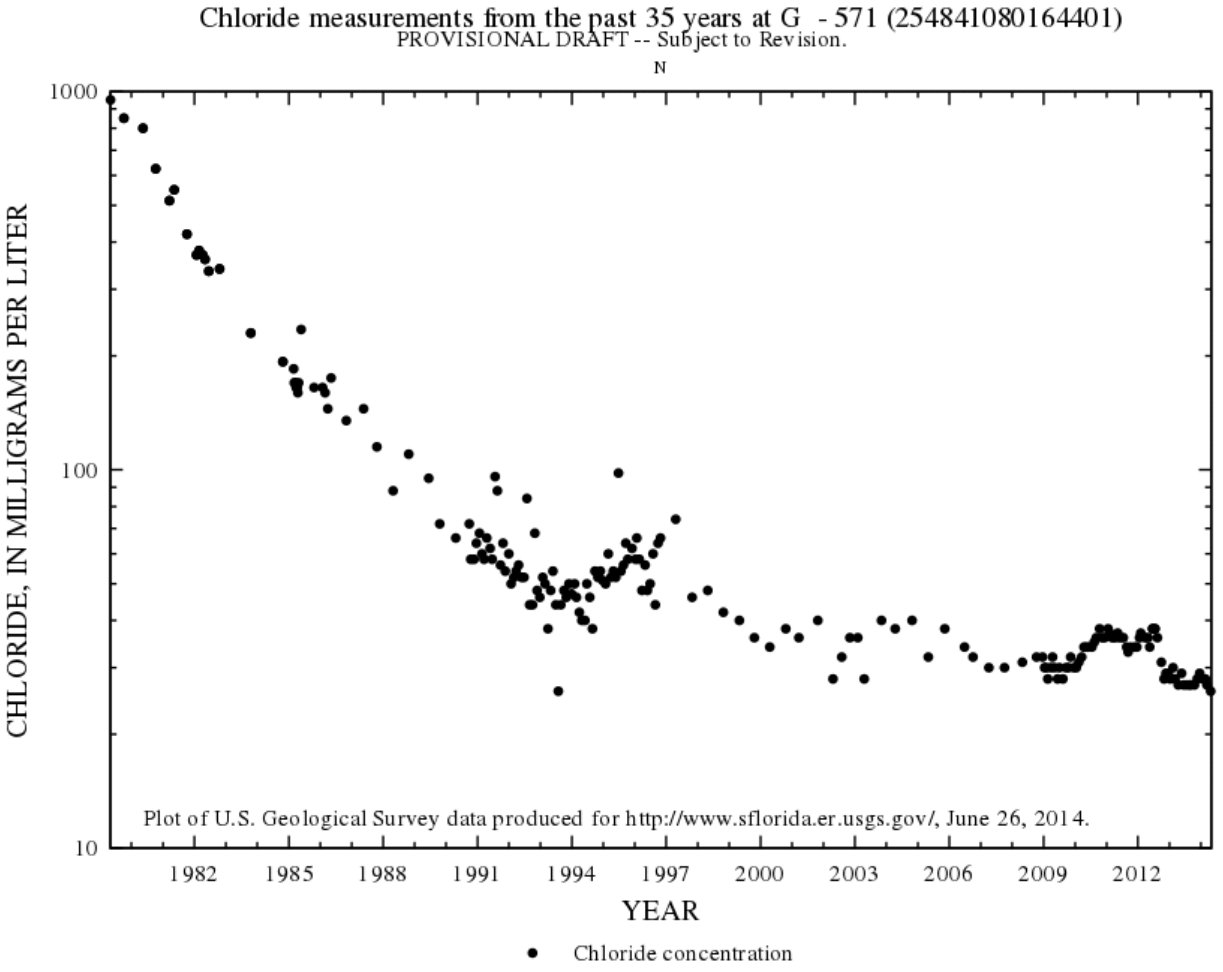

G-896
Chloride (mg/L)
2003-2015
Concentration (mg/L)
600
500
400
300
200
100
0
2/4/2003
5/4/2003
8/4/2003
11/4/2003
2/4/2004
5/4/2004
8/4/2004
11/4/2004
2/4/2005
5/4/2005
8/4/2005
11/4/2005
2/4/2006
5/4/2006
8/4/2006
11/4/2006
2/4/2007
5/4/2007
8/4/2007
11/4/2007
2/4/2008
5/4/2008
8/4/2008
11/4/2008
2/4/2009
5/4/2009
8/4/2009
11/4/2009
2/4/2010
5/4/2010
8/4/2010
11/4/2010
2/4/2011
5/4/2011
8/4/2011
11/4/2011
2/4/2012
5/4/2012
8/4/2012
11/4/2012
2/4/2013
5/4/2013
8/4/2013
11/4/2013
2/4/2014
5/4/2014
8/4/2014
11/4/2014
2/4/2015
5/4/2015
8/4/2015
11/4/2015
2/4/2016
Collection Date
Chloride (mg/L)

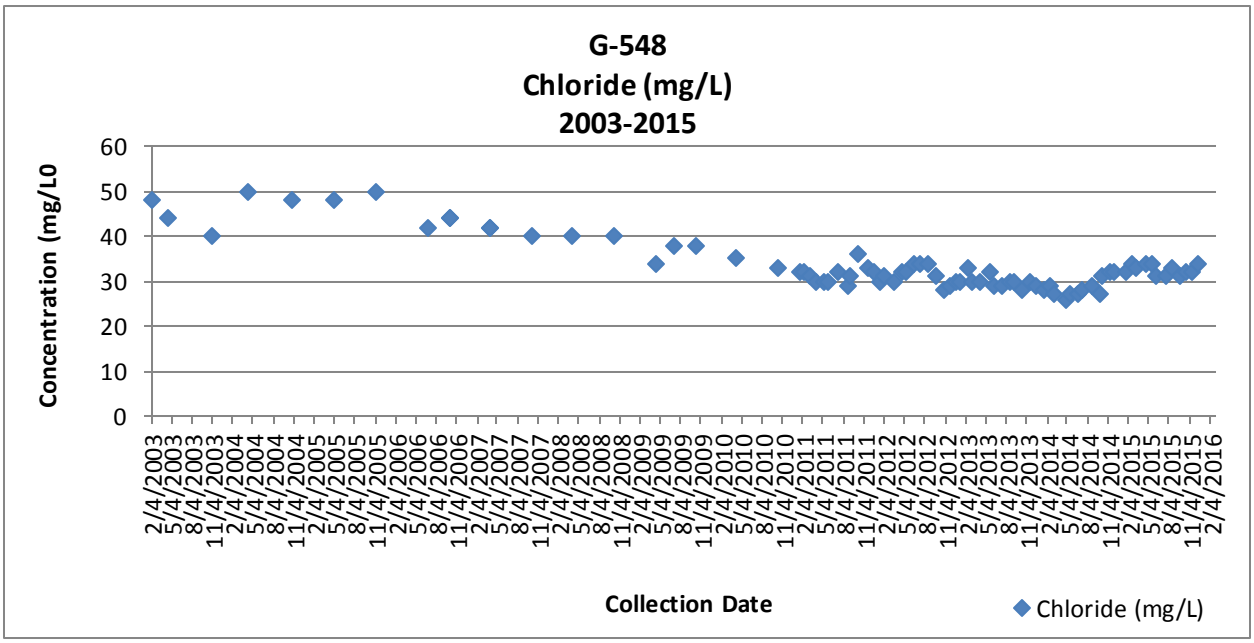

Chloride measurements from the past 35 years at G - 896 (254107080165201)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
100
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 25, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

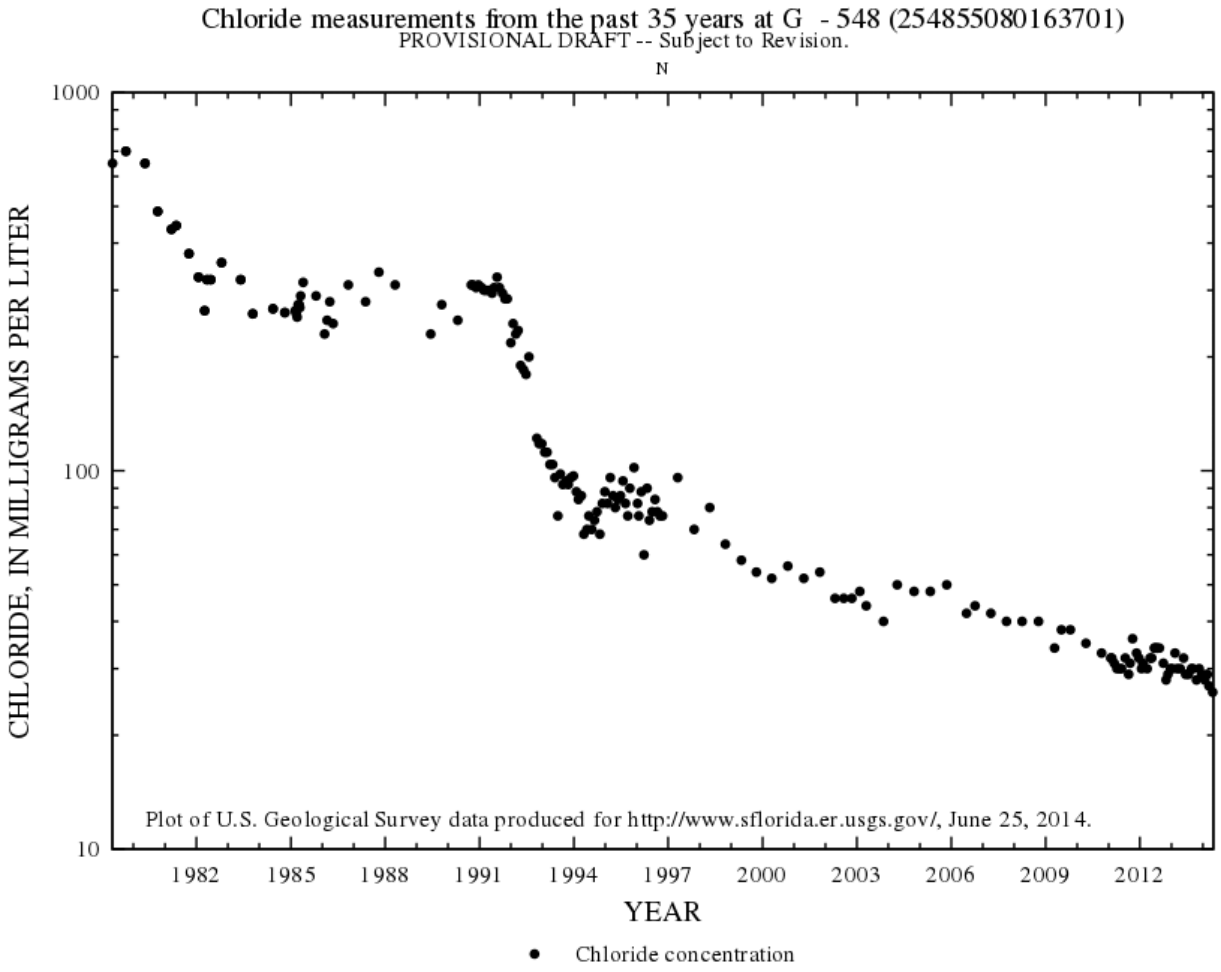

G-894
Chloride (mg/L)
2003-2015
Concentration (mg/L)
40
35
30
25
20
15
10
5
0
4/18/2003
7/18/2003
10/18/2003
1/18/2004
4/18/2004
7/18/2004
10/18/2004
1/18/2005
4/18/2005
7/18/2005
10/18/2005
1/18/2006
4/18/2006
7/18/2006
10/18/2006
1/18/2007
4/18/2007
7/18/2007
10/18/2007
1/18/2008
4/18/2008
7/18/2008
10/18/2008
1/18/2009
4/18/2009
7/18/2009
10/18/2009
1/18/2010
4/18/2010
7/18/2010
10/18/2010
1/18/2011
4/18/2011
7/18/2011
10/18/2011
1/18/2012
4/18/2012
7/18/2012
10/18/2012
1/18/2013
4/18/2013
7/18/2013
10/18/2013
1/18/2014
4/18/2014
7/18/2014
10/18/2014
1/18/2015
4/18/2015
7/18/2015
10/18/2015
1/18/2016
Collection Date
Chloride (mg/L)

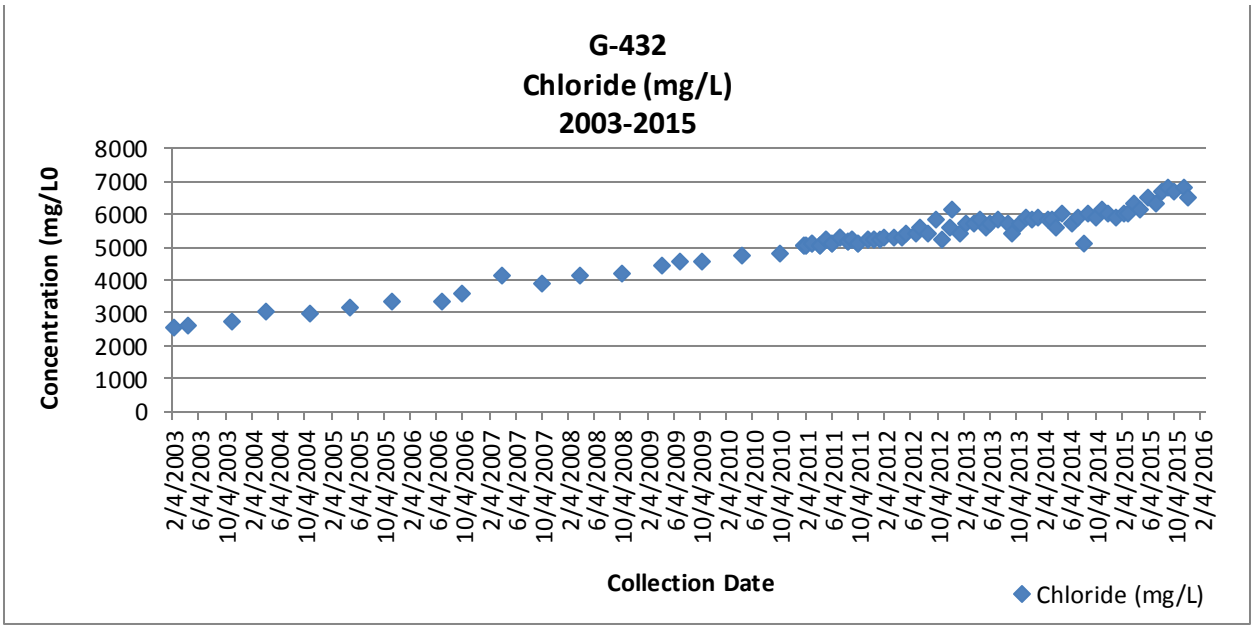

Chloride measurements from the past 35 years at G - 894 (255350080105801)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
100
10
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 26, 2014.
Chloride concentration

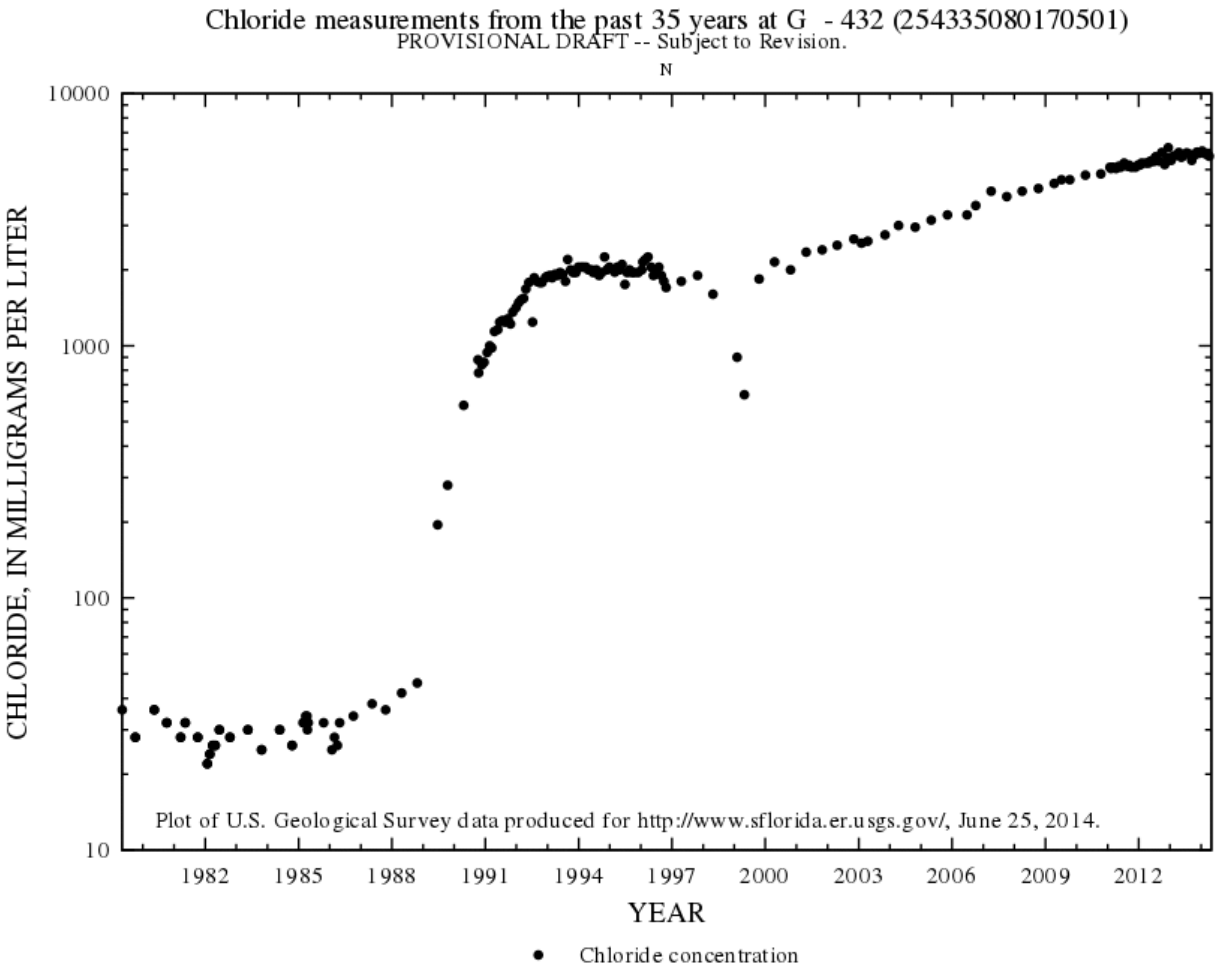

G-571
Chloride (mg/L)
2003-2015
Concentration (mg/L)
45
40
35
30
25
20
15
10
5
0
11/5/2003
11/9/2005
4/5/2007
10/10/2008
2/17/2009
6/11/2009
10/13/2009
2/11/2010
6/3/2010
10/12/2010
2/8/2011
6/1/2011
10/6/2011
2/2/2012
6/20/2012
10/29/2012
3/8/2013
7/18/2013
11/18/2013
3/11/2014
7/7/2014
11/14/2014
3/12/2015
7/20/2015
11/16/2015
Collection Date
Chloride (mg/L)

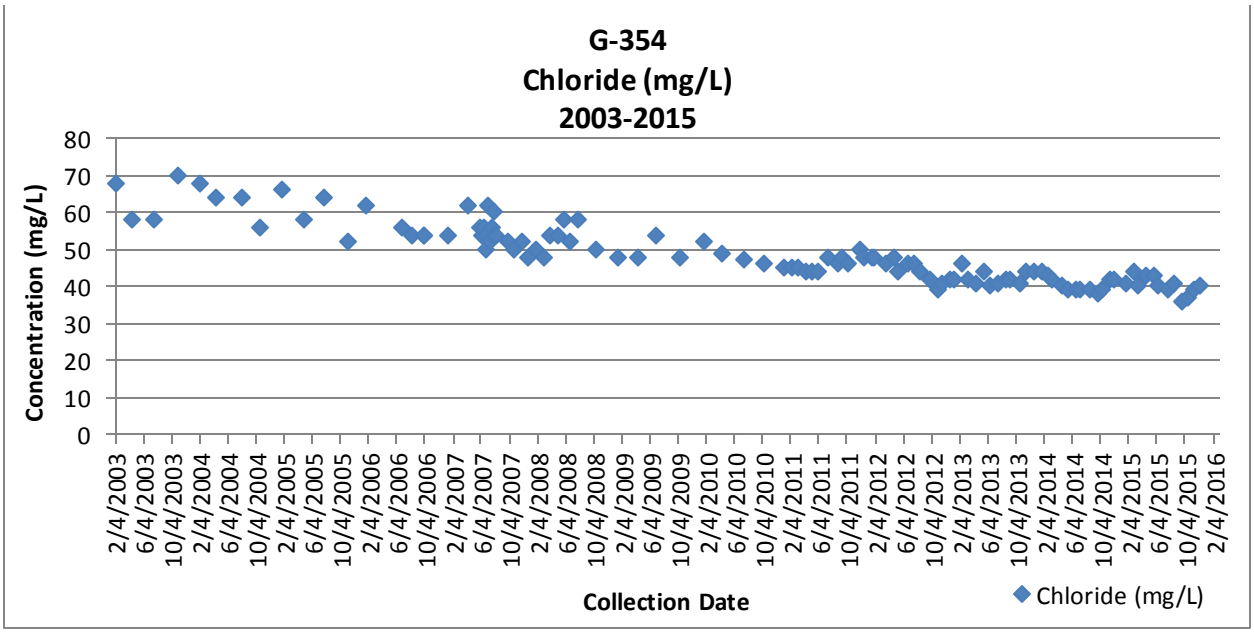

Chloride measurements from the past 35 years at G - 571 (254841080164401)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
1000
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 26, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

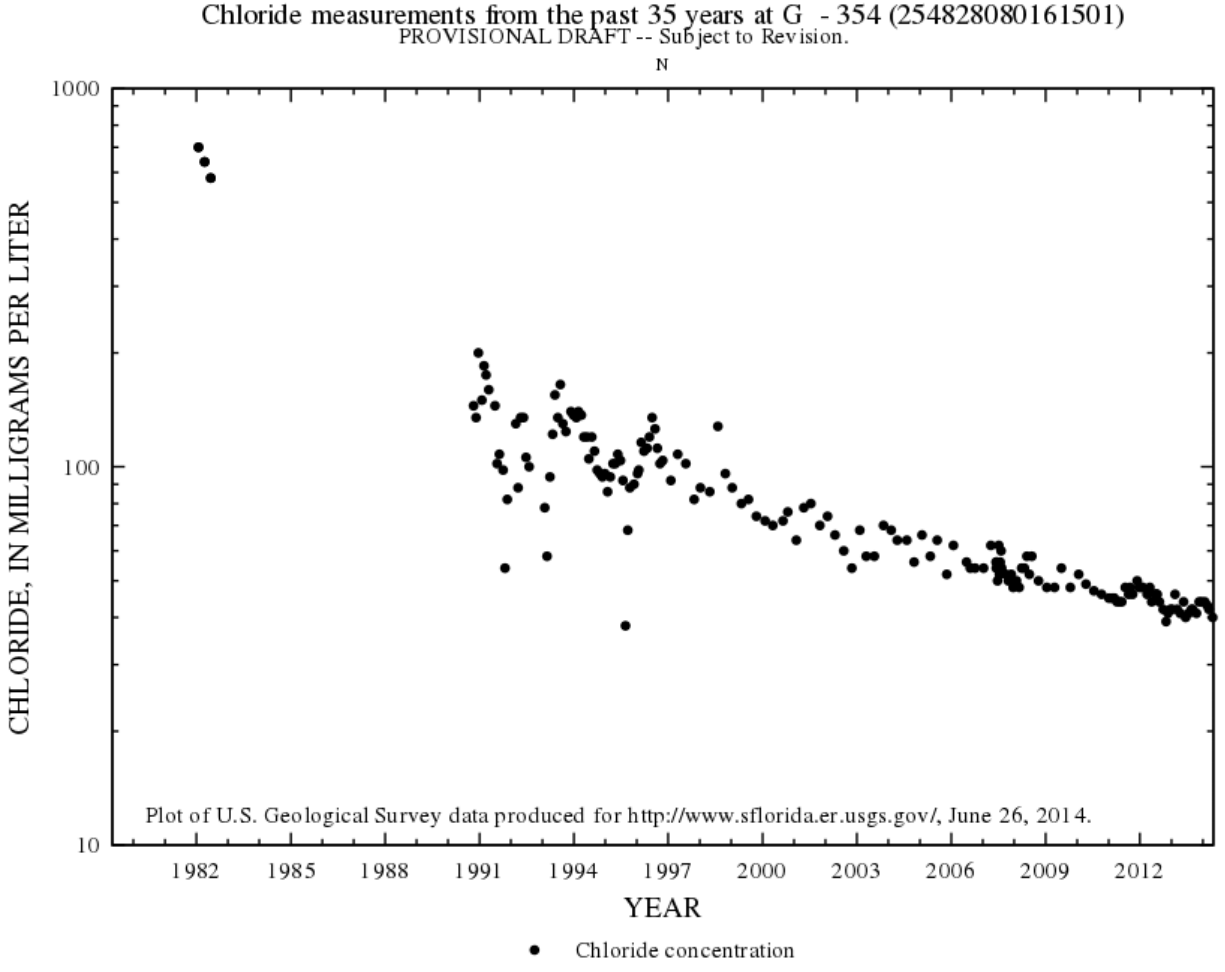

G-548
Chloride (mg/L)
2003-2015
Concentration (mg/L0
60
50
40
30
20
10
0
2/4/2003
5/4/2003
8/4/2003
11/4/2003
2/4/2004
5/4/2004
8/4/2004
11/4/2004
2/4/2005
5/4/2005
8/4/2005
11/4/2005
2/4/2006
5/4/2006
8/4/2006
11/4/2006
2/4/2007
5/4/2007
8/4/2007
11/4/2007
2/4/2008
5/4/2008
8/4/2008
11/4/2008
2/4/2009
5/4/2009
8/4/2009
11/4/2009
2/4/2010
5/4/2010
8/4/2010
11/4/2010
2/4/2011
5/4/2011
8/4/2011
11/4/2011
2/4/2012
5/4/2012
8/4/2012
11/4/2012
2/4/2013
5/4/2013
8/4/2013
11/4/2013
2/4/2014
5/4/2014
8/4/2014
11/4/2014
2/4/2015
5/4/2015
8/4/2015
11/4/2015
2/4/2016
Collection Date
Chloride (mg/L)

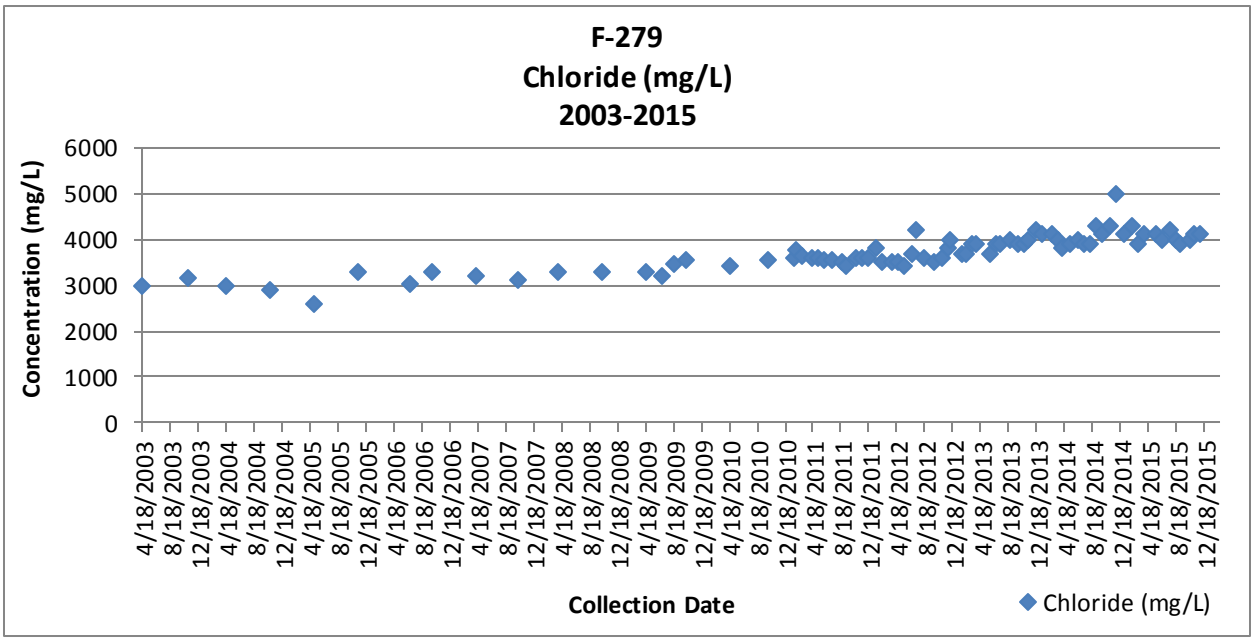

Chloride measurements from the past 35 years at G - 548 (254855080163701)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
1000
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 25, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

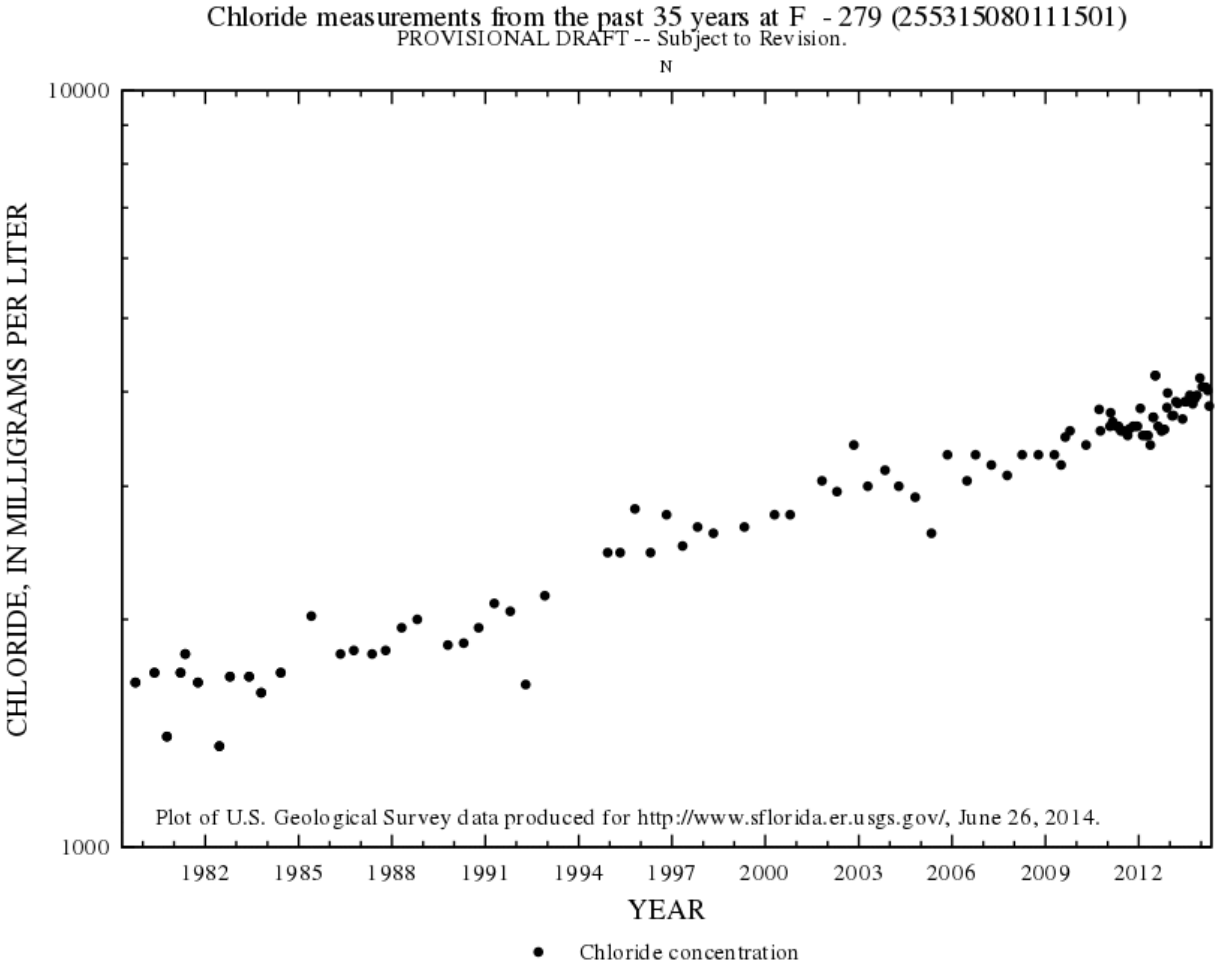

G-432
Chloride (mg/L)
2003-2015
Concentration (mg/L0
8000
7000
6000
5000
4000
3000
2000
1000
0
2/4/2003
6/4/2003
10/4/2003
2/4/2004
6/4/2004
10/4/2004
2/4/2005
6/4/2005
10/4/2005
2/4/2006
6/4/2006
10/4/2006
2/4/2007
6/4/2007
10/4/2007
2/4/2008
6/4/2008
10/4/2008
2/4/2009
6/4/2009
10/4/2009
2/4/2010
6/4/2010
10/4/2010
2/4/2011
6/4/2011
10/4/2011
2/4/2012
6/4/2012
10/4/2012
2/4/2013
6/4/2013
10/4/2013
2/4/2014
6/4/2014
10/4/2014
2/4/2015
6/4/2015
10/4/2015
2/4/2016
Collection Date
Chloride (mg/L)

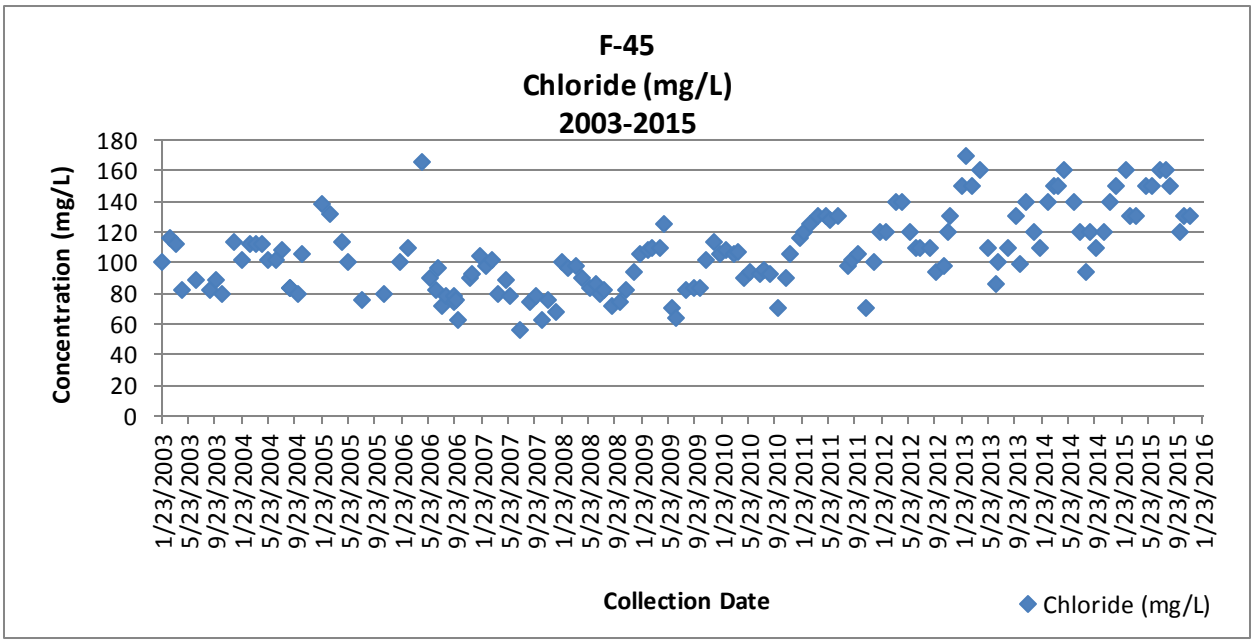

Chloride measurements from the past 35 years at G - 432 (254335080170501)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 25, 2014.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

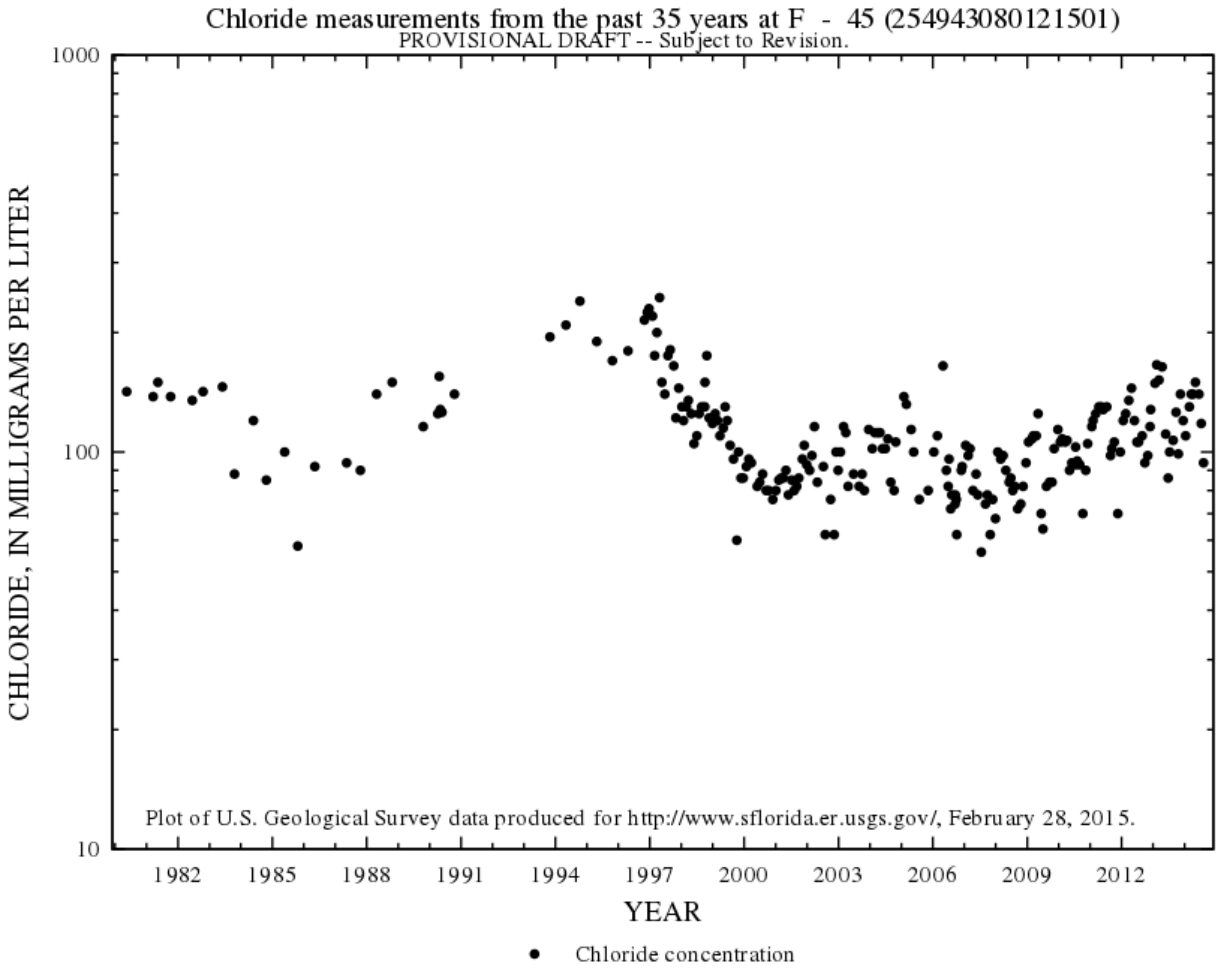

G-354
Chloride (mg/L)
2003-2015
Concentration (mg/L)
80
70
60
50
40
30
20
10
0
2/4/2003
6/4/2003
10/4/2003
2/4/2004
6/4/2004
10/4/2004
2/4/2005
6/4/2005
10/4/2005
2/4/2006
6/4/2006
10/4/2006
2/4/2007
6/4/2007
10/4/2007
2/4/2008
6/4/2008
10/4/2008
2/4/2009
6/4/2009
10/4/2009
2/4/2010
6/4/2010
10/4/2010
2/4/2011
6/4/2011
10/4/2011
2/4/2012
6/4/2012
10/4/2012
2/4/2013
6/4/2013
10/4/2013
2/4/2014
6/4/2014
10/4/2014
2/4/2015
6/4/2015
10/4/2015
2/4/2016
Collection Date
Chloride (mg/L)

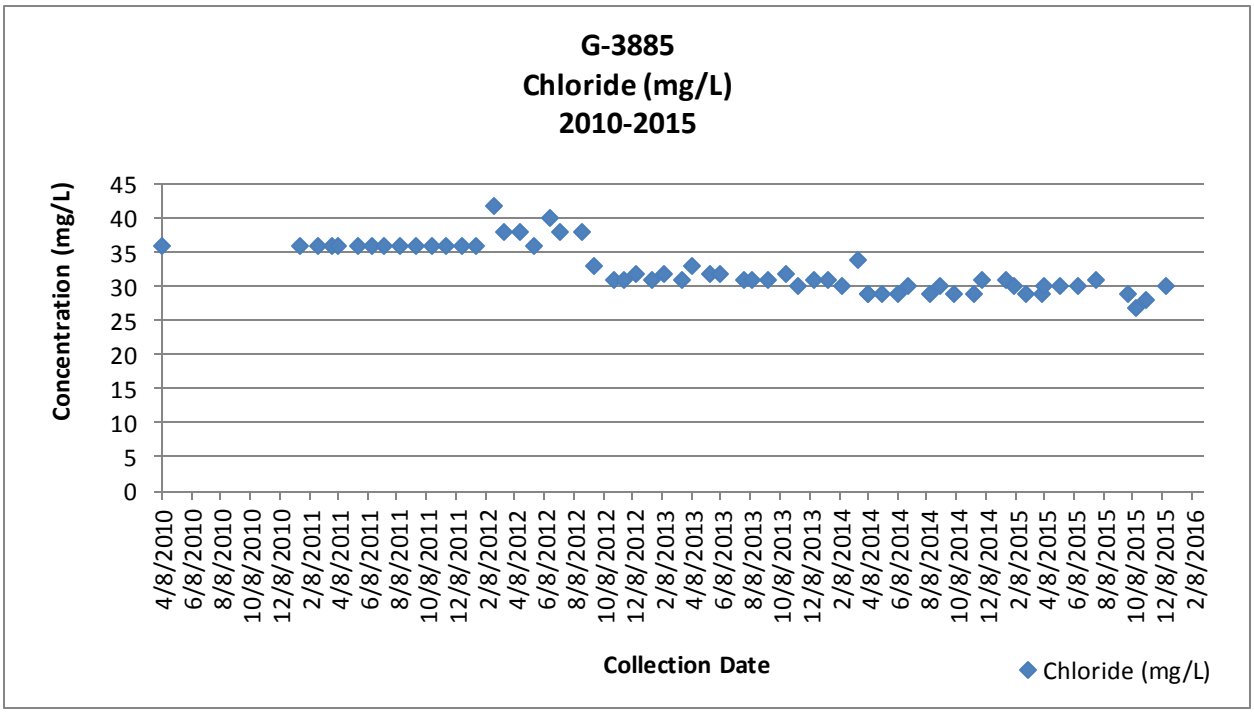

Chloride measurements from the past 35 years at G - 354 (254828080161501)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
1000
100
10
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 26, 2014.
Chloride concentration

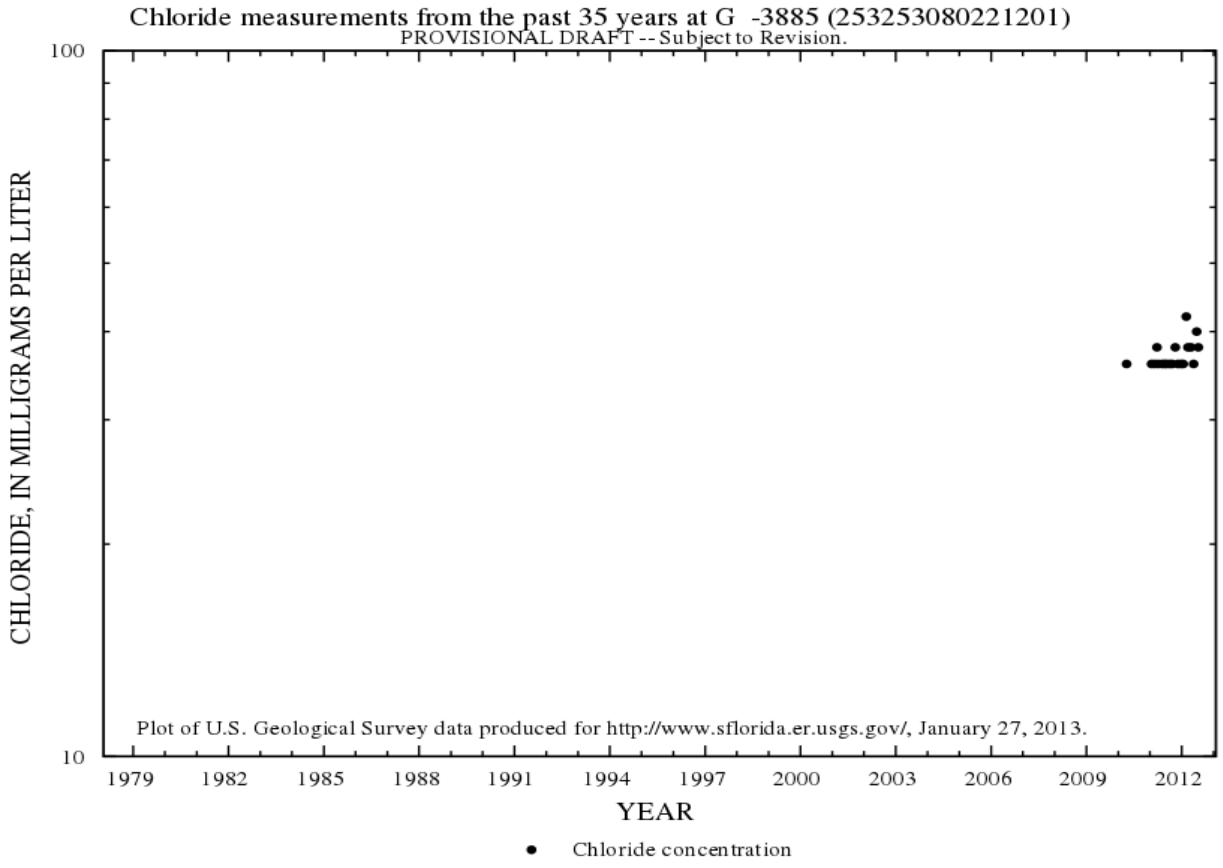

F-279
Chloride (mg/L)
2003-2015
Concentration (mg/L)
6000
5000
4000
3000
2000
1000
0
4/18/2003
8/18/2003
12/18/2003
4/18/2004
8/18/2004
12/18/2004
4/18/2005
8/18/2005
12/18/2005
4/18/2006
8/18/2006
12/18/2006
4/18/2007
8/18/2007
12/18/2007
4/18/2008
8/18/2008
12/18/2008
4/18/2009
8/18/2009
12/18/2009
4/18/2010
8/18/2010
12/18/2010
4/18/2011
8/18/2011
12/18/2011
4/18/2012
8/18/2012
12/18/2012
4/18/2013
8/18/2013
12/18/2013
4/18/2014
8/18/2014
12/18/2014
4/18/2015
8/18/2015
12/18/2015
Collection Date
Chloride (mg/L)

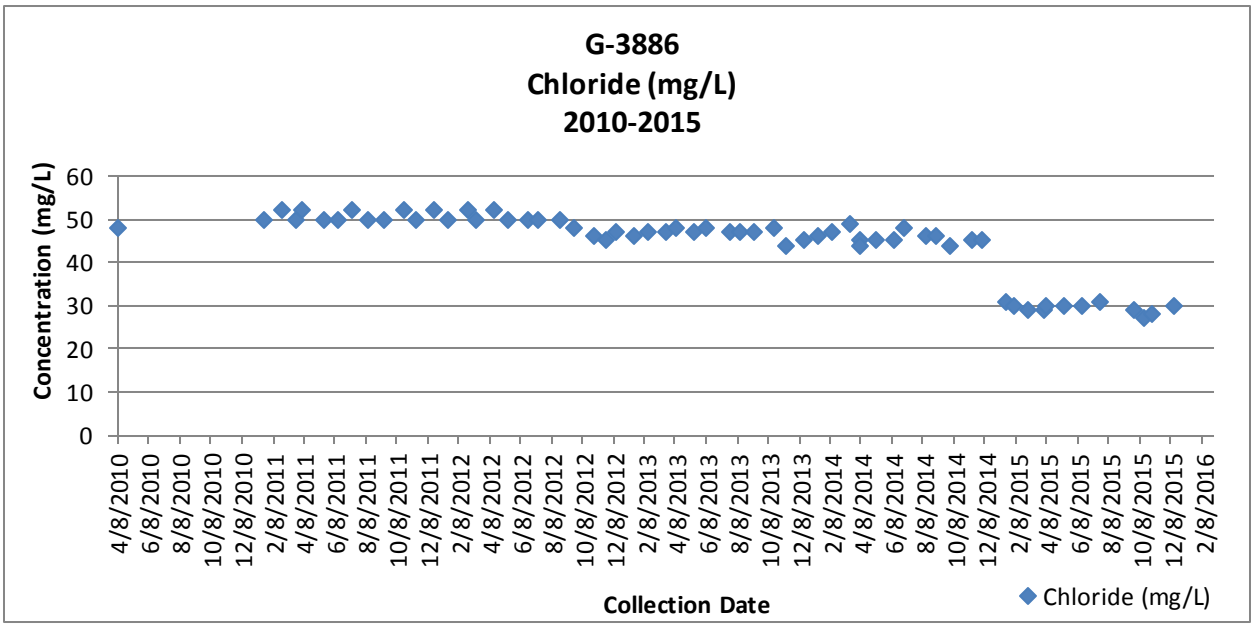

Chloride measurements from the past 35 years at F - 279 (255315080111501)
PROVISIONAL DRAFT -- Subject to Revision.
N
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, June 26, 2014.
Chloride concentration

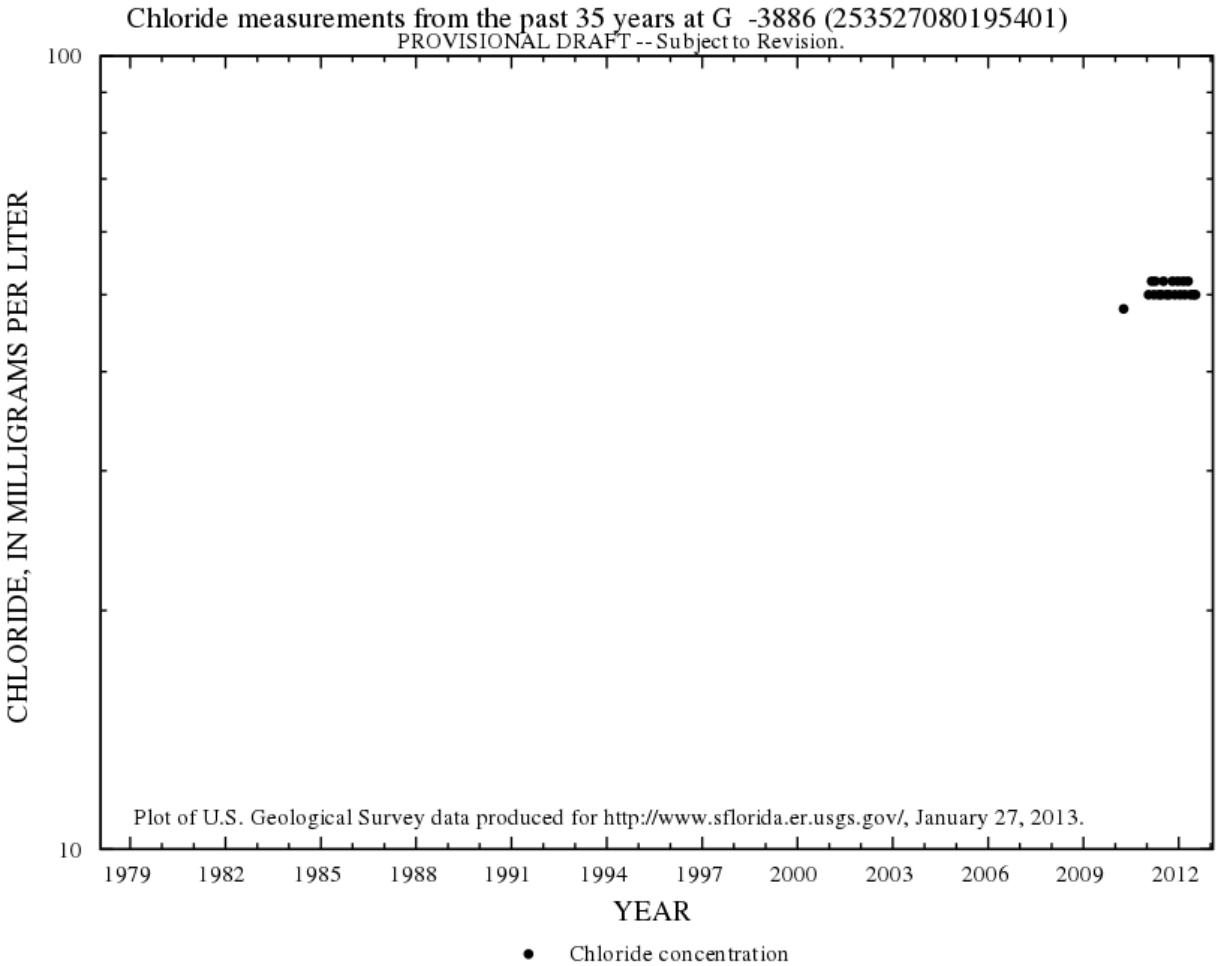

F-45
Chloride (mg/L)
2003-2015
Concentration (mg/L)
180
160
140
120
100
80
60
40
20
0
1/23/2003
5/23/2003
9/23/2003
1/23/2004
5/23/2004
9/23/2004
1/23/2005
5/23/2005
9/23/2005
1/23/2006
5/23/2006
9/23/2006
1/23/2007
5/23/2007
9/23/2007
1/23/2008
5/23/2008
9/23/2008
1/23/2009
5/23/2009
9/23/2009
1/23/2010
5/23/2010
9/23/2010
1/23/2011
5/23/2011
9/23/2011
1/23/2012
5/23/2012
9/23/2012
1/23/2013
5/23/2013
9/23/2013
1/23/2014
5/23/2014
9/23/2014
1/23/2015
5/23/2015
9/23/2015
1/23/2016
Collection Date
Chloride (mg/L)

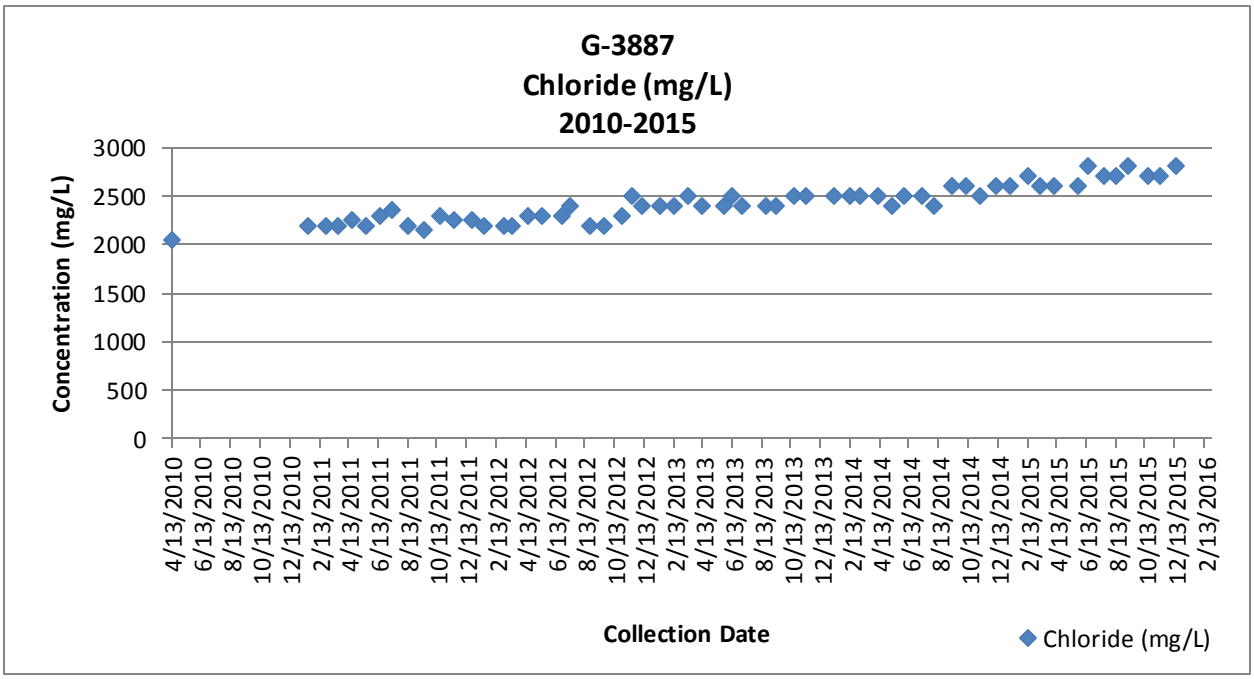

Chloride measurements from the past 35 years at F - 45 (254943080121501)
PROVISIONAL DRAFT -- Subject to Revision.
CHLORIDE, IN MILLIGRAMS PER LITER
1000
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, February 28, 2015.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

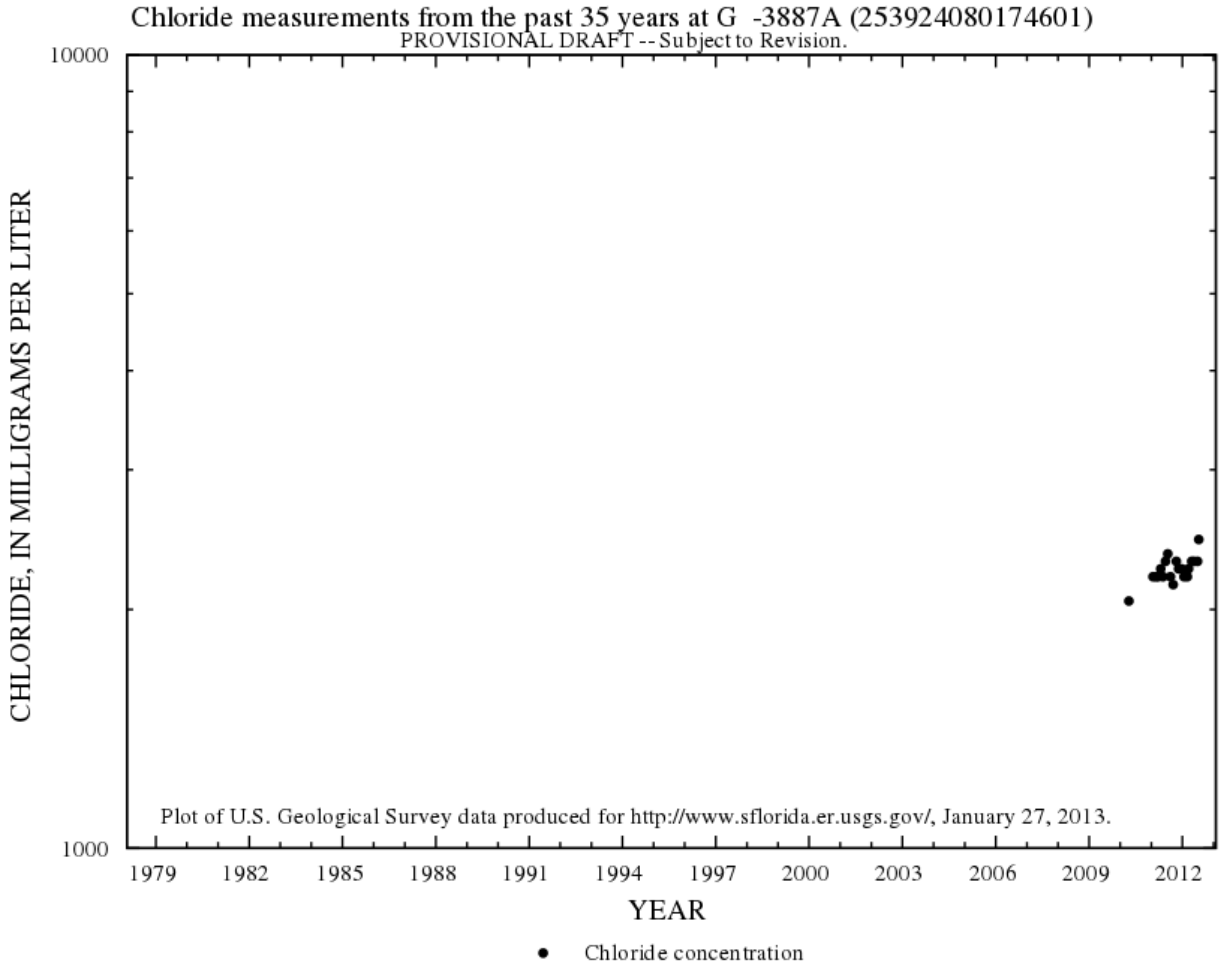

G-3885
Chloride (mg/L)
2010-2015
Concentration (mg/L)
45
40
35
30
25
20
15
10
5
0
4/8/2010
6/8/2010
8/8/2010
10/8/2010
12/8/2010
2/8/2011
4/8/2011
6/8/2011
8/8/2011
10/8/2011
12/8/2011
2/8/2012
4/8/2012
6/8/2012
8/8/2012
10/8/2012
12/8/2012
2/8/2013
4/8/2013
6/8/2013
8/8/2013
10/8/2013
12/8/2013
2/8/2014
4/8/2014
6/8/2014
8/8/2014
10/8/2014
12/8/2014
2/8/2015
4/8/2015
6/8/2015
8/8/2015
10/8/2015
12/8/2015
2/8/2016
Collection Date
Chloride (mg/L)

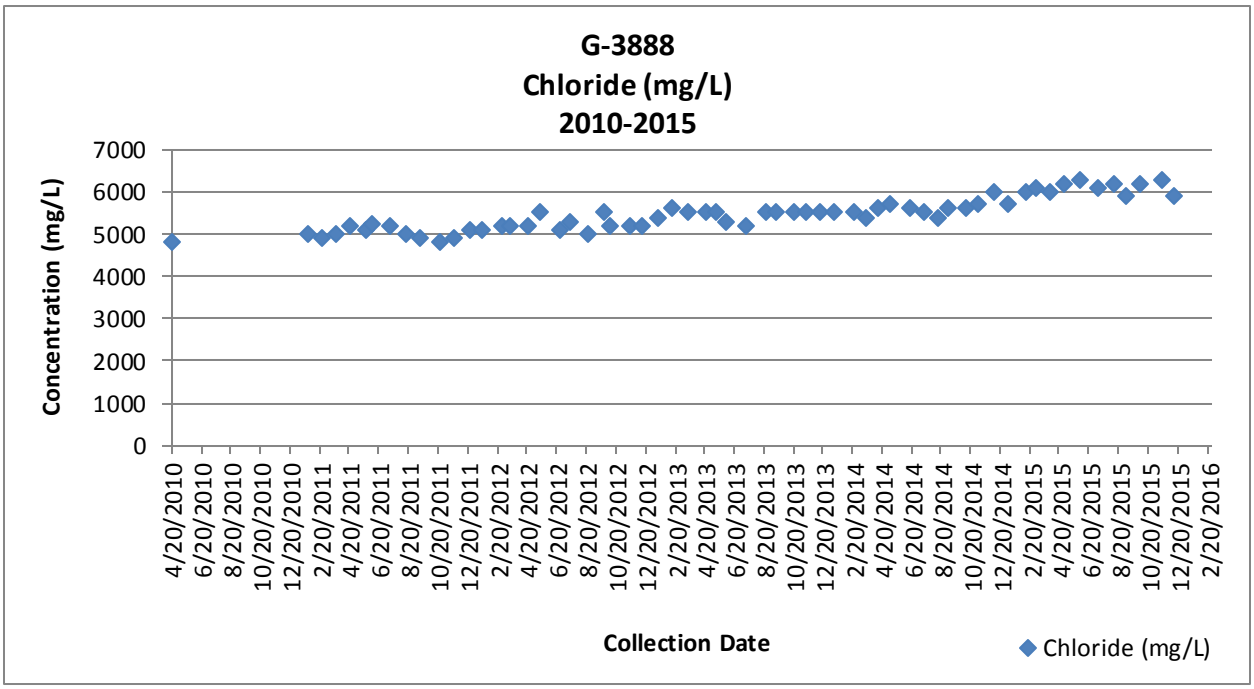

Chloride measurements from the past 35 years at G -3885 (253253080221201)
PROVISIONAL DRAFT -- Subject to Revision.
CHLORIDE, IN MILLIGRAMS PER LITER
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, January 27, 2013.
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

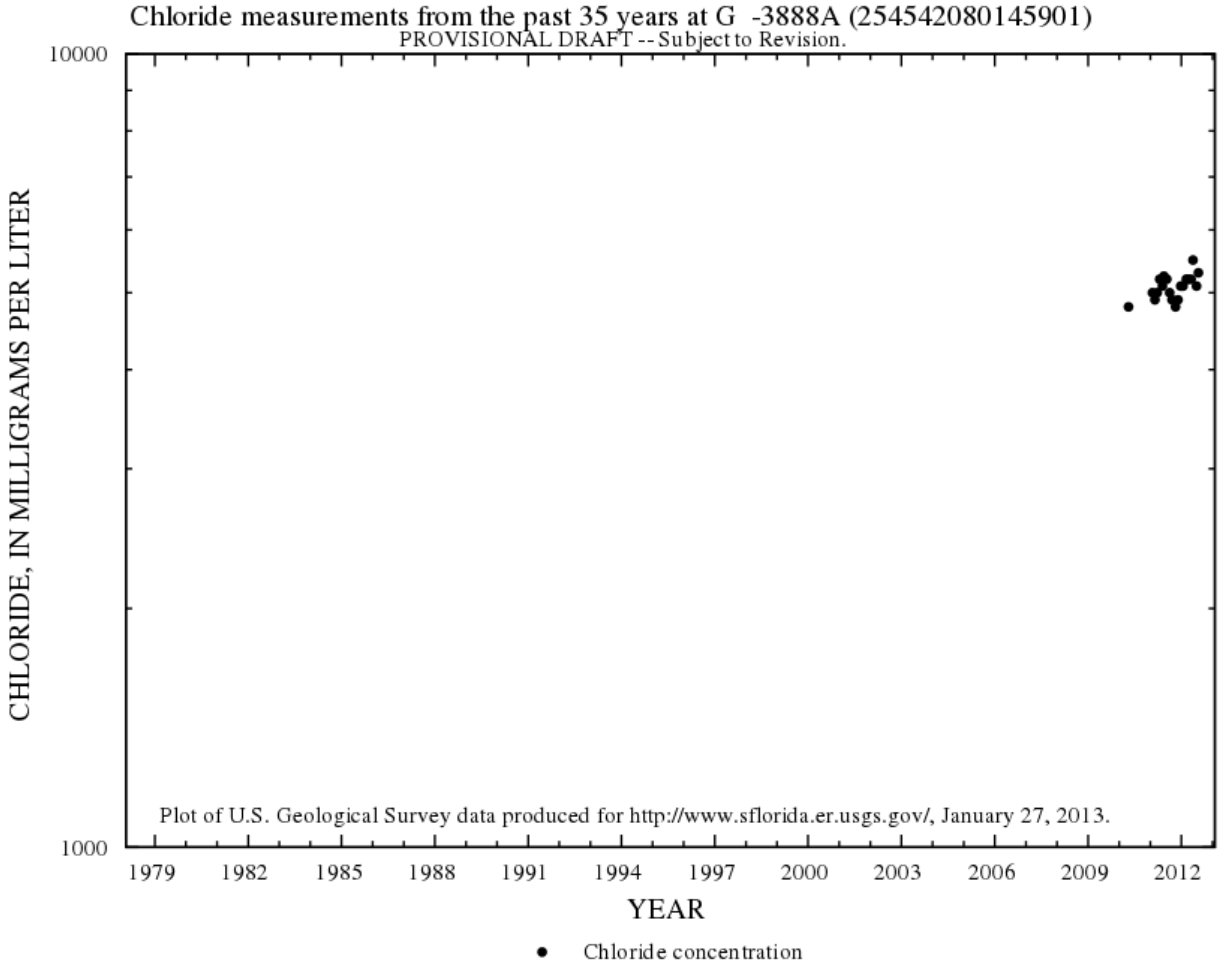

G-3886
Chloride (mg/L)
2010-2015
Concentration (mg/L)
60
50
40
30
20
10
0
4/8/2010
6/8/2010
8/8/2010
10/8/2010
12/8/2010
2/8/2011
4/8/2011
6/8/2011
8/8/2011
10/8/2011
12/8/2011
2/8/2012
4/8/2012
6/8/2012
8/8/2012
10/8/2012
12/8/2012
2/8/2013
4/8/2013
6/8/2013
8/8/2013
10/8/2013
12/8/2013
2/8/2014
4/8/2014
6/8/2014
8/8/2014
10/8/2014
12/8/2014
2/8/2015
4/8/2015
6/8/2015
8/8/2015
10/8/2015
12/8/2015
2/8/2016
Collection Date
Chloride (mg/L)

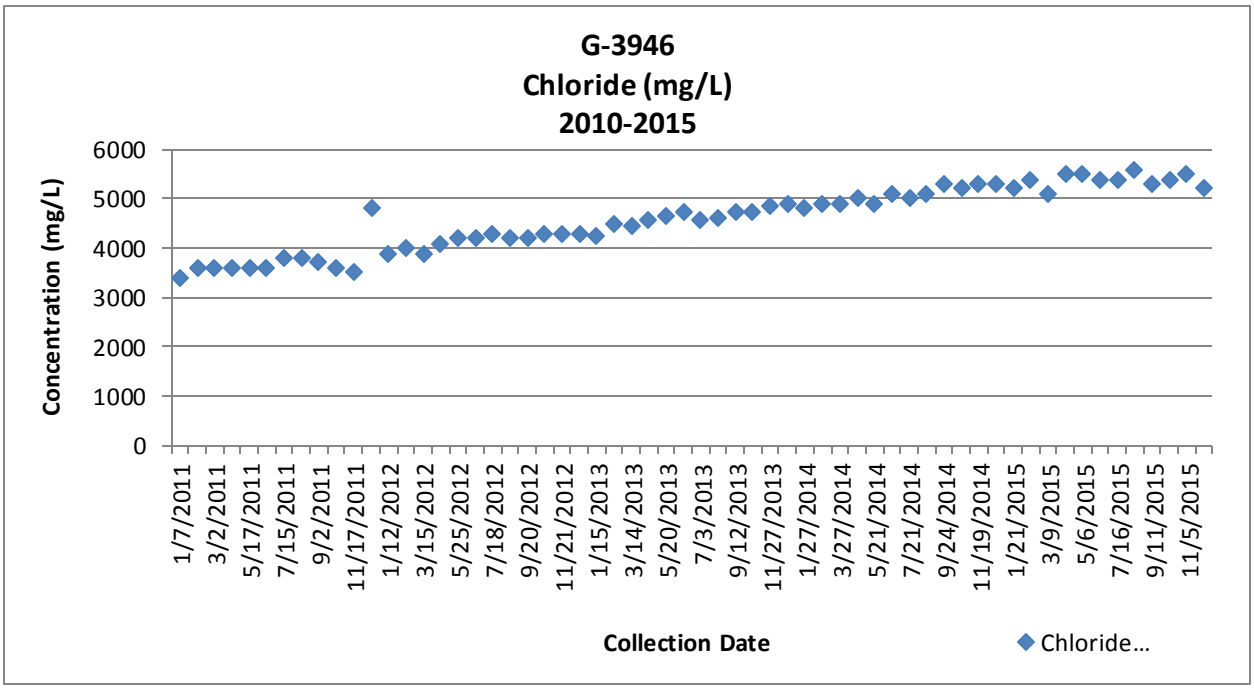

Chloride measurements from the past 35 years at G -3886 (253527080195401)
PROVISIONAL DRAFT -- Subject to Revision.
CHLORIDE, IN MILLIGRAMS PER LITER
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, January 27, 2013.
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

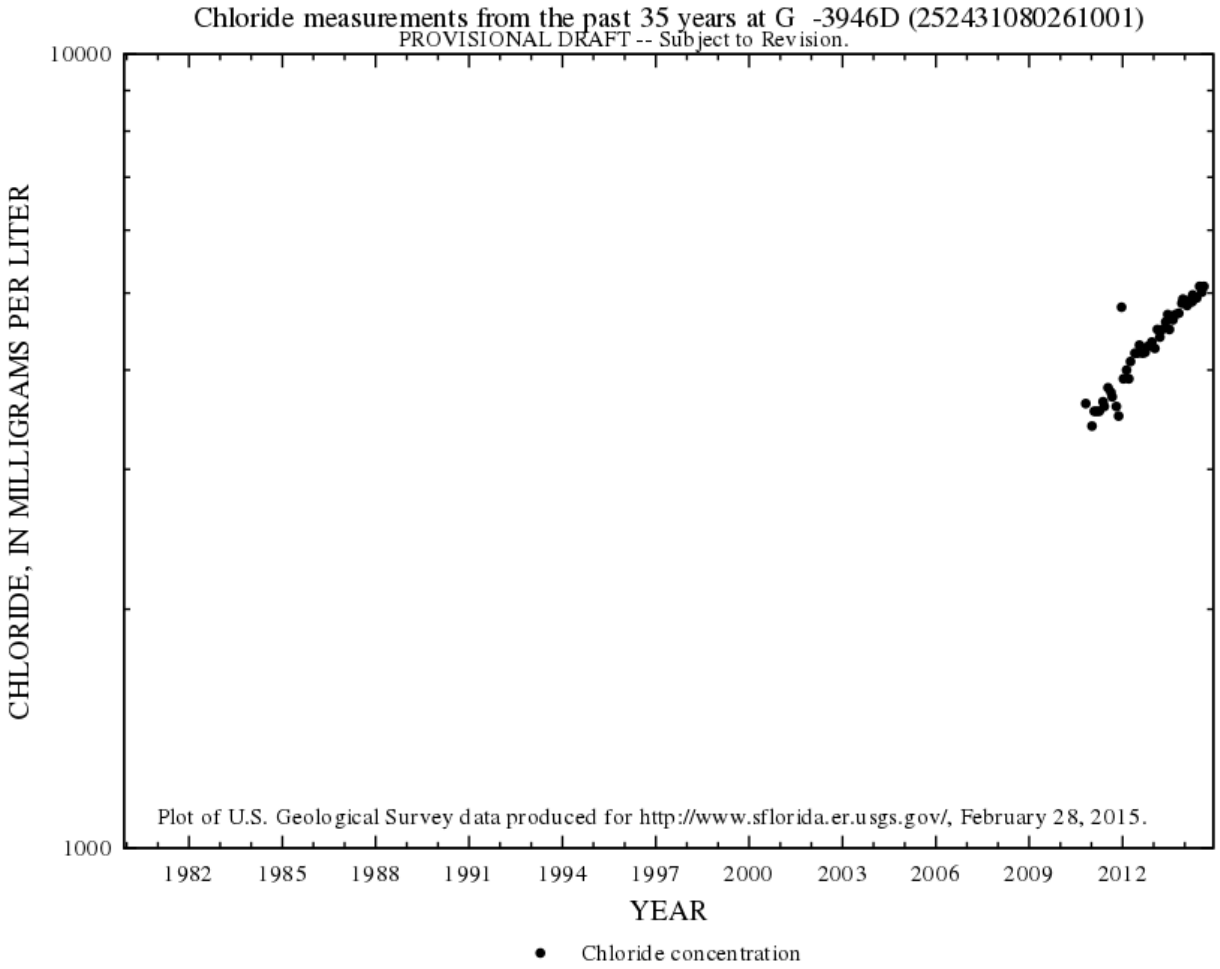

G-3887
Chloride (mg/L)
2010-2015
Concentration (mg/L)
3000
2500
2000
1500
1000
500
0
4/13/2010
6/13/2010
8/13/2010
10/13/2010
12/13/2010
2/13/2011
4/13/2011
6/13/2011
8/13/2011
10/13/2011
12/13/2011
2/13/2012
4/13/2012
6/13/2012
8/13/2012
10/13/2012
12/13/2012
2/13/2013
4/13/2013
6/13/2013
8/13/2013
10/13/2013
12/13/2013
2/13/2014
4/13/2014
6/13/2014
8/13/2014
10/13/2014
12/13/2014
2/13/2015
4/13/2015
6/13/2015
8/13/2015
10/13/2015
12/13/2015
2/13/2016
Collection Date
Chloride (mg/L)

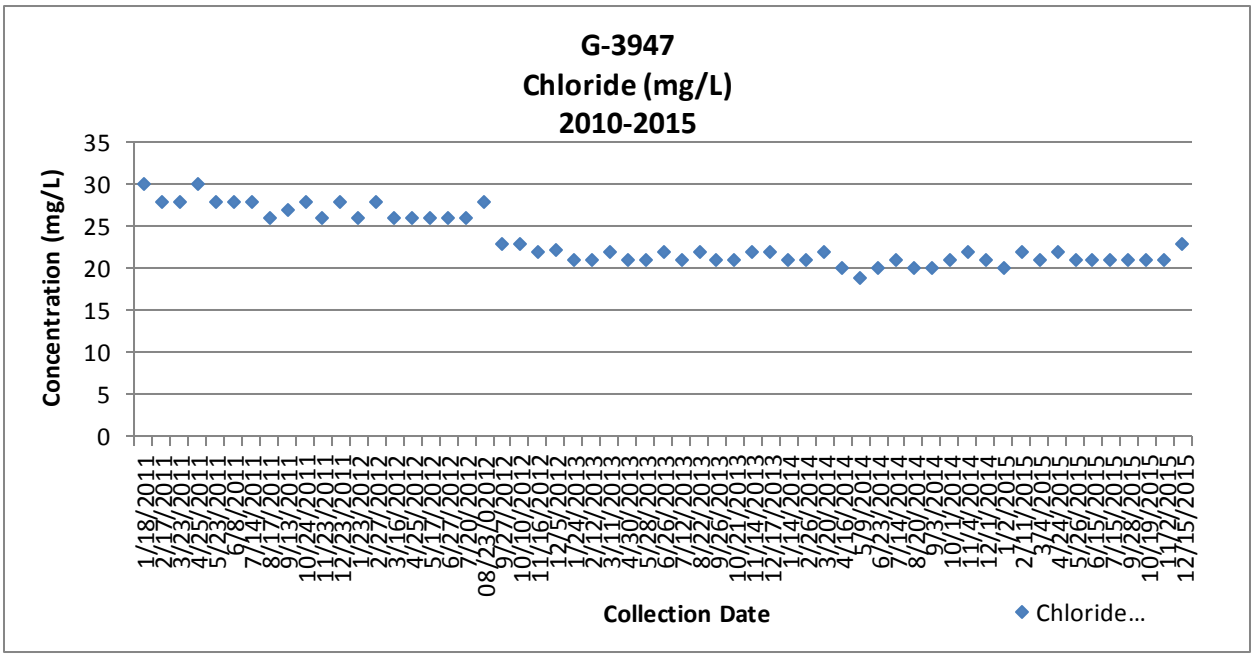

Chloride measurements from the past 35 years at G -3887A (253924080174601)
PROVISIONAL DRAFT -- Subject to Revision.
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, January 27, 2013.
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

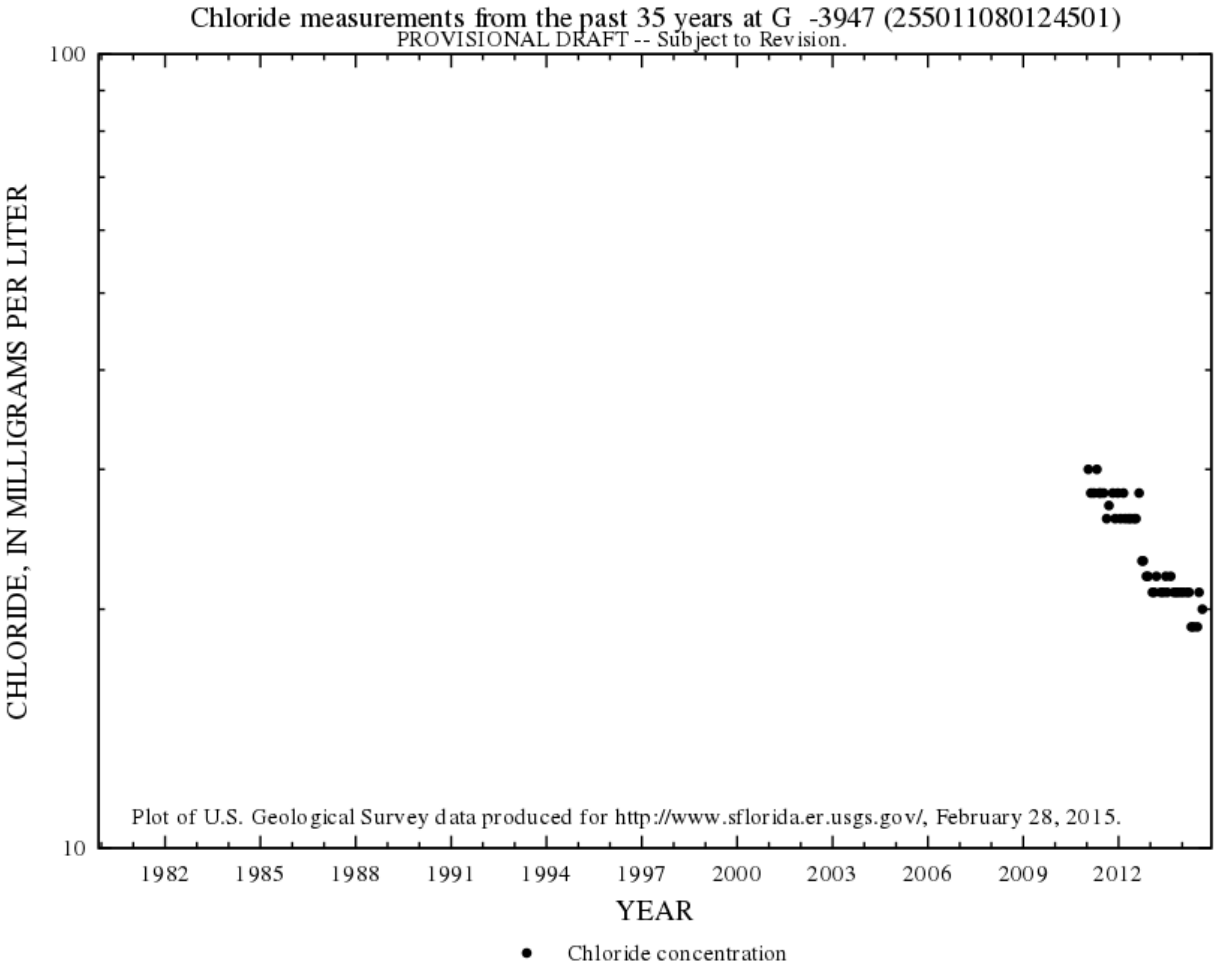

G-3888
Chloride (mg/L)
2010-2015
Concentration (mg/L)
7000
6000
5000
4000
3000
2000
1000
0
4/20/2010
6/20/2010
8/20/2010
10/20/2010
12/20/2010
2/20/2011
4/20/2011
6/20/2011
8/20/2011
10/20/2011
12/20/2011
2/20/2012
4/20/2012
6/20/2012
8/20/2012
10/20/2012
12/20/2012
2/20/2013
4/20/2013
6/20/2013
8/20/2013
10/20/2013
12/20/2013
2/20/2014
4/20/2014
6/20/2014
8/20/2014
10/20/2014
12/20/2014
2/20/2015
4/20/2015
6/20/2015
8/20/2015
10/20/2015
12/20/2015
2/20/2016
Collection Date
Chloride (mg/L)

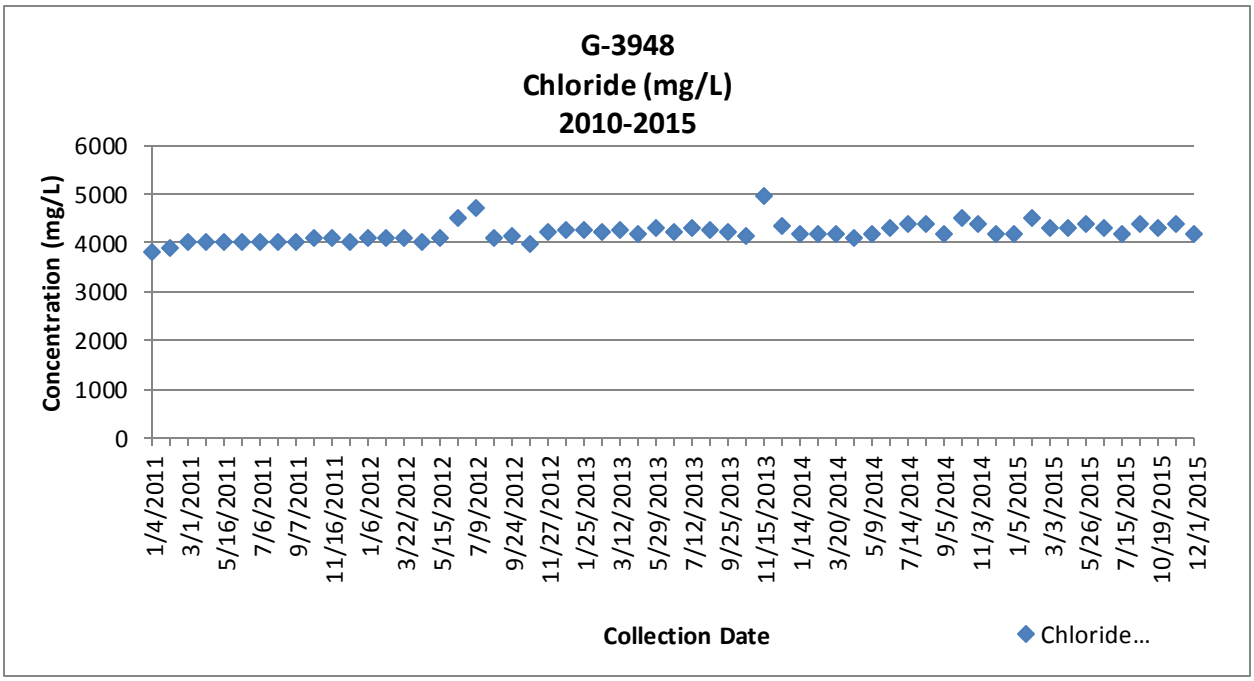

Chloride measurements from the past 35 years at G -3888A (254542080145901)
PROVISIONAL DRAFT -- Subject to Revision.
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, January 27, 2013.
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

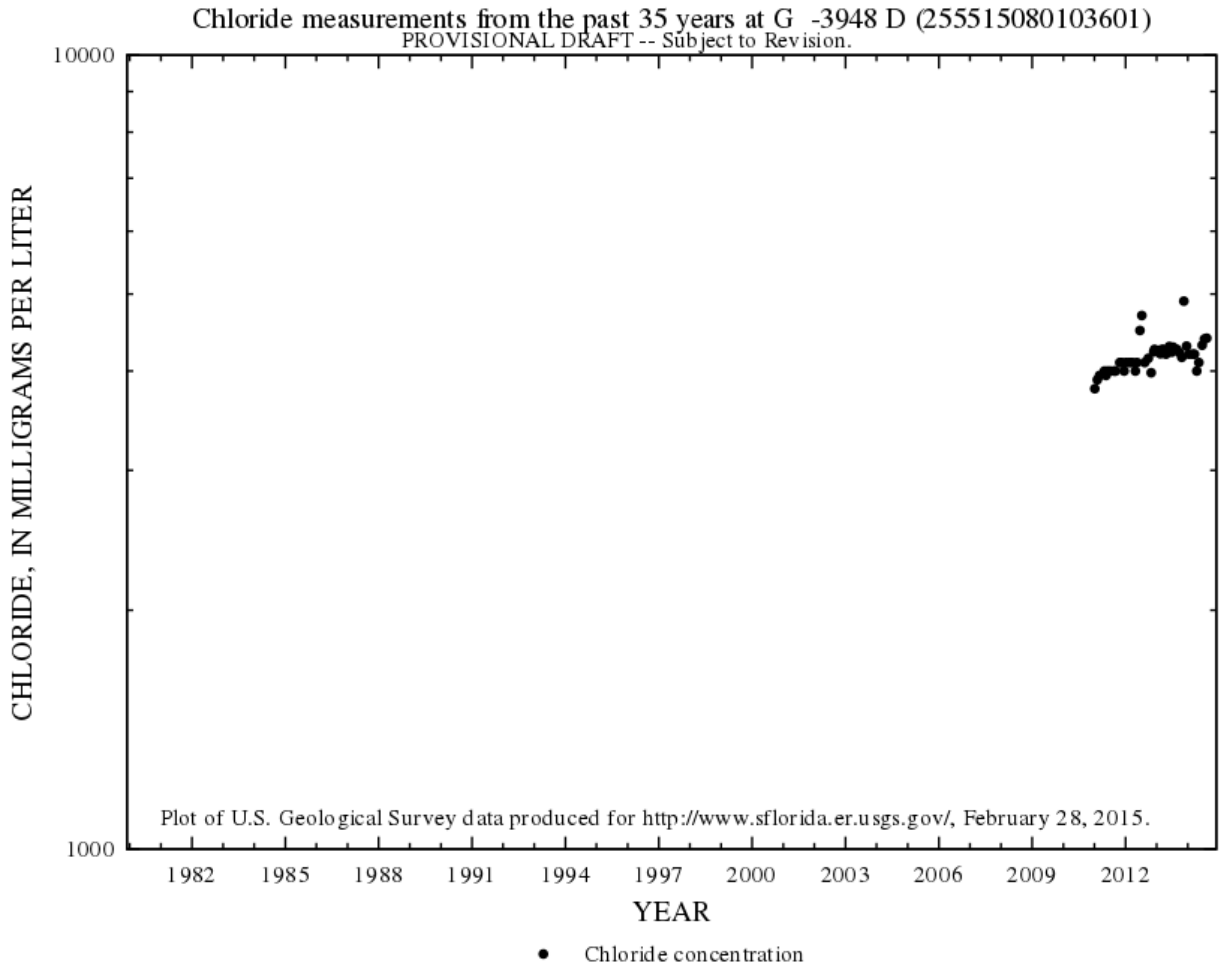

G-3946
Chloride (mg/L)
2010-2015
Concentration (mg/L)
6000
5000
4000
3000
2000
1000
0
1/7/2011
3/2/2011
5/17/2011
7/15/2011
9/2/2011
11/17/2011
1/12/2012
3/15/2012
5/25/2012
7/18/2012
9/20/2012
11/21/2012
1/15/2013
3/14/2013
5/20/2013
7/3/2013
9/12/2013
11/27/2013
1/27/2014
3/27/2014
5/21/2014
7/21/2014
9/24/2014
11/19/2014
1/21/2015
3/9/2015
5/6/2015
7/16/2015
9/11/2015
11/5/2015
Collection Date
Chloride…

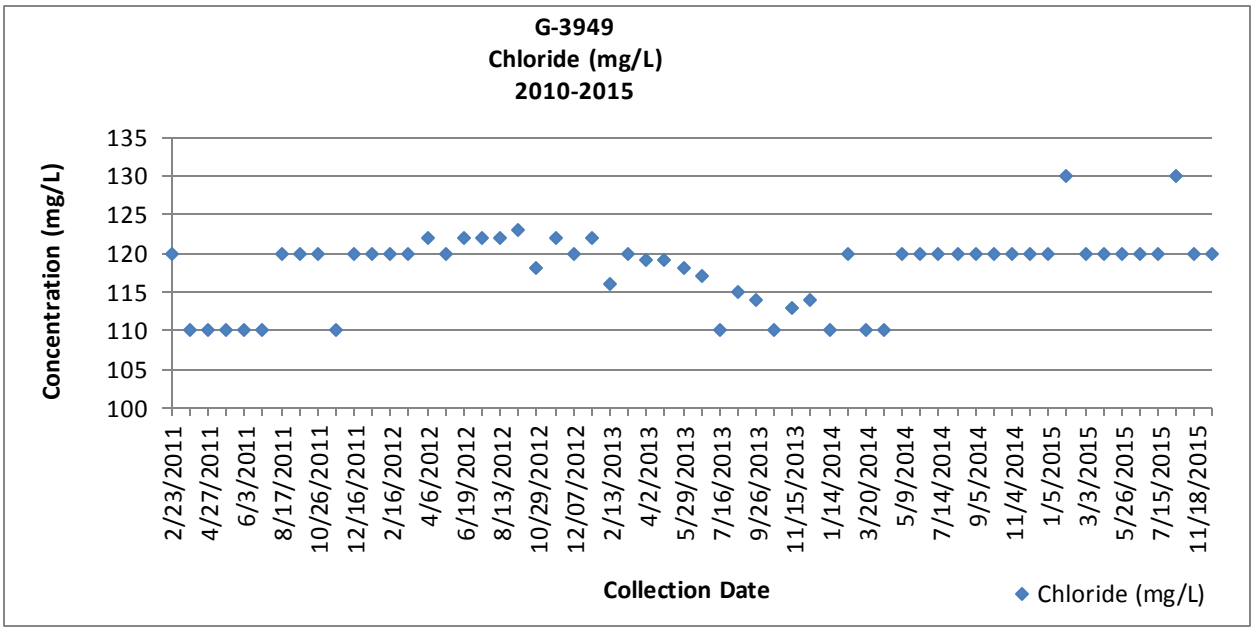

Chloride measurements from the past 35 years at G -3946D (252431080261001)
PROVISIONAL DRAFT -- Subject to Revision.
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, February 28, 2015.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration

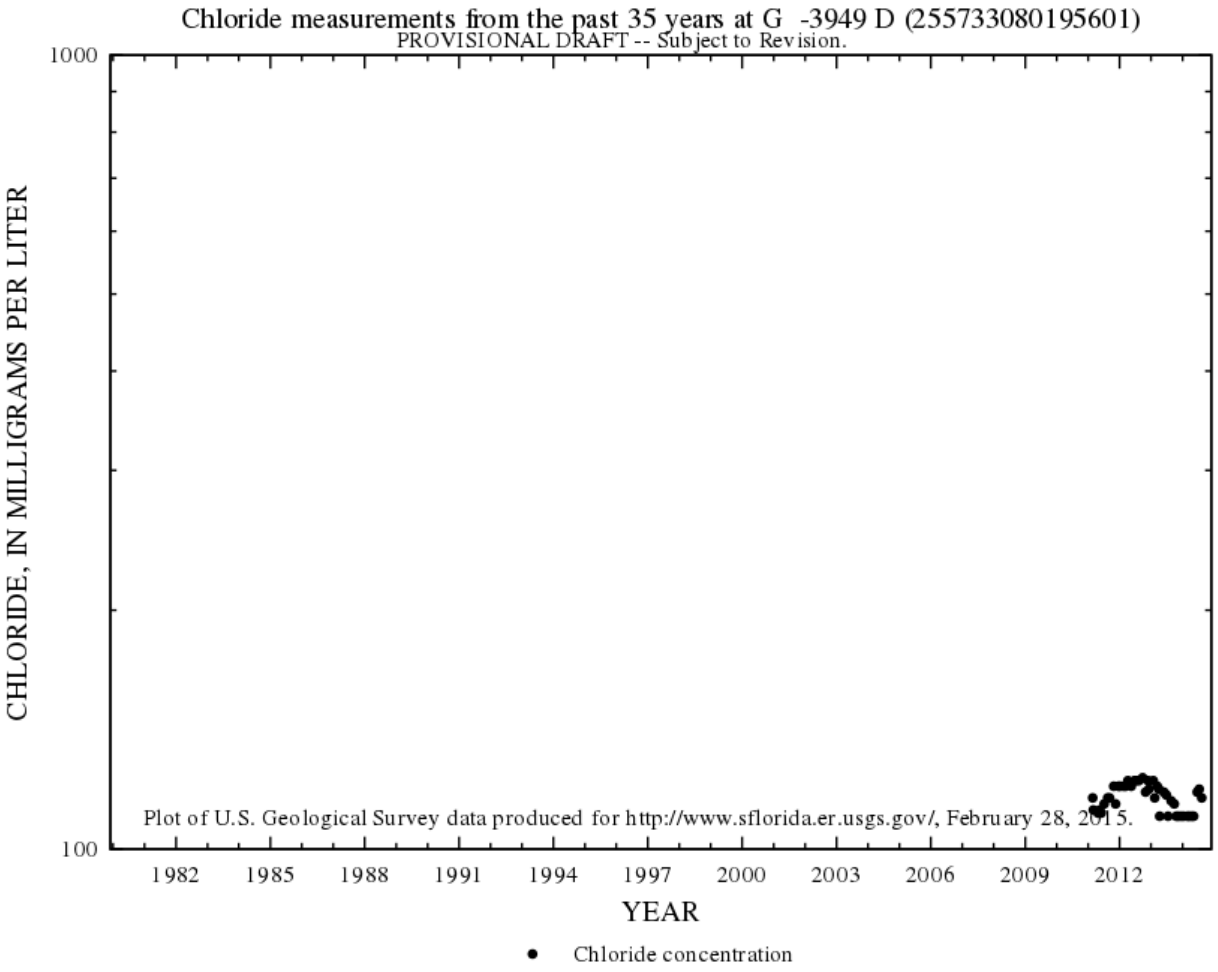

G-3947
Chloride (mg/L)
2010-2015
Concentration (mg/L)
35
30
25
20
15
10
5
0
1/18/2011
2/17/2011
3/23/2011
4/25/2011
5/23/2011
6/28/2011
7/14/2011
8/17/2011
9/13/2011
10/24/2011
11/23/2011
12/23/2011
1/27/2012
2/16/2012
3/15/2012
4/25/2012
5/17/2012
6/27/2012
7/20/2012
08/23/2012
9/27/2012
10/16/2012
11/27/2012
12/5/2012
1/24/2013
2/12/2013
3/11/2013
4/30/2013
5/28/2013
6/26/2013
7/12/2013
8/26/2013
9/26/2013
10/21/2013
11/14/2013
12/17/2013
1/14/2014
2/26/2014
3/20/2014
4/16/2014
5/9/2014
6/23/2014
7/14/2014
8/20/2014
9/3/2014
10/1/2014
11/4/2014
12/1/2014
1/2/2015
2/11/2015
3/4/2015
4/24/2015
5/26/2015
6/15/2015
7/15/2015
9/28/2015
10/19/2015
11/12/2015
12/15/2015
Collection Date
Chloride…


Chloride measurements from the past 35 years at G -3947 (255011080124501)
PROVISIONAL DRAFT -- Subject to Revision.
CHLORIDE, IN MILLIGRAMS PER LITER
100
10
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, February 28, 2015.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration


G-3948
Chloride (mg/L)
2010-2015
Concentration (mg/L)
6000
5000
4000
3000
2000
1000
0
1/4/2011
3/1/2011
5/16/2011
7/6/2011
9/7/2011
11/16/2011
1/6/2012
3/22/2012
5/15/2012
7/9/2012
9/24/2012
11/27/2012
1/25/2013
3/12/2013
5/29/2013
7/12/2013
9/25/2013
11/15/2013
1/14/2014
3/20/2014
5/9/2014
7/14/2014
9/5/2014
11/3/2014
1/5/2015
3/3/2015
5/26/2015
7/15/2015
10/19/2015
12/1/2015
Collection Date
Chloride...


Chloride measurements from the past 35 years at G -3948 D (255515080103601)
PROVISIONAL DRAFT -- Subject to Revision.
CHLORIDE, IN MILLIGRAMS PER LITER
10000
1000
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, February 28, 2015.
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Chloride concentration


G-3949
Chloride (mg/L)
2010-2015
Concentration (mg/L)
135
130
125
120
115
110
105
100
2/23/2011
4/27/2011
6/3/2011
8/17/2011
10/26/2011
12/16/2011
2/16/2012
4/6/2012
6/19/2012
8/13/2012
10/29/2012
12/07/2012
2/13/2013
4/2/2013
5/29/2013
7/16/2013
9/26/2013
11/15/2013
1/14/2014
3/20/2014
5/9/2014
7/14/2014
9/5/2014
11/4/2014
1/5/2015
3/3/2015
5/26/2015
7/15/2015
11/18/2015
Collection Date
Chloride (mg/L)


Chloride measurements from the past 35 years at G -3949 D (255733080195601)
PROVISIONAL DRAFT -- Subject to Revision.
CHLORIDE, IN MILLIGRAMS PER LITER
1000
100
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
YEAR
Plot of U.S. Geological Survey data produced for http://www.sflorida.er.usgs.gov/, February 28, 2015.
Chloride concentration

Attachment 5

INSURANCE, AND LONG-TERM RISK MANAGEMENT

September 2016

Final Report for Resolution R-49-15 in support of the Sea Level Rise Task Force final recommendations

Table of Contents

Note on all figures:

If you have any questions or trouble reading any of the figures, please contact the Office of Resilience at green@miamidade.gov to request additional information or a higher resolution version.

Introduction – Supporting Resolution & Context

In January 2015, the Miami Dade Board of County Commissioners passed Resolution 49-15, which directed the Mayor

> "to initiate discussions related to climate change with private insurance and reinsurance professional organizations, member local governments in the Southeast Florida Climate Change Compact, the Florida Office of Insurance Regulation's Department of Finance Services, and other key stakeholders to develop long-term risk management solutions."

This resolution built upon previous efforts including a roundtable discussion in September 2014, hosted by the Mayor, the Beacon Council, the British Consulate General in Miami, and the British Ambassador to the United States, with key leaders from the insurance and business communities. This meeting focused on issues and opportunities associated with climate change and sea level rise in the U.K. and Southeast Florida. In addition, the Mayor announced he would convene a group of business, financial and insurance leaders to continue the dialogue around these critical business and financial issues at the Sixth Annual Southeast Florida Climate Leadership Summit.

To further this discussion the Office of Resilience, the Beacon Council, and the British Consulate General in Miami conveyed a second roundtable on January 11, 2015 with key representatives from the private and public sectors. A full list of meeting participants, the agenda, discussion questions, and presentations are provided in Appendices 1-4.

The three principle goals of this discussion were to draw upon the technical expertise of the private sector to help Miami-Dade County (County) staff:

1) better understand the physical and economic risks to Miami-Dade County,
2) improve the future insurability of County and privately-owned assets,
3) understand best practices and their potential implementation in Miami-Dade County

The roundtable discussion was held at the Beacon Council and included presentations from technical experts from the insurance and reinsurance industries, followed by a discussion structured around the three meeting goals.

The following report will first describe why the County chose to focus on insurance in the context of climate change and provide a summary of the key considerations and long-term risk management options available to the County that were discussed at the roundtable.

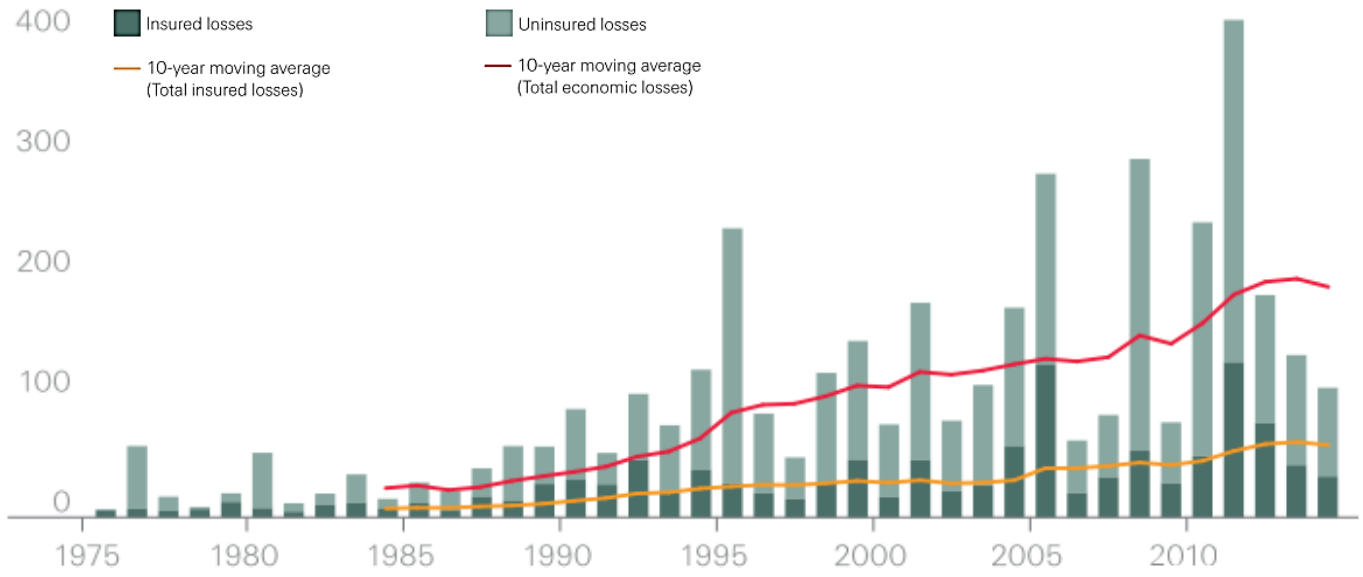
Why Focus on Insurance and Risk Management?

Miami-Dade County is vulnerable to multiple natural hazards which will likely be exacerbated by climate change, due to rising sea levels, the potential increase of more intense hurricanes, and changes in precipitation patterns. Despite projected risks, the County has a long history of preparing for similar hazards. Since Hurricane Andrew, the County has made substantial investments in preparing for hurricanes by strengthening building codes and improving internal capacity. As a result, the County can now draw upon both deep internal expertise within emergency management, risk management, stormwater management, and regional partners such as the South Florida Water Management District, the Southeast Florida Regional Climate Change Compact, and the Florida Climate Institute to better prepare for projected hazards.

As losses from disasters around the world increase (see Figure 1), governments are recognizing the importance of prioritizing investments in the long-term economic resilience of their communities. Hurricanes Sandy and Katrina underscore the importance of continually improving preparations and adopting new tools and best practices. The insurance and reinsurance industries have recently made significant improvements to their risk management tools and therefore engaging these industries to leverage their expertise can help the County better identify, prepare for, and insure the risks that cannot be mitigated.

Insurance and risk management are key components of Miami-Dade's long-term economic resilience. County residents annually pay more than $147 million in flood insurance premiums alone. The County, therefore, will continue to work cooperatively with the private sector and others to identify opportunities to more effectively prepare for hazards that will be exacerbated by climate change.

Figure 1: Global Natural Catastrophe Losses between 1975 and 2014 (in 2014 billion USD)



Source: Swiss Re Economic Research and Consulting and Cat Perils

Key Considerations

The following are key considerations that are likely to impact Miami-Dade County and the ability of local and regional private businesses and residents to acquire affordable insurance coverage.

- Recent development, population growth, and rising sea levels have increased the exposure of assets vulnerable to flooding and storms in Miami-Dade County

  A recent analysis by the World Bank economist Stephan Hallegatte, found that of 136 global metropolitan areas evaluated, Miami was the U.S. metropolitan area with the greatest exposure to a 100-year flood as measured by asset value. This study found that in the event of a 100-year flood Miami had over $366 billion in exposed assets.[1] The Miami metropolitan region was also considered most vulnerable when evaluated in terms of expected average annual loss with an expected loss of $672 million. The exposure identified in the study is growing due to population growth, coastal development, and rising sea levels. The study also examined implications of the mentioned factors on future risks and found that in 2050, average annual losses due to flooding in the Miami metropolitan area could approximate $7.34 billion without adaptation measures and $2.55 billion with adaptation.

  A separate study by Lloyd's and the University of Cambridge, *Lloyd's City Risk Index*, found that over the next ten years (2015-2025) Miami risks losing $4.02 billion to flooding losses and $2.28 billion to wind storms.[2] According to Florida International University's Florida Public Hurricane Loss Model, expected personal residential insured losses due to wind damage alone would be approximately $6.4 billion in a Category 1 storm and $31.6 billion in a Category 5 storm. These estimates were based on 2007 exposure data and do not include an increase in exposed assets since 2007.[3] Several other American cities, including New York and New Orleans are also among the worlds' most vulnerable. A recent report noted this is in part due to the fact that coastal assets in U.S. cities have, "a relatively high overall value and relatively low levels of protection compared to other wealthy countries."[4]

- The Federal Emergency Management Agency is currently remapping coastal areas within Miami-Dade County and insurance rates are likely to change in certain areas

  The National Flood Insurance Program (NFIP) administered by the Federal Emergency Management Agency (FEMA) provides the majority of flood insurance policies with the County. FEMA determines flood insurance premium rates based on the Flood Insurance Rate Maps (FIRM) they develop. These maps are periodically revised and the coastal portion of Miami-Dade County is currently under revision. The new maps are expected to be published in 2017-2018 and the revised maps are likely to show deeper potential flood depths along the coast and a floodplain that extends further west in some areas. Updated maps are likely to show a

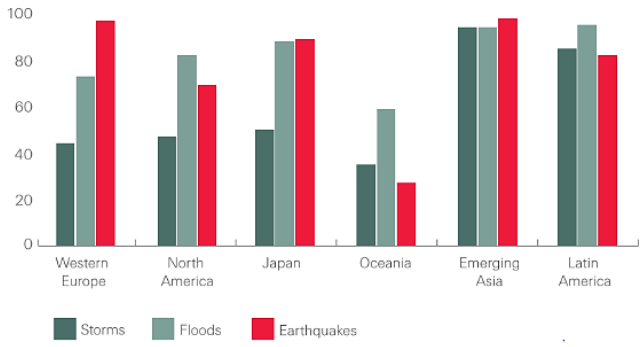
[1] Hallegatte, S. et al., "Future Flood Losses in Major Coastal Cities," Nature Climate Change 2013. Available at http://www.nature.com/nclimate/journal/v3/n9/full/nclimate1979.html
[2] Lloyd's City Risk Index 2015-2025 Miami, US Factsheet (2015). Available at www.lloyds.com/cityriskindex
[3] This is not accounting for deductibles. Source: S. Hamid, H. Loss, P. Model "The Florida Public Hurricane Loss Model"
[4] Eddins, Q., "Rising Vulnerability to floods risk devastating property losses in U.S. cities" CBRE 27 Oct. 2015

higher base flood elevation (or the expected height of a 100-year flood) in certain areas. This means that new buildings will need to be built at a higher elevation and flood insurance premiums will be higher for buildings built below this height. Insurance rates are likely to change in certain areas as a result of changes in floodplain boundaries or expected flood elevations, which determine insurance premiums. Rates are more likely to increase for older buildings, constructed under less restrictive building codes and prior to the publication of the first Flood Insurance Rate Maps. These changes may disproportionately affect lower income areas in the County.

- Many businesses and families vulnerable to flooding do not have adequate insurance

Because disasters are relatively rare, people systematically underestimate their risk. One study found that because people underestimate risk, they are often unwilling to pay the actuarially fair rate for insurance premiums. [5] This may lead people to drop insurance coverage because it is perceived as too expensive. In other cases, financial hardship causes people to drop coverage. Many residents also incorrectly assume that their homeowners insurance includes coverage from flood damage.

Figure 2: Uninsured natural catastrophe losses as a percent of economic losses by region 1975-2014 based on events from which insured and economic losses were known and for which total losses were larger than USD



Source: Swiss Re Economic Research and Consulting and Cat Perils;

When Hurricane Sandy hit New York, most affected property owners did not carry adequate flood insurance. More than half of the buildings flooded were outside FEMA's 100-year floodplain, so they were not required to carry flood insurance. Even for those within the demarcated floodplain, less than 50 percent of residential buildings had flood insurance. [6] According to FEMA, nearly 25 percent of all National Flood Insurance Program claims are received from people outside of the mapped high-risk flood areas. [7] Neither Citizens Property Insurance Corporation nor the National Flood Insurance Program maintain current figures on the number of property owners within Miami-Dade County who do not maintain insurance, making it challenging to quantify exactly how many owners do not carry insurance. A recent report from The Wharton Risk Management and Decision Processes Center found an average NFIP market penetration rate of 30 percent (meaning approximately 70 percent are without flood

[5] Logue, K., Ben-Shahar, O., "The Perverse Effects of Subsidized Weather Insurance" Law & Economics Working Papers. Paper 111. 1 May 2015. Available at http://repository.law.umich.edu/cgi/viewcontent.cgi?article=1221&context=law_econ_current

[6] "Stronger More Resilient New York" PlanNYC. (2013) http://s-media.nyc.gov/agencies/sirr/SIRR_singles_Lo_res.pdf

[7] "Low-Risk Flood Zone." Federal Emergency Management Agency, 26 Sept. 2014. https://www.fema.gov/faq-details/Low-Risk-Flood-Zone

insurance).[8] In some watersheds the coverage rate ("the implied market penetration rate") was as low as 10 percent (C-3 West) and 17 percent (C-7).

When property owners do not maintain insurance it directly affects their families and businesses by slowing recovery after an event, therefore affecting a region's resiliency. Inadequate insurance also affects the wider economy following an event. According to SwissRe,

> "By facilitating investment and reconstruction, insurance can minimize the negative impact of natural catastrophes on economic growth... In a poorly insured catastrophe … uninsured losses were the driver of an output decline over several years. This is consistent with the findings of a 2012 study… which looked at nearly 2,500 major natural catastrophes that occurred between 1960 and 2011. In countries with high insurance penetration, the study concluded, the indirect costs of a natural catastrophe event are lower, the overall economic impact is lower, and these countries recover faster from catastrophic events than less-insured countries." [9]

The level of insurance coverage in Miami-Dade County will impact not only uninsured and underinsured families and businesses following an event, but has the potential to impact the wider regional economy and the speed of recovery. In North America, uninsured flood losses between 1975 and 2014 accounted for upwards of 80 percent of total economic losses (see Figure 2).[10]

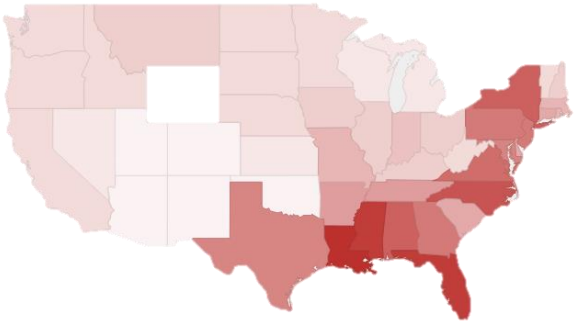
- The County's economy and credit rating could be affected by a natural disaster

A recent article published by Fitch Ratings underscored that sea level rise may become increasingly important as a credit factor in Fitch's rating decisions. This report notes that, "local governments that respond hesitantly to climate change may face higher mitigation costs and potentially much higher disaster recovery costs in the future, particularly should federal support mechanisms decrease over time."[11] A report released in September 2015 from Standard & Poor's (S&P) Rating Services also noted that severe natural disasters can impact a government's credit standing.[12] In a separate report S&P noted that their rating services consider, "the dangers from rising sea levels to be a long-term macro-credit risk that is unlikely

[8] Czajkowski, J. et al. "Economic impacts of urban flooding in south Florida: Potential consequences of managing groundwater to prevent salt water intrusion" (2015) Wharton University of Pennsylvania.
[9] "Closing the protection gap – Disaster Risk Financing: Smart solutions for the public sector" (2015) Swiss Re. Zurich. http://media.swissre.com/documents/Closing_the_Gap_2015_FINAL.pdf
[10] "Closing the protection gap – Disaster Risk Financing: Smart solutions for the public sector" (2015) Swiss Re. Zurich. http://media.swissre.com/documents/Closing_the_Gap_2015_FINAL.pdf
[11] Levitz, L. et al., "Sea Level Rise May Pose Challenges for Some US Local Governments" Fitch Ratings 16 Sept. 2015
[12] "Storm Alert: Natural Disasters Can Damage Sovereign Creditworthiness" Standard and Poor 10 Sept. 2015

to be a significant factor in the next five years. But in our view, the failure of states and localities to start planning for the logistical, structural, and financial risks of more water in the wrong places could leave them struggling to protect existing investments in seaside infrastructure."[13]

Figure 3: 1980-2014 Billion-Dollar Flooding and Tropical Cyclone Disasters by State (CPI – Adjusted)



***Please note that the map reflects a summation of billion-dollar events for each state affected (i.e. it does not mean that each state shown suffered at least $1 billion in losses for each event).**

Source: "Billion-Dollar Weather and Climate Disasters: Mapping" National Oceanic and Atmospheric Administration, http://www.ncdc.noaa.gov/billions/mapping

Maintaining adequate insurance can help partially insulate the County from this risk as a recent report from SwissRe illustrated,

> "The rating agency Standard & Poor's (S&P) also emphasizes the positive role of disaster insurance arrangements on sovereign financial resilience. The economy with higher insurance coverage recovers more quickly and suffers from a lower cumulative GDP damage than in absence of insurance coverage. For a sample of 48 countries and a hypothetical natural disaster shock equivalent to 5% of a country's capital stock, S&P estimates that credit ratings would on average decline between two and three notches if there was no insurance protection at all. This compares to a decline of only about one notch, if 50% of the damage was insured."[14]

Standard & Poor also notes that insurance cannot completely offset the economics and ratings impact of a disaster and therefore local governments must prepare. They note that, "even with insurance coverage at 100%, it will take time to rebuild infrastructure and other capital. During that time government spending is likely to be at least as high as in the absence of a natural disaster while tax receipts will fall comparatively short, leading to a deterioration of the fiscal position."[15] Florida and Miami-Dade County are particularly vulnerable to flooding and tropical cyclones as illustrated in Figure 3. The state has experienced 16 one billion-dollar disasters due

[13] McNatt, R., "Climate Resilience Can Protect Ratings From Sea-Level Rise and Threats To U.S. Coastal Infrastructure" Standard and Poor 22 Oct. 2015

[14] "Closing the protection gap – Disaster Risk Financing: Smart solutions for the public sector" (2015) Swiss Re. Zurich. http://media.swissre.com/documents/Closing_the_Gap_2015_FINAL.pdf citing "Storm Alert: Natural disasters can damage creditworthiness," published by Standard & Poor on September 2015 available at www.globalcreditportal.com/ratingsdirect/renderArticle.do?articleId=1449131&SctArtId=339895&from=CM&nsl_code=LIME&sourceObjectId=9327571&sourceRevId=1&fee_ind=N&exp_date=20250909-22:42:56

[15] Mrsnik, M. et al., "The Heat is On: How Climate Change Can Impact Sovereign Ratings" November 25, 2015. Standard & Poor.

to flooding or tropical storms since 1980.[16] It is therefore important to invest in preparedness in order to minimize the impact of these events locally.

- **Some flood insurance premiums are underpriced and do not fully reflect actuarial risk**

  A significant portion of the available insurance for flooding is provided by the federal government through the National Flood Insurance Program (NFIP), which subsidizes a portion of its policies.[17] The program is subsidized, meaning premiums collected are not sufficient to cover claims and because the deficit is passed on to the Treasury Department, the U.S. taxpayer is currently the primary reinsurer of the program. Because NFIP policies are often cheaper than flood insurance sold in the private market, they have come to dominate the flood risk market.[18] As a result price signals do not fully reflect the true cost of living in highly vulnerable regions.[19]

  The NFIP subsidies have been found to result in a regressive redistribution of subsidies favoring affluent homeowners and inducing development in storm-stricken and erosion-prone areas. This same study found a strong correlation between subsidy and wealth, wherein the wealthier households receive higher subsidies in the form of underpriced insurance.

  Following Hurricane Sandy, legislation was introduced to reduce many of these subsidies in the Biggert-Waters Flood Insurance Reform Act; however, there was substantial pushback after this legislation was passed and many changes were repealed. The subsequent legislation, The Homeowner Flood Insurance Affordability Act of 2014,[20] repealed many of the changes made in the Biggert-Watters legislation. The Homeowner Flood Insurance Affordability Act also addressed many affordability concerns and limited rate increases for individual premiums to 18 percent of the premium and limited increases for average rate classes to 15 percent; however, the NFIP is still pursuing mandatory increases for certain subsidized policyholders.

  The United States Government Accountability Office has noted that the NFIP revenues will likely be insufficient to repay the billions of dollars borrowed from the Treasury to cover claims from the 2005 and 2012 hurricanes. As of December 2014 FEMA still owed approximately $23 billion.[21] Because the NFIP is still not self-supported through the premiums it collects from policyholders it is reasonable to expect there may be future adjustments to the program. These changes may affect rates in Miami-Dade County.

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[16] "Billion-Dollar Weather and Climate Disasters: Mapping." National Oceanic and Atmospheric Administration. Available at www.ncdc.noaa.gov/billions/mapping

[17] Logue, K., Ben-Shahar, O., "The Perverse Effects of Subsidized Weather Insurance" Law & Economics Working Papers. Paper 111. 1 May 2015. Available at http://repository.law.umich.edu/cgi/viewcontent.cgi?article=1221&context=law_econ_current

[18] According to a RAND study published in 2006, 49 percent of all SFHs in SFHAs had NFIP policies and another 1 to 3 percent had private policies. Lloyd Dixon, Noreen Clancy, Seth A. Seabury & Adrian Overton, Rand, The National Flood Insurance Program's Market Penetration Rate: Estimates And Policy Implications (2006), available at www.rand.org/content/dam/rand/pubs/technical_reports/2006/RAND_TR300.sum.pdf

[19] Logue, K., Ben-Shahar, O., "The Perverse Effects of Subsidized Weather Insurance" Law & Economics Working Papers. Paper 111. 1 May 2015. Available at http://repository.law.umich.edu/cgi/viewcontent.cgi?article=1221&context=law_econ_current

[20] FEMA provides an overview of this legislation and expected changes at this website www.fema.gov/flood-insurance-reform-law

[21] "Preparing for Climate-Related Risks: Lessons from the Private Sector" United States Government Accountability Office. November 2015. Washington D.C.. GAO-16-126SP < www.gao.gov/products/GAO-16-126SP>

Recommended Long-Term Risk Management Practices

- **Mitigate the County's own exposure**

  The County's schedule of values is in excess of $16 billion for both real and personal property. The County currently pays approximately $19 million annually for insurance premiums to insure these assets. In the wake of a hurricane the cost of insurance would likely increase. In the long-term, if climate change continues to increase the physical vulnerability of County assets, that is likely to result in higher premiums.

  The most effective means to stabilize these costs in the long-term is to reduce the vulnerability of the County's assets. Furthermore, reducing the vulnerability of these facilities will also have a number of co-benefits, such as improving the ability of critical facilities to operate during or immediately after a hurricane or other event. Due to the interdependencies between the government and private sector, reducing the County's own exposure will also support the economic resilience of the entire community.[22] Ensuring that public infrastructure and services are resilient to disruptions will reduce losses due to business interruption and thereby support business continuity and growth.

  To reduce vulnerability of the County's assets new projects should be designed resiliently. For example, they could be built to comply with the Federal Flood Risk Management Standard,[23] Resilience STAR™,[24] or other standards. The County could also choose to incorporate an extra margin of safety into the design of key buildings such as fire stations or emergency shelters. These efforts should not be limited to only buildings in the NFIP demarcated floodplain as these boundaries can change and buildings outside of the official 100 year floodplain can still be vulnerable to flooding.

  Loss mitigation assessments, which identify ways to make buildings safer, are currently optional and focus primarily on mitigating wind and fire damage. Loss mitigation should be required for all new County projects and should incorporate flood risk. For existing properties these loss mitigation assessments should be completed in a phased manner, focusing first on critical facilities such as shelters, fire stations, medical facilities and police stations.

  Continuing to fund mitigation projects already identified in the Local Mitigation Strategy (LMS) will also help reduce the County's own exposure as well as the exposure of the community more broadly.[25] As of December 2015 the LMS contained more than 1020 projects identified as having the potential to reduce the County's exposure to known hazards.[26]

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[22] "Preparing for Climate-Related Risks: Lessons from the Private Sector" United States Government Accountability Office. Nov. 2015. Washington D.C.. GAO-16-126SP < http://www.gao.gov/products/GAO-16-126SP>

[23] More information about the Federal standard is available at http://www.fema.gov/federal-flood-risk-management-standard-ffrms

[24] More information about the standard is available at https://disastersafety.org/ibhs-news-releases/first-ever-resilience-star-homes-designated-national-preparedness-month-height-hurricane-season/

[25] More information about the Local Mitigation Strategy is available at http://www.miamidade.gov/fire/mitigation.asp

[26] The most recently published list of LMS projects is available at http://www.miamidade.gov/fire/library/OEM/local-mitigation-strategy-part-2-projects.pdf

- **Promote the Community Rating System**

  The Community Rating System (CRS) is a voluntary incentive program that is part of the National Flood Insurance Program. This program rewards communities that go beyond the minimum floodplain management requirements and proactively reduce potential flood damage. The more actively communities manage their risk and improve their rating, the deeper the discount passed onto policy holders.

  By participating in the program and achieving a high rating of Class 5, Miami-Dade County saves residents in unincorporated areas more than $19 million annually. The program has saved residents more than $295 million since the County started participating in 1994. If the County were to improve its rating to a 4, the community would receive approximately $3.8 million in additional discounts annually. Research from the University of Cambridge has demonstrated the effectiveness of strategies, such as participation in the CRS program, for mitigating the adverse impacts of flooding.[27]

  The County currently provides technical assistance to municipalities to improve their own ratings; however, dedicating additional resources to this effort would help residents in incorporated areas see further discounts to their own insurance premiums. The Local Mitigation Strategy (LMS), which is maintained by the Miami-Dade County Office of Emergency Management, actively works with the CRS communities in the County and has been working to expand the LMS to incorporate elements to support the CRS scores of communities. The LMS Working Group meets quarterly and discusses hazards, mitigation measures, and shares best practices amongst the stakeholders that includes local, state, and federal government representatives, universities, hospital and health care, private non-profit agencies, and public for profit agencies.

- **Work to address gaps in coverage, particularly for sub-groups which are more vulnerable to disasters and are least able to afford insurance coverage**

  The consequences of not carrying adequate insurance can be especially severe in low and moderate income communities, where residents have fewer personal resources to draw upon after an event. Unfortunately, it is also the case that many low and moderate-income families may be unable to maintain adequate insurance coverage due to financial constraints. Other vulnerable sub-groups include retirees who have paid off their mortgage and are therefore no longer required to carry insurance, renters who do not carry renters insurance, or homeowners who are unaware that their home insurance does not cover flood damage. Not carrying adequate insurance leaves residents dependent upon disaster aid or other government assistance, which can be delayed and is often inadequate to help a family fully recover. Again, it is often the poorest that are least able to bear the immediate short-term costs incurred before receiving disaster aid, for example, buying replacement goods, staying at a hotel, or hiring a contractor to seal a dwelling and prevent further water damage. Working to educate the

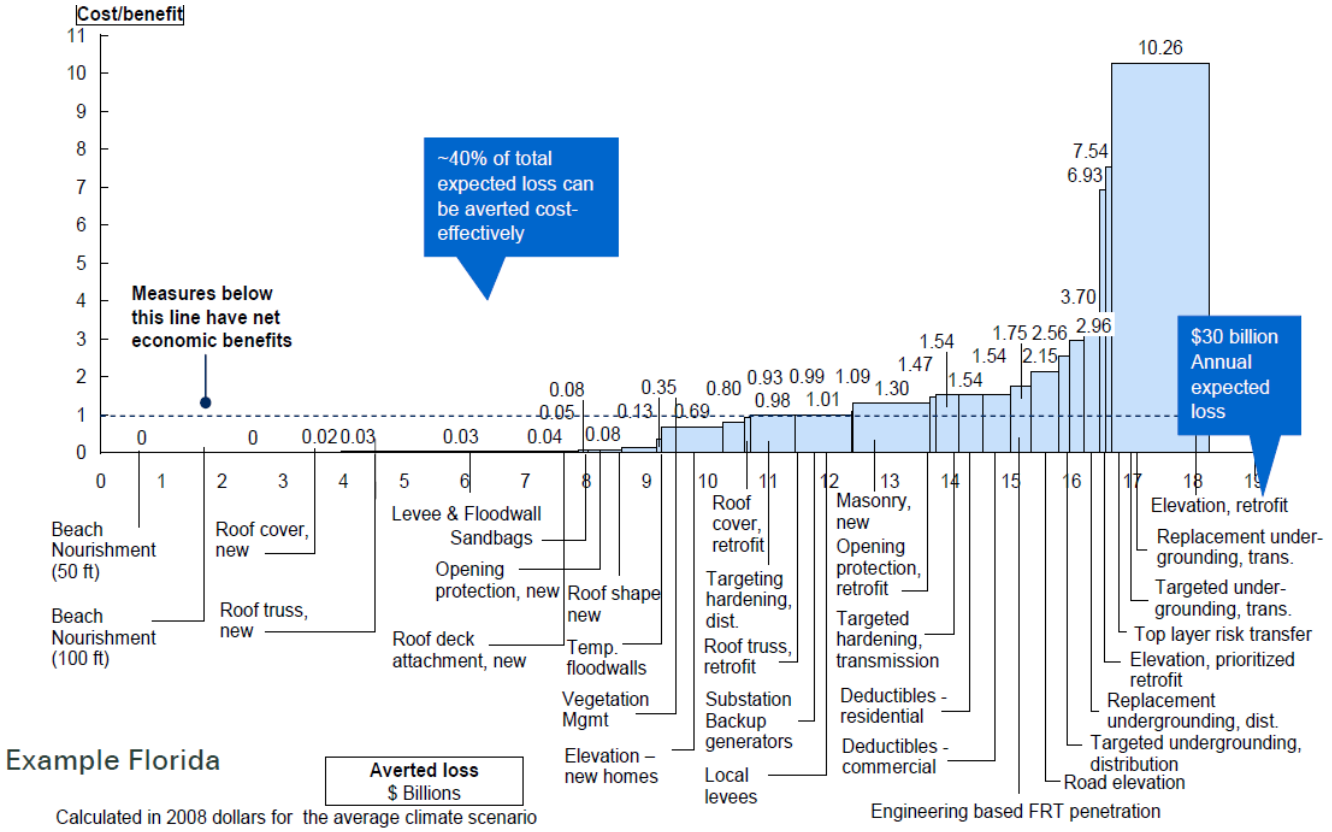
[27] Brody, S., Highfield, W., Kang, J. Rising Waters: The Causes and Consequences of Flooding in the United States (2011) Cambridge University Press.

community about the benefits of insurance, including the ability to recover more quickly after a storm, would help improve Miami-Dade County's economic resilience as a whole.

- **Work more closely with the insurance and reinsurance sector to share knowledge and expertise to identify risk and develop risk transfer solutions**

  As losses from disasters have increased over the past several decades, there has been an increased investment in developing risk management tools such as catastrophe models and risk transfer solutions such as catastrophe bonds. Continuing to engage the private sector and academia around these issues and drawing upon their technical expertise will help ensure the County is informed about the most recent developments and best available tools. The County can also follow national and international forums covering these issues such as the United Nation's 1-in-100 Initiative,[28] ClimateWise,[29] and the Association of State Floodplain Manager's Flood Insurance Committee.[30]

Figure 4: Locally specific cost /benefit analysis of different adaptation measures



Source: Swiss Re Global Partnerships, Alex Kaplan, Slide No. 11, Risk Management Roundtable Discussion, The Beacon Council, Miami, Florida, January 11, 2016

[28] More information is available at http://www.un.org/climatechange/summit/wp-content/uploads/sites/2/2014/09/RESILIENCE-1-in-100-initiative.pdf
[29] More information is available at http://www.climatewise.org.uk/
[30] More information is available at http://www.floods.org/index.asp?menuID=246

Furthermore, by working more closely with the private insurance companies the County can leverage their expertise to determine the most cost effective risk management measure. For example, SwissRe recently completed an analysis of the cost / benefit of different measures in Southeast Florida and found that approximately 40 percent of total expected losses could be cost-effectively averted with mitigation measures (Figure 4). This analysis revealed several measures that have a positive economic benefit such as beach nourishment, changing roof covers and shapes on new buildings, managing vegetation, and elevating new homes. By this same metric many measures have less favorable cost / benefit ratio and are likely less attractive as initial mitigation measures. This type of analysis can help inform the County's own response and policy choices to ensure adaptation is pursued in a strategic and sustainable manner.

- **Promote more resilient development**

Miami-Dade County is a low-lying coastal community that is vulnerable to hurricanes and flooding. As such buildings in the community should be adapted to local conditions and should be able to safely weather a typical storm or a period of heavy rain. As a recent World Bank study noted, "[N]atural disasters, despite the adjective, are not 'natural.' Although no single person or action may be to blame, death and destruction result from human acts of omission—not tying down the rafters allows a hurricane to blow away the roof—and commission—building in flood-prone areas. Those acts could be prevented, often at little additional expense."[31] Miami-Dade County should continue to promote cost-effective ways to prevent damage before the storm by incorporating best practices into codes and other planning and zoning requirements. A first priority should be working with the providers of key community services such as electricity, medical services, food distribution, and transportation to ensure their assets are resilient.

[31] "Natural Hazards, Unnatural Disasters: The Economics Of Effective Prevention" World Bank and The United Nations 2010. Available at https://www.gfdrr.org/sites/gfdrr/files/publication/NHUD-Report_Full.pdf

Conclusion and Next Steps

There was resounding consensus at this year's roundtable that hosting an annual or bi-annual discussion around these issues would be fruitful. It will be particularly helpful to continue the dialogue between the public and private sectors because the issues of climate change, risk management, and risk modeling are quickly evolving. The Office of Resilience will continue to coordinate with the Beacon Council and the British Consulate to reconvene regular discussion around this topic. In the intervening time the Office of Resilience will engage local universities, and business schools in particular, to identify opportunities to leverage their expertise and resources to further these discussions. As the dialogue progresses the stakeholders involved will undoubtedly continue to shift and expand.

Beginning immediately, smaller internal working groups will continue to meet to implement and refine recommendations discussed in this report. These groups will initially focus on four areas:

1. expediting the County's own mitigation efforts,
2. effectively communicating these efforts to the industry,
3. engaging the industry and others to stay abreast of the most current data and tools, and
4. addressing issues of affordability and public education for the uninsured and underinsured.

These work groups will report back and provide the Mayor with specific recommendations for how Miami-Dade County can stay ahead of these issues and be a leader in this field. These workgroups will collaborate with local academic institutions and community-based organizations to the greatest extent possible. These focus areas will be refined and adjusted to meet the evolving needs of the community.

Appendix 1: Roundtable Participants

Sector	Affiliation	Individual
Insurance & Reinsurance	Willis Re, Inc	Antony Phillips, Managing Director, Willis Latin America & Caribbean Adam J. Canning, Senior Vice President Pete Thomas
	SwissRe	Alex Kaplan, Senior Client Manager, Vice President, Global Partnerships
	Llyod's	Rodney Smith, CIC, CRM, Regional Director, Southeast US
	Arthur J. Gallagher & Co.	Tony Abella, Jr.
Economists	University of Miami	Professor David Letson, Ph.D., Natural Resource Economist
Academia	University of Miami	Dr. Ben Kirkman, Professor and Associate Dean for Research Program Director: Physical Sciences and Engineering, Center for Computational Science
Commercial real-estate	Colliers International	John K. Scott, RPA, Senior Executive Managing Director
	CBRE	Tim Gifford, FRICS, Senior Vice President Quinn W. Eddins, Director, Research and Analysis
	Mitig8 Risk Management LLC	David S. G. Baxter, BSc (Hons) MRICS, SIIRSM, President
	Florida East Coast Industries	Fancois Illas, Vice President – Corporate Development Jose Gonzalez, Senior Vice President – Corporate Development
Local business community	Greater Miami Chamber of Commerce	Barry Johnson, President/CEO
	The Beacon Council	Larry K. Williams, President and CEO Steve Beatus, Executive Vice President, Economic Development Marc S. Schlag, Manager, Public Relations and Events Stanley Rigaud, Manager, International Economic Development Programs
Non-profit community	Catalyst Miami	Kamalah Fletcher, Senior Director of Community Engagement
	Miami Foundation	Stuart Kennedy, Director of Program Strategy and Innovation
	The Nature Conservancy	Kathy Baughman McLeod, Director, Climate Risk & Resilience
British Consulate		Dave Prodger, HM Consul General Alexander Close, Head of Politics, Press, and Public Affairs Cynthia Conner Chonchol Gupta, Vice Consul, Trade and Investment Officer
SE FL Regional Climate Change Compact	Institute for Sustainable Communities	Nancy Schnieder, Senior Program Officer
	City of Miami Beach	Amy Knowles, Deputy Resiliency Officer
	City of Miami	Matthew S. Haber, Assistant City Attorney
	Broward County	Samantha Danchuk, Assistant Director, Environmental Protection and Growth Management Department

	Palm Beach County	Natalie Schneider, Climate Change & Sustainability Coordinator
	Monroe County	Kevin Madok, Senior Director of Strategic Planning
County government	Office of the Mayor	Hon. Carols A. Gimenez Ed Marquez , Deputy Mayor
	Internal Services Department, Risk Management	Tara Smith, Director, Internal Services Department Barbara Dunlap, Property and Casualty Manager Baunie McConnell, Director, Risk Management Division
	Office of Emergency Management	Curtis Sommerhoff, Director Cathie Perkins, Emergency Management Planner
	Office of Management and Budget	Jennifer Moon, Director
	Office of Intergovernmental Affairs	Joe Rasco, Director, Office of Intergovernmental Affairs
	Regulatory and Economic Resources	Lee Hefty, Assistant Director, Environmental Resources Management, Regulatory and Economic Resources Department Nichole Hefty, Deputy Resilience Officer, Office of Resilience, Regulatory and Economic Resources Department Katie Hagemann, Sustainability Initiatives Coordinator, Office of Resilience, Regulatory and Economic Resources Department Jim Murley, Chief Resilience Officer, Office of Resilience, Regulatory and Economic Resources Department Tere Florin, Communications Manager, Regulatory and Economic Resources Department
	Miami-Dade County Water and Sewer	Bertha Goldenberg, Assistant Director, Regulatory and Compliance Division

Appendix 2: Roundtable Agenda

Date: Monday January 11, 2016

Location: The Beacon Council, 80 SW 8th St #2400, Miami

9:00 Welcoming remarks

- Larry Williams (Beacon Council)
- Dave Prodger (British Consul General)
- Carlos A. Gimenez & Jim Murley (Miami-Dade County)

9:15 – 10:15 Introduction to Key Issues

- Jim Murley (Miami-Dade County)
- Antony Phillips & Adam Canning (Willis Re) *Modelling Climate Risk and A Holistic Approach to Financial Mitigation*
- Alex Kaplan (Swiss Re) *Resilience and the Economics of Risk*
- David Baxter & Tim Gifford (RICS) *Driving Responsible Solutions Across the Built Environment*
- Rodney Smith (Lloyd's America, Inc.) *Lloyds: Climate Change*

10:15 – 10:30 Coffee Break

10: 30 – noon Facilitated Discussion

- How do we better understand the physical and economic risks posed by climate change to Miami-Dade County?
- What can we learn from existing best practice?
- How do we ensure future insurability?
- What strategies for adaptation/mitigation would be most suitable for Miami-Dade?

12.00 Adjourn

Appendix 3: Roundtable Discussion Questions

The following questions served as a framework for initiating discussion and to spark a broader conversation.

How do we better understand the physical and economic risks posed by climate change to Miami-Dade County?

1. How do we best model and evaluate climate risk and the balance of risk between catastrophic and long-term effects as well as wind versus flood?
2. How could catastrophe models be better used to help understand the impacts of different climate change scenarios? How do we evaluate Miami-Dade's economic exposure and over what timeframes?
3. Are there opportunities to leverage the insurance industry's expertise to help Miami-Dade County determine the most cost-effective flood planning levels? For example, understanding the economic benefits of requiring additional free board or strengthening building codes?
4. How could catastrophe models be better used to determine the effects of various adaptation measures and determine which measures would be most cost effective?
5. Are there other innovative risk management tools that could help Miami-Dade County better manage our exposure?
6. Are there tools that could be better utilized to help private property owners understand their exposure?

What can we learn from existing best practice?

7. What steps could be taken to better encourage property owners to take actions to mitigate their risks to flooding and hurricanes (wind damage) before an event?
8. What programs exist to reward policyholders who take steps to reduce their vulnerability to hurricanes and flooding? What are the barriers to these programs being more fully utilized?
9. How could communications be improved between insurance companies who are aware of steps that can be taken to mitigate risks and policyholders who are less aware?
10. Do programs exist to increase up-front funding for adaptation retrofits?
11. How do we ensure public property stock and building codes reflect adaptation/mitigation?

How do we ensure future insurability?

12. Given that sea level rise is increasing the risks of flooding annually and climate change may also impact the intensity of future hurricanes, what steps can Miami-Dade County take as a government to improve the insurability of our own assets and private assets within the County?
13. Given that backstop insurance programs, such as the National Flood Insurance Program and Florida Citizens, are serving as the primary insurers for many, how could climate change affect these programs and policyholders in Miami-Dade County? What steps could be taken to limit these risks?
14. Given that insurance policies are typically written for one to three years future risks from climate change, such as sea level rise may not be incorporated into the insurance rates policyholders are paying today. How could policyholders, such as Miami-Dade County, get a clearer picture for how insurance rates are likely to change over the medium and long-term?

15. Should we encourage a longer-term view of climate risk mitigation to match financing/mortgage cycle?

What strategies for adaptation/mitigation would be most suitable for Miami-Dade County?

16. What steps could Miami Dade County take to finance needed adaptation measures?
17. How can we provide adequate but accessible contingency and how should this be balanced between Federal and State?

Appendix 4: Quarterly Reports

First Quarter Update (January 31, 2015- April 30, 2015)

Background

In July 2013, the Board created the Miami-Dade Sea Level Rise Task Force (SLRTF) for the purpose of reviewing current and relevant data, science and reports, and to assess the likely and potential impacts of sea level rise and storm surge to Miami-Dade County over time. On July 1st, 2014, the Task Force presented a report to the Board entitled, "Miami-Dade Sea Level Rise Task Force Report and Recommendations," providing the requested assessment along with recommendations of how Miami-Dade County may more specifically begin planning and preparing for projected sea level rise impacts. In addition, Resolution R-451-14 and Ordinance 14-79 were adopted in 2014, requiring that planning, design and construction of County infrastructure consider potential sea level rise impacts. On January 21st, 2015, the Board passed seven separate resolutions, each supporting the implementation of one of the seven recommendations included in the Sea Level Rise Task Force's Report. Resolution R-49-15 directs the Mayor to initiate discussions related to climate change with the insurance sector and other key stakeholders to develop long term risk management solutions.

On September 29, 2014, the Mayor and the Beacon Council co-hosted a meeting with the UK Ambassador, the UK Consul General, and key leaders in the business and insurance sectors of Miami-Dade to discuss issues and opportunities associated with climate change and sea level rise in Southeast Florida. In addition, the Mayor announced in his opening remarks at the Sixth Annual Southeast Florida Climate Leadership Summit on October 1st, 2014, that he will convene a group of business, financial and insurance leaders to begin a dialogue around these critical business and financial issues.

Quarter 1 Progress (January 31, 2015 – April 30, 2015)

The following steps have been taken during the first quarter towards implementation of this Resolution:

The Nature Conservancy contacted Miami-Dade County in March 2015 with information regarding their collaborative work with Swiss Re to demonstrate the cost effectiveness of coastal ecosystems in adaptation and risk reduction. They have developed "a set of tools and approaches for quantifying risks from coastal hazards and climate change," and provided a Project Note (see attached), summarizing the methodologies used and tools and models developed. They are proposing consideration of parametric insurance policy based on their existing model. Staff from the Regulatory and Economic Resources Department and Internal Services Department's Risk Management Division are currently evaluating the information provided for applicability and use by Miami-Dade County.

In addition, RER staff are working with the Office of Intergovernmental Affairs to identify appropriate stakeholders and candidates to include in an initial meeting, which will occur during the next Quarter.

If you have questions concerning the above, please contact Mark R. Woerner, AICP, Assistant Director for Planning, Department of Regulatory and Economic Resources, at (305) 375-2835 or mwoerner@miamidade.gov.

Second Quarter Update (May 1, 2015- July 30, 2015)

The following work has taken place during the Second Quarter in order to prepare the report referenced in this resolution:

- RER staff have developed a list of appropriate stakeholders and candidates to include in meetings to discuss insurance and long term risk management solutions. These stakeholders are drawn from several key sectors including commercial and residential real estate, insurance, reinsurance, and finance. Several risk management experts in the public sector will also be invited to participate. These meetings will serve as listening sessions to understand the concerns and questions of private sector partners and to introduce the work underway within Miami-Dade County and regionally. This will be followed by discussions throughout the fall which will work through the potential for direct assistance and collaboration between the public and private sectors to minimize the uncertainty and potential impact of flooding and severe storms.

- These meetings will also explore the potential impact of a changing insurance market and its implications for the larger economy and development within Miami-Dade County. The intention is that this group can begin to outline the information, stakeholders, and working relationships that will be needed to create more formal public-private partnerships to work to identify financing options for needed investments for adaptation and minimizing flooding risks and economic disruption.

- Staff from RER and Internal Services Department's (ISD) Risk Management Division have evaluated the information provided by The Nature Conservancy regarding their collaborative work with Swiss Re to demonstrate the cost effectiveness of coastal ecosystems in risk reduction. Given the wealth of natural buffer areas throughout Miami-Dade County, this research is very relevant to our long-term adaptation and will be considered as part of a holistic adaptation approach.

Third Quarter Update (July 31, 2015- October 15, 2015)

The following discussions have been taken during the third quarter in order to prepare the report referenced in this resolution:

- During this quarter, RER staff continued several initiatives including conversations with The Nature Conservancy regarding their collaborative work with Swiss Re to demonstrate the cost effectiveness of coastal ecosystems in risk reduction. Staff also continued to contact the list of key stakeholders drawn from commercial and residential real estate, insurance, reinsurance, and finance. In addition RER has continued to work closely with the Risk Management Division within the Internal Services Department (ISD) to identify additional contacts.

- On July 29, 2015, staff spoke with regional Compact partners and the Chambers of Commerce from Miami-Dade and Broward counties to determine how the Compact could more directly engage the business community. Through this discussion a number of opportunities were identified to present to different business groups. For example, in January 2016, the Miami-Dade Chamber of Commerce will be hosting a panel discussion on climate change. RER staff are working directly with the Chamber to identify potential speakers and will continue to help with shaping the content of the event.

- On August 21, 2015 RER staff also met with the Beacon Council to discuss how best to approach and engage the business community regarding the issues of sea level rise and climate change. At this

meeting the staff outlined a work plan to hold a series of small focus group meetings with key business leaders which represent several key industries within Miami-Dade County. These initial conversations are intended to serve as the foundation for a broader engagement strategy once the appropriate messaging has been developed.

- On August 31, 2015, Miami-Dade County hosted a delegation of 35 representatives from Lloyd's of London, one of the largest reinsurance agencies in the world. The Lloyd's delegation came to Miami to learn of our challenges associated with sea level rise and climate change, and what the County is doing at a local and regional level to plan and prepare for impacts. The meeting was also an opportunity to learn more about how Lloyd's is approaching these challenges from their perspective. During the discussion Lloyds raised a number of questions about the County's current floodplain regulations and how the County was going to integrate sea level rise considerations into future land use planning. They discussed how, in the United Kingdom, the insurance industry has effectively negotiated with the government to increase overall insurability. In the United Kingdom, it is the responsibility of the government to put adequate regulations in place which reduce the riskiest forms of development, and in exchange, the insurance industry agrees to continue to offer insurance. Recently, as flood risks and losses have increased, the insurance industry has renegotiated that agreement and has pushed the government to do more in terms of flood defenses. This meeting with the Lloyd's representatives also provided new insights into the potential for the County to use catastrophe models (which are already utilized) to better inform our risk mitigation investments, reduce the County's exposure to extreme events, and reduce insurance premiums. The Lloyd's delegation also raised important considerations about how climate change and the associated increase in risk moving forward will impact insurance premiums and the ability to purchase insurance.

- On September 25, 2015, the British Consulate of Miami facilitated a meeting at their office between RER staff and representatives from CBRE Real Estate Services and Royal Institution of Chartered Surveyors (RICS). RICS promotes and enforces the highest professional qualifications and standards in the development and management of land, real estate, construction and infrastructure. CBRE provides a broad range of professional services with a particular emphasis on the real estate market. This meeting focused on professional standards relating to construction, insurance, and climate change. The discussion also revolved around the future effect of sea-level rise, exacerbated by natural catastrophe, on the economic and environmental resilience in Florida.

- On September 25, 2015, staff drawn from ISD, Planning, Sustainability, and Emergency Management, sat down with representatives from AJG and AIR Worldwide to discuss how the County could make better use of the outputs of the annual catastrophe models that are conducted for the Risk Management Division of ISD. The secondary goals of the meeting were to discuss how the use and scope of the catastrophe models could be expanded in the future to better guide the County's mitigation efforts. Given Miami-Dade County currently uses its annual catastrophe analysis primarily to determine the Average Annual Loss (AAL), the discussion focused on how these tools could also be used to help the County reduce the exposure of its own assets. The discussion centered on how these risk mitigation tools, used primarily for insurance purposes, could be fed more directly to Emergency Management to prioritize mitigation strategies, which will in turn increase the County's resilience to sea level rise and potentially reduce insurance premiums. The potential to broaden the current scope of this work to incorporate sea level rise was also discussed.

- On September 25, 2015, staff drawn from the ISD, RER Planning, the Office of Sustainability, and the Office of Emergency Management, held a separate discussion with Swiss Re, a global reinsurance

company, regarding work they completed for New York City as part of the city's *Stronger, More Resilient New York* initiative. Swiss Re supported the development of the coastal protection plan for New York using an iterative process examining the cost effectiveness of different adaptation measures. This process also utilized catastrophe models. This meeting focused on the potential to draw upon the reinsurance industry's risk management expertise to help expedite the development of a comprehensive plan to increase Miami-Dade County's resilience to sea level rise.

Appendix 5: Roundtable Presentations

RISK MANAGEMENT ROUNDTABLE DISCUSSION

January 11, 2016

The Beacon Council, Miami Florida

British Consulate-General Miami

MIAMI-DADE COUNTY

The Beacon Council
Miami-Dade County's Official Economic Development Partnership

WELCOME

Larry K. Williams, President & CEO, The Beacon Council
Dave Prodger, British Consul General in Miami
Carlos A. Giménez, Mayor Miami-Dade County

AGENDA

9	Welcoming remarks
9:15 – 10:15	Introduction to Key Issues • Antony Phillips & Adam Canning (Willis) • Alex Kaplan (Swiss Re) • David Baxter & Tim Gifford (RICS) • Rodney Smith (Lloyds)
	Break
10: 30 – 12	Facilitated Discussion
Noon	Adjourn

AGENDA

9:15 – 10:15 Introduction to Key Issues

- **Jim Murley** (Miami-Dade County)
- **Antony Phillips & Adam Canning** (Willis) *Modelling Climate Risk and a holistic approach to financial mitigation*
- **Alex Kaplan** (Swiss Re) *Resilience and the Economics of Risk*
- **David Baxter** (RICS) *Driving Responsible Solutions Across the Built Environment*
- **Rodney Smith** (Lloyd's) *Lloyds: Climate Change*

CONTEXT

Jim Murley (Miami-Dade County)

MODELLING CLIMATE RISK & A HOLISTIC APPROACH TO FINANCIAL MITIGATION

Antony Phillips & Adam Canning (Willis Towers Watson)

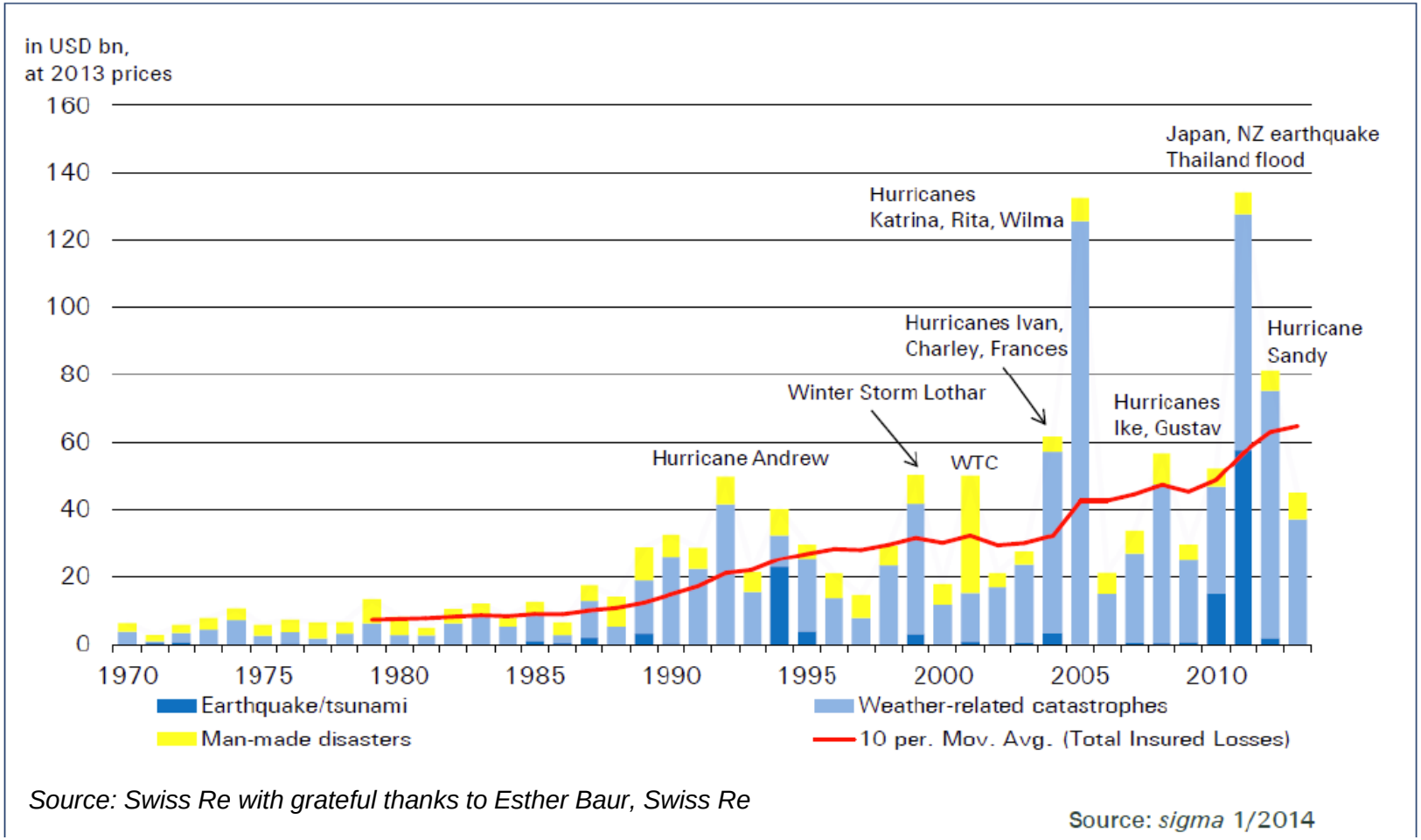
Long-Term Risk Management and Insurance

Modelling climate risk & a holistic approach to financial mitigation

WillisRe

Global Re/insurance Sector 1992 – 2015: from Ruin to Resilience

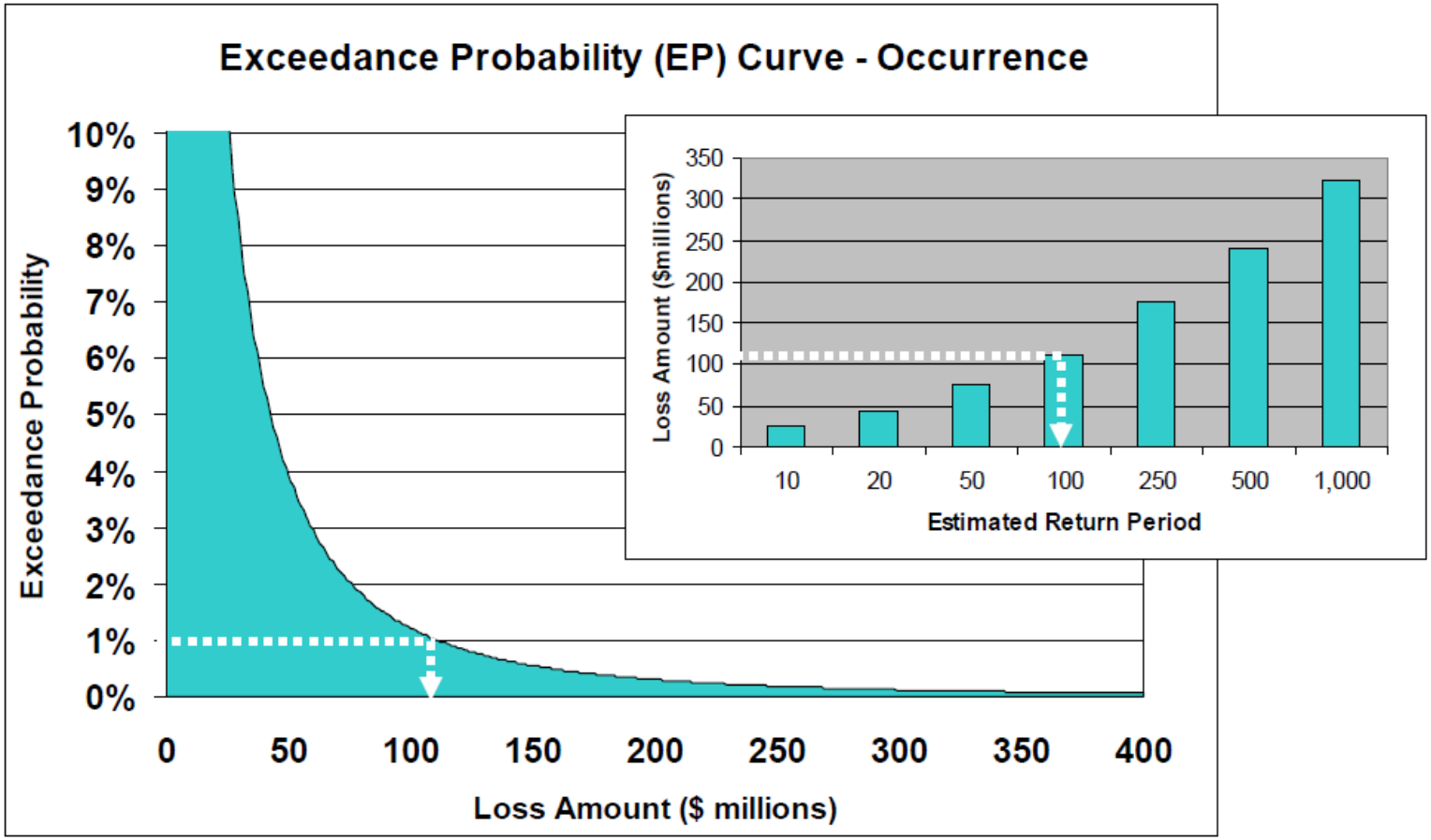
The story of climate risk stress tests and industry reform



Source: Swiss Re with grateful thanks to Esther Baur, Swiss Re

The Output that Transformed a Market

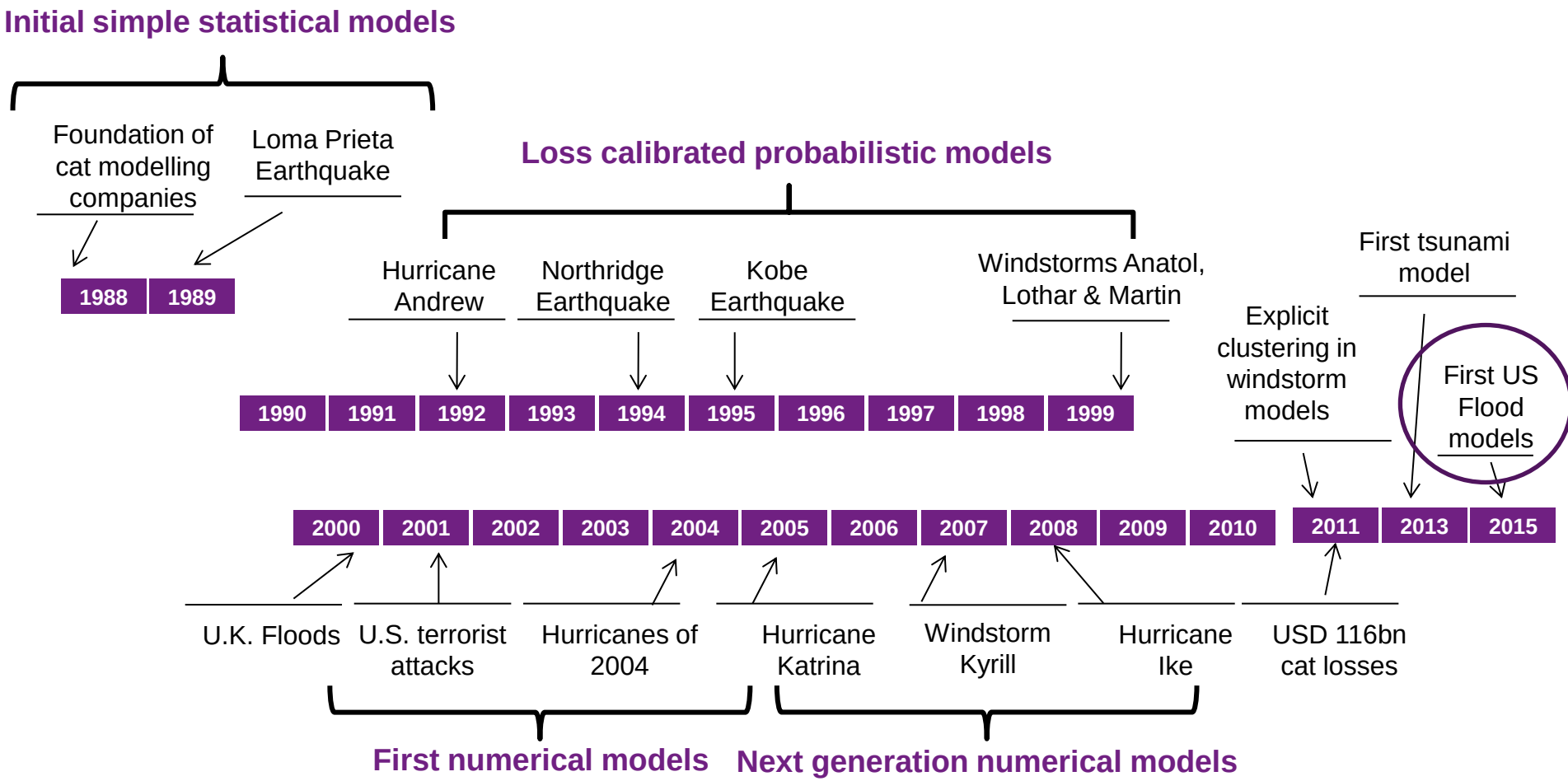
The Loss Exceedence Probability Curve



Source: AIR Worldwide

Quantifying risk through Catastrophe risk models

A brief history



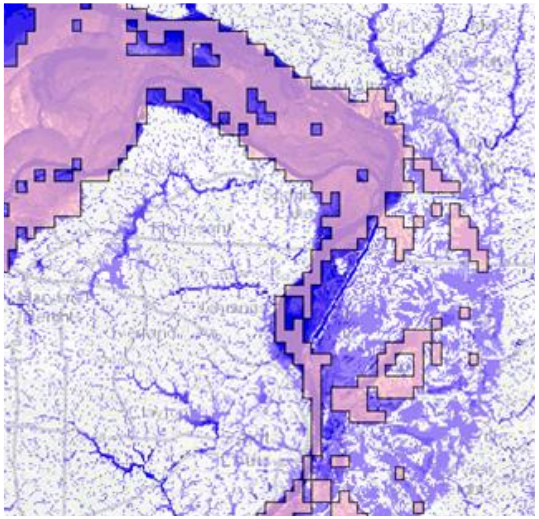
Quantifying the Risk

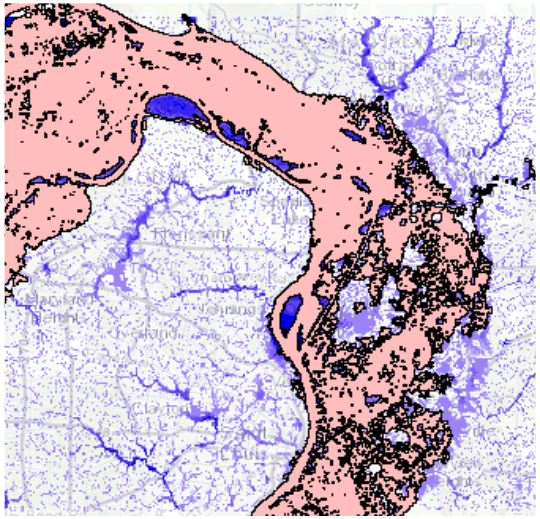
Flood Catastrophe Modeling

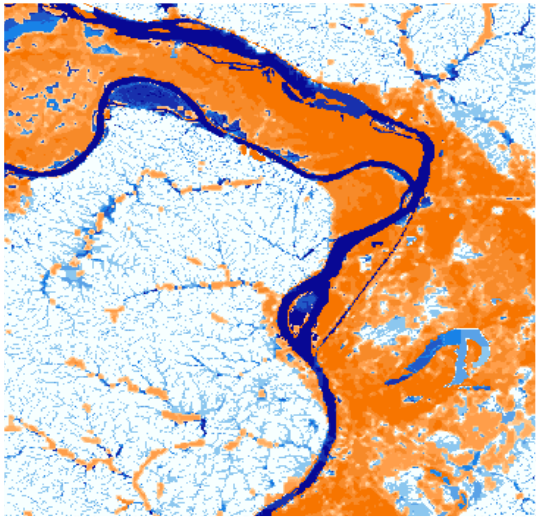
Ability to model flood exposure has developed slower than models for Hurricane or Earthquake, however the past few years has seen a marked increase in the availability of commercial models and hazard maps for risk quantification.

Willis Re has evaluated the large majority of those and assessed:

- Coverage (e.g. pluvial)
- Scientific methodology (e.g. 2D modelling)
- Resolution

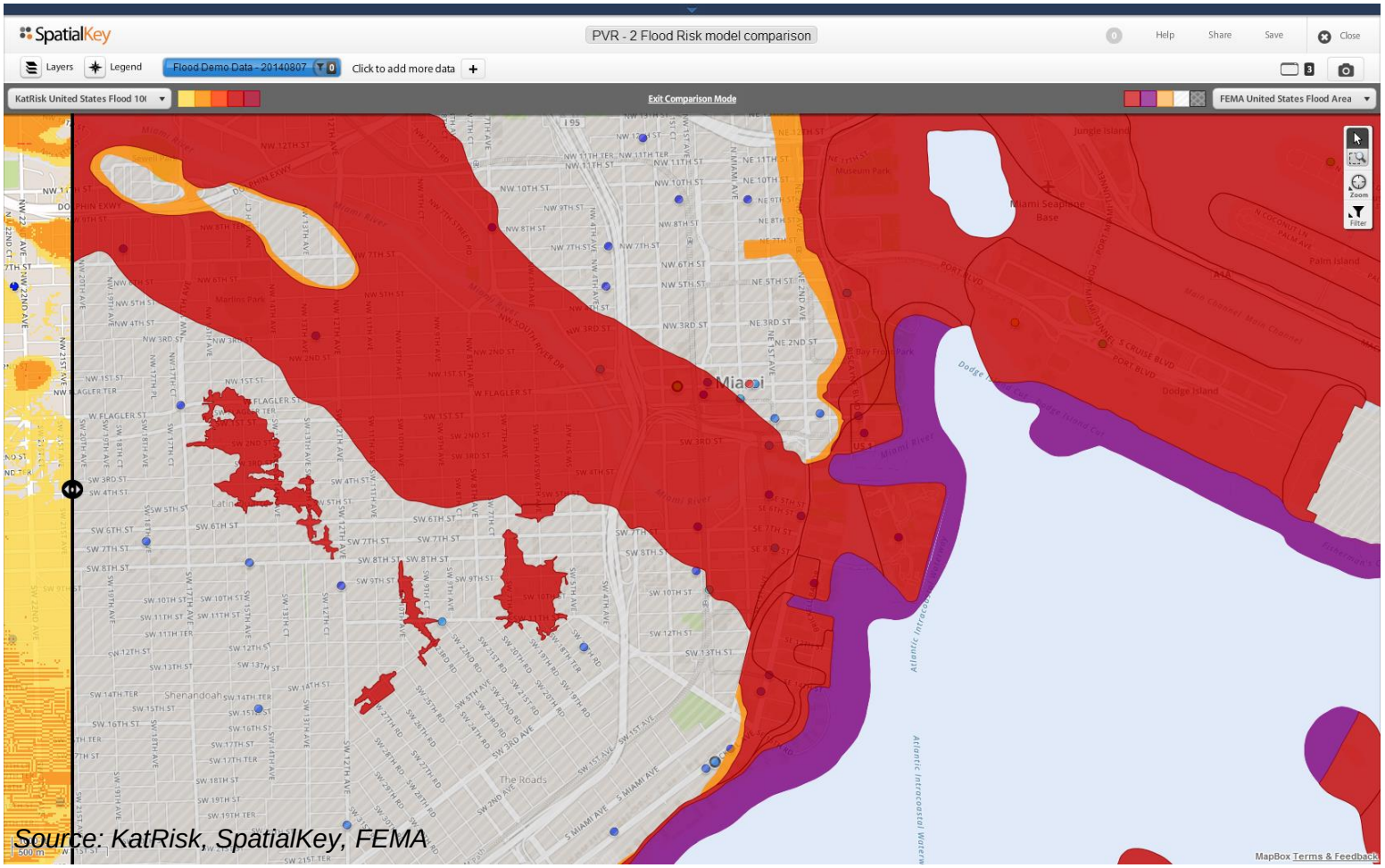






Supplementing the NFIP View of Risk

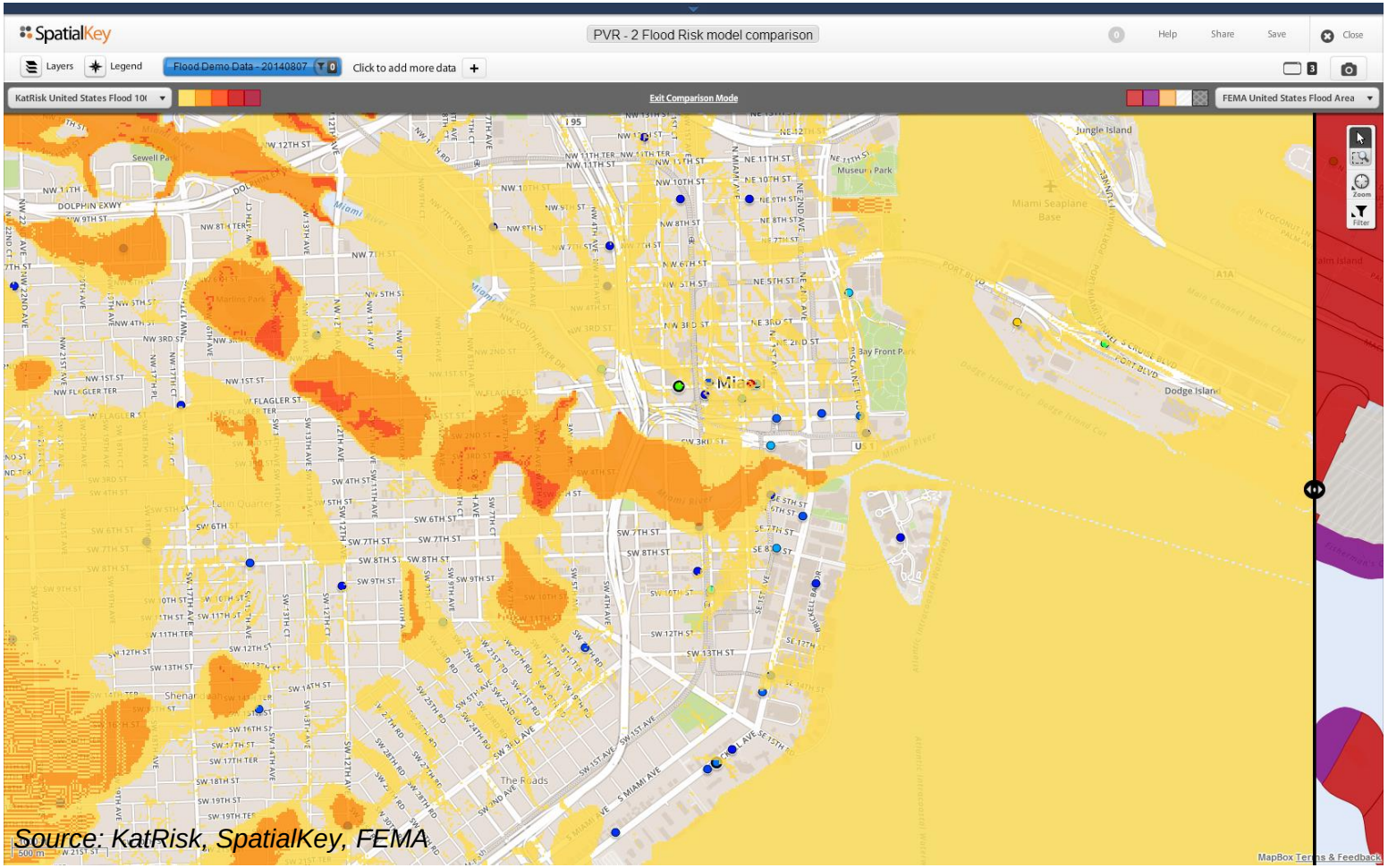
US flood hazard layer comparisons



Source: KatRisk, SpatialKey, FEMA

Supplementing the NFIP View of Risk

US flood hazard layer comparisons



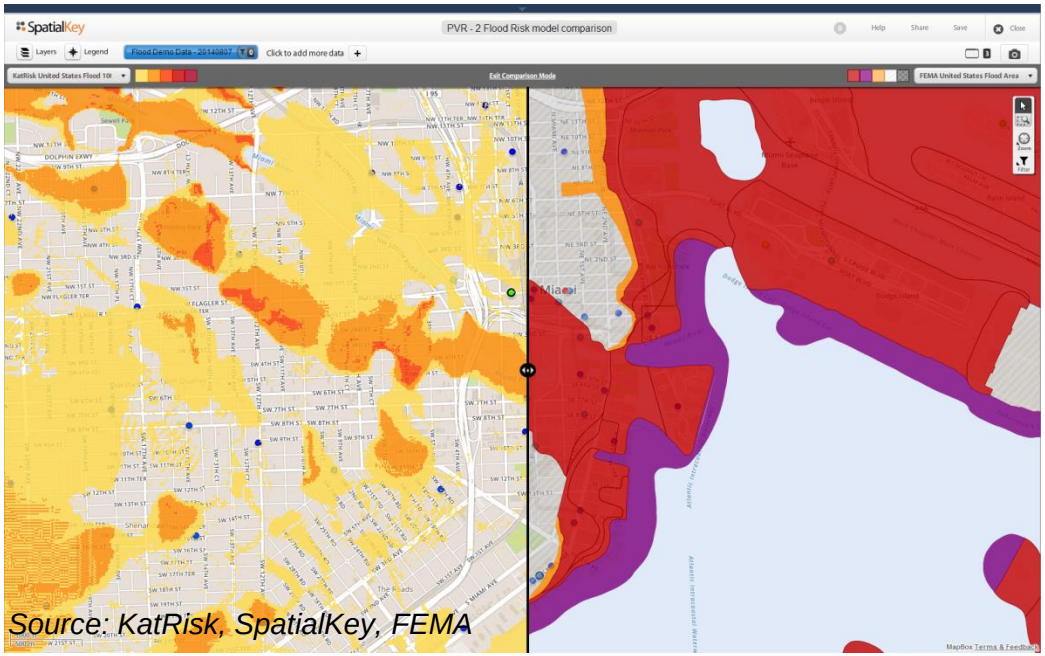
Source: KatRisk, SpatialKey, FEMA

Supplementing the NFIP View of Risk

US flood hazard layer comparisons

‘Tying Flood Insurance to Flood Risk for Low-Lying Structures in the Floodplain’
(National Academy of Science)

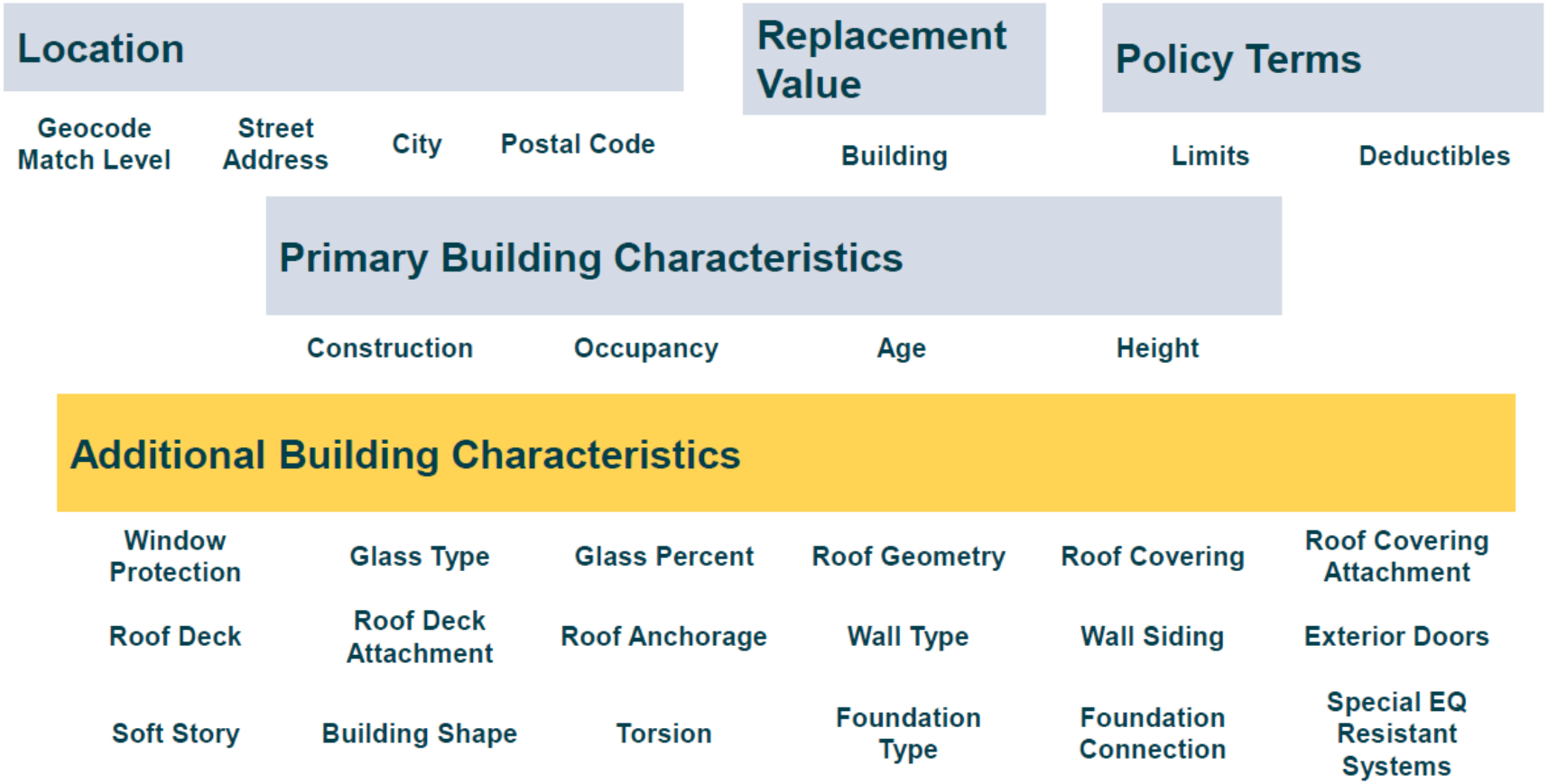
“Modern technologies, including analysis tools and improved data collection and management capabilities, enable the development and use of comprehensive risk assessment methods, which could improve NFIP estimates of flood loss”



Source: KatRisk, SpatialKey, FEMA

Exposure data relevant for Climate Risk Modelling

Understanding the underlying risk attributes



Post-Andrew, Miami-Dade Construction Codes improved, wind-driven reasons but will also help improve resilience to flood

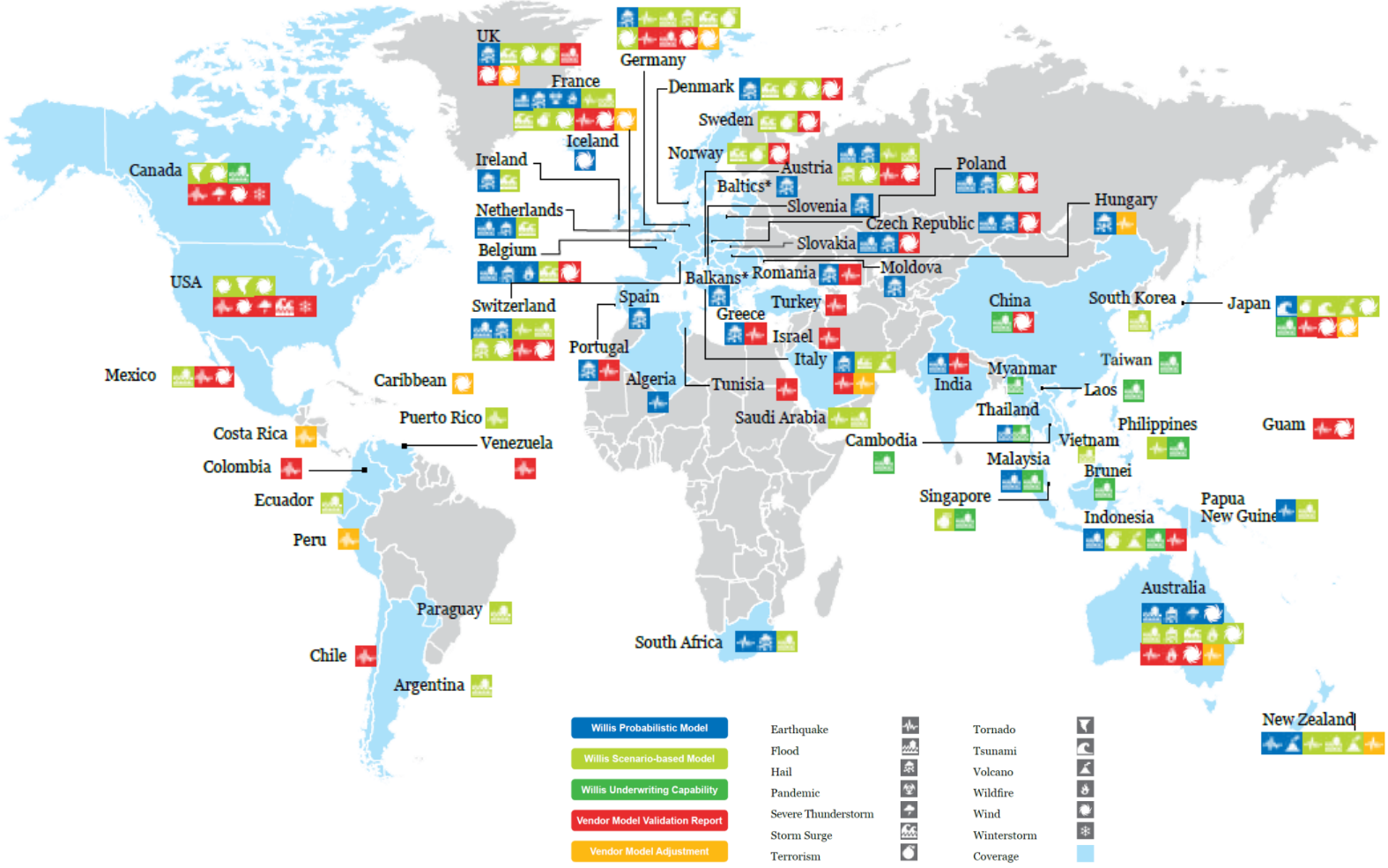
‘Re/Insurance Style’ Climate Risk Stress Tests

Benefits & Implications

- A tried and tested approach, 25 years in re/insurance risk trading, management and regulation.
- Same framework, tools and methodologies can be used to evaluate future risks and wider risk factors, including public policy.
- By placing a tractable and proportionate price on risk we provide a reasoned and proportionate value on risk reduction and resilience and a mechanism for enabling that equation to be integrated into financial decisions.
- Using insurance style assessment approaches, feasible to undertake trial/research stress tests on Cities to physical climate risk – now and in the future.
- Groups of interested parties are already emerging, such as the ‘1 in 100 Initiative’ and ‘Insuring Resilient America’.

Willis Re supporting flood quantification globally

The Willis Re View of Risk

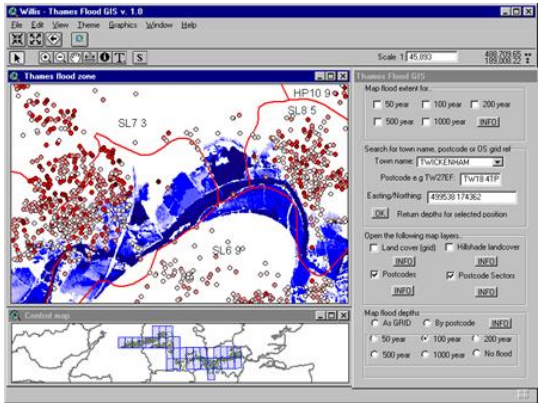


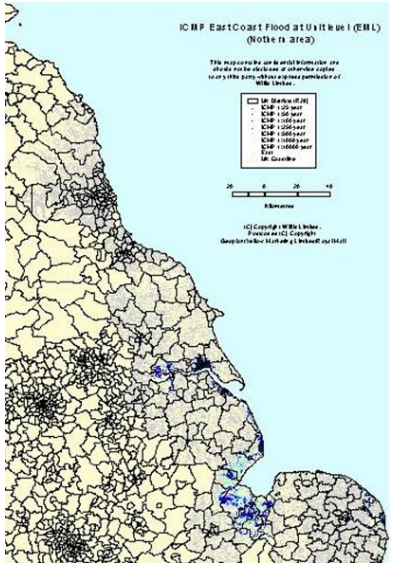
Flood quantification at the forefront of WTW analytics

A history of managing flood risk

A few examples of our flood modelling pedigree:

- UK River Thames and Coastal Surge models
- Australia flood mapping, quantifying the risk and enabling flood insurance for the market
- Latin America Mega-cities
- Pan-European flood and regional / catchment correlation
- South-East Asia comprehensive flood analytics
- Developing rates to assist in first-to-market Personal Lines flood policy in Canada





Willis Towers Watson academic partners and research

Capital Science & Policy / WRN

- Investment in our future
- Climate change
- Strategic advisor to the U.N.
- Willis Research Network (WRN) is the world's largest collaboration of industry & academia

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Long-Term Risk Management and Insurance

Modelling climate risk & a holistic approach to financial mitigation

Willis Re

RESILIENCE AND THE ECONOMICS OF RISK

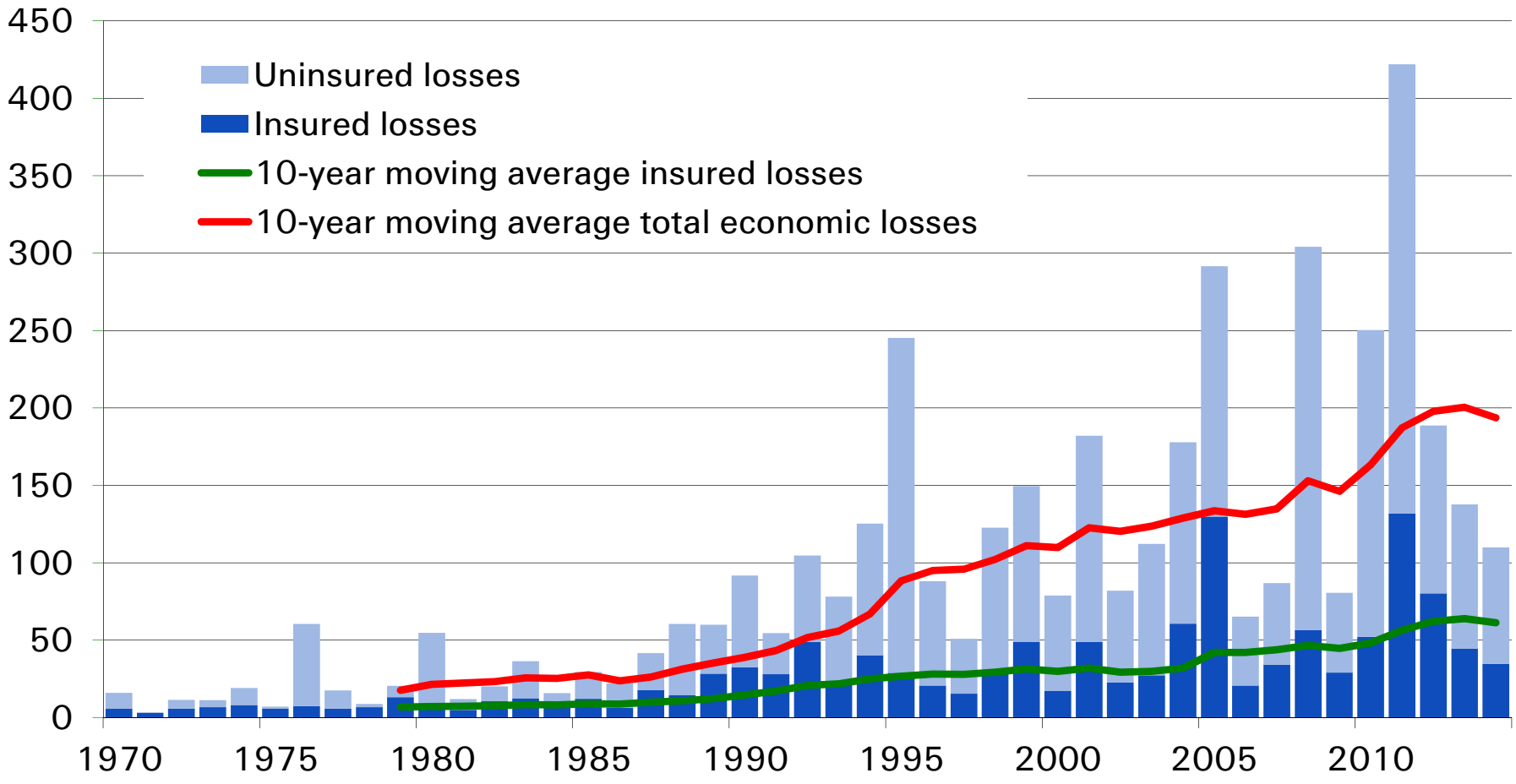
Alex Kaplan (Swiss Re)

Resilience and the Economics of Risk

Miami-Dade County Mayor's Discussion on Long-Term Risk Management and Insurance
January 2016

The growing burden of uninsured losses

Natural catastrophe losses 1970 – 2014 (in 2014 USD)



Source: Swiss Re Economic Research & Consulting and Cat Perils.

Climate change is not the main driver for rising natural catastrophe losses in recent decades

Ocean Drive, FL, 1926

Ocean Drive, FL, 2013

Drivers

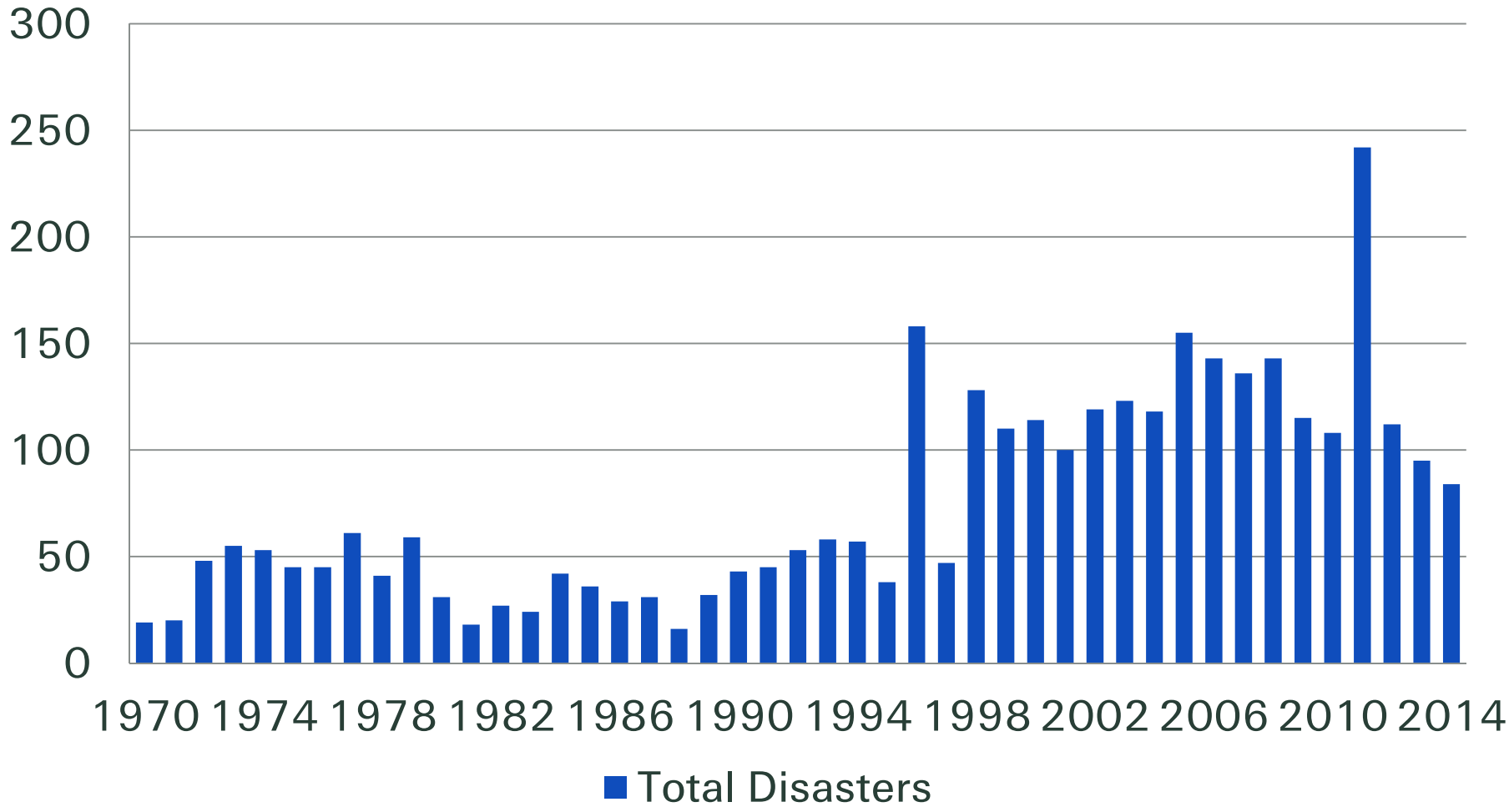
Growth of wealth

Concentration of values in exposed areas (e.g. coasts)

Increasing vulnerability

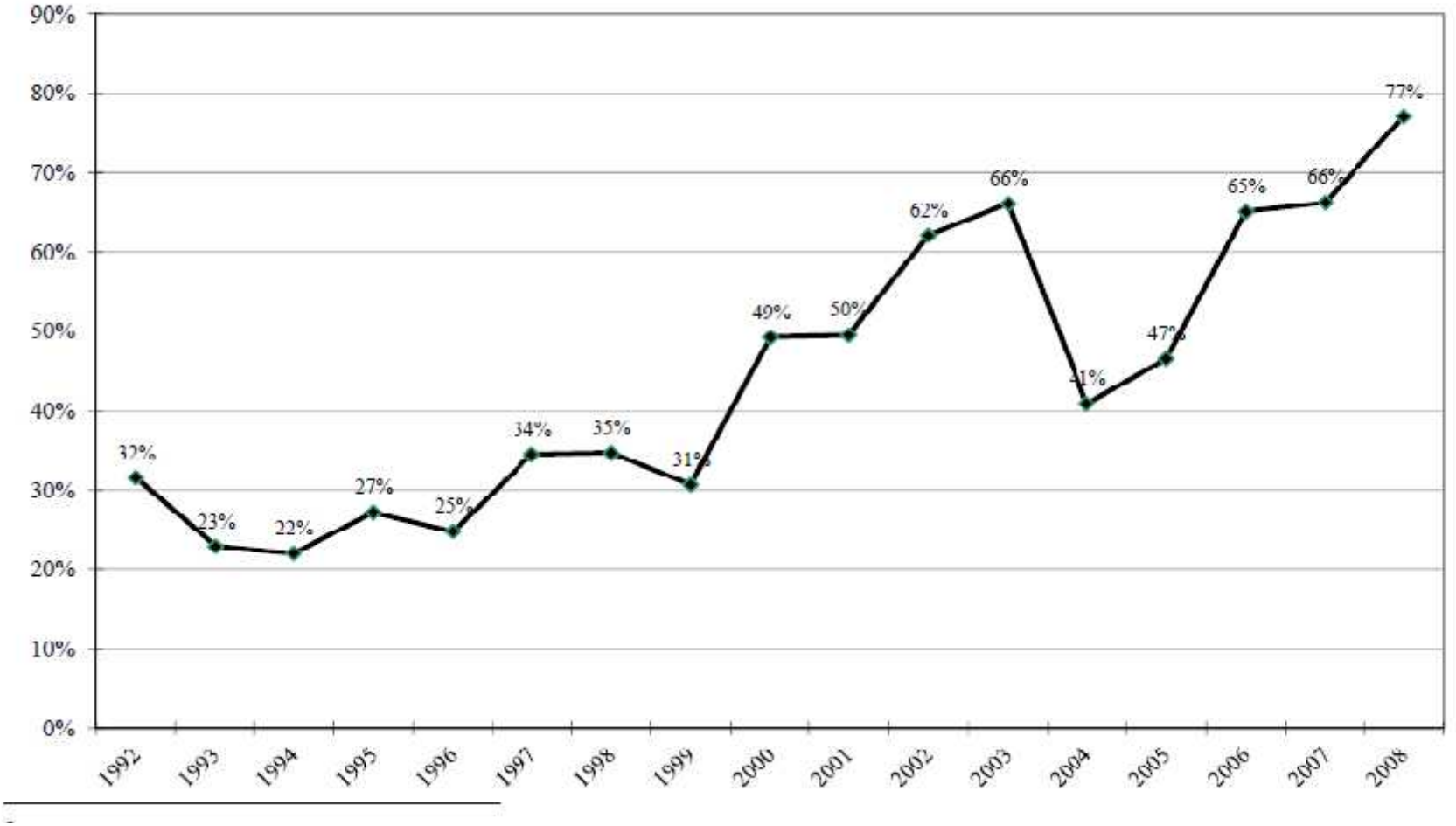
Climate change as a potential new driver in future (storms, floods, droughts)

FEMA Disaster Declarations – 1970-2014
Disasters Have Tripled Since in the 1970s



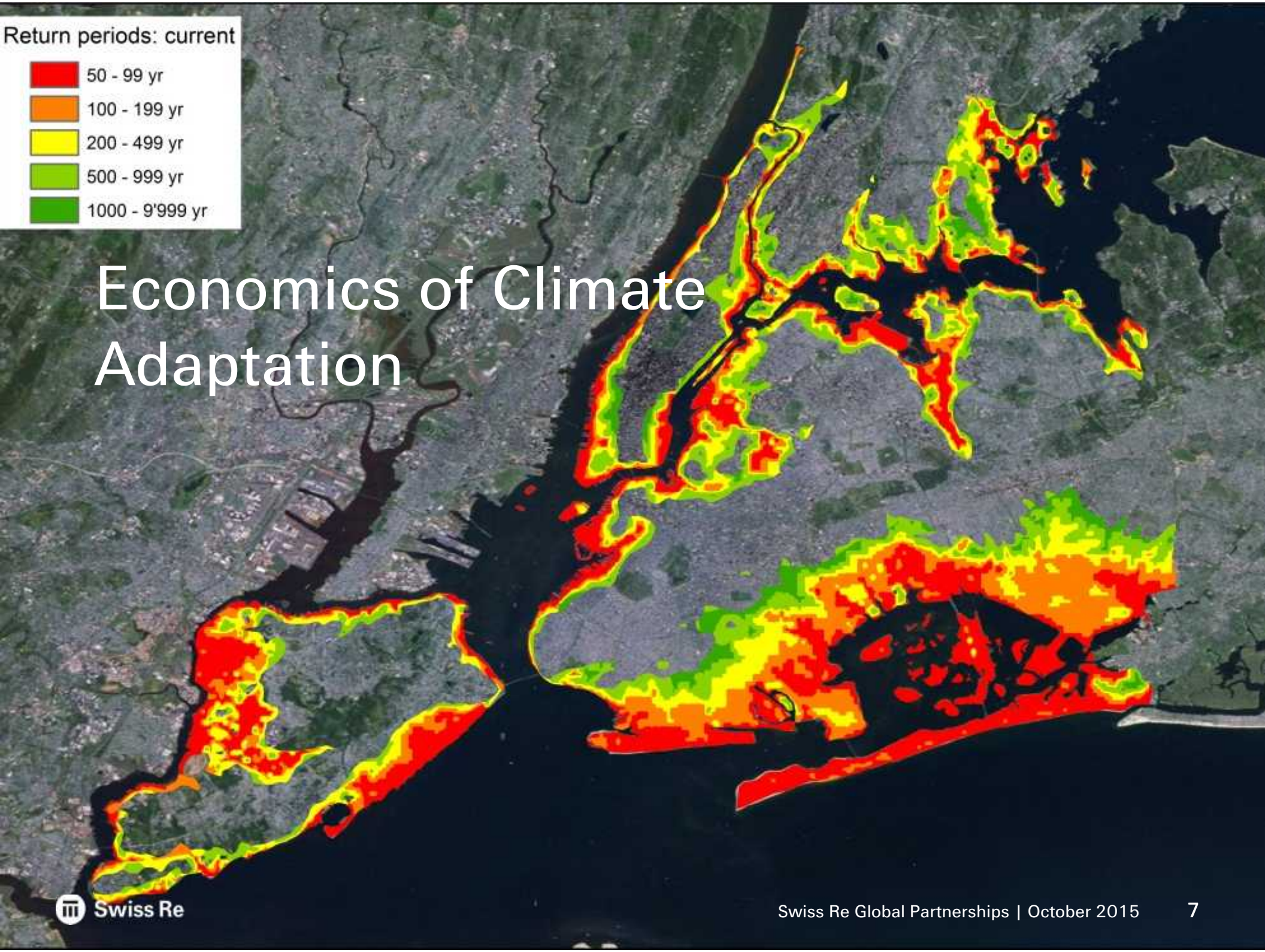
The proportion of economic losses absorbed by the USG: Is this sustainable?

Figure 4: Ratio of Total Federal Government Disaster Expenditures to Measured Losses
Source: Cummins, Suher, and Zanjani (2010)[2]



In the US, the price tag is large and growing.

- Since 2005, the US taxpayer has spent over **$300 billion on direct costs** of extreme weather and fire alone.
- Firefighting expenses have **tripled in 20 years**.
- In 1991, firefighting made up **13%** of the Forest Service budget. In 2013, it was **50%**
- Natural catastrophes (earthquake and weather related) cause average economic losses of **$60-100 billion** annually. (Hurricane Sandy = ~$70 billion)
- The US Government spent **$96b** in 2012 to pay for climate-related events
  - If this so-called "Climate Disruption Budget" were included in the actual budget, it would be the largest non-defense discretionary budget item.
  - The Government paid more for climate-related losses than it did for transportation or education.



Economics of Climate Adaptation

Climate adaptation is an urgent priority

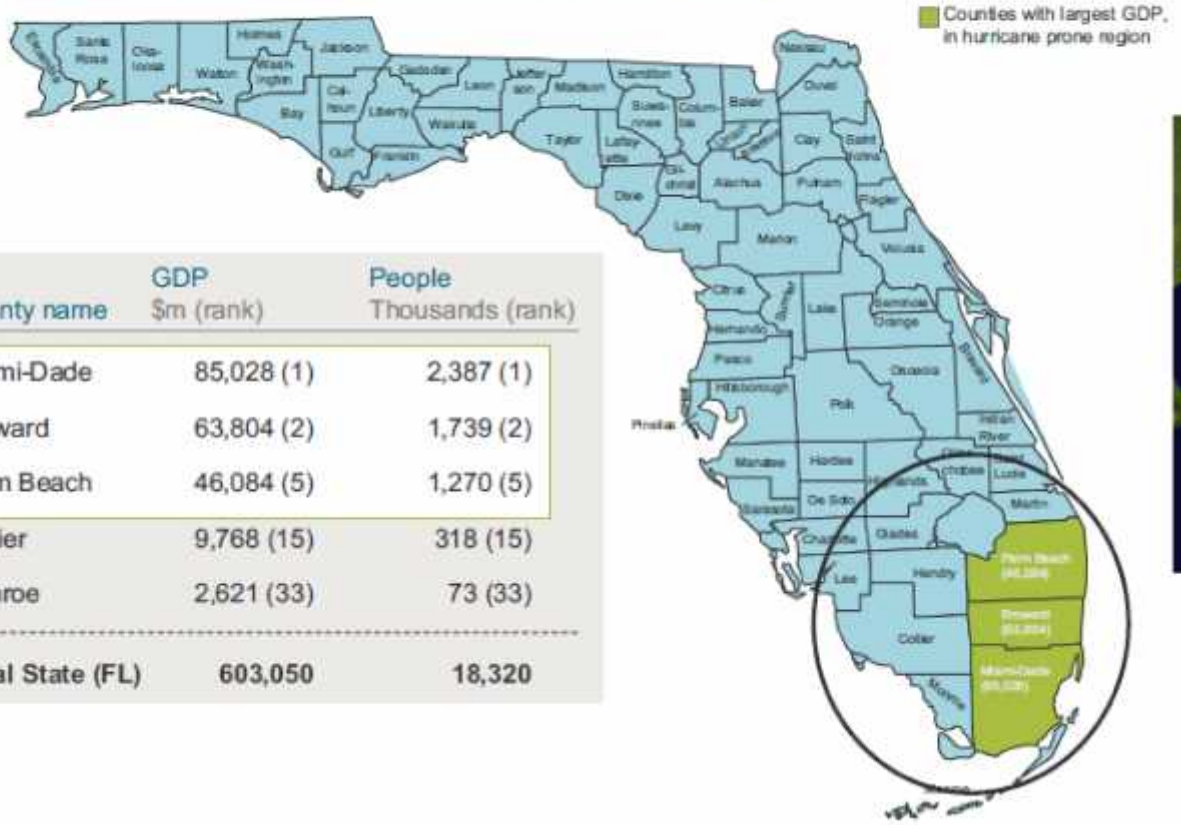
Decision makers ask

- What is the potential climate-related damage over the coming decades?
- How much of that damage can we avert, with what measures?
- What investments will be required to fund those measures and will the benefits of that investment outweigh the costs?

South Florida Case Study:
Focus on Risk from Hurricanes

02

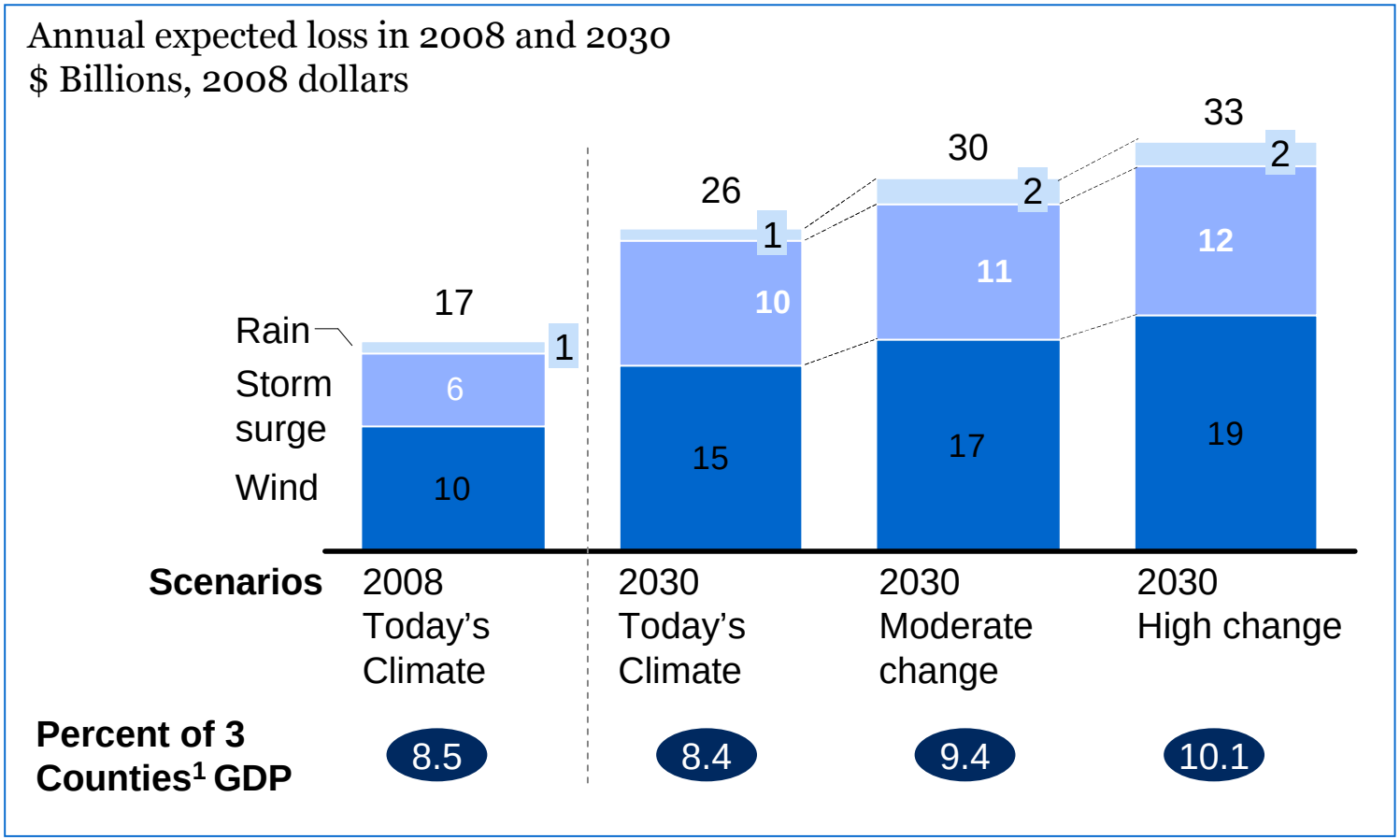
The case study area is home to some of the most populated and economically successful counties in the State



County name	GDP $m (rank)	People Thousands (rank)
Miami-Dade	85,028 (1)	2,387 (1)
Broward	63,804 (2)	1,739 (2)
Palm Beach	46,084 (5)	1,270 (5)
Collier	9,768 (15)	318 (15)
Monroe	2,621 (33)	73 (33)
Total State (FL)	**603,050**	**18,320**

Result: Expected losses by scenarios and by hazard

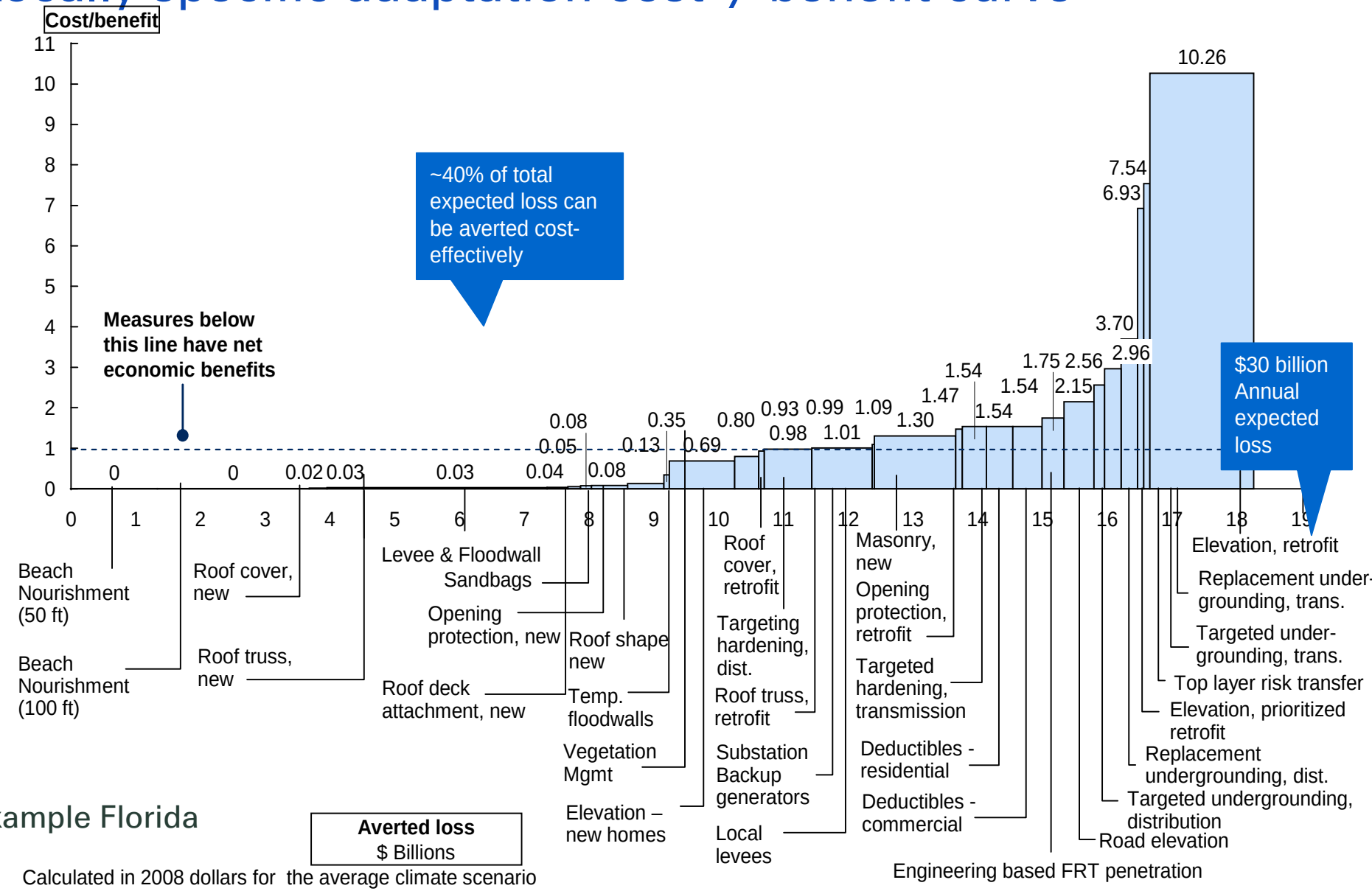
Example Florida



1 2008 Moody's

SOURCE: Swiss Re; team analysis

Locally specific adaptation cost / benefit curve

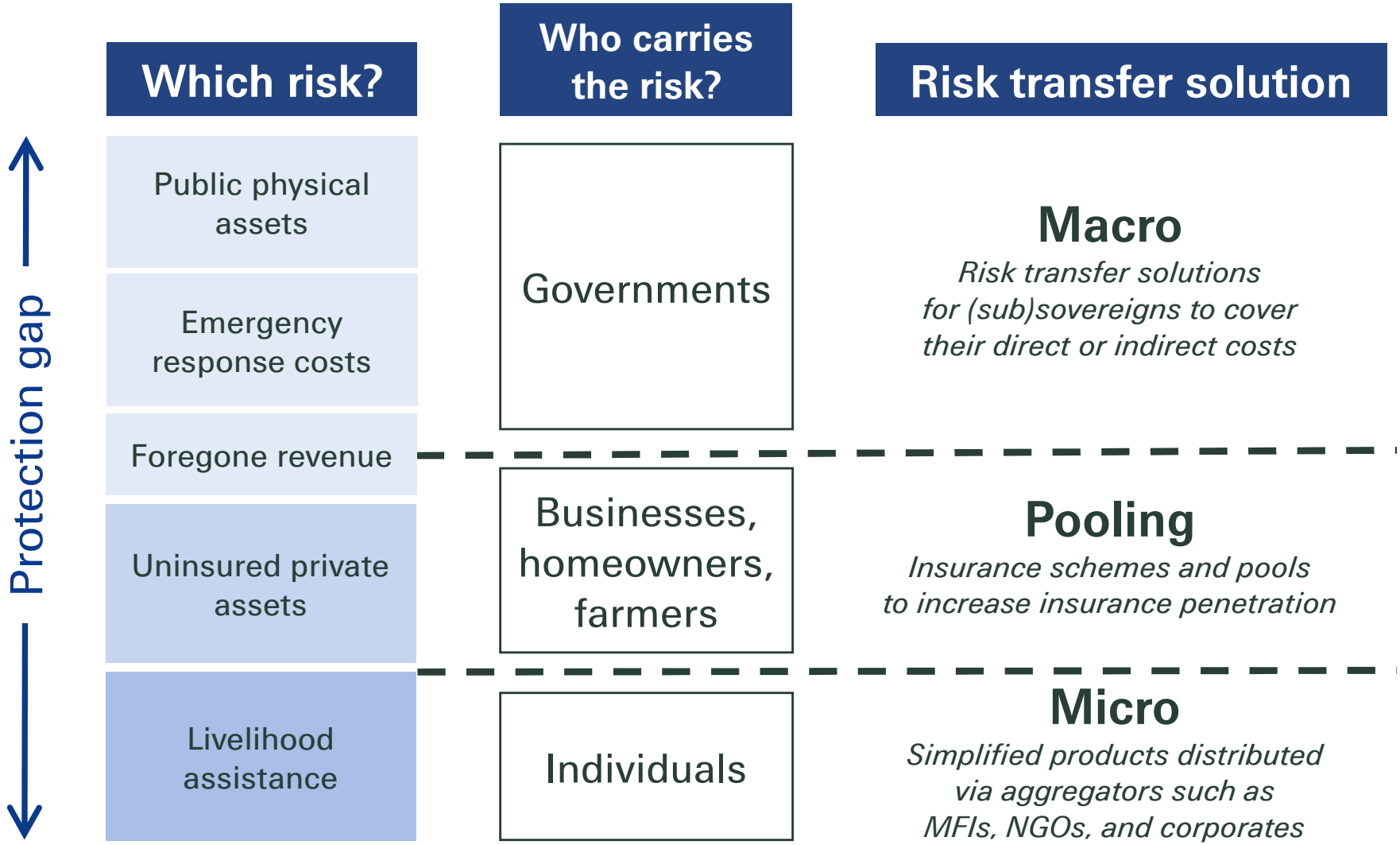


Example Florida

Calculated in 2008 dollars for the average climate scenario

Closing the gap

How to close the protection gap



Financing is a pillar of integrated disaster risk management

1 Identification

What risks do we **face**?

- Systematic
- Cross-sectoral

2 Assessment

Can we **quantify** it?

- Frequency
- Severity

3 Prevention & mitigation

How can we **minimize** it?

- Improve quality
- Build new protection

4 Adaptation

How can we manage the **residual risk**?

- Change behavior
- Pre-finance
- Risk transfer

Disaster Risk Financing: Case Studies

Case study Caribbean:
Caribbean Catastrophe Risk Insurance Facility (CCRIF)

Solution features

- The CCRIF offers parametric hurricane and earthquake insurance policies to 16 CARICOM governments
- The policies provide immediate liquidity to participating governments when affected by events with a probability of 1 in 15 years or over
- Member governments choose how much coverage they need up to an aggregate limit of USD 100 m
- The mechanism will be triggered by the intensity of the event (modelled loss triggers)
- The facility responded to events and made payments:

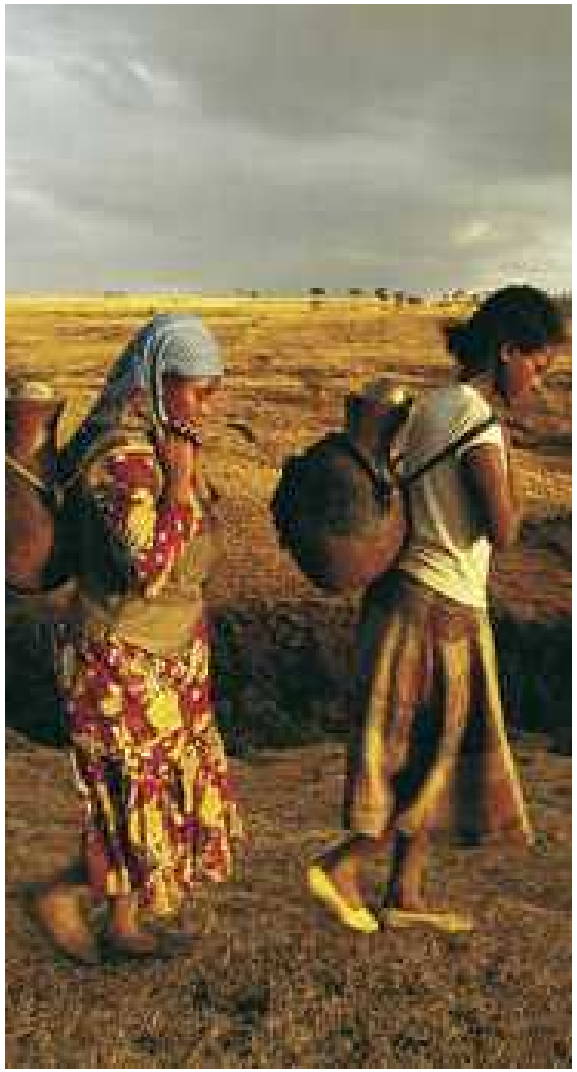
Involved parties

- Reinsurers: Swiss Re and other overseas reinsurers
- Reinsurance program placed by Guy Carpenter
- Derivative placed by World Bank Treasury

Payouts to date

- 2010: Haiti USD7.7m (earthquake), Barbados USD 8.5m (hurricane), St. Lucia USD 3.2m (hurricane), St. Vincent & The Grenadines USD 1.1 (hurricane), Anguilla USD 4.2m (hurricane).
- 2008: Turks & Caicos USD 6.3m (hurricane)
- 2007: St. Lucia USD 418k (hurricane), Dominica USD 528k (hurricane).

Case study African Risk Capacity: Insuring governments' drought response costs



Solution features

- African Risk Capacity (ARC), through its insurance subsidiary ARC Insurance Ltd., is a sovereign insurance pool, which provides African governments with index-based macro drought cover (in a later stage also flood).
- It incepted in May 2014 with five countries and will expand over the next years to cover more countries. The pool is capitalized with USD 200 million to offer maximum cover of USD 30 million per country.
- To establish the payout rules, ARC has developed a software application, Africa Risk View (ARV), which translates satellite-based rainfall information into near real-time response cost estimates.
- Each country is required to customize and define its own insurance parameters and to submit a contingency plan, addressing the distribution of potential payouts to the affected population to ensure fast response.
- Certificate of good standing issued by ARC agency is a pre-requisite to participate in the insurance pool.

Involved parties

- Set up as Special Agency of the African Union with support from WFP, DfID, SIDA, SDC, Rockefeller Foundation, IFAD;
- Insurance entitiy ARC Insurance Ltd capitalized by DfID and KfW.
- Risk transfer to international insurers and reinsurers through broker.

Payouts to date

For 2014, Niger, Senegal and Mauritania received a combined payout of USD 26m, of which USD 16.5m to Senegal.

Case study:
Miami Dade County Public Schools–
Custom multi-year structured cover

Solution features

- Insured peril: Named Windstorm and associated flood
- Multi-year structured cover: USD 100m
- Covering indemnified losses from NWS to soften impact to broader school system
  - 3 year coverage with unlimited reinstatements
  - Term Aggregate Deductible
  - Fixed premium over term
  - No claims bonus
- Time horizon: May 2013– May 2016
- Customized multi-year structured risk transfer for major school district

Involved parties

- Insured: Miami-Dade County Public Schools
- Swiss Re: Lead structurer and sole underwriter
- Broker: AJ Gallagher

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DRIVING RESPONSIBLE SOLUTIONS ACROSS THE BUILT ENVIRONMENT

David Baxter & Tim Gifford (RICS)

Driving Responsible Solutions Across the Built Environment

David Baxter, BSc (Hons) MRICS
Director, Mitig8 Risk Management LLC
RICS Chapter Member and Past Chair RICS (West Midlands UK)

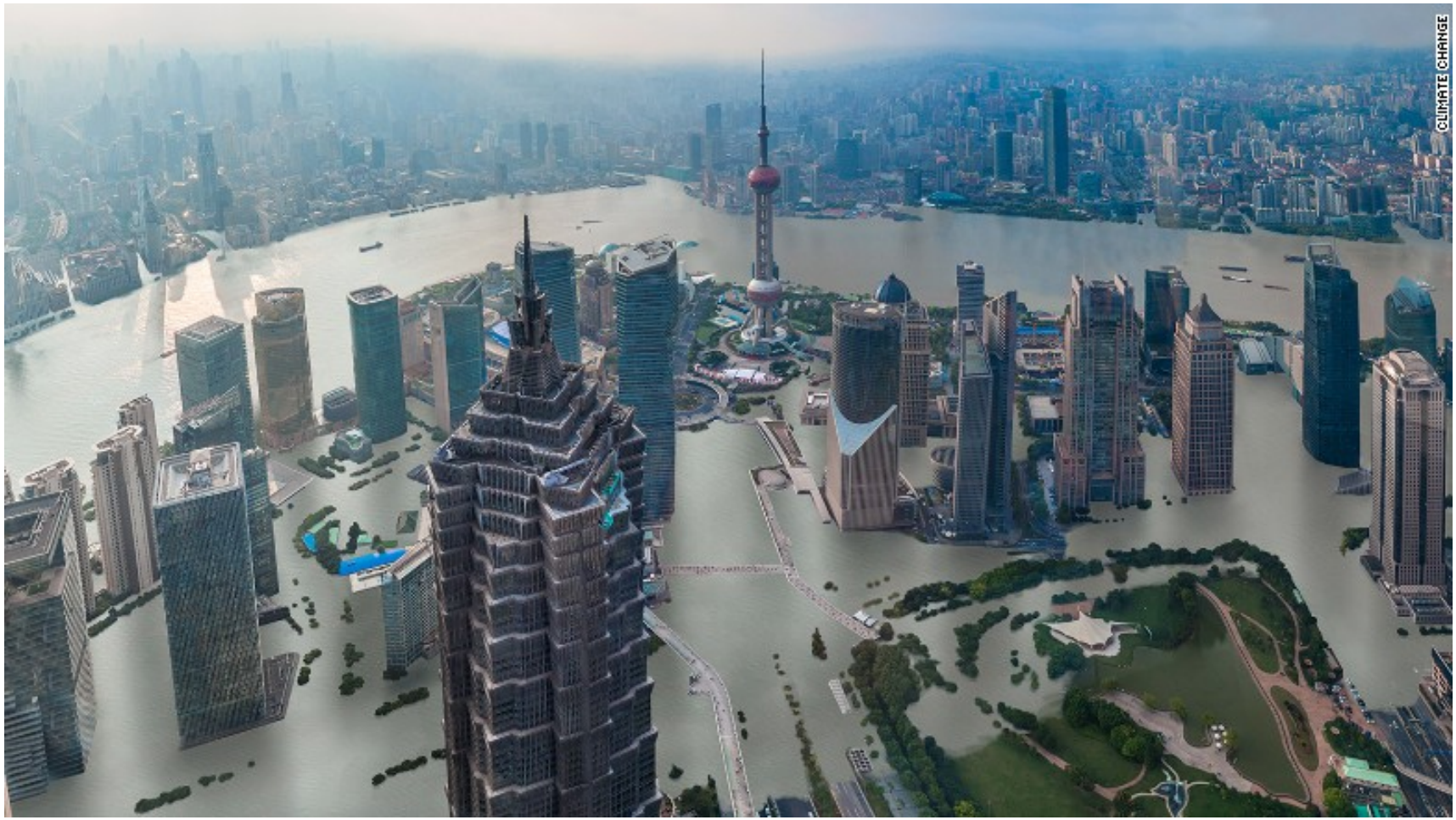
Tim Gifford, FRICS
Senior Vice President, CBRE
RICS Florida Chapter Chair

Driving Responsible Solutions Across the Built Environment

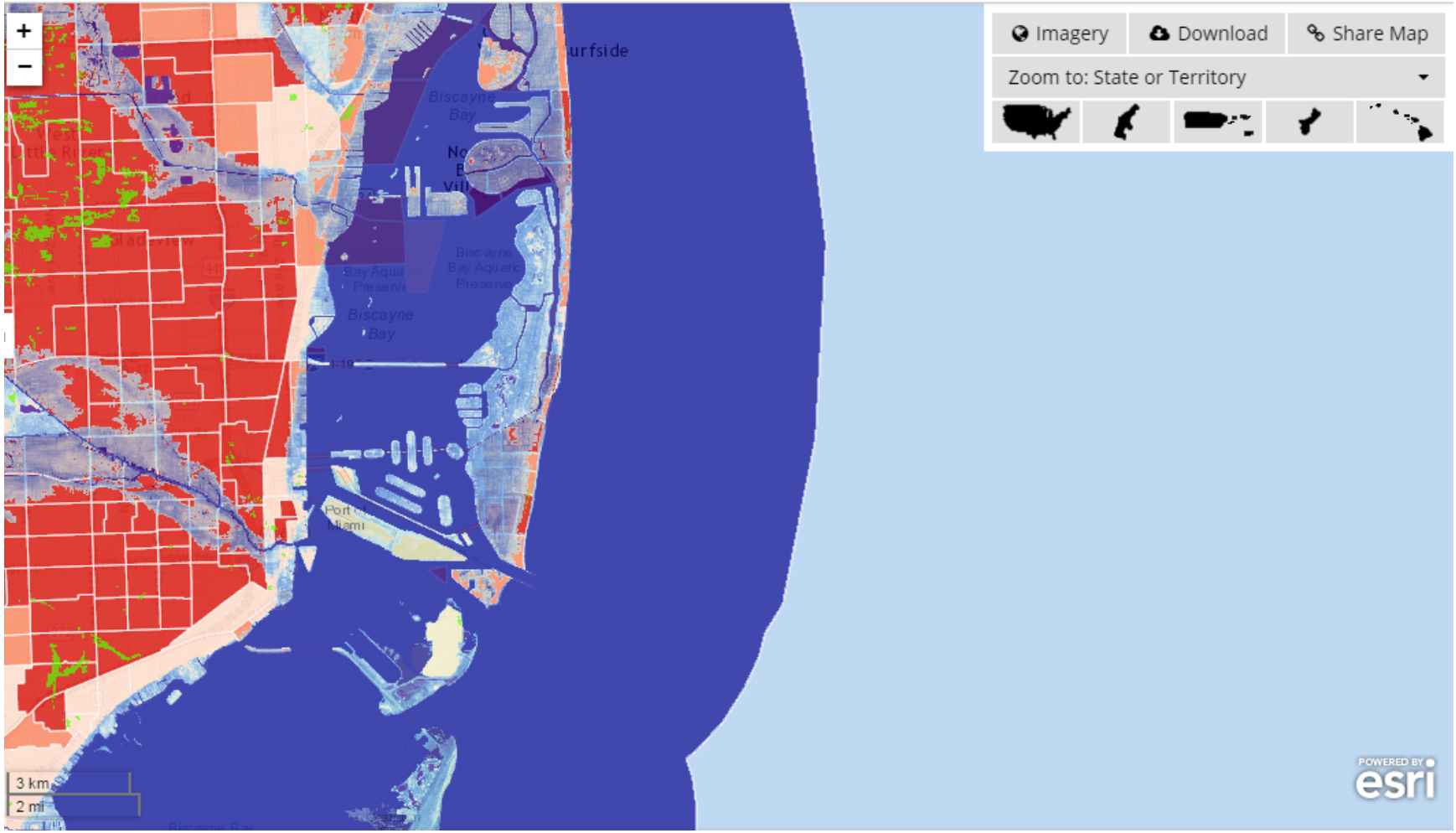
Agenda

- COP21 Video (2.30 mins)
- The Built Environment (1 min)
- Demand for Low-energy Buildings (1.30 min)
- RICS Professionals and Low-energy Assets (2 min)
- RICS Commitments (2 mins)
- Conclusion (1 min)

Shanghai – 2-degree Celsius



Miami Beach – 6 feet SLR



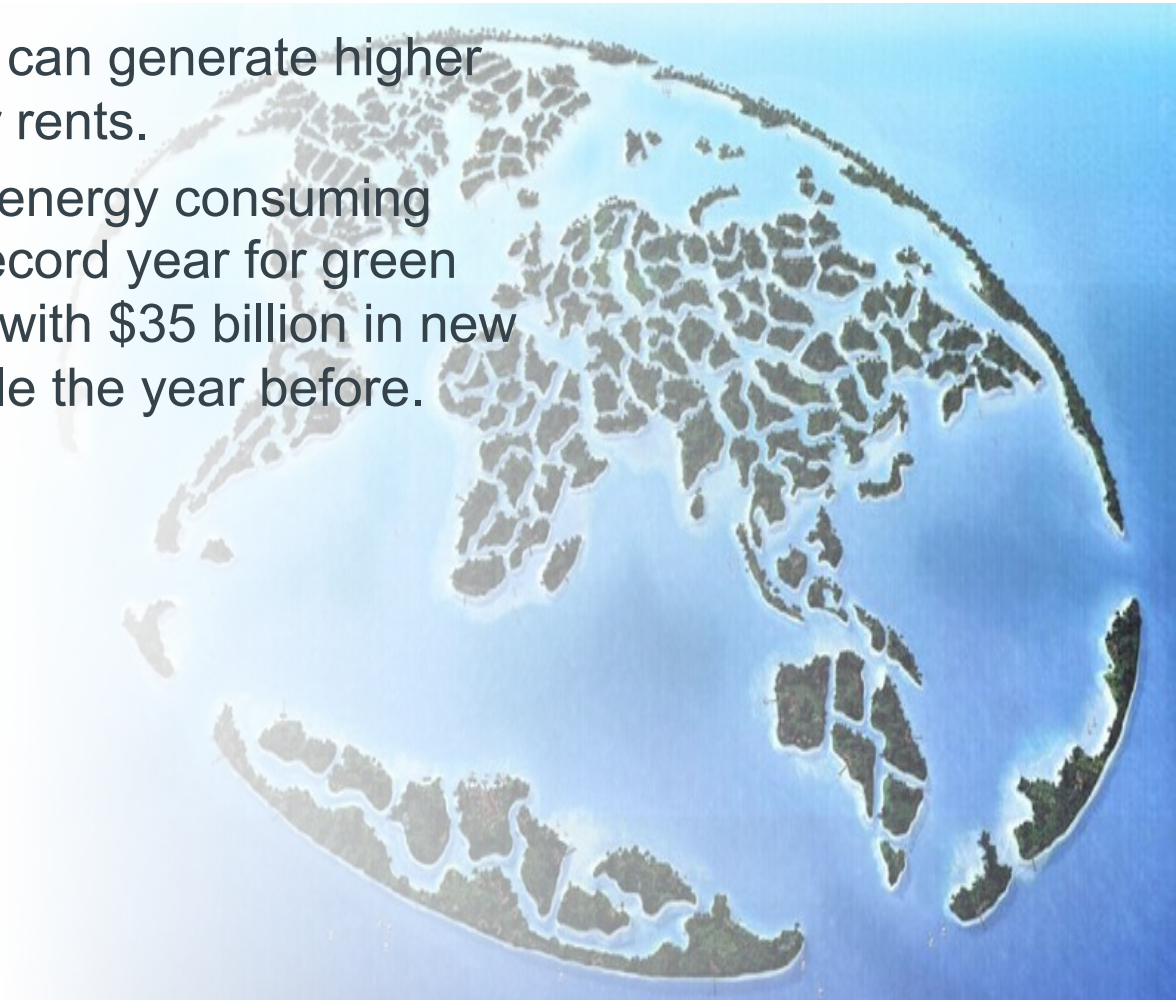
The Built Environment

RICS COP21

- 40% of the worlds energy is consumed by the built environment.
- Emits up to 30% of global greenhouse emissions.
- Carbon emissions could triple by 2050 if we do no ACT.
- Property sector is global
- Occupied by multinational corporate tenants
- Financed by international investors
- Developed and managed by global firms
- Our population is heading toward 9 Billion People
- 66% of future population will live in urban cities
- Land and Real Estate accounts for 70% of the worlds wealth

The Demand of for Low-Energy Buildings

- Energy efficient buildings can generate higher yields and achieve higher rents.
- Growing demand for low-energy consuming buildings - 2014 was a record year for green buildings internationally , with $35 billion in new issuances, more than triple the year before.



RICS Professionals and Low-energy assets

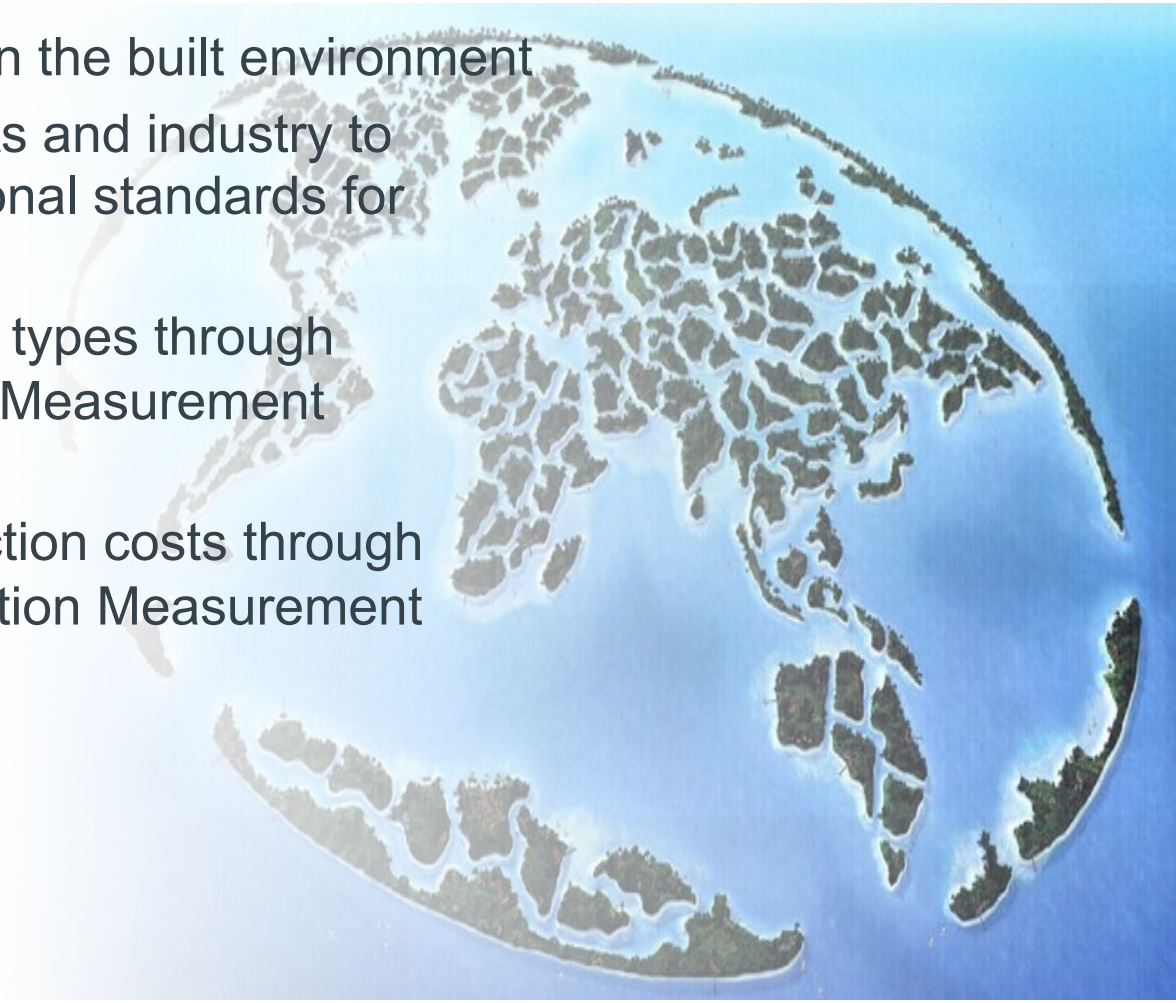
- As professionals, how do we deploy our expertise and professional standards to make a difference?
  - Transparency and comparability underpin investment decisions
  - If a deal lacks transparency, it is considered more risky
  - Investments need to be compared on a like-for-like basis
  - Measurements in buildings around the world can vary by 24% - reducing transparency and risk
  - Distorts how we measure and benchmark energy consumption and carbon emissions from buildings

RICS Commitment

- Strengthen business case for energy efficiency measures and Green Buildings.
- RICS already made sustainability an integral part of the Red Book professional valuation guidance.
- Developing “RenoValue” sustainability training programmes and e-learning.

RICS Commitment

- Promoting transparency in the built environment
- Working with governments and industry to devise common international standards for measuring:
  - the size of all property types through International Property Measurement Standards (IPMS)
  - all aspects of construction costs through International Construction Measurement Standards (ICMS)



RICS Commitment – South Florida

- Promoting discussion and thought leadership amongst RICS Florida members and other industry professional bodies.
- Influencing industry leaders through RICS Florida sponsored member events.
  - RICS holds member and non-member Round Table events to drive discussion
- Educating members and non-members on subject matter through research reports and courses.

Conclusion

- **Buildings have a major impact** on our environment; they are key to achieving our climate commitments.
- The Built Environment is **significant in underpinning investment** into the financial Eco-system of the world
- **We need to ensure** the way we deal with urbanization is in a sustainable way, maximizing our use of limited resources.
- Building energy **performance measures can help us monitor** and assess progress towards our targets and drive behaviour change.
- Meaningful progress requires a **common standard** for measuring buildings.
- **IPMS offers a solution** which is becoming established in the property industry. Governments should get behind this solution too.
- Need to **drive dialogue** on topic matter to broad audience of professional real estate practitioners.

Thank you.

www.rics.org

www.ipmsc.org

LLOYD'S: CLIMATE CHANGE

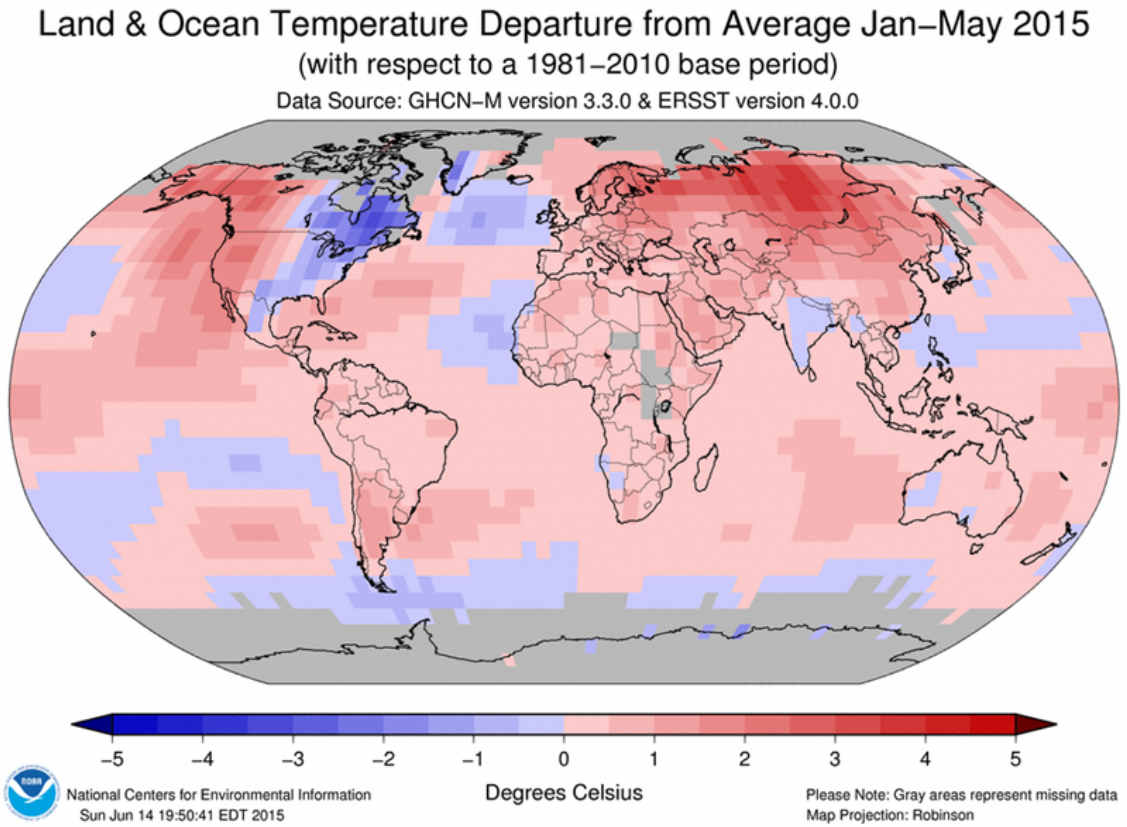
Rodney Smith (Lloyd's America, Inc.)

Lloyd's: Climate Change

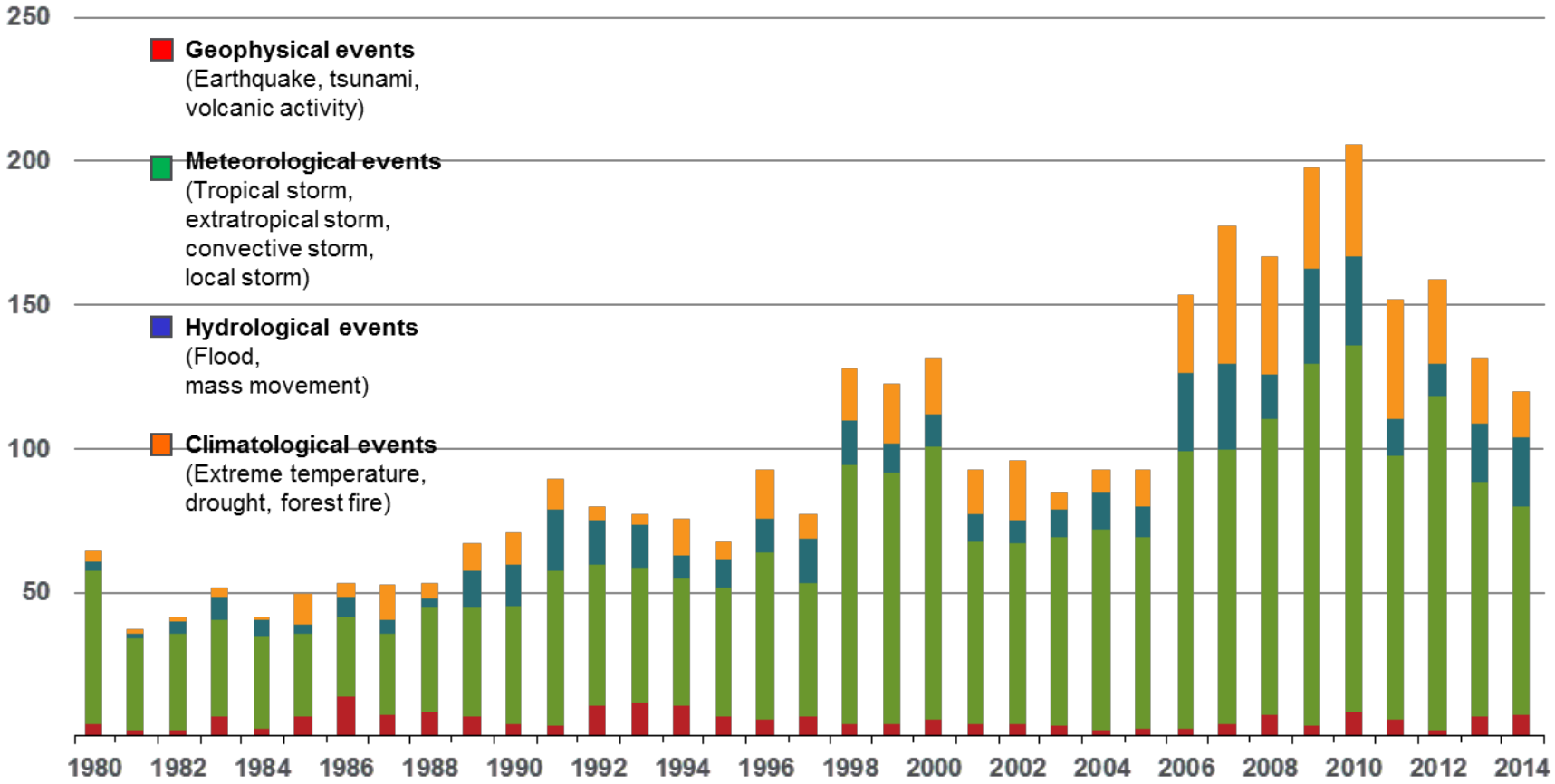
Rodney Smith, Director, Lloyd's America

The World is Warmer...With An Exception

- 2014 was the warmest year across global land and ocean surfaces since records began in 1880.
- 9 of the 10 warmest years in the 135-year period of record have occurred in the 21st century. 1998 currently ranks as the fourth warmest year on record.
- January to May 2015 warmest first five months on record!

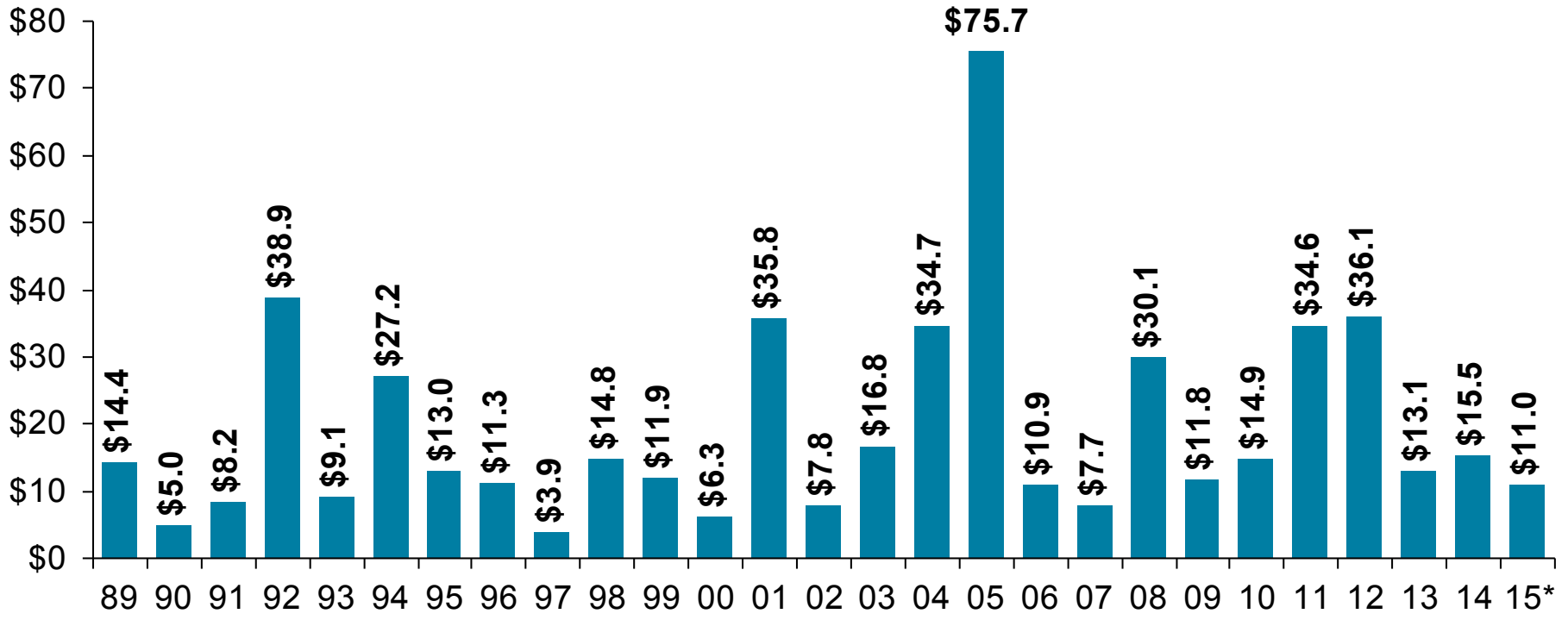


Loss events in the US, 1980 – 2014



Source: Geo Risks Research, NatCatSERVICE

U.S. Insured Catastrophe Losses



*Through 9/30/15 in 2015 dollars.

Note: 2001 figure includes $20.3B for 9/11 losses reported through 12/31/01 ($25.9B 2011 dollars). Includes only business and personal property claims, business interruption and auto claims. Non-prop/BI losses = $12.2B ($15.6B in 2011 dollars.)

Sources: Property Claims Service/ISO; Insurance Information Institute.

Managing the escalating risks of natural catastrophes in the US

1 The first step in protecting US property owners from natural catastrophe losses is ensuring there is a healthy, private insurance market

2 Government intervention in private insurance markets should be kept to a minimum

3 Risk-based pricing is the fairest and most sustainable solution

4 Specialist international insurers and reinsurers add value to the US natural catastrophe market through additional capacity and expertise

5 Government and insurers must respond to changing trends in the frequency and severity of losses

Managing the escalating risks of natural catastrophes in the US

6 Government has an important role to play in helping develop risk mitigation measures and rewarding adaptation to reduce the overall costs to the economy

7 The insurance industry has a key role to play in helping build more resilient communities

8 Good quality data and hazard mapping is critical to robust underwriting

9 We believe in encouraging a responsible approach to risk in society

Florida Citizens Exposure to Loss, 2002 – 2015* ($ Billions)

*As of October 6, 2015.

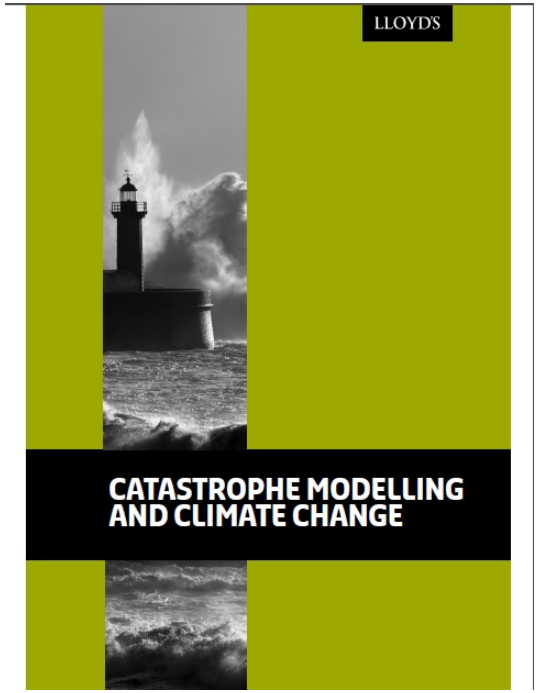
Source: PIPSO; Florida Citizens https://www.citizensfla.com/about/bookofbusiness/; Insurance Information Institute (I.I.I.).

Climate Change and Catastrophic Modeling

Increasing magnitudes of warming is increasing the likelihood of severe and pervasive impacts

Peak river flows from 10% to 15% over the period between 2015 and 2039, rising to a range of 20% to 30% by 2080

Rising sea levels around the world could have significant implications for insurers in the context of storm surge



The ClimateWise principles:

- Lead in risk analysis
- Inform public policymaking
- Support climate awareness
- Investment strategies
- Reduce environmental impact
- Report and be accountable

ClimateWise

Thank you! Stay in touch.

Email rodney.smith@lloyds.com **Website** lloyds.com/america

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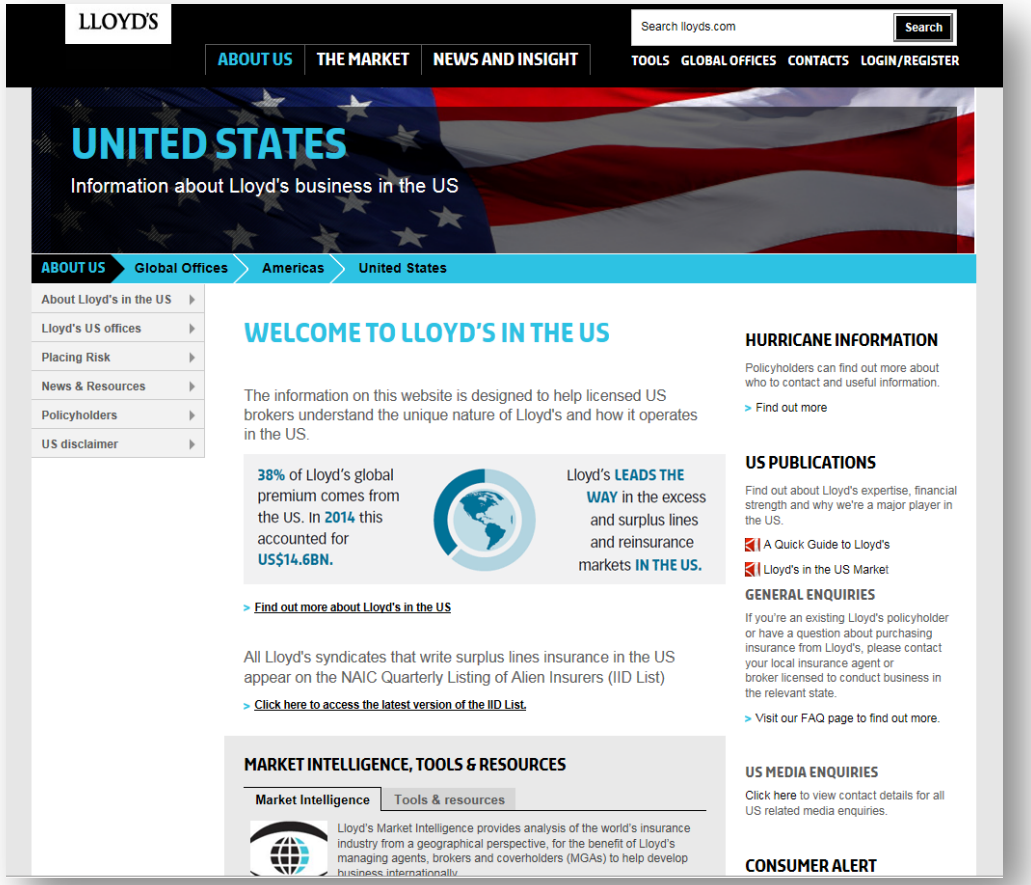


COFFEE BREAK

10:15 - 10:30

FACILITATED DISCUSSION

10:30 - Noon

DISCUSSION QUESTIONS

- How do we better understand the physical and economic risks posed by climate change to Miami-Dade County?
- What can we learn from existing best practice?
- How do we ensure future insurability?
- What strategies for adaptation/mitigation would be most suitable for Miami-Dade?

ADJOURN

Noon

Attachment 6

CLIMATE CHANGE ADVISORY TASK FORCE

September 2016

Final report for Resolution R-45-15 in support of the Sea Level Risk Task Force final recommendations

TABLE OF CONTENTS

Note on all figures: If you have any questions or trouble reading any of the figures, please contact the Office of Resilience at green@miamidade.gov to request additional information or a higher resolution version.

HISTORY

The Climate Change Advisory Task Force (CCATF) was created in 2006 and chaired by the Clerk of Courts, the Honorable Harvey Ruvin. The Task Force was supported by nearly 200 members of the community drawn from academia, the private sector, municipal and county government, and built on over a decade of climate change work within the County. The CCATF and its seven subcommittees reviewed information, hosted technical experts, and met over 50 times over a period of five years and developed a series of recommendations to both prepare our community for many of the expected impacts of climate change (also known as adaptation) as well as recommendations for how the County could reduce its own contribution to the problem of climate change (also known as mitigation). The majority of the recommended steps to reduce carbon emissions also have co-benefits such as increasing the County's operational efficiency, saving tax dollars, reducing local air pollution, improving public health, improving public spaces and natural areas, and ultimately improving the livability and attractiveness of our community. The CCATF released its first set of recommendations in April of 2008 and the Final Report and Recommendations in April 2011. These recommendations were taken into consideration in the development of initiatives for both GreenPrint, Miami-Dade County's community-wide sustainability plan, and the 2011 Regional Climate Action Plan, developed by the Southeast Florida Regional Climate Change Compact (Compact).

In January of 2015, the Board of County Commissioners passed Resolution R-45-15 directing the Mayor to review the status of the CCATF's recommendations and to put forward and action plan for implementation. This report is the final report in support of this Resolution.

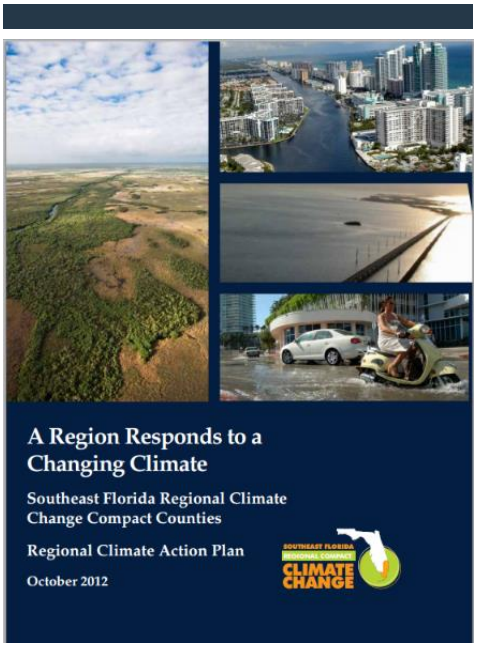
RECENT PROGRESS

In 2010, while the CCATF was still convening and developing recommendations, the **Southeast Florida Regional Climate Change Compact** was formed. The Compact has become the regional clearinghouse and forum for the much of the County's and region's work on climate change. Through this ground-breaking partnership, County staff work closely with peers in other county governments, municipalities, state and federal agencies, community-based and not-for-profit organizations, and universities. This close collaboration and pooling of resources has allowed the County to make substantially more progress on climate change efforts than would have been possible working independently. Furthermore, the collaboration facilitated by the Compact has helped the region secure additional funding and technical assistance grants from a number of federal agencies including the National Oceanographic and Atmospheric Administration (NOAA) and US Army Corps of Engineers as well as from private foundations. This external support has allowed County staff to work collaboratively on adaptation with experts from the Netherlands, New Orleans, New York and other areas.

Through the Compact Miami-Dade County works with other partners to develop an annual state and federal legislative program and jointly advocate for better state and federal climate policies and additional funding. The Compact also

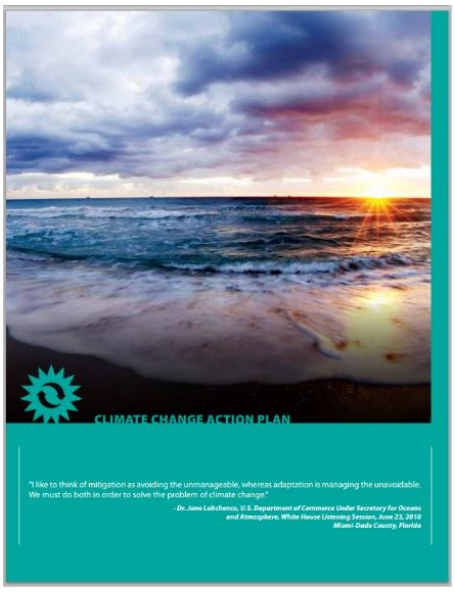
> The success of the Compact has been recognized internationally and nationally. President Obama recently remarked, "Five years ago, local leaders down here, Republicans and Democrats, formed the bipartisan Southeast Florida Regional Climate Change Compact -- an agreement to work together to fight climate change. And it's become a model not just for the country, but for the world."

annually convenes the Regional Climate Leadership Summit to mark progress and identify emerging issues. In 2014, Miami-Dade hosted the summit in Miami-Beach and welcomed experts from around the world to speak, including representatives from the White House, the business community, and the Consul Generals of Germany, Canada, France, the Netherlands and the United Kingdom. Most importantly, the Compact allows the County to coordinate adaptation and mitigation strategies across the region as well as with neighboring communities and municipalities within Miami-Dade County through the implementation of the Regional Climate Action Plan, described in the next section.



Through the Compact the County also contributed to the development of the **Regional Climate Action Plan** (RCAP). This plan contains over 100 recommendations which focus on sustainable communities, transportation planning, water supply, management and infrastructure, natural systems, agriculture, energy and fuel, risk reduction and emergency management, and outreach and public policy. Compact members, both municipalities and counties, track the implementation of these recommendations and share best practices through work groups. The lessons learned through implementation are shared with the wider public through the publication of case studies. There are also regular implementation workshops and accompanying guidance documents, which have focused on addressing some of the most challenging issues such as transportation, integrating climate change and water supply planning, stormwater management, and creating Adaptation Action Areas. The Regional Climate Action Plan is a living document, which has been successfully serving as a roadmap for the entire region since it was released in 2012, and has contributed to the implementation of Miami-Dade's own adaptation and mitigation strategies. It is also being actively implemented by local municipalities within Miami-Dade County such as Miami Beach. As seen below, there is significant overlap between CCATF and RCAP recommendations. The RCAP is a five year plan that will be revised in 2017 to reflect progress made and new priorities.

The nexus of the County-specific work on climate change is outlined in **GreenPrint**, a county-wide sustainability plan. This plan has a broad purview that extends beyond climate and includes goals that focus on strong leadership, water and energy efficiency, our environment, responsible land use and smart transportation, a vibrant economy, and healthy communities.



GreenPrint's final chapter contains the County's **Climate Action Plan**, which lays out aggressive goals to reduce the County's Greenhouse Gas (GHG) emissions by 80% by 2050. The plan also includes a number of measures to adapt to known climate impacts such as sea level rise. The Climate Action Plan also comprehensively reviews the current and future regional threats, such as salt water intrusion and coastal erosion, and provides a detailed analysis of emissions sources.

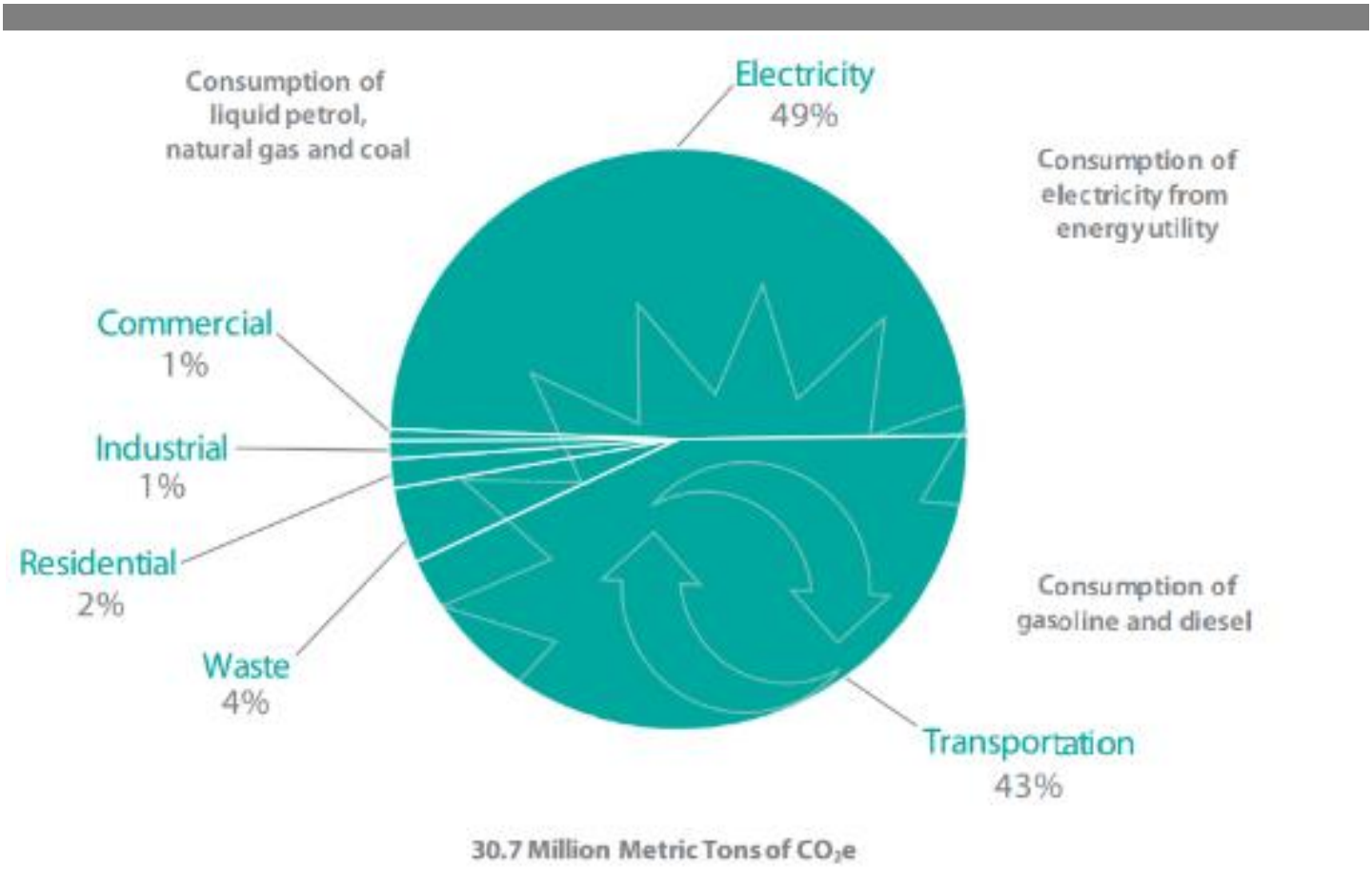
GreenPrint builds directly on the CCATF process. When GreenPrint was originally drafted, the planning team attended CCATF meetings throughout the entire process with the goal of incorporating its recommendations into GreenPrint where possible. As seen in Figure 3 many CCATF concepts were incorporated directly into GreenPrint. While the specific wording and emphasis is often different, many of the same themes are central to both. For example, both focus heavily on reducing the County's greenhouse gas emissions through greater energy efficiency, increasing the use of more fuel-efficient vehicles and public transportation, and increasing cooperation with other governments.

The first five year cycle of GreenPrint concluded in December 2015 and County staff are now working with internal and external stakeholders to revise each goal and reprioritize. This year's timely review of the CCATF recommendations has facilitated a thorough review of which concepts are most aligned with the strategic goals of the County. Many CCATF recommendations which were included in the first iteration of GreenPrint will be carried forward, and in some cases, the original CCATF recommendations will receive more emphasis in the second iteration. In some instances priorities have changed since the original task force. For example, many CCATF recommendations focused on improving the fuel efficiency of medallion-holding taxi cabs; however, because the market has changed so substantially over the past few years the next iteration of GreenPrint will strategically focus on other transportation initiatives. While reducing transportation emissions remains one of the County's top strategic priorities GreenPrint will strategically prioritize other reduction measures such as increasing transit ridership, walking, biking and transit-oriented development.

Due to recent improvements, the County is able to more strategically prioritize various GHG reduction strategies. By utilizing the Clearpath software to measure and monitor direct and community-wide emissions (Figure 1), the County can carefully track emissions through time and more accurately estimate the effectiveness of past reduction strategies. Clearpath is the newest emissions calculation software developed by ICLEI – Local Governments for Sustainability. Most importantly, Clearpath also allows users to evaluate the potential reductions from future initiatives. For example, the County is able to evaluate the relative efficacy of lighting retrofits, increasing transit ridership, or increasing water conservation efforts. Staff can also quantitatively determine how these efforts should be scaled up to reach the County's targets. This tool is currently being used to help determine the most impactful Greenhouse Gas emission reduction strategies which should be included in the next iteration of GreenPrint.

While the full analysis of reduction strategies is not yet complete, staff are able to utilize past GHG inventories to shape initial priorities. For example, as seen in Figure 1, transportation accounted for 43% of the County's emissions in 2005 and therefore is an important target area. Furthermore, the inventory indicates that the County's direct emissions are a relatively small (but still significant) portion of the community's entire emissions (less than 1/30th). Therefore it is important to focus on decision-making processes which have the greatest potential value to reduce community emissions, such as facilitating more sustainable transportation options.

FIGURE 1: MIAMI-DADE COUNTY 2005 EMISSIONS BY SOURCE AND SECTOR



THE STATUS OF THE CCATF RECOMMENDATIONS

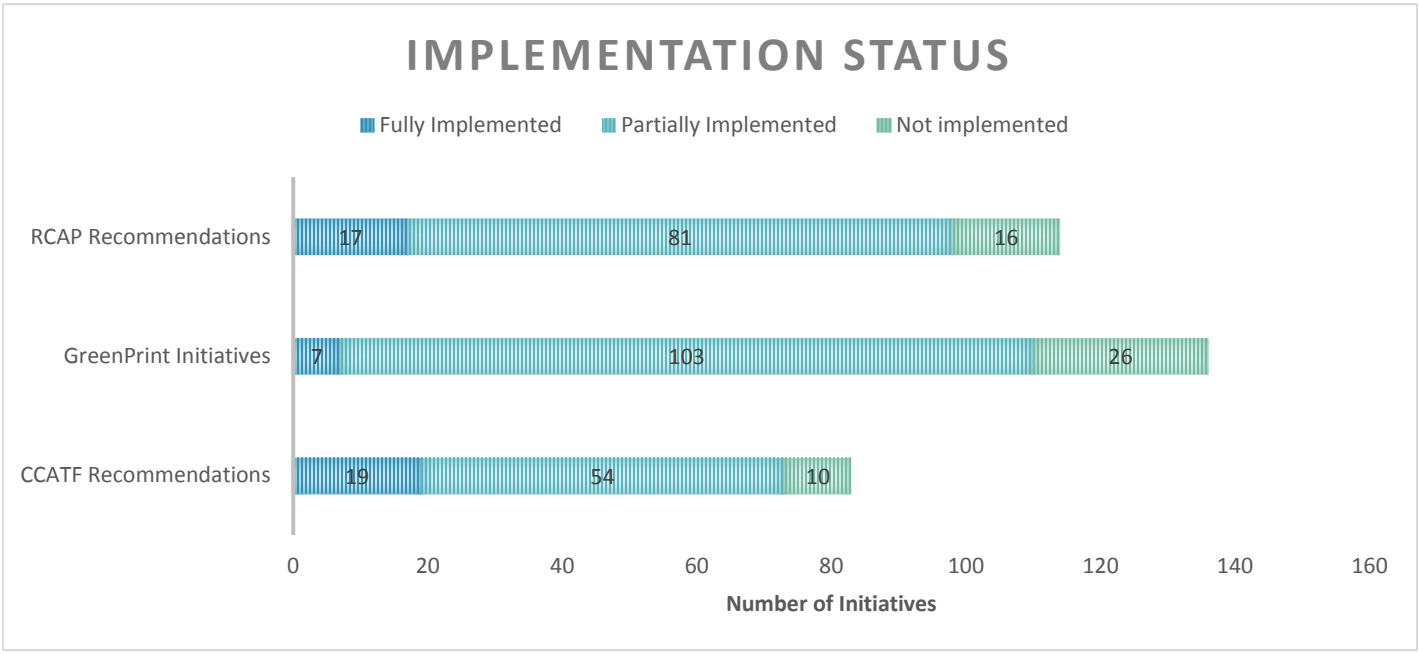
The following section provides a summary of the status of the CCATF recommendations including how many initiatives have been incorporated into more recent plans, their implementation status, and finally, the recommendations to accelerate implementation of the County's climate change goals. In retrospect, many of the CCATF recommendations were too specific, making it more difficult to implement them specifically, in whole. However the purpose or intent of many of them have been implemented in a variety of ways through various GreenPrint and RCAP initiatives. A review of the status of each CCATF recommendation is provided in Appendix 1.

Having completed their assigned task of developing recommendations to the Miami-Dade Board of County Commissioners for actions the County could take to continue Greenhouse Gas emissions reductions and begin preparing for expected impacts from climate change, the Climate Change Advisory Task Force was sunset in early 2011. Reports on the progress of the CCATF and development of recommendations were periodically published between 2007 and 2011, including an initial set of recommendations in 2008 and a supplemental set of recommendations in 2010; however, because many recommendations were incorporated into GreenPrint and the Regional Climate Action Plan, monitoring and reporting efforts shifted to GreenPrint after 2011.

Figure 2 shows the general implementation status of recommendations and initiatives in three primary plans. As can be seen in this chart, the vast majority of CCATF recommendations are at some stage

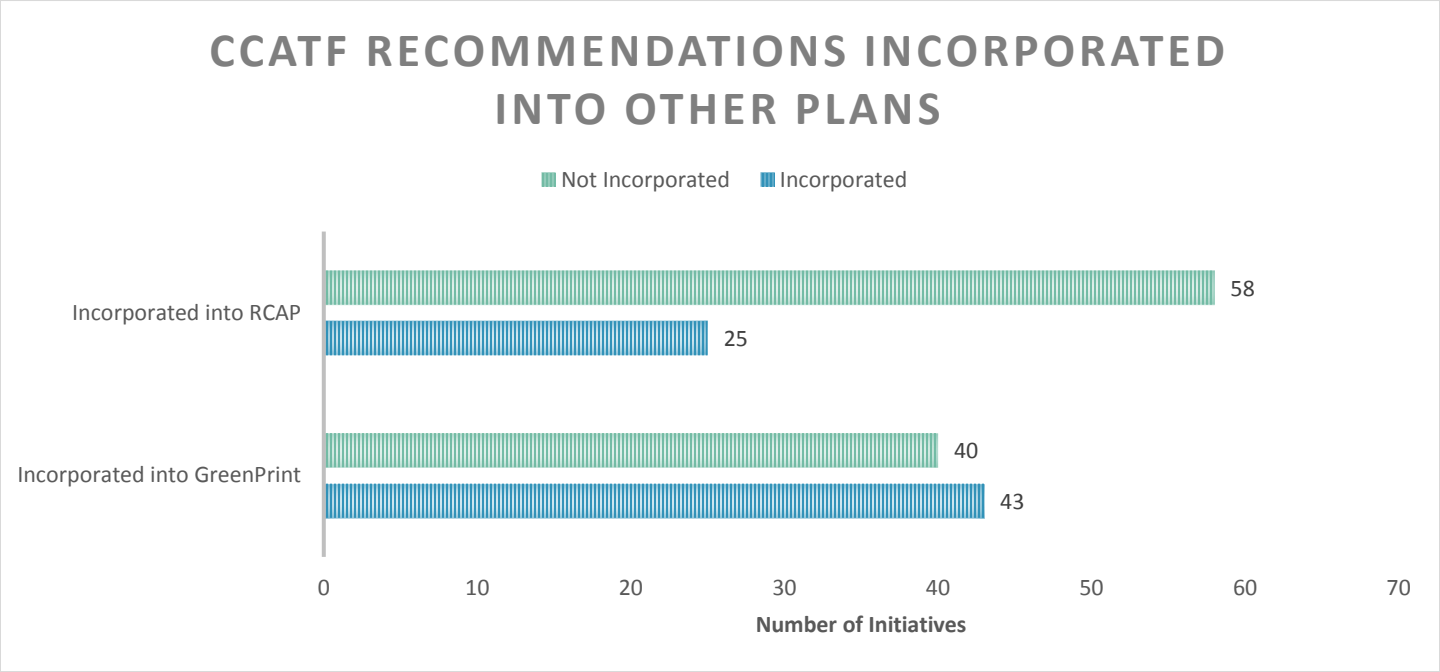
of implementation. For the purposes of this chart an initiative has been considered "partially implemented" if it is ongoing or being partially implemented as part of another related project or initiative. For example, recommendation C8 directed Miami-Dade to "advocate for amendments to the Florida Building Code that will reduce the impact of greenhouse gas emission and improve climate change resiliency." Since the recommendations were finalized there have been changes to the building code that improve energy efficiency and resiliency; however, the County and Compact continue to advocate for additional improvements and will continue to do so for the foreseeable future. This recommendation has therefore been classified as partially implemented. Many other recommendations are similarly on-going efforts that will continue to be implemented over the next several years. However, as illustrated by the earlier example relating to regulating medallion-holding taxi cabs, some priorities have shifted. For reference, the implementation status of the Regional Climate Action Plan and GreenPrint initiatives are also included in the figure.

FIGURE 2: THE STATUS OF THE CCATF RECOMMENDATIONS



As seen in Figure 3 many of the CCATF recommendations were incorporated into subsequent plans, namely GreenPrint and the Regional Climate Action Plan. The greatest areas of overlap are in terms of the recommendations pertaining to adaptation to sea level rise, energy efficiency and transportation.

FIGURE 3: CCATF RECOMMENDATIONS INCORPORATED INTO OTHER PLANS



It is important to remember that measuring the number of recommendations implemented is a process-based metric, and it could be argued that outcome-based metrics may be a better way to measure progress in the context of climate change. For example, an outcome-based metric of mitigation might be the reduction in greenhouse gas emissions on a project by project basis, with an overall goal of absolute emissions reductions within Miami-Dade County. Using this type of metric would shift the emphasis to the results and effectiveness of different initiatives and potentially could be more useful in measuring success toward the goal of reducing the County's contribution to global climate change. Miami-Dade County has completed greenhouse gas emissions inventories on a frequent basis, providing a baseline for evaluating the outcome of some of the recommendations considered in this report. However, it is important to note that absolute greenhouse gas emissions reductions are affected by other factors such as data accuracy, methodology/protocol used to complete greenhouse gas emissions inventory, and the economy of the region. Another example of an outcome-based metric could be the percent of critical facilities such as fire stations that are protected against flood risks. Using outcome-based metrics may be a more useful way to focus attention on the ultimate goals of all of these climate change plans.

PRIORITY INITIATIVES: ENHANCED IMPLEMENTATION NEEDS

Given the scale of the challenge, additional resources are required to more fully implement the County's climate mitigation and adaptation goals. At the same time there is also a need to be strategic and focus efforts on the most important initiatives that are likely to yield the most results. Therefore, the CCATF recommendations are grouped into three larger baskets that are critical priorities for Miami-Dade: reducing emissions by increasing energy efficiency, reducing emissions from transportation, and adapting to rising sea levels. These priorities encompass several key CCATF recommendations and are well aligned with the priorities outlined in other climate change plans. Most importantly, these three priorities address the two largest sources of emissions and the most pressing adaptation challenge.

The following section outlines the additional implementation needs required to make further progress toward these priorities.

Priority I: Reduce greenhouse gas emissions by increasing energy efficiency

Relevant CCATF recommendations: B11, B12, B13, B14, B15, B17, C1, C7, C8, F10, and F11

Resource and staffing needs:

Generally speaking, departments can be more successful in reducing energy and fuel consumption if they are provided incentives for doing so, and if they are held more accountable for the fuel and electricity they do use. There are several recommended actions or incentives with this in mind that can lead to further reductions in emissions from the County's own operations. For example, increasing direct engagement with the department heads to prioritize energy efficiency and integrating energy efficiency into departmental and staff performance metrics would help incentivize improvements. Similarly, tracking departmental energy and water consumption through the County's performance tool "Active Strategy" would help bring more awareness and accountability to all departments.

One important program the County should continue to use and expand is EnergyCAP. This tool is available to all department staff at no cost and includes a dashboard that is easy to use. Staff currently have the ability to use EnergyCAP to manage energy consumption, identify performance problems, and prioritize capital improvement projects and retrofits. The tool can also be used to compare all County buildings' energy consumption by square footage or building type and prioritize retrofits across all assets. However, it is not being used to its full potential. This tool, should be integrated into daily building management to maximize its full potential. One possible step to increase the use of EnergyCAP is to elevate energy efficiency as a priority across departments, as previously mentioned. This tool also has the capability to help manage water consumption and waste management and adding these two components to the system would further help improve the County's operational efficiency.

The County should also continue the Energy Performance Contracting program which has already significantly improved energy efficiency within government facilities. It is recommended that these efforts be expanded to result in increased savings in energy and money.

Rewarding success by allowing departments which reduce their energy costs to keep those savings would help build momentum behind energy efficiency projects. However, currently there

are not strong financial incentives for many departments to invest in energy efficiency. Therefore, it is recommended that departments be allowed to keep all, or a portion of, the savings achieved through energy efficiency/conservation projects. This would allow them to re-invest that savings into additional energy efficiency/conservation projects and create a mechanism to reward and incentivize further energy efficiency/conservation efforts by individual departments. Energy efficiency can be further supported by making it a priority for departments to implement the Electricity Master Plan and expand it to all sources of energy, including fuels for vehicles.

Reducing community-wide emissions through energy efficiency initiatives will require significantly increased public outreach and engagement on the topic. It is important to provide information about the various potential technologies which range from the small-scale, such as solar hot water heaters that have a very short payback period, to a larger scale solar installation of solar arrays at parking lots facilities which provide solar capacity and shade. Depending on the needs of the business or homeowner, there are a myriad of appropriate technologies that would reduce electricity costs and emissions. Benchmarking and transparency is one of these tools that when implemented will yield not only energy savings, GHG reductions but also will create jobs and financial savings for property owners. Furthermore, promoting financing options such as Property Assessed Clean Energy (PACE) programs can further incentivize investment in this area.

The County is only one player in a much larger effort, however, the County could increase its support of community efforts around water and energy efficiency by participation in the U.S. Environmental Protection Agency (EPA) Battle of the Buildings competition, or increasing the educational value of the County's own LEED-certified buildings by increasing their visibility and signage about efficient features. Most importantly, the County can increase the success of energy efficiency strategies by cultivating active partnerships with other organizations and universities that provide direct outreach. For example, the Association of Energy Engineers is creating a Sunshine Chapter, so becoming more engaged with this group could facilitate implementation of best practices locally. There are many successful examples from other metropolitan areas that can serve as models to emulate, such as the Southeast Energy Alliance (SEEA) which recently started serving the State of Florida and works on promoting energy efficiency as a catalyst for economic growth. The County can also play a more direct role by continuing to work with the Building Code officials to improve enforcement and compliance with the Energy Code and promote best practices including voluntary compliance with green building codes. This may be further accomplished by dedicating additional resources to code compliance and training to provide guidance and assistance with the Florida Energy Conservation Code to all municipalities within Miami-Dade County. The County should also continue to partner with Florida Power & Light to promote energy efficiency, smart metering, benchmarking and disclosure, and increasing renewable energy generation.

Priority II: Reduce greenhouse gas emissions from transportation

Relevant CCATF recommendations: B1, B2, B3, B4, B7, B8, B9, B10, B11, B14, and C1

Resource and staffing needs:

More significant and effective fuel related emissions reductions from the County's direct activities will require vesting new responsibilities to a designated department. Key information such as how much fuel is being used by the County overall and how much is being spent on fuel, is not centralized or consistently tracked. This, in turn, makes it more difficult to identify problems or identify opportunities to reduce costs and reduce emissions and quickly improve operational efficiency. Tracking departmental fuel consumption through the County's performance tool "Active Strategy" will bring awareness and accountability to all departments. Designating dedicated staff or a department section to oversee the fuel consumption, amount spent, and the type of vehicles procured, and vesting that department with the authority to make the ultimate decisions, would likely create opportunities to reduce costs and emissions. This department could also provide information and technical assistance to other County staff about how to improve their fleet efficiency.

Additionally, when the County considers adopting a new fuel type or substantially changing the amount of a certain fuel type purchased, it would be beneficial to comprehensively evaluate the life-cycle costs and environmental benefits and have those considerations incorporated into procurement policies.

In terms of transportation emissions, however, the County can have the greatest impact by addressing community-wide emissions. The County can help create the infrastructure to allow residents to choose more sustainable transportation options. Substantial work is underway in this regard and progress could be accelerated by increasing the resources and staffing dedicated to County and municipal initiatives which support public transportation, complete streets, transit-oriented development, and the safety and connectivity of bike and pedestrian paths. Mayor Gimenez took a significant step in this direction early in 2016 when he consolidated all transportation related departments and divisions into the new Transportation and Public Works Department. Continuing to focus specifically on promoting and facilitating more sustainable transportation and transportation options could help advance these efforts across all County transportation related activities and services.

Priority III: Adapt to climate change and rising sea levels

Relevant CCATF recommendations: A1, A2, C1, C2, C5, D1- D10, E1-E4, F1-F9

Resource and staffing needs:

Adapting to rising sea levels is a long-term challenge within Miami-Dade County. Since it is very likely that the resources needed will evolve as different issues arise, it is recommended that the resource and staffing needs be reviewed on a regular basis to ensure they are adequate. As described in the final reports in response to R-46-15 and R-48-15, additional resources may be required to support those efforts. Additional funding and resources will be needed to address research gaps as they are identified. Increasing resources within the Water and Sewer Department

and the Water Management Division within the Regulatory and Economic Resources Department to improve monitoring and modeling of flooding and saltwater intrusion will help expedite adaptation efforts. Allocation of additional resources to the Stormwater Master Planning Program will expedite the integration of new information about groundwater levels into the stormwater modeling efforts. More information is needed on the elevation of key assets to assess exposure. Sustained funding to maintain current and more accurate elevation data would provide information critical to determining areas more vulnerable to inundation and flooding, which is important when prioritizing where to focus planning and resources needed to adapt or build resilience to those challenges. Again, as described in the final report of R-44-15, resources should be dedicated to identifying and addressing the first Adaptation Action Areas in the most vulnerable areas. Across all of these efforts it would be beneficial to increase the ability of the Office of Resilience to communicate with key stakeholders about climate change issues as well as directly with the general public and affected residents. Focusing staff with expertise in communications and climate science will help accelerate adaptation efforts, improve partnerships with private entities, and help the County speak with a unified voice on these issues. Continued participation in, and support of, the Southeast Florida Regional Climate Change Compact is also a key element in continuing the County's own adaptation efforts.

LOOKING FORWARD

Both the County and the Compact have laid out ambitious goals for reducing contributions to, and adapting to, climate change. Achieving these goals requires a sustained effort and closer collaboration across all government departments and with the wider community. For this reason both GreenPrint and the Regional Climate Action Plan were developed with the help of a wide range of representatives from different levels of government, academia, the private sector and community-based organizations. To successfully implement these recommendations, it is important to continue collaboration at multiple levels within and amongst County, state and federal organizations, as well as with a broad array of community stakeholders in order to move climate change from a standalone issue to something that is integrated seamlessly into County planning, operations, and delivery of services. As the next iteration of GreenPrint and the Regional Climate Action Plan are developed, due out in 2016 and 2017 respectively, the recommendations made by the Climate Change Advisory Task Force will continue to serve as a foundation upon which to build and implement more current and relevant initiatives. Furthermore, the CCATF recommendations, as well as GreenPrint, and the Regional Climate Action Plan, will serve as a source of information and inspiration as the County works with its partners, the City of Miami and the City of Miami Beach, to develop a resilience strategy for Greater Miami and the Beaches, as part of the Rockefeller 100 Resilient Cities designation, awarded in May of 2016. It is through these key action documents that implementation of the Climate Change Advisory Task Force recommendations will continue, and these recommendations will serve as a sound foundation for action well in to the future.

APPENDIX 1: QUARTERLY REPORT

FIRST QUARTER UPDATE (JANUARY 3, 2015 – APRIL 30, 2015)

On January 21, 2015, the Board of County Commissioners passed seven separate resolutions, each supporting the implementation of one of the seven recommendations included in the "Miami-Dade Sea Level Rise Task Force Report and Recommendations." Resolution R-45-15, which requires quarterly status reports and a final report within one year of adoption, directs the Mayor or his designee to prepare an Action Plan and Report to implement the Miami-Dade County Climate Change Advisory Task Force Recommendations of (I) establishing departmental oversight for the implementation of the Task Force recommendations and (II) dedicating sufficient resources and staffing to review, update, and implement the Miami-Dade County Climate Change Advisory Task Force recommendations. Pursuant to R-45-15, this first Quarterly Status Report is submitted for your review. In accordance with Ordinance 14-65, this memorandum and report will be placed on the next available Board of County Commissioners (Board) meeting agenda.

Background

In July 2013, the Board created the Miami-Dade Sea Level Rise Task Force (Task Force) for the purpose of reviewing current and relevant data, science and reports, and to assess the likely and potential impacts of sea level rise and storm surge to Miami-Dade County over time. On July 1, 2014, the Task Force presented a report to the Board entitled, "Miami-Dade Sea Level Rise Task Force Report and Recommendations," providing the requested assessment along with recommendations of how Miami-Dade County may more specifically begin planning and preparing for projected sea level rise impacts. In addition, Resolution R-451-14 and Ordinance 14-79 were adopted in 2014, requiring that planning, design and construction of County infrastructure consider potential sea level rise impacts.

The Miami-Dade Climate Change Advisory Task Force (CCATF) referenced in Resolution R-45-15 was established in 2006 to review existing science and projections of climate change impacts to Southeast Florida, and to develop recommendations for further action by the County to further reduce Greenhouse Gas Emissions and begin climate adaptation planning for community resilience to extreme weather and other projected climate change impacts. Many of the CCATF recommendations were incorporated into the County's Sustainability Plan, "GreenPrint, Our Design for a Sustainable Future" in 2010 and were also incorporated into the Regional Climate Action Plan, developed by the Southeast Florida Regional Climate Change Compact.

In November of 2013, a review of the implementation status of the CCATF recommendations was conducted and an update provided to the Miami-Dade Sea Level Rise Task Force. At that time, it was determined that 33 of the 55 CCATF recommendations, or 60 percent, were in progress and 20 recommendations, or 37 percent, were slated for future implementation.

Quarter 1 Progress (January 31, 2015 – April 30, 2015)

The following steps have been taken during the first quarter towards implementation of Resolution R-45-15:

- Staff of the Office of Sustainability, within the Planning Division of the Department of Regulatory and Economic Resources, began reviewing the current implementation status of the CCATF

recommendations in December of 2014. This review and update of CCATF recommendation status is continuing as part of the GreenPrint data collection being compiled in preparation for the final progress report of GreenPrint's first five (5) years of implementation.

If you have questions concerning the above, please contact Mark R. Woerner, AICP, Assistant Director for Planning, Department of Regulatory and Economic Resources, at (305) 375-2835 or mwoerner@miamidade.gov .

cc: Honorable Harvey Ruvin, Clerk of Courts, Eleventh Judicial Circuit
Robert A. Cuevas, Jr., County Attorney
Office of the Mayor Senior Staff
Jack Osterholt, Deputy Mayor/Director, Department of Regulatory and Economic Resources
Lourdes M. Gomez, Deputy Director, Department of Regulatory and Economic Resources
Christopher Agrippa, Clerk of the Board
Charles Anderson, Commission Auditor
Eugene Love, Agenda Coordinator

SECOND QUARTER UPDATE (MAY 1, 2015- JULY 30, 2015)

R-45-15: Prepare an Action Plan and Report to Implement the Miami-Dade County Climate Change Advisory Task Force Recommendations

This resolution directed the Mayor or the Mayor's designee to prepare an action plan and report to implement the Miami-Dade County Climate Change Advisory Task Force Recommendations of (I) establishing departmental oversight for the implementation of the task force recommendations and (II) dedicating sufficient resources and staffing to review, update, and implement the Miami-Dade County Climate Change Advisory Task Force recommendations.

The following steps were taken during the Second Quarter in order to prepare the report referenced in this resolution:

- Staff of the Office of Sustainability within the Planning Division of the Department of Regulatory and Economic Resources (RER) is continuing to review the current implementation status of the Climate Change Advisory Task Force (CCATF) recommendations and is approximately 75 percent complete with that review. Currently, the majority of staff time for this effort is dedicated to coordinating with staff in other divisions and departments who manage specific aspects of the CCATF recommendations such as taxi cabs, the county fleet, and procurement. These consultations with other divisions and departments are also serving as the basis for broader conversations about alternative ways climate change considerations might be integrated into these various operations.
- Staff of the Office of Sustainability have fully completed a review to determine where the CCATF recommendations directly overlap with current recommendations in GreenPrint and the Regional Climate Action Plan, drafted by the Southeast Florida Regional Climate Change

Compact (Compact). The Office of Sustainability is currently in the process of revising GreenPrint in preparation for the release of the next five year plan in 2016, and has fully integrated the review of the individual CCATF recommendations into that planning process. Staff are currently considering the inclusion of additional CCATF recommendations into the next version of GreenPrint as one component of revising the climate mitigation and adaptation strategies. This internal review is scheduled to be completed this fall. For each recommendation, staff have already begun assessing the resources required for further implementation and efforts in the next Quarter will be focused more heavily on preparing the action plan. Finalizing the action plan and articulating the resources needed for implementation will be developed in consultation with other departments and divisions, and will be the focus of the Fourth Quarter.

THIRD QUARTER UPDATE (JULY 31, 2015- OCTOBER 31, 2015)

R-45-15: Prepare an Action Plan and Report to Implement the Miami-Dade County Climate Change Advisory Task Force Recommendations

This resolution directed the Mayor or the Mayor's designee to prepare an action plan and report to implement the Miami-Dade County Climate Change Advisory Task Force Recommendations of (I) establishing departmental oversight for the implementation of the task force recommendations and (II) dedicating sufficient resources and staffing to review, update, and implement the Miami-Dade County Climate Change Advisory Task Force recommendations. This resolution requires quarterly status reports and a final report within one (1) year of the effective date.

The following steps were taken during the third quarter in order to prepare the report referenced in this resolution:

- As of this quarter, Department of Regulatory and Economic Resources (RER) staff have completed the analysis comparing the Climate Change Advisory Task Force (CCATF) recommendations to the Regional Climate Action Plan and GreenPrint and have identified where CCATF recommendations were integrated into these subsequent plans. The staff will consider the incorporation of the other recommendations into the next iteration of GreenPrint where the recommendations are still relevant and appropriate.
- The staff have also completed the research on the implementation status of each recommendation and have prepared a first draft of that component of the final report which will be submitted to the Board in January of 2016.
- During the final quarter, staff will work with other departments and divisions to finalize the determination of resources and staffing that will be necessary to implement the remaining relevant recommendations

Climate Change Advisory Task Force Recommendations

Science Recommendations

Recommendations	GreenPrint	Regional Climate Action Plan	Implemented
A1. The County should use the Science Committee's Statement on Sea Level in the Coming Century to guide future climate change mitigation and adaptation policy.	Yes	Yes	Yes
• The Southeast Florida Regional Climate Change Compact (Compact) published *A Unified Sea Level Rise Projection for Southeast Florida* which is available at http://www.southeastfloridaclimatecompact.org//wp-content/uploads/2014/09/sea-level-rise.pdf. The Compact Counties recognized the critical need to unify the existing local sea level rise (SLR) projections to create a single regional projection. • Scientists specializing in the areas of sea level rise and climate change were invited to participate as the Compact Technical Ad hoc Work Group (Work Group). The Work Group reviewed the existing projections and the current scientific literature related to sea level rise with particular emphasis on the impact of accelerating ice melt on projections. • The Work Group published the first sea level rise projection in 2011 which was based on the U.S. Army Corps of Engineers July 2009 Guidance Document. The projection used Key West tidal data from 1913-1999 as the foundation of the calculation and references the year 2010 as the starting date of the projection. Two key planning horizons are highlighted: 2030 when sea level rise was projected to be 3-7 inches and 2060 when sea level rise was projected to be 9-24 inches. Sea level was projected to rise one foot from the 2010 level between 2040 and 2070, but a two foot rise was determined to be possible by 2060. • This Work Group was reconvened in 2014 and 2015 to review the most recent and best available science. Through a series of meetings over several months, the scientists revised the original projection. Due to the accelerated rates of ice melting and other climate variables, the projections were revised slightly, to reflect changing global projections and to incorporate scientific literature released since the original projections. The updated projection was extended to 2100 in recognition of the need for longer range guidance for major infrastructure. As updated, the anticipated range of sea level rise for the region from 1992 is 6 to 10 inches by 2030, 14 to 34 inches by 2060 and 31 to 81 inches by 2100. • This group will reconvene as needed to continue to ensure the most recent science and critical local/regional considerations are incorporated into the projections.			
A2. The County should commission detailed maps for all of Miami-Dade County created from calibrated LIDAR surveys (or other elevation survey technology that employs best known practices). The maps will allow identification of which areas will become flooding in association with different sea levels.	Yes	Yes	Yes
• Over the past several years a number of parallel efforts have been completed and a number of published maps now identify areas that may be flooded during different sea level scenarios. The National Oceanographic and Atmospheric Association has published a user-friendly and freely accessible online viewer allowing users to adjust the "slider" to view how different sea level rise scenarios will affect their area (http://coast.noaa.gov/digitalcoast/tools/slr). The agency has also published an online viewer that reviews coastal flooding exposure (http://coast.noaa.gov/digitalcoast/tools/flood-exposure) which illuminates areas of societal exposure (for example socially vulnerable populations), infrastructure exposure, and ecosystem exposure. This map includes sea level rise as one of the types of flooding it reviews. • The Nature Conservancy has also published another freely accessible, user friendly viewer to help visualize the potential impacts of sea level rise. This tool also contains a wealth of other relevant information such as critical erosion areas, areas with concentrations of repetitive loss properties, on-going and completed Miami-Dade County Shoreline projects, and existing land use and flood zones. • Climate Central has also published a similar tool known as *Surging Seas* (http://sealevel.climatecentral.org/ssrf/florida). This tool offers a similar viewer of impacts at different sea levels; however, the tool also offers an analysis page giving users insight into the population (broken down by race and level of social vulnerability) that will be impacted at different water levels. The tool also provides similar data about the buildings (broken down by type), infrastructure, land, and potentially contaminated sites (i.e. landfills or hazardous waste sites) that are likely to be inundated. All of the tools above offer invaluable insights into the areas of the county that are low-lying and vulnerable to flooding currently and moving forward as sea			

levels rise. These tools offer sufficient detail for a scoping analysis to identify “hot spots” that are likely to be problematic in the future. All of these tools use up to date LiDAR data and a “bathtub” inundation model.

- Similar analysis was used to complete the Southeast Florida Climate Compact vulnerability analysis (http://www.southeastfloridaclimatecompact.org//wp-content/uploads/2014/09/vulnerability-assessment.pdf) which provided an initial high-level look at certain critical infrastructure (i.e. roads, schools, hospitals, etc.) in the four-county Compact region that would be vulnerable to inundation and flooding, and included maps detailing the areas that would be affected by 1, 2 and 3 feet of sea level rise. Because these tools do not explicitly include changes in ground water levels and existing stormwater infrastructure, the County has partnered with the United States Geological Survey to develop a novel surfacewater-groundwater integration model which will more accurately model how changing sea levels will affect our County and our hydrology. The results of this analysis are being processed and are being used to refine the maps that will be used for County planning efforts. As soon as this analytical work is completed these maps will also be made available.

Greenhouse Gas Recommendations

Recommendations	GreenPrint	Regional Climate Action Plan	Implemented
B1. Ordinances related to the award/allocation of taxicab medallions include a requirement for all new medallions issued after January 1, 2008 to be allocated to hybrid or other vehicles having a combined average fuel efficiency of 28 MPG or higher.	No	No	Partially
• Despite extensive efforts by County staff in 2008 to facilitate incorporation of more fuel efficient vehicles into the taxicab fleet, an initial ordinance sponsored by Commissioner Bruno Barreiro, requiring phase-in of more fuel efficient hybrid vehicles, was opposed by the taxicab industry and deferred indefinitely. • After 2008, the Board approved the following taxicab medallion lotteries/auctions: a lottery of 25 taxicab medallions in 2009, a lottery of 10 taxicab medallions in 2012, a public auction of 6 taxicab medallions in 2012. None of the taxicab medallions awarded were required to be operated with a hybrid vehicle or vehicles with fuel efficiency of 28 mpg or higher. • On January 29, 2014, the Board approved Ordinance No. 14-09, creating the Ambassador Cabs Program with the purpose of improving the level of taxicab service provided at Miami International Airport and the Port of Miami. Among other things, the ordinance mandated technological improvements in all cabs serving the ports, including credit card machines, GPS, security cameras and warning lights, and reduced the vehicle age from the existing maximum 8 years to 6 years maximum. Due to the fact that newer taxicabs generally are more fuel efficient, this measure will lead to an increase in fleet efficiency. The Ambassador Cabs ordinance also provides an incentive to taxicab operators using alternative fuel vehicles (as defined in section 403.42(2)(b), Florida Statutes) by granting them priority access to the airport and seaport terminal for passenger pickup. • On the same date, the Board also approved Ordinance No. 14-08 which requires that effective April 1, 2016 all taxicab vehicles (not only those serving the ports) comply with the new technological and vehicle age requirements. Thus, we expect to see newer, more fuel-efficient taxicabs operating in Miami-Dade County in the near future.			
B2. Require that taxicabs being retired be replaced with new hybrid or other vehicles having a combined average fuel efficiency of 28 MPG or higher. Implementation of this recommendation is expected to affect 300 owners each year. The County should develop a financing mechanism to either subsidize the initial purchases or provide a revolving loan fund to assist owners to purchase new hybrids on reasonable terms and at reasonable interest rates	No	No	Partially
• As per the description in B1 above, County staff were unable to implement this recommendation as specifically written, however due to more recent mandates in Ordinance No.'s 14-08 and14-09, passed in 2014, the fuel efficiency of the taxicab fleet will improve due to other changes.			
B3. It is recommended that Miami-Dade County regularly evaluate greenhouse gas emission reductions and the net environmental benefit of each fuel and vehicle under consideration for purchase and use in internal operations in order to ensure the use of the most efficient vehicles and sustainably-sourced alternative fuels, including those that are locally produced, and adjust investment accordingly. Net environmental benefit shall be determined.	Yes	No	Partially
Fuels: • Decisions about fuel purchases do not currently require a review of the net environmental benefit of each fuel type. • County staff does not currently have the expertise or facility to technically evaluate greenhouse gas emissions reductions and net environmental benefit of each fuel type at the County level. • The County has already been successfully using hybrid heavy and light fleet vehicles, in particular, many that use electricity as a fuel source. Miami Dade Transit, now the Department of Transportation and Public Works (DTPW), conducted bio-diesel B20 testing in the bus fleet in 2008 and implemented a pilot project using biodiesel in the County bus fleet in 2009. • The County is in the middle of a procurement process that will enable it to fuel a portion of its bus fleet and solid waste vehicles that currently run on diesel, with Compressed Natural Gas (CNG). Use of compressed natural gas will diversify the County fuel sources and increase fuel flexibility, but it is a fossil fuel, not a renewable fuel. Using compressed natural gas results in a decrease in emissions for some pollutants at the tailpipe, but an increase in others, compared to a current model year diesel vehicle. Overall life-cycle greenhouse gas emissions for			

compressed natural gas are higher when considering current fugitive emissions estimates and the near-term impacts on global warming - due to methane's short lifespan and its efficiency at trapping heat. Depending on the vehicle technology, selected Mobile source air toxics emissions may be higher in a CNG-fueled vehicle. In addition, when operating in typical stop and go operating conditions, compressed natural gas -fueled buses have higher emissions compared to hybrid buses.

- It is recommended that the County conduct a comprehensive evaluation of the right fuel for each potential vehicle application, and develop a comprehensive energy plan for fuels and fueling infrastructure, modeled after the Miami-Dade County Electricity Master Plan. This plan should create a strategy that works toward using renewable fuels and establishes policy on which, if any, bridge fuels the County will use in the meantime.
- As a first step to the comprehensive energy plan, the County should perform an economic analysis that compares electricity versus compressed natural gas as a fuel source. The study should assess life-cycle greenhouse gas emissions, the cost of building infrastructure and procuring vehicles, and ongoing vehicle maintenance and operational costs for the two fuel types.

Vehicles:

- The County's Internal Services Department (ISD) continues to recommend that departments purchase hybrid or electric light vehicles but individual departments are not required to utilize these suggestions and can require other specifications and vehicles when going through the procurement process. At this time, each department is allowed to make these types of decisions themselves with oversight by ISD Fleet Management. The ISD does not currently have the authority to require departments to purchase vehicles that are more economically and environmentally beneficial. For example, several departments recently purchased Ford Focus sedans (a non-hybrid vehicle) due to lower up-front capital costs without doing a life cycle costs analysis as required by AO 11-3.
- The County is no longer purchasing vehicles in bulk.
- The County continues to purchase hybrid sedans for "pool" vehicles and for other departments. There are currently 534 hybrid sedans in the County's fleet.
- According to ISD, it is not difficult to determine the practical life-cycle cost of vehicles (cost to purchase vehicle plus fuel consumption over 100,000 miles using the federal government fuel economy website with 65% city and 35% highway utilization) before making purchasing decisions; however, this is not currently a required standard practice.
- The County has purchased 64 hybrid hydraulic garbage trucks in the past couple of years; future purchases of this equipment type, however, are on hold pending resolution of reliability issues.
- ISD Procurement Management has processed vehicle procurements for the Department of Transportation and Public Works using Practical Life Cycle Costs for hybrid vehicles. Hybrids were specified by the Grant MDT (DTPW) received.
- The County has purchased two sets of hybrid buses for transit (FTA – buy America requirements) using Environmental Protection Agency's fuel efficiency information for all vehicles. This criteria was incorporated into the procurement RFP and used to determine the contract award DTPW has purchased five sets of diesel/electric hybrid transit buses. DTPW reviewed and considered fuel efficiency information provided by the manufacturer and fuel mileage information reported in the Surface Transportation and Uniform Relocation Assistance Act Bus Testing report for the bus model purchased. Fuel efficiency was used to calculate greenhouse gas emissions which was considered by Environmental Protection Agency (EPA) when making grant awards. (Note that EPA fuel efficiency information was not used to determine the contract award.)
- The County should require that departments maximize MPG fuel efficiency for all non-specialty vehicle procurement and use sources such as EPA's Green Vehicle Guide as a procurement guide. Another procurement tools to use for alternative fuel vehicles: http://www.afdc.energy.gov/calc/

B4. Procurement Management Department should take necessary steps to improve pricing and access to sustainably-sourced alternative fuels and high efficiency vehicles for County operations. This would include forming a joint committee or committees to pursue collective purchasing opportunities and to evaluate the costs and benefits of collective bids.	Yes	No	Partially

Vehicles

- The Internal Services Department (ISD), Procurement Management Division handles solicitations; however, the ISD Fleet Management Division or other user departments provide their desired specifications for vehicles. Currently Procurement does not frequently suggest those vehicle specifications be modified to favor vehicles with a lower life cycle cost (i.e. more fuel-efficient vehicles).

• Departments that own or maintain their fleet put out bids to match their own requirements and they do not necessarily require evaluating the fuel efficiency of vehicles. • It is more common to evaluate potential vehicles primarily on the basis of capital cost rather than on their life-cycle cost (efficiency). • The ISD Fleet Management Division purchases most vehicles, but some departments also purchase some of their vehicles (Department of Transportation and Public Works, the Water and Sewer Department, Miami-Dade Fire Department, Miami-Dade Aviation Department, and the Miami-Dade Parks, Recreation and Open Space Department). To implement this initiative more effectively, it is recommended that the ISD Fleet Management Division be granted full authority to make purchase decisions for all County departments, regardless of financial impact. Fuels: • On April 5, 2010, the County awarded a new contract for unleaded and diesel fuel which includes options to procure various biodiesel and ethanol blends. • For bio-diesel purchases B5 is now the standard (put into state specifications for the fuel) • E10 is now standard for unleaded fuel. • Reviews in the past raised concerns about the impact of biodiesel on the fleet; The Office of Resilience had strong concerns about purchasing biodiesel that was not sustainably sourced and verifiable due to environmental and social impacts of non-sustainably sourced biodiesel. • A local manufacturer makes biodiesel from food-waste feedstock (a sustainable source) but is not currently a supplier for the County and it is unknown whether their product would meet County fleet specifications. • The Transit Department tested bio-diesel at higher levels (B-20) and commissioned a study. • Explore purchasing sustainably sourced alternative fuels through the state bulk fuel contract. • In August 2011 a bid was rejected for Biodiesel due to the high price per gallon.			
B5. The Climate Change Advisory Task Force recommends that Miami-Dade County fueling facilities are built, modified, or upgraded, they be designed and constructed to accommodate alternative fuels, including, but not limited to E85 and B100. In addition, the County should consider dispensing E85 at two Miami-Dade County fueling stations within 6 months of it becoming locally available as determined by the process described in Recommendation B3. It is recommended that Miami-Dade re-evaluate the use of E85 six months after dispensing is initiated to assess local availability, overall net costs and environmental impacts. Furthermore, new vehicles being purchased now and in the future by Miami-Dade County should have the capability of using ethanol and biodiesel, without the need for retrofit.	No	No	Yes
• The ISD Fleet Management Division has converted all of its single wall tanks to double wall tanks to comply with the Environmental Protection Agency's requirements for all fuel storage tanks. These retrofits allow for alternative fuels storage. • Regarding a County Manager memorandum indicating that by April 2009, the County should be using B20 diesel fuel, the County is currently buying E10 and B5 fuels. ISD has determined that using E85 and B100 is not economically feasible. • Most of the tanks will accommodate E85 and B100 but holding those fuels would first require cleaning and more filter changes. • Switching to certain biofuels may raise concerns with vehicle warranties and incompatibility with older engines. • Alcohol fuels (ethanol based) are more challenging in our humid environment which can result in mechanical failures and add cost. • Two electric vehicle charging stations have been installed at the County fueling facility on N.W. 1st Street for County vehicle use only and also at the Overtown Transit Village Parking Garage. There are five charging stations at Overtown and two are accessible to the public.			
B6. Require the use of sustainably-sourced biodiesel in all County diesel fleet vehicles and equipment (except standby equipment) as determined by the process described in Recommendation B.3, starting with B5 and increasing to B20 in 6 months. The Climate Change Advisory Task Force recommends that a portion of the local option gasoline tax (LOGT) be used to offset the cost difference for biodiesel.	Partially	No	No

• This recommendation will require County Commission action, since this would require a policy shift. LOGT dollars are currently committed to other efforts for the most part. (See comment above under B3). • The use of the gas tax revenues would require Board approval and therefore has not proceeded. • The County is currently unable to determine whether the biodiesel it is procuring is sustainably-sourced. • The County is currently using B5 biodiesel and E10 ethanol in most County operations. • The source of Biodiesel higher than B5 is uncertain. • County departments met on July 19, 2010 to discuss increasing its biodiesel blend to B10; however, there would be additional costs involved with the use of B10 or any increase higher than the standard diesel type B5. • The County was monitoring the cost differential while using B5; however, this was discontinued because it was superseded by changes at the state level which required fuels to contain at least 5% biodiesel. • There would be an increase in cost to increasing the purchase of bio-diesel due to the current economies of scale for purchasing large quantities of regular diesel (B5). • The County never moved to higher content biodiesel blends because of the concerns about the impact on vehicles and the increased cost. • The current bid for transit service vehicles requires the potential to be able to run on biodiesel fuels.			
B7. Require that Miami-Dade County develop a vehicle procurement process, which ensures that vehicles owned by MDC increase their mpg by 5% annually per vehicle class (whenever higher MPG vehicles are available) and that the cost of carbon emissions is included in the life cycle cost analysis process.	Partially	No	Partially
• The County has not been buying vehicles in bulk over the past eight years and therefore the fuel efficiency of the County's aged fleet is not necessarily tracking with national trends of increasing fuel efficiency. • While ISD does have the current MPG statistics available for the fleet vehicles that they monitor, and this information is accessible by other County Departments, the fuel efficiency of the County's fleet as a whole is not currently being monitored comprehensively enough to determine if a 5% annual increase in fuel efficiency has been realized. • Fully implementing this recommendation would require a policy change (perhaps at the Board level or from the Mayor) and would be easier to implement if the County was working to achieve a specified level of fuel efficiency (as measured by vehicle MPG) rather than working to achieve an annual percent increase in fleet efficiency because the comprehensive data needed to measure and monitor that may not be easy to attain. • To fully implement this recommendation would require a policy change to procurement procedure.			
B8. The purchase of a hybrid SUV shall be an allowable alternative for Miami-Dade County fleet procurement if that vehicle is determined to be more fuel-efficient than a light truck or comparable vehicle.	No	No	Yes
• The County's current policy is to allow for replacement of an SUV with another SUV; however, additional SUV requests and upgrades to SUVs are being approved and purchased on a case-by-case basis. • Hybrid SUVs are not typically purchased because they are currently at the high end of the market and are significantly more expensive than non-hybrid SUVs. • Currently purchasing decisions do not require comparison with other vehicles in terms of fuel-efficiency.			
B9. Direct the Office of Resilience to initiate an energy and fuel conservation incentive and awareness campaign for employees in conjunction with the Miami-Dade County's Resource Conservation Committee, DERM's Pollution Prevention and Environmental Education work groups, and the GSA Department. This campaign should use information from the Chicago Climate Exchange membership, the Climate Change Advisory Task Force (CCATF) Science Committee, and other pertinent sources to highlight the environmental, health, and economic benefits of energy conservation and communicate the importance of energy conservation and communicate the importance of conserving energy and fuel. The	Yes	No	Partially

information about energy efficiency and fuel conservation currently provided as part of the Miami-Dade County New Employee Orientation Program should be expanded to include the campaign components listed above. Funding needs and options shall be identified for the implementation of this recommendation.			
• There have been several awareness campaigns that have raised the visibility of energy and fuel conservation, and in many cases, the energy usage in County buildings and vehicles has been reduced. For example County staff implemented the Green Deeds program as part of GreenPrint (Initiative #23. Develop incentives for County employees to save energy through the Idea Machine). The Green Deeds program incentivized employees to implement energy, fuel, and resource conservation initiatives at work and at home. Another example is the Power it down campaign which was a competition between two County buildings, the Stephen P. Clark Center and the Gerstein Court House, to reduce energy consumption. The County has implemented numerous employee education program through the years and continues to explore new opportunities. More information about other educational programs implemented can be found in items B.13.1 and B.14.9 below. • Over the years, Miami-Dade County's Fleet Management Division has successfully reduced overall pool vehicle usage, resulting in fewer miles driven. In 2005 the County had over 600 pool vehicles versus approximately 200 pool vehicles in 2016. Some of the measures implemented to achieve these results were policies that encouraged staff to schedule meetings accessible to mass transit and increasing the usage of teleconferencing. • GreenPrint initiatives #26 (continue fuel reduction and monitoring programs) supports implementation of this recommendation.			
B10. The Climate Change Advisory Task Force supports any recommendations put forth as a result of the most recent Miami-Dade County fleet analysis that lead to an increase in fleet fuel efficiency and a reduction in vehicle miles traveled (VMT). The Task Force recommends that the County further strengthen these recommendations by creating incentives to reduce VMT and by not excluding any departments or vehicle types in reduction initiatives. As an example, it is recommended that hybrid sedans be purchased for non-pursuit police vehicles at the time of replacement.	Partially	No	Partially
• There have been a number of initiatives to reduce vehicle miles traveled (VMTs) and fuel usage for County vehicles. • One such initiative was a Five Year Fuel Reduction Resolution wherein the County reduced fuel consumption by 13%. This reduction was amongst the target population of County light vehicles excluding police vehicles. • All County hybrid vehicles (534) are used in non-pursuit applications and the Miami-Dade Police Department is currently operating 15 hybrid sedans.			
B11. The Task Force recommends that Miami-Dade County implement the following steps to ensure their ability to meet the Cool Counties greenhouse gas reduction commitments: i. Commit to a 20% reduction in GHG emissions by 2020 through an annual 2% reduction from the base year of 2005 for both County government and County-wide GHG emissions. Provide annual reporting on greenhouse gas emissions for the County government and Countywide GHG emissions. This annual report should include steps taken to reduce GHG emissions internally and geographically, results, and steps needed to meet the next year's target. Ii. Recognize this commitment takes dedicated resources to develop, implement and report on these plans. The County Manager intends to adequately resource this initiative to achieve targets established in the Cool Counties resolution and in paragraph (i) of this resolution. Iii. The County establish a countywide alliance of municipalities and large corporations, public and nonprofit institutions that will need to collaborate in order to meet previously established targets. This consortium will be used to: a. Enlist partners to explicitly adopt all primary goals of the Cool Counties GHG reduction targets and to report on their own GHG reductions. B. Identify and implement strategies for the financing and performance of energy efficiency and	Partially	No	Partially

renewable energy upgrades in Miami-Dade County/South Florida, c. Increase purchasing power of energy efficiency related financing, services and products, & d. Enlist partners to assist with the dissemination of information and incentives designed to assist individuals and small businesses in meeting these reduction goals. (This alliance could also be used to coordinate Countywide adaptation efforts)			
• In 2008 Miami-Dade County committed to the U.S. Cool Counties goals and objectives, to reduce greenhouse gas (GHG) emissions from 2008 levels by 80% by 2050. • As part of the 2016 update of Miami-Dade County's community-wide sustainability plan, GreenPrint, the County is setting an interim greenhouse gas emissions reduction goal of 20% relative to 2008 levels by 2020. • Two comprehensive inventories of both direct emissions (County government) and community-wide emissions have been conducted since 2008 (2008 and 2010) and an update is being conducted (2013) to inventory emissions in 2015. • Currently, a comprehensive inventory takes 6-12 months to complete and resources in the Office of Resilience and the Division of Environmental Resources Management (DERM) do not allow for annual reporting on emissions. However, it is the opinion of the Office of Resilience staff that annual reporting would not provide a meaningful improvement and additional resources should instead be dedicated to implementing projects that reduce greenhouse gas emissions, such as energy efficiency retrofits or improving the efficiency of the transit fleet. • Meeting the targeted reductions (20%) will require dedication of additional time and effort. Since 2008 greenhouse gas emissions have continued to increase and the 2015 inventory is expected to show a similar upward trend in emissions. • The County is currently working with several municipalities through the Southeast Florida Regional Climate Change Compact. Many of these municipalities have greenhouse gas reduction goals. • The following 7 municipalities have signed on to the Mayor's Climate Action Pledge and are working to implement the Regional Climate Action Plan: Miami Beach, South Miami, Surfside, Pinecrest, Coral Gables, Key Biscayne, and Hialeah. • To monitor the implementation of the Regional Climate Action Plan by municipalities, a survey was distributed by the Compact in 2014. The survey was conducted over eight weeks in November and December of 2014. Within this time, 27 of the 34 municipalities in Miami-Dade successfully responded to the survey. Several municipalities in Miami-Dade County were among the top ten municipalities in terms of having the highest implementation rate. Miami Beach, for example, is implementing 61 and Sweetwater is implementing 55 of the Regional Climate Action Plan recommendations. • Municipal partners are helping to disseminate information and incentivize individuals and small businesses to meet these reduction goals. • There have been steps to increase the purchasing power of energy efficiency related financing, services and products. The County has been using Energy Performance Contracts for several decades to purchase energy efficient equipment and technologies. The County partnered with the Miami-Dade County Credit Union to offer low interest loans to employees who want to purchase a limited number of energy efficient appliances. Unfortunately, this loan program was discontinued due to lack of interest. • Strategies have been implemented for the financing and performance of energy efficiency and renewable energy upgrades. The County has worked diligently to implement a PACE program for Unincorporated Miami-Dade. However, due to a lawsuit filed with the Florida Supreme Court in 2015, this program has been delayed.			
B12. The CCATF recommends that Miami-Dade County implement the following in order to promote energy conservation and efficiency in buildings owned by Miami-Dade County and support Resolution R-228-09 (Resolution to Reduce Miami-Dade County's Electrical Energy Consumption). 1. Conduct a feasibility study and develop a plan for retrofitting all County-owned outdoor lighting to high efficiency lighting technologies. The study should include a review and summary of current standards and case studies of implementation in other communities. High efficiency light options to be considered may include: Light emitting diodes (LED), induction lighting, with a preference given to solar powered lights. Additionally, an evaluation should be made to improve the efficiency of outdoor lighting with the goal to reduce non-essential outdoor lighting during daytime hours.	Yes	No	Partially

- The Electricity Master Plan includes plans to increase outdoor lighting retrofits and install LED lights.
- Several Departments, such as Miami-Dade Parks, Recreation and Open Spaces, have started retrofiring their outdoor lighting.
- Even though there is significant potential to reduce the County's energy consumption if new technologies were installed, it is currently difficult to justify retrofitting outdoor lighting. The Energy Efficiency and Conservation Block Grant supported a technology demonstration and enabled retrofits for a few outdoor lights around the downtown area. The demonstration project was successful; however, due to the current pricing structure offered by Florida Power & Light (FPL), efficient lighting is not economically conducive for non-metered poles. Other local governments have been able to successfully negotiate other pricing structures with their utilities (FPL, Duke, etc.); however, Miami-Dade County has not pursued a similar negotiations. This issue was included within Miami-Dade's 2016 legislative package for the Office of Resilience and the Southeast Florida Regional Climate Change Compact. The package included a provision to support and advocate for utilities to develop competitive rates for efficient outdoor lighting.

B12 2. Require that all county buildings that annually consume more than 500,000 kilowatt hours (kwh) and have not received a comprehensive energy audit in the last 5 years, receive a comprehensive energy audit and/or retro commissioning, with the intent of identifying energy saving and carbon footprint reducing opportunities.	Yes	No	Partially

- The Young Green Professionals program audited several fire rescue facilities.
- The Energy Performance Contracting Program, which started in 1998, continues to audit several facilities including the Miami International Airport, Port of Miami, and some park facilities. As new Energy Performance Contracts are initiated additional buildings will be audited, for example the Miami International Airport was audited in 2014/2015 as part of a successful Performance Contract.
- The County has decide to use Energy Star Portfolio Manager to manage energy use at its facilities. With the new utility billing management software (EnergyCAP), data for buildings (such as electricity bills and size data, etc.) can be automatically submitted to Energy Star Portfolio Manager.
- At present there is no particular requirement to audit buildings consuming over 500,000 kilowatt hours.
- It is important to recognize that energy audits alone are not sufficient. Resources are needed to implement the retrofits and reduce energy demand. Energy Performance Contracting is a successful financing mechanism, but other options need to be found. There is also a disincentive for building managers to reduce their utility bills due to the fact that utility budgets are typically fixed. When a building manager is proactive and takes steps to save money on their utility bills, they are not able to keep those savings, but instead will have their future budgets reduced. It is important for the County to find ways to either change this funding structure or work to educate facility managers about the other benefits of improving efficiency.
- Save Energy and Money (SEAM) program was implemented in 2010 to help fund and facilitate small energy and water retrofits in County facilities. Several projects were successfully completed via SEAM at the Parks, Recreation and Open Spaces Department, the Corrections Department, and Internal Services Department.

B12 3. Require that all County departments include their goals and plans for greenhouse gas reduction and climate change adaptation in their strategic plans and that each Department Director's performance evaluation include a reporting on outcomes. Present sustainability award to Departments and Directors that achieve most impressive results. One department (e.g., Office of Resilience, DERM and/or GSA) could be responsible for providing strategies, tools and resources to each department to assist departments in achieving their reduction goals.	Partially	No	Partially

- Departments were asked to include sustainability-oriented goals in their ASE scorecards. This included metrics such as energy consumption and water consumption, which are significant contributors to greenhouse gas (GHG) emissions.
- During the countywide greenhouse gas inventories, all GHG emissions from departments are included; however, they are not currently broken down by department. It is the opinion of the Office of Resilience staff that tracking energy usage by department is an effective proxy for tracking greenhouse gas emissions and that additional resources should be concentrated on providing assistance to departments to reduce their energy usage. Additional resources in the form of staff time would be needed to scale up this outreach and engagement effort.
- The EnergyCap utility billing management software tracks energy consumption at the department and facility level. The Office of Resilience is proposing to expand the use of the EnergyCap to include water utilities as a new initiative in the next GreenPrint cycle.

- Previously, the County implemented a sustainability acknowledgment program called GreenDeeds for employees, but that program was discontinued due to a reduction in resources and low participation. Currently, there is no program to present awards specifically focused on sustainability.
- The Idea Machine is an on-going program that recognizes and rewards employees who implement any cost savings measures including but not limited to energy or water savings measures.

B13. The CCATF recommends that Miami-Dade County continue to support funding opportunities available through the American Recovery and Reinvestment Act (ARRA) and other federal programs to retrofit homes, commercial, and housing facilities for energy and water efficiency, and educate residents and homeowners about conservation. The following should be included in order to optimize, leverage, and facilitate energy conservation federal programs and funding. Including but not limited to Neighborhood Stabilization Program, Weatherization programs, Public Housing Capital improvements, Community Development Block Grants, Community Services Block Grants, and homelessness prevention	Yes	No	Yes

- Through the Energy Efficiency and Conservation Block Grant (EECBG), the County created a comprehensive community-wide three-year energy and sustainability education program that leveraged and expanded existing community communication, marketing, and programs to provide information, educational programming and incentives for the public related to energy conservation.

- Through the Energy Efficiency and Conservation Block Grant program, a stand-alone green portal (http://www.miamidade.gov/green/) was created to serve as the one-stop shop of county green programs and to provide content in a user-friendly format for the portal.
  - Through the 750 Challenge Program, the County provided educational outreach to the community.
  - When the Energy Efficiency and Conservation Block Grant ended, it was calculated that the marketing strategies implemented resulted in the following estimated reductions:
    - Light Bulb Exchange: 20,000 Light Bulbs, 1,230.25 CO_2e reduction;
    - Home Workshops: 700 attendees, 272.7 CO_2e reduction;
    - Home Rebates (refrigerators): 500 rebates, 239.5 CO_2e reduction;
    - $750 Savings Challenge: 3,000 pledges, 9,107.3 CO_2e reduction;
    - Green Business Certification/workshops: 350 businesses, 1,117 CO_2e reduction;
    - Commercial Rebates: 140 rebates, 90 mt CO_2e reduction;
    - Website: 25,000 households, 9,739.5 CO_2e reduction;
    - Employee Green Pledge: 25,000 employees, 11.62 CO_2e reduction.
    - Grant to Non-profits (G2GN)
  - Some of these programs continued after the Energy Efficiency and Conservation Block Grant funding ended such as: the Green Portal website, 750 Challenge, light bulb exchange, and the Green Business Certification program.
  - Florida Power and Light (FPL) has installed smart meters in County facilities and countywide for all residential customers except for (a) customers who do not want a smart meter and have agreed to pay an additional fee for on-site meter reading and (b) a small number of inaccessible residential properties.
  - Miami-Dade County provided a version of EnergyCAP to homeowners; however, it is not widely used due to the lack of an automated link with FPL or other utilities.
  - Community Action and Human Services' (CASHD) low-income weatherization program helps reduce energy bills of low-income families. Therefore, saving money through weatherization usually liberates funds for spending on more pressing family issues. On average, weatherization reduces overall energy bills by $358 per year at 2015 prices. The program serves an average of 90 homes each year depending on the size of the project and the services needed. Specific energy conservation measures include: installing or adding attic insulation; installing solar films; repairing or replacing deteriorated exterior doors and windows; installing thresholds and weather-stripping; installing low flow showerheads and pipe insulation on

water heater lines; installing water heater jackets; installing exhaust fans to improve quality air ventilation; replacing inefficient air conditioners, A/C filters and repairing A/C ducts; installing energy efficient light bulbs; replacing refrigerators and replacing water heaters. In addition, the Weatherization Assistance Program (WAP) requires that Energy Star equipment replacements, educational materials, and tips are provided during the initial and final inspections of all weatherized projects. • An Energy Performance Contract project specifically for public housing was approved by the Board of County Commissioners on September 2015. This project is expected to be completed in 24 months. In total the project identified 14 energy conservation measures across 37 elderly and 52 family public housing sites in Miami-Dade County. The main energy conservation measures included the installation of high efficiency toilets, low-flow shower heads and faucets, and upgrading of common area, apartment, and exterior area lighting.			
B13 1. Incorporate educational, behavioral, and operational training programs with all retrofit and renovation options.	Yes	No	Partially
• Most energy efficiency projects implemented by Miami-Dade County such as the Energy Performance Contracts include educational, behavioral, and operational training programs. A comprehensive list of all programs implemented so far cannot be included in this report due to space limitation. However, a few examples are highlighted below. • As part of the projects funded by the Energy Conservation Block Grant behavioral campaigns were completed for selected facilities and the TV monitors were installed with energy displays and fliers were distributed. The behavioral campaign, "Power it Down Challenge," was launched for employees at the Stephen P. Clark Government Center and the Richard E. Gerstein Courthouse. The campaign was meant to drive behavior changes among County employees by promoting healthy competition among the various floors and departments in order to reduce energy consumption. • The campaign was launched on August 1st, 2012, and ran for six consecutive weeks. Savings over the six weeks totaled 7,561.34 kWh or $756 and a reduction of 4 metric tons of CO_2e greenhouse gases. The campaign was designed to be re-launched a couple of times a year however due to reduction of staffing of the Office of Resilience this has not been possible. • The Office of Resilience continues to monitor and display electricity use at both facilities and plans to engage staff and visitors in a second Power It Down campaign in the future. • While this has not been widespread it has been successful at selected facilities. • An educational campaign was launched as part of the 2014/2015 Energy Performance Contract at Miami International Airport. The campaign is displayed in selected TV monitors in the airport for employees and passengers.			
B13 2. Monitor and analyze results of retrofits to include but not be limited to obtaining an energy rating of all renovated homes and public housing facilities.	Yes	No	Partially
• The Current public housing model doesn't support implementation of the Sustainable Buildings Program due to the fact that most public housing projects are developed and operated by private developers. However, The President's Climate Action Plan calls for a target of 100 megawatts of installed capacity of renewable energy on-site at federally subsidized housing by 2020. On July 2015 this goal was increased to 300 megawatts of installed capacity. • In addition, The Department of Housing and Urban Development recommends the use of Energy Star for public housing projects, therefore many of the public housing projects achieve this standard. • An Energy Performance Contract project for public housing was approved on September 2015. This project is expected to be completed in 24 months. The project identified 14 energy conservation measures across 37 elderly and 52 family public housing sites in Miami-Dade County. The main energy conservation measures include installation of high efficiency toilets, low-flow shower heads and faucets, and upgrading lighting in common areas, apartments, and exterior areas.			
B13 3. Use some or all of the funds created from the resale of foreclosed and renovated homes for further development and promotion of energy and water efficiency outreach programs.	No	No	No
• No steps have been taken on this initiative at this time.			
B13 4. Maximize the use of Smart Meters to monitor results and complimentary behavioral programs.	Yes	No	Yes
• The County has implemented EnergyCap for its facilities. EnergyCAP provides a single utility billing management platform for use county-wide and improves utility bill auditing and accountability while increasing overall energy management efficiency. Through the implementation of EnergyCAP, paper billing from Florida Power & Light (FPL) has been replaced by electronic billing.			

• In addition, EnergyCAP automatically uploads electricity consumption data to the Environmental Protection Agency's ENERGY STAR Portfolio Manager. The Environmental Protection Agency's website calculates an energy performance score and sends it back to EnergyCAP. This allows the County to benchmark its buildings, enabling departments to prioritize energy performance improvement projects, use actual data to measure savings stemming from performance improvement projects, and seek ENERGY STAR building certification.			
B 14. The CCATF recommends that Miami-Dade County develop incentives for energy and water efficiency, conservation, and distributed low- and no-carbon energy generation for existing residential, industrial, and commercial buildings. The CCATF recommends that the County:			
B14 1. 1. Explore development of a public/private partnership that would provide financing and technical assistance to smaller scale commercial, multifamily and residential facilities to retrofit homes for improved energy and water efficiency. This should support current and future technologies (e.g., metered charging stations in parking garages for electric vehicles and roof hook ups for PV, and, where feasible, the installation of renewable energy technologies such as solar water heaters).	Yes	Yes	Yes
• Funded by Energy Efficiency and Conservation Block Grant, a revolving loan fund program (Renovation for Energy Efficiency Loan – REEL) was created for local businesses to implement energy efficiency retrofits in their facilities; however, it was closed in July 2011, primarily due to the lack of interest. • The County is still developing a PACE program, which could be a potential mechanism to accelerate the financing of energy efficiency retrofits and solar photovoltaic expansion. • Funded by Energy Efficiency and Conservation Block Grant, Miami-Dade County created the Grants to Green Nonprofits (G2GN) program in April 2011 which is now complete. Through this program Miami-Dade County funded $1 million in energy-savings retrofits for 55 nonprofit facilities. Florida Power & Light Company was a partner on this program. • The Miami-Dade County Credit Union E2 loan program was implemented to offer county employees low interest loans to do energy efficiency in their homes. The program was discontinued in 2015 due to lack of interest.			
B14 2. In the short term, identify potential partners to develop and implement a financing solution for solar water heaters similar to Lakeland Electric.	No	No	No
• FPL announced in 2015 that they will eliminate solar rebates including the water heater rebates. This decision was made in accordance with an earlier decision of the Public Service Commission in November 2014 to cut demand-side management programs. • As part of a new pilot program authorized by the Florida Public Service Commission, FPL is partnering with not-for-profit low-income-housing builders under the Solar Water Heating Low-Income New Construction Program to install 1,000 solar water heaters in low-income housing units over the next five years.			
B14 3. Analyze and maximize GHG reduction opportunities through all county services to residents and businesses.	Yes	No	Partially
• Miami-Dade County has conducted several comprehensive greenhouse gas inventories and has identified the largest sources of community-wide greenhouse gas emissions as vehicles. • The County's sustainability plan, GreenPrint, includes a detailed greenhouse gas mitigation strategy to reduce emissions to 28.9 million metric tons. • GreenPrint outlines a number of emissions reduction opportunities that were estimated to reduce emissions by 1.47 million metric tons of CO_2 equivalents and avoid emissions of more than 3.05 million metric tons. • The Division of Environmental Resources Management and the Office of Resilience are currently completing an updated greenhouse gas inventory and will develop an updated mitigation strategy to help Miami-Dade County achieve its commitment to reduce emissions by 20% by 2020.			
B14 4. Work with FPL on the installation of a real-time, web-based smart meter program in County government and other large public institutions.	No	No	Yes
• FPL installed smart meters in all County facilities that meet the requirements to have a smart meter. • Furthermore, the County implemented the EnergyCap program with the goal establishing a centralized method for quantifying County electricity consumption and its associated costs to enable the County to measure, manage and monitor the performance of its facilities.			

• Through the use of EnergyCAP and smart meters the County has been able to correct issues that otherwise would have not been noticed until the end of the billing cycle. For example, setting changes in Building Management Systems after regular maintenance that could have gone unnoticed for several months and could have cost an unnecessary increase in energy usage.			
B14 5. Promote the use of green roofs, e.g. vegetative roofing, high reflectivity roofing materials, etc.	No	No	Partially
• The Miami-Dade Building Code Compliance Office (BCCO) has developed information about green roofs which was presented to Building Officials in 2014. Green roofs are approved individually since they do not meet the current Building Code (Code). Roof systems must have a product approval or engineering system approval. Since green roofs do not have product approval, all green roofs built in Miami-Dade County are approved using the engineering system approval method. BCCO is planning to do another presentation about green roofs and reflective roofs to Building Officials in 2016. Currently, there are some concerns with the installation of green roofs in existing buildings, primarily due to weight issues. • Reflective roofs are widely used and there are many with product approval that are compliant with the Code. Furthermore, the current Code requires reflective roofs through prescriptive methods for code compliance. However, most people use energy models as the path of compliance with the Energy Code and therefore reflective roofs are not always included. • There is also an existing ordinance that requires cool roofs for all Housing Department projects in excess of $1 million. • Also, through the Miami-Dade Sustainable Building Program, County facilities are being built to LEED standards which include cool roofs and green roofs. • A portion of the Children's Courthouse has been constructed with a green roof.			
B14 6. Include solar reflectance, emissivity and Solar Reflectance Index (SRI) values into the roof system product approval process.	No	No	No
• This is currently not mandatory by code; however, it is a best management practice that is encouraged by the MDC building officials.			
B14 7. Develop incentives for retrofitting buildings to accommodate energy-saving additions such as PV panels on rooftops and metered charging outlets/stations in parking garages for electric vehicles.	Partially	Yes	Partially
• There are no additional incentives specifically for retrofitting buildings at this time; however, there is an expedited permitting approval process for green buildings. • There are other efforts to include electric vehicles and renewable energy. For example, there are currently five electric vehicle charging units installed at the OTV parking garage and two charging units at OTV are available for the public to use. Please see item B14.8 below for additional information pertaining to electric vehicle charging stations.			
B14 8. Develop incentives for the addition of customer-paid electric vehicle (EV) charging stations in portions of public and county-run parking lots.	No	Yes	Partially
• The number of electric vehicle charging stations in Miami-Dade County has increased in recent years. • Miami-Dade County has five EV charging stations at Overtown Transit Village. Three of these are used to charge County/RER Toyota Prius' that were modified by the Division of Environmental Resources Management to have plug in capability and the other two charging units are available for public use. • There are also charging stations at the County's downtown motor pool for the two County Leaf vehicles. • Miami-Dade Transit is planning to roll out EV charging stations in its park and ride facilities as well as its parking garages. • New charging stations are frequently being installed by businesses and several websites provide maps of available stations (for example http://www.carcharging.com/ev-drivers/locations/#map_top or http://www.plugshare.com/) • With the support of a $500,000 grant from the US Department of Energy, regional partners including Miami-Dade County and the South Florida Regional Council, were able to develop an EV infrastructure regional plan. Drive Electric Florida completed its EV Community Readiness Plan which is located at: http://www.floridagoldcoastcleancities.com/Grant_Opportunities2.html. The report is titled "Getting Southeast Florida Plug-In Ready", Volume I of the Plan includes guidance on infrastructure, policies and permitting, fleet adoption, and education/outreach as well as snapshots of the state, region, and the seven counties that participated in the Plan. Volume II is the master plan for a U.S. 1 Corridor car-share pilot project proposed to be adjacent to Metro Rail.			

- Miami-Dade County Zoning Division has been working on an ordinance to require EV charging stations in off-street parking lots. This ordinance has not been approved as of this report date.
- The County passed a resolution (File Number 160424) that directs County staff to craft a plan to install electric vehicle charging stations to serve the general public. This report and plan is due to be released in summer 2016.
- The Office of Management and Budget has been asked to look at potential funding sources for installing EV charging stations.

B14 9 Consider a demonstration retrofit of a County-owned building that could be used as a public outreach and education vehicle for promoting energy-saving retrofits.	Yes	No	Yes

- The County has completed 10 LEED-certified buildings which are used for public outreach and education.
- All of these LEED facilities include a public education component focused on the benefits of green best management practices implemented in the project, for example benefits of Florida friendly yards, etc. For example, the Verde Gardens Project in Homestead is the first LEED Gold certified homeless sheltering project in Florida. The project received LEED Gold certification for the townhome models and the Fresh Market, while the Community Center received LEED Silver certification. The Children's Courthouse, which was completed in late 2014, earned LEED Gold certification in September 2015.
- The Sustainability Project at the Miami International Airport is educating customers about energy and water efficient retrofits through monitors installed at the airport. This project is one of the largest energy savings programs in the state of Florida and it is estimated to reduce the airport's energy consumption by 35 million kWh per year and save approximately 28 million gallons of water per year.

B15. The CCATF recommends that Miami-Dade County educate the business sector and the public on energy and water efficiency and conservation. The CCATF recommends that this would best be accomplished if Miami-Dade County collaborates with corporate, nonprofit, and educational organizations to develop a broad scale and culturally competent media and community based educational campaign dedicated to promote the adoption of conservation, efficiency and renewable behaviors, systems and technologies in residences and businesses. CCATF suggests that this educational campaign should:

B15 1 1. Inform residents and the business sector of the economic benefits of, and resources available for, energy efficiency and appropriate renewable technologies (e.g., green roofs, solar water heaters, smart meters, etc.).	Yes	No	Yes

- The County initiated a special loan program for energy efficient home improvements for County employees, Home Energy Efficiency Assistance Loan Program (E^2 Loan), through the Miami-Dade County credit union. Unfortunately, after a flurry of initial interest the program did not attract many customers.
- FPL also received a grant to install smart meters in Miami-Dade County. Those installations are expected to be completed soon for residential and small business customers.
- Energy efficiency efforts have slowed following the decision of the Public Service Commission to eliminate and/or reduce the utilities' "demand side" programs, which focus on energy efficiency and consumption.
- Miami-Dade County created the green.miamidade.gov website. The webpage creates a sustainability umbrella/brand for residents and all portal visitors, consolidates existing common information into one place, and provides an entrance feature to organization's departmental pages. For example, the page includes green tips and links to rebates and incentives.
- However, as part of Energy Efficiency and Conservation Block Grant, the County did do outreach and offered rebates to the residential and business sector for energy-efficient appliances.
- The County also reached out to the community via a marketing campaign (known as the 750 Challenge) which focused on energy and water efficiency.
- Also, as part of the same grant, the County created a grant program targeted at nonprofits. The program helped the non-profit recipients do energy efficiency retrofits to their buildings.
- The County is currently involved in a grant project called WE-Lab with the nonprofit "Dream in Green." The project involves outreach to residents and businesses to discuss water and energy efficiency.
- Kilowatt meters have been made available for loan to the public at every public library branch. These meters are small devices that allow residents to assess the energy consumption (and cost) of plug-in appliances and help identify where replacement with more efficient units would be most effective.

B15 2 2. Develop two separately designed and targeted campaigns and approaches: one for residents and one for business. For consumer/resident examples, refer to the Home Energy Saver (attached) and Green Homes Challenge (attached) descriptions. For a business example see www.e4s.org , the Entrepreneurs for Sustainability website.	Yes	No	Yes
• Several campaigns have been developed to promote energy-efficiency and conservation. Funded by Energy Efficiency and Conservation Block Grant, Miami-Dade County partnered with Dream in Green and hosted several Home Energy Savings Workshops, which educated residents about energy efficiency and conservation and provided homeowners with the information, resources, and incentives to reduce their utility costs. • The County launched a free online energy and utility tracking tool powered by GreenQuest, which serves as a personal energy dashboard for homes and/or businesses. This tool helps educate the community, promote energy and water conservation, and helps residents save money. • As part of the $750 Challenge, an easy to use on-line checklist was developed to show residents how they can save $750 through basic efficiency measures. • The Energy Efficiency and Conservation Block Grant program also included a campaign targeted at home owners and small businesses. • WELAB continues that effort but on a smaller scale. • The examples highlighted by the CCATF (such as the Green Homes Challenge) were drawn upon to inform the outreach campaign but were modified for the County. • The Miami-Dade Green Business Certification Program was launched to provide guidance to businesses seeking to green their operations. For those applying to become a certified green business, Miami-Dade County offered $10,000 in commercial rebates for the purchase of new ENERGY STAR appliances or select equipment. By encouraging the replacement of older and inefficient appliances, these rebates helped decrease energy consumption and increase savings on energy bills. This incentive was discontinued after Energy Efficiency and Conservation Block Grant funds ended.			
B15 3 3. As part of this education campaign, include information about the Energy Gauge performance rating system for new and existing commercial and residential buildings and encourage property buyers to ask for the rating.	No	No	Partially
• Energy Gauge is a computer tool for Florida Energy Code compliance for residential new building construction and Florida Home Energy Rating System (HERS) calculations. Disclosure of Energy gauge performance is not required by code. For example, for County facilities it was decided to use Energy Star as the tool to measure energy performance of existing buildings and as recommend that Department of Housing and Urban Development. However all county facilities have met or exceed the Florida Energy Code. • The County as a permitting agency cannot recommend a specific tool for compliance with the code. • HERS rating is not currently required to be published as part of code compliance. • The County is interested in using the HERS index for rating and has recommended it be included as an initiative in the next iteration of the County's sustainability plan, GreenPrint. • The Building Code Compliance Office (BCCO) offers three free workshops per trade per year. These workshops, which cover Energy Gauge, are aimed at certain aspects which have a significant impact on the energy-efficiency of building trades, such as mechanical plumbing and electrical professionals. These workshops, which are led by the building inspectors, are also open to designers, contractors, architects, and engineers.			
B16 WASD is the County's highest consumer of electricity and one of the highest consumers in the State of Florida. The CCATF recommends that Miami-Dade County undertake an assessment of the County's water and sewer rates and conservation/efficiency programs. The County should:			
B16 1. Conduct a long term comparative cost/benefit analyses on the combination of increasing electricity and water generation vs. ramping up conservation and efficiency programs. The CCATF recognizes that both options may be necessary but a preference should be given to increasing conservation and efficiency.	No	No	Partially
• Several incentive programs have been implemented to encourage the efficient use of water and help residents save money. They include: plumbing retrofits, landscape irrigation evaluations and residential and commercial water use evaluations and rebates. • As a result consumption has dropped significantly. The current demand for finished water is 44 million gallons per day lower than what was projected in November 2007.			

• In 2009 the Miami-Dade County Board of County Commissioners amended Chapters 8 and 32 of the Code of Miami-Dade County establishing new standards for water saving fixtures for new construction. The new requirements include the development and publication of a Water-Use Efficiency Standards Manual under Section 32-84 of the Code of Miami-Dade County. The manual provides specific code changes per Ordinances 08-14 and 08-100 regarding high efficiency flow rate requirements for bathroom and kitchen fixtures. The manual also provides additional guidance and recommendations for new development in Miami-Dade County with the intent of achieving the maximum water savings in new residential and commercial developments in both unincorporated and incorporated areas of Miami-Dade County. • The lower demand is the result of lower-than-projected population growth, permanent landscape irrigation restrictions, water loss reduction and the success of the water conservation initiatives and best management practices that have been implemented. • As a result of the lower-than-projected demand, the Miami-Dade Water and Sewer Department re-evaluated the County's water use projections and has adjusted the schedule of capital water supply projects. This collective awareness has allowed for the per capita use to drop from 158 to 134 gallons per person per day during the same period of time.			
B16 2. Provide consumer education on the current comparatively low rates they have enjoyed and the need for increasing rates to pay for efficiency and conservation efforts. The goal of this education is to build voter acceptance that increased rates are essential to maintaining and improving the quality of life here.	No	No	Partially
• Through their website (http://www.miamidade.gov/water/rates.asp) the Water and Sewer Department has provided information about the comparatively low water rates in Miami Dade County. This website compares our water rates to other municipalities around the country and explains how water rates can encourage wise use of our water resources. • Water rates have increased slightly, but remain some of the lowest in the country. • the Water and Sewer Department published the Water-Use Efficiency Standards Manual at http://www.miamidade.gov/waterconservation/library/instructions/water-use-efficiency-standards-manual.pdf and has revamped its conservation section of its website http://www.miamidade.gov/waterconservation/			
B16 3. Determine the feasibility of using Miami-Dade County's Water and Sewer Department (WASD) facilities for installation of renewable energy technologies, including for water and sewer operations.	No	No	No
• There was an effort to assess the potential for renewable energy technologies in the Executive office. This study looked at the Water and Sewer Department's and other large county properties to see if they were feasible for installation of renewable technologies and at that time they were deemed to be unsuitable. Lack for incentives for renewable energy generation and the low cost of energy in Florida are many of the reasons why renewable energy projects continue to not be as economically favorable in Miami-Dade County. • The Water and Sewer Department is using recaptured methane from a landfill and digesters at the South Dade facility and capture the digester gas at the North Dade facility.			
B 17 Recognizing that support at the state and federal level are important in facilitating action at the local level, the Climate Change Advisory Task Force recommends that Miami-Dade County advocate that:			
B17 1. The Florida Public Service Commission require FPL to achieve at least a 20% reduction in GHG generation from the 2005 baseline by 2020. This would include incorporating the costs of the proposed nuclear power plants by Florida Power and Light at Turkey Point in the comparative costs and benefits of energy efficiency and renewable energy systems and improve and expand incentive structures for energy efficiency, energy conservation and renewable generation. These incentive structures need to promote both customer owned and utility owned energy efficiency and demand side renewable energy systems. Additionally, the cost benefit analysis needs to place a greater emphasis on reducing overall energy consumption, not just capacity reduction, to achieve greater reduction in greenhouse gas emissions.	No	No	Partially
• This has not been implemented; however, the County sends legislative urgings in its annual legislative package in support of energy efficiency and renewable energy systems. • While there has never been a request for comparative cost benefit analysis examining adding new generation as opposed to exploring energy efficiency, many other related components have been included in the legislative package. The relevant section from the 2016 State Legislative request is below:			

Energy Efficiency and Buildings

- *ADVOCATE for the preservation and enforcement of the Florida Energy Code. This includes, but is not limited to: Increase compliance by assigning responsible parties to enforce each element of the code or create an Energy Inspector with overall responsibility for the Energy Code compliance; ADVOCATE for the Florida Building Commission, the Energy Technical Advisory Committee, and Energy Code Work Groups to ensure that new construction, major renovation and retrofitting, and replacement of equipment increase energy efficiency and promote the use of renewable energy; ADVOCATE to remove exemption from energy code of renovated buildings that estimated costs of renovation is less than 30 percent of the assessed value of the structure; and ADVOCATE that the Florida Energy Code adopt the national Home Energy Rating System (HERS) and require a HERS Index less than 88 for Florida Energy Code compliance.*
- *ADVOCATE for revenue decoupling in the energy markets. Under such a compensation scheme, revenues are "decoupled" from sales and are instead allowed to adjust so that utilities receive fair compensation regardless of fluctuation in sales.*
- *ADVOCATE the adoption of the International Green Construction Code (IGCC) as the standard, state-wide. Until this becomes possible, pursue all of the following pathways such as:*
    - *SUPPORT a change in state law that prevents local jurisdictions from enacting more stringent energy performance standards that would better meet local community needs and goals.*
    - *SUPPORT use of the IGCC as a statewide alternate compliance code on a strictly voluntary basis for those individuals or projects that wish to surpass current state energy code minimums, and offer incentives for such voluntary compliance.*
- *ADVOCATE for the use of green building rating systems for new construction and existing buildings as one of several model options for achieving verifiable greenhouse gases (GHG) emissions reductions and improving energy efficiency including but not limited to the National Association of Homebuilders' (NAHB) Green Building Standards, the Florida Green Building Coalition's Green Building Standards, Green Globes' Standards and the U.S. Green Building Council's LEED rating systems.*
- *ADVOCATE with the Florida Building Code Commission to ensure that new construction and major renovations include smart meters, pre-wiring of buildings to accommodate future GHG-reducing retrofits such as solar hot water heaters, photovoltaic (PV) panels or other distributed renewable power sources on rooftops, and metered charging outlets in parking garages for electric vehicles.*
- *ADVOCATE that Florida pass an energy efficiency resource standard (EERS), a target that will help utility companies reduce electricity usage by 15%.*

- *ADVOCATE legislation that furthers local Property Assessed Clean Energy (PACE) energy efficiency and renewable energy improvements. For example, ADVOCATE for legislation that guarantees local government the right to establish clean energy programs, and URGE the Department of Energy and Housing Finance Authority to agree to program elements that remove barriers to PACE and PACE-like programs in order to ensure broad applicability and access for residential and commercial interests and to provide sufficient Congressional guidance for the protection of property owners, lenders and investors.*

B17 2. The Florida Building Commission, the Energy Technical Advisory Committee, and the 2010 Energy Code Work Group work to ensure that new construction and significant renovations and replacement equipment requirements increase energy efficiency and promote renewables by requiring a combination of methods and elements to include: solar water heaters, photovoltaic panels, shading devices, vegetative roofing, controllers and monitoring equipment, best practices and quality installation procedures such as HVAC sizing and duct testing, pre-wiring of buildings to accommodate future GHG reducing technologies such as monitoring devices, HVAC zoning, centralized data centers and distributed renewable power sources on rooftops and metered charging outlets in parking garages for electric vehicles. Advocate for the use of green building standards including the National Association of Homebuilders' (NAHB) Green Building Standards and the Florida Green Building Coalition as one of several model options that can be used to reduce GHG emissions and promote energy efficiency.	Yes	No	Yes

• This is included in GreenPrint intitaive #9 which is to work with local Board of Rules and Appeals and other stakeholders to maintain the Florida Energy Code and to better define and set forth responsibilities of each trade in order to improve compliance with and enforcement of the Code (Within the Florida Energy Code and 2010 Florida Statutes, Chapter 468, Part XII). As a result of the implementation of this GreenPrint initiative, a report which provides recommendations to increase compliance with Energy Code was completed. The Board of Rules and Appeals issued recommendations which are not mandatory and allow building officials discretion in complying with the recommendations. The recommendations were distributed to Building Officials in 2014. • Florida has a good energy code, promoting "beyond code standards" has been included in the County's legislative requests since 2009. • The Miami-Dade County Building Code Compliance Office provided four hours of training about the International Green Construction Code in 2014. Training is offered in a yearly basis and beyond compliance codes are always a topic included in these trainings.			
B17 3. Florida and/or the United States pass an energy efficiency resource standard (EERS), a target that will help utility companies reduce electricity usage by 15%.	No	No	No
• To date, no progress has been made at the state or federal level; however, this issue has been included in the legislative requests of the Office of Resilience for several years.			
B17 4. State and Federal Renewable Portfolio Standards of at least 20% by 2020 be implemented.	No	No	No
• While Florida does not have a Renewable Portfolio Standard as of January 2016, this issue is included in the annual legislative requests of the Office of Resilience. • Through an Executive Order the Federal Government has committed to ensuring that 25 percent of all federal agencies total energy (electric and thermal) consumption is from clean energy sources by 2025.			
B17 5. The Federal Clean Energy bill includes a goal of reducing GHG reduction by 20% from 2005 by 2020. (This would parallel the County's current target.)	No	No	Partially
• Through an Executive Order the Federal government has committed to cut the Federal Government's greenhouse gas (GHG) emissions 40 percent over the next decade from 2008 levels and increase the share of electricity the Federal Government consumes from renewable sources to 30 percent. It is estimated that this reduction will save taxpayers up to $18 billion in avoided energy costs. • Together, the combined results of the Federal Government actions and new supplier commitments will reduce greenhouse gas emissions by 26 million metric tons by 2025 from 2008 levels, the equivalent of taking nearly 5.5 million cars off the road for a year. Specifically, the Executive Order directs Federal agencies to: Ensure 25 percent of their total energy (electric and thermal) consumption is from clean energy sources by 2025. Reduce energy use in Federal buildings by 2.5 percent per year between 2015 and 2025. Reduce per-mile greenhouse gas emissions from Federal fleets by 30 percent from 2014 levels by 2025, and increase the percentage of zero emission and plug in hybrid vehicles in Federal fleets. Reduce water intensity in Federal buildings by 2 percent per year through 2025.			
B17 6. Federal appropriations for the Energy Efficiency Conservation Block Grant (EECBG) program are continued, at least at current levels.	No	No	Partially
• The Energy Efficiency Conservation Block Grant program has ended; however, the County has included requests that the program be extended in its annual legislative package.			

Building Environment Adaptation

Recommendations	GreenPrint	Regional Climate Action Plan	Implemented
C1. Require all County agencies (and entities that receive County funding for significant infrastructure or built investments) to assess climate change impacts on the agency's/entity's responsibilities. This assessment should be incorporated into their master planning agenda or such a planning process should be initiated if it does not exist. The assessment should include the impact of sea level rise on all public investments and identification of vulnerabilities in order to produce strategies for mitigation and adaptation. These assessments should utilize a 50-year planning horizon.	Yes	No	Partially
• The Water and Sewer Department has already completed a very comprehensive assessment of how sea level rise will impact their investments. This assessment relied on the best available science and most recent analytical techniques. Through this comprehensive assessment it was determined that it is more appropriate to use several planning horizons depending on the life of the project and its sensitivity to flooding. • The County is addressing this recommendation on public investments, which is a GreenPrint initiative. The recommendations on how the County should proceed with implementation are based on precedents established by other metropolitan areas such as San Francisco and Seattle and by individual departments such as the Water and Sewer Department. • County staff are exploring ways to incorporate climate change adaptation planning into departments' master planning process by incorporating into department scorecards. • Following Resolution R-451-14 all County Departments are required to consider sea level rise in their capital planning process. • The CDMP has been amended to include a policy achieving the recommendations: ICE-5G. All County departmental master plans and strategic business plans shall include and prioritize climate change mitigation and adaptation strategies. Climate change related amendments shall be recommended through the next feasible, regularly scheduled amendment process or departmental master plan update for each respective planning document.			
C2. Use County charter authority to establish minimum criteria and standards related to climate change (including sea level rise), for public investment for all municipalities in Miami-Dade County.	No	No	No
• A similar recommendation was also a recommendation of the Sea Level Rise Task Force and has been adopted in R-46-15 which passed in January of 2015. This resolution requires the Mayor or his designee to "prepare an action plan and report to accelerate the climate change adaptation planning process by evaluating the engineering and other relevant expertise needed to develop an enhanced capital plan that includes, but is not limited to, flood protection, salinity structures, pump stations, and road and bridge designs, and to determine the costs of retaining the experts needed." • The implementation of this resolution will lead to the incorporation of sea level rise (an important impact of climate change) into the County's capital planning process. Additional work and coordination would be required to urge the municipalities to pursue similar measures; however, many municipalities such as Miami Beach, the City of Miami and Pinecrest are taking proactive steps to address climate change. County staff have been seeking input from municipalities on GreenPrint, coordinating through the League of Cities and through the Southeast Florida Regional Climate Change Compact. See item B 11 above regarding the seven municipalities have adopted the Mayor's Climate Action Pledge in support of and committing to collaboration on implementation of the Regional Climate Action Plan and GreenPrint. The Miami-Dade County League of Cities adopted a resolution (Resolution Number 2013-2) on June 6, 2013 encouraging all municipalities adopt the Pledge. • A Municipal Green Initiatives Survey has been completed, which will serve as a tool for benchmarking climate change efforts and facilitate future collaboration. • The Shoreline Review Committee provides another opportunity to work more directly with the municipalities and should be an area of future exploration.			
C3. Expand the mission of the County's Office of Resilience (OOS), and thus its resources and staffing, to provide a centralized agency for climate change information, monitoring, analysis, and benchmarking. a.) Establish a base case of information at an identified current or recent past date, to which all ensuing data might be compared;	Yes	No	Yes

b.) Assist in integrating the activities of the various entities including the coordination of data collection so that it can be used across departments/disciplines for analysis and comparison; and determine the appropriate metrics for critical issues; c.) Monitor the effects of climate change on Miami-Dade County using the evolving data base, and publish the results for use by elected leaders, public agencies, and the general public.			
• The Office of Resilience was created in 2008 to facilitate the sustainable transformation of the County with respect to organizational culture, operations, infrastructure, and service delivery. It assists departments and leads initiatives that enable the County to target and realize improved performance that simultaneously values economic, social and environmental impacts and opportunities. • The Office, now known as the Office of Resilience, provides knowledge on energy, renewable energy, infrastructure, water resources, resource conservation and transportation, and includes outreach and educational programs. • The Office of Resilience in cooperation with the Division of Environmental Resources Management and many other agencies has completed a greenhouse gas inventory in 2008, 2010, 2013, and is completing the inventory for 2015. The inventory for 2008 is being used as the baseline for future greenhouse gas reduction targets. The Office of Resilience also contributed to the development of the Southeast Florida Regional Greenhouse Gas Inventory and is in the process of updating that inventory again with the help of ICLEI and the Institute for Sustainable Communities. • In addition to the greenhouse gas emissions reduction targets there are a myriad of other environmental performance metrics that are included in Green Print, the county's sustainability plan. Miami-Dade County was chose in February 2009 by ICLEI (International Council on Local Environmental Initiatives) and New York City, as one of three local governments nationwide to receive technical assistance in developing a sustainability plan. The progress towards the greenhouse gas emissions reduction goals and the GreenPrint goals are monitored and tracked on two online platforms that are easily shared with other departments. • In partnership the Southeast Florida Regional Climate Change Compact, the South Florida Water Management District, the Water and Sewer Department, Public Works and Waste Management, and the Office of Emergency Management, the Office of Resilience is contributing to the on-going monitoring, refinement, and publication of climate change indicators. These indicators include sea level rise, salt water intrusion, precipitation and a myriad of others. • A recent budget change memo passed in October 2015 directed the Office of Resilience staff to be shifted to the Office of Resilience and the staff have been expanded to include a new Chief Resilience Officer. Discussions are underway to determine additional staff resources needed to accomplish the Mayor's priorities outlined in the October budget memo.			
C4. The CCATF recommends that Miami-Dade County use the on-going cycle of the Evaluation and Appraisal Report to include amendments to the Comprehensive Development Master Plan that will further the principles of Smart Growth.	Yes	No	Yes
• The Comprehensive Development Master Plan includes multiple policies which further the principles of smart growth, such as promoting transit-oriented development, promoting the use and accessibility of public transportation, and expanding and enhancing complete streets in key neighborhoods. • Furthermore, the urban development boundary and other policies are helping to promote infill development and maximize the existing resources and infrastructure within the growth boundary. • The principles of smart growth are also encapsulated in a number of other county plans including the Open Space Master Plan, GreenPrint and the Long Range Transportation Plan. • The Comprehensive Development Master Plan policies that promote smart growth are reviewed and updated during the Evaluation and Appraisal Report of the plan.			
C5. The County should begin a process of planning and public education, coordinated with the South Florida Regional Council and the Metropolitan Planning Organization that integrates the mapping of projected sea level rise and storm surge impacts with the locations of infrastructure and other public investment, and with the locations of projected growth and development. The goal is to ensure the safety and resilience of public investment, and to consolidate private investment on transit-served high ground.	Yes	Yes	Partially
• Several sea level rise viewer tools are already publicly available including The National Oceanographic and Atmospheric Administration's sea level rise viewer and flooding exposure mapping tool, The Nature Conservancy's Coastal Resilience Tool, and Climate Central's Surging Seas tool. All of these interactive web-based viewers allow users to overlay changing sea levels with			

a number of other variables such as population density, social vulnerability, location of critical facilities such as schools and hospitals, properties with repetitive flood losses, Federal Emergency Management Agency's designated flood zones and many others. While these tools offer only a first approximation and should not be used for official planning and zoning they do help illuminate areas that will be most immediately impacted and those that will be more naturally resilient to flooding due to their higher elevations. • Work is on-going to integrate the recent results of the U.S. Geological Survey's newly-developed surface/groundwater model into existing stormwater modeling efforts and to develop vulnerability assessments based on that information. Because the cascading impacts of flooding are not limited to the areas that will be inundated and because there is already an existing highly interdependent drainage network across the county and the region it will require an iterative and careful process to develop maps that can serve as official guidance for areas that are most desirable for increasing investment. • The Federal Highway Administration provided grant funding for a regional (including Miami-Dade County) climate change study, "South Florida Climate Change Vulnerability Assessment and Adaptation Pilot Project (February 2015) to map and rank vulnerability of local transportation infrastructure. As an outcome of this first study, there is currently a new project building on the results of the first one that will be modeling for potential sea level rise and storm surge impacts on mobility in the region. One of the goals of the new project is to help foster greater understanding of the role of critical evacuation and other broader network routes to assist with future emergency management and other types of planning. • To date there has been no formal collaboration between the South Florida Regional Council, the MPO and the County on these issues; however, the County does actively collaborates informally with both the Regional Council and the MPO on climate change efforts and will continue to do so.			
C6. The CCATF recommends that Miami-Dade County (by its departments of Planning and Zoning, DERM, MPO, and Public Works) develop a memorandum of understanding for integrated planning efforts with the Florida Department of Transportation and the South Florida Regional Council.	Partially	No	Partially
• The Miami-Dade Metropolitan Planning Organization did the 2040 long range transportation plan in which Department of Transportation District 6 and the South Florida Regional Council were both significant collaborators. • The expansion of Tri-Rail was another collaborative effort and integrated planning effort. • The South Florida Regional Council, Department of Transportation, City of Miami, Miami-Dade County, and the Downtown Development Authority of the City of Miami are currently involved in integrated planning in support of the Downtown Miami Development of Regional Impact Increment III project. • The Responsible Land Use and Smart Transportation goal area of GreenPrint contains initiative 55 to coordinate among County departments and other agencies to implement the CDMP and County code.			
C7. The CCATF recommends that Miami-Dade County develop mandates and incentives for building designs that meet green building standards such as those established by Energy Star, the Florida Green Building Coalition, the U.S. Green Building Coalition (USGBC) Leadership in Energy and Environmental Design (LEED) or the National Association of Home Builders (NAHB) Green Building Standards. These standards must comply with the Florida Building Code and not conflict with the Comprehensive Development Master Plan. If the County does develop such mandates and incentives, the CCATF further recommends that:			
C7 1. Buildings eligible to receive an EPA rating using Energy Star's Portfolio Manager, should achieve an energy performance rating of at least 70.	No	No	No
• Through EnergyCap the County is implementing this recommendation for county facilities, but there are not currently plans to require a certain performance rating for county facilities. The ratings are being used to help prioritize retrofits and help prioritize retirement of inefficient facilities. • For community buildings the County has implemented an expedited review and permitting process for green buildings with a third party certification such as LEED. • Furthermore the next GreenPrint cycle may include an initiative to mandate benchmarking and disclosure of community buildings above certain size.			
C7 2. Buildings not eligible to receive an EPA rating using Portfolio Manager, demonstrate energy efficiently in at least the 20th percentile for typical buildings of similar type using benchmarking against national median energy source data provided in the Portfolio Manager tool.	No	No	No

- Portfolio Manager Energy Star continues to add new facilities types regularly. In addition there are many beyond the code standards that can be applied to many building types not included in Energy Star such as parking garages standards.
- Miami-Dade County doesn't have staff with expertise to develop such a program.
- The Energy Star program and other benchmarking programs are constantly expanding and improving and therefore it is likely that holes in these programs will be filled in the next decade.

C8. The CCATF recommends that Miami-Dade County advocate for amendments to the Florida Building Code that will reduce the impact of greenhouse gas emission and improve climate change resiliency.	Yes	Yes	Partially

- The Compact advocated to amend the Florida Energy Act to allow commercial buildings to qualify for energy efficiency program funding through the Local Option Sales Tax.
- MDC has included in their state policy package an urging for preservation and enforcement of the Florida Energy Code. Increase compliance by assigning responsible parties to enforce each element of the code.
- The 2014 Compact State Policy Package includes: a. SUPPORT - greater incorporation of adaptation strategies in state climate/energy policies, legislation, and appropriations priorities. b. SUPPORT - integrated resource planning/least cost planning for electric utilities to ensure that energy efficiency and renewable energy sources are fully considered as strategies for meeting future needs. (c) SUPPORT - energy efficiency and renewable energy finance options to advance greenhouse gas emissions goals, alternative and renewable energy technologies, and green sector economic development. (d) SUPPORT - stringent energy efficiency and conservation targets set by the Florida Public Service Commission pursuant to the Florida Energy Efficiency & Conservation Act, as amended. (e) SUPPORT – rebate programs, tax credits, and other financial incentives that encourage property owners to invest in energy efficiency and renewable energy systems. (f) SUPPORT – renewable portfolio standards (RPS) for utilities that would require a set percentage of electricity to be generated from renewable energy sources by a given date.
- In 2010 and again in 2013, the Office of Resiliency facilitated sponsorship travel so that Miami-Dade County code officials could to attend International Code Council (ICC) meetings where voting delegates from local governments can influence national building and other code policy, which in turn influences state and local codes. At these meetings there are often several proposals to make electricity codes less stringent in terms of efficiency; and the votes of the Miami-Dade County officials were critical to ensuring that these initiatives were not passed and the strong code was maintained.

Natural Systems Adaptation

Recommendations	GreenPrint	Regional Climate Action Plan	Implemented
D.1 Fully support the Comprehensive Everglades Restoration Plan (CERP), and increase funding and resources for other regional and local habitat restoration and preservation efforts and initiatives.	Yes	Yes	Partially
• Miami-Dade County continues to participate in interagency technical planning teams and provide technical support. • Miami-Dade County continues to be a vocal supporter of dedicating additional resources to restoration and management of the Everglade system, including Resolution number R-520-15 passed in June of 2015 urging the Florida State Legislature to pass additional legislation in support of Everglades restoration. • The restoration of the Everglades continues to be a priority outlined in GreenPrint, a priority of the South Florida Water Management District, the Division of Environmental Resources Management and several other entities; however, due to funding constraints and changing priorities, some CERP restoration projects intended to occur in this county have been put on hold, pushed into the future, or broken into phases with no certainty for completion of phase two. • The progress of the restoration of this large and complex network is tied directly to the availability of funding which may be helped by the recent passage of Amendment 1, which was designed to bring additional funding to conservation and restoration of natural areas statewide. • In October 2015 the BCC passed Resolution Number R-913-15 urging the expediting of the Biscayne Bay Coastal Wetlands and C111 Spreader Canal project (part of the Comprehensive Everglades Restoration Plan (CERP)).			
D2. Increase funding and resources for land acquisition and management programs of Miami-Dade County. Investigate new and creative mechanisms to boost funding, such as the creation of a County-administered "carbon credit purchasing" program, as a potential alternative to current development, industry, and government mitigation requirements.	Yes	Yes	Partially
• The Division of Environmental Resources Management is actively studying mechanisms to increase funding and resources for land acquisition for the Environmentally Endangered Lands (EEL) program. Funding for acquiring properties on the acquisition lists includes the EEL Acquisition Trust Fund and the Building Better Communities General Obligation Bond funds. These funding sources have been specifically designated for EEL land purchases by referendum and Board approval. The program's land management activities are currently funded through the EEL Program's Management Fund. The program has been increasingly successful in the last few years at securing other funds and engaging community partners and volunteers to help meet unmet management needs in EEL Preserves. However, these do not provide long-term assurance that program activity levels can be sustained. Therefore, it is important that long-term and sustainable funding options be identified. One potential option includes allocation of funds made available under Florida Constitutional Amendment 1. • Carbon credit purchasing was explored as a potential funding mechanism. It was determined that available carbon credit purchasing programs were not a good match for the EEL program. EEL staff are actively engaged in exploring new alternatives as they arise. • In January 2015 the Board of County Commissioners passed R-63-15 urging the United States Congress and the Florida Legislature to fund restoration of the Everglades.			
D3. Acquire all undeveloped lands needed for restoration purposes and for mitigation and adaptation to climate change effects. Secure strategic open lands to provide transition zones to accommodate retreat or spatial shifts in natural areas, such as coastal wetlands and freshwater marshes.	Partially	Yes	Partially
• Please refer to comments under recommendation D2 regarding the County's Environmentally Endangered Lands (EEL) program • The Southeast Florida Regional Climate Change Compact (Compact) has established the Shoreline Resilience Working Group in partnership with The Nature Conservancy and other stakeholders to specifically focus on this issue. The Shoreline Resilience Working Group is working closely with scientist and other experts to develop a comprehensive catalog of potential projects which will facilitate ecological transitions and enhance coastal resilience in key ecosystems such as mangroves, dunes, and beaches. • On-going efforts to protect, enhance and restore other lands are actively incorporating climate change considerations into programmatic planning.			

• This has been an area of focus for the Compact, the Division of Environmental Resources Management, the Office of Resilience and the Parks, Recreation and Open Spaces Department and will continue to be a priority moving forward. This will be one of the key initiatives of the next iteration of GreenPrint.			
D4. Create a plan to locate infrastructure and development outside coastal or flood hazard prone areas using projections of sea level rise to identify those areas. Describe a transitional zone between the hazard area and the built area to be protected and prohibit incompatible land uses that would convert open lands in the transitional zone. Establish a comprehensive planning and zoning policy, such as development setbacks and limits on density and infrastructure in coastal and transitional zones to consider vulnerability to sea level rise and saltwater intrusion.	Yes	Yes	Partially
• While preliminary maps already exist, efforts are currently underway to improve the County's ability to accurately map areas that are projected to be impacted by sea level rise. These new maps will be based upon new surface/groundwater modeling efforts developed by the Water and Sewer Department and the U.S. Geological Survey. • The Federal Emergency Management Agency's National Flood Insurance Program is currently engaged in a multi-year project to update local flood hazard maps and more accurately demarcate inundation boundaries using the most recent data and analytical methods. • Establishing appropriate land uses and planning and zoning policies for vulnerable and transition areas remains a top priority for the Office of Resilience and the Planning Department. This will continue to be an area of strategic focus moving forward.			
D5. Encourage the continued funding of the County Agriculture Purchase of Development Rights Program beyond the current funding levels to maintain open lands for aquifer recharge, habitat, and buffers.	No	Yes	Partially
• The County funded the Purchase of Development Rights program with $30 million by the General Obligation Bond. • In 2008, the County's Agricultural Manager acquired federal grants that matched local dollars fifty percent. • The County continues to purchase conservation easements on properties to ensure agricultural uses that achieve the benefits targeted by this CCATF recommendation. Approximately $27 million remains in GOB funding and there are approximately $6.5 million additional matching funds acquired from U.S. Department of Agriculture Farm and Ranch Protection Program. • Development rights have been acquired on 165 acres (2 farms) and a contract is pending on 145 acres and 395 acres expected to close in 2016. • The Program is actively pursuing eligible and appropriate properties from the 3,000 acres received in applications.			
D6. Provide incentives to study and develop best practices for agricultural management that contribute to carbon sequestration and reduce greenhouse gas emissions.	Yes	Yes	Partially
• The USDA has created a climate smart agriculture program (http://www.usda.gov/wps/portal/usda/usdahome?contentidonly=true&contentid=climate-smart.html) that is promoting best practices for agricultural management in the face of climate variability and also promote approaches to reduce greenhouse gas emissions. • The County also secured a grant from the Environmental Protection Agency (EPA), funded with American Recovery and Reinvestment Act dollars, which the County used to provide money to farmers to replace old irrigation pump engines with more energy efficient engines.			
D7. Increase funding for County-administered management activities like those programs within Natural Areas Management and Environmentally Endangered Lands. Establish a multi-agency task force to expand County capacity and coordinate conservation activities. Develop a collaborative and integrated approach to conservation involving universities, government agencies, landowners, botanic gardens, zoos, and non-governmental organizations.	Yes	No	Partially
• The EEL Program has succeeded in leveraging this original investment made by County taxpayers and has accrued $198 million in revenue since its inception. Through the EEL program, the County has been able to protect more than 23,000 acres of natural areas that are critical to our region's ecological health and our ability to adapt to climate change. • The EEL Program has been strategically complementing other regional restoration efforts to maximize their value as conservation lands and reduce fragmentation. By acquiring larger, contiguous areas and completing the acquisition of partially acquired preserves the program can provide ecological and managerial benefits.			

• Miami-Dade County benefits from several long-range plans that inform how we preserve open space including the Parks and Open Space Master Plan and the Comprehensive Everglades Restoration Plan. The EEL Program is a key component of this comprehensive effort to ensure the health and protective value of our natural resources. • With the recent passage of HB 968, the Legacy Florida bill, it is likely that the County will be able to better coordinate land acquisition with the South Florida Water Management District and support restoration efforts, particularly in South Dade.			
D8. Review current stormwater management operations, including the operation of canals and structures, in order to eliminate unnecessary over-drainage and limit the extent of saltwater intrusion into ground and surface water resources. Additionally, require water conservation measures for all users of the Biscayne Aquifer.	Yes	Yes	Partially
• Water conservation measures implemented by the Water and Sewer Department have seen significant results in reducing demand. • Current stormwater management operations are the focus of a number of in-depth studies through the Water and Sewer Department, Division of Environmental Resources Management, U.S. Geological Survey and the South Florida Water Management District. • The potential impact of rising sea levels on the extent of salt water intrusion into drinking water wells is the focus of extensive study and investment in monitoring equipment and infrastructure to minimize the potential impacts.			
D9. Develop a "Vital Signs" monitoring program, following the model of the National Park Service, to serve as a multi-parameter ecosystem monitoring program that will help track climate change effects. Expand current ongoing monitoring efforts, such as those within the Comprehensive Everglades Restoration Plan (CERP), to include specific areas of Miami-Dade County, to provide a better view of how natural areas are changing over time and what forces are responsible. Dedicate a source of funds to collect information and establish and maintain a long-term data management system.	Yes	Yes	Partially
• Through the Southeast Florida Regional Climate Change Compact climate indicators have been developed which provide a monitoring program that will help track climate change effects. These indicators have been developed with the help of local scientists and academics. • Several of these indicators are related to the response of natural ecosystems to changing environmental conditions.			
D10. Miami-Dade County should establish partnerships, both formal and informal, with other governmental entities, including local, State, and Federal governments; the private sector; non-governmental organizations; and other stakeholders in the County. Partnerships should focus on cooperative efforts to restore existing natural ecosystems; protect natural and open lands; mitigate impacts; and monitor natural systems and indicators of climate change. Partnerships should also be undertaken to effectively practice adaptive management as we increase our understanding over time of the effects of climate change on natural systems in the County and implement management actions to restore and protect natural systems in the County.	Yes	No	Partially
• The County has established fruitful partnerships to strengthen the adaptive capacity of our natural ecosystems such as the Shoreline Resilience Workgroup through the Southeast Florida Regional Climate Change Compact. The Shoreline Resilience work is led by scientists with The Nature Conservancy and members are drawn from academia, the non-profit community and all levels of government. The Shoreline Resilience work has focused on identifying and cataloging the critical areas where the protective value of our existing natural infrastructure can be bolstered and the ecological value of restoration efforts can be enhanced. • There are also a number of private collaborations built around the protection of natural resource systems, which complement the on-going efforts of existing County-led programs such as the Environmentally Endangered Lands (EEL) program and our Open Space Master Plan.			

Economic, Social, & Health Adaptation

Recommendations	GreenPrint	Regional Climate Action Plan	Implemented
E1. The Task Force recommends that the Miami-Dade County Comprehensive Development Master Plan (CDMP) be revised to include a new policy to restrict land uses in areas that would be at risk from sea level rise and associated impacts within the next 50 years as per the CCATF Science Committee's Statement on Sea Level in the Coming Century report and projections. A continuous 50-year planning horizon should be used.	Yes	Yes	Partially
• The Comprehensive Development Master Plan currently contains objectives and policies aimed at directing growth away from vulnerable areas. For example, Objective CM-9 of the CDMP states that "Miami-Dade County shall continue to orient its planning, regulatory, and service programs to direct future population concentrations away from the Coastal High Hazard Area (CHHA) and the FEMA V Zone." • In addition, Climate Change/Sea Level Rise was addressed as a "Major Issue" in the 2010 Evaluation and Appraisal Report (EAR) of the CDMP. This process allowed for a comprehensive analysis of climate change impacts over all County policies and processes. To respond to the breadth of impacts identified, the Board of County Commissioners approved amendments to multiple Elements of the CDMP in 2013 to integrate climate change considerations. Incorporating climate change language throughout the CDMP allowed for more targeted implementation across the various County policies and processes. • The following CDMP policies, added as part of the 2013 EAR-based amendments, are aimed at adapting the built environment to the anticipated impacts of sea level rise: • Policy LU-3E: By 2017, Miami-Dade County shall initiate an analysis on climate change and its impacts on the built environment addressing development standards and regulations related to investments in infrastructure, development/redevelopment and public facilities in hazard prone areas. The analysis shall consider and build on pertinent information, analysis and recommendations of the Regional Climate Change Action Plan for the Southeast Florida Regional Climate Change Compact (Compact) Counties, and will include the following elements: a) An evaluation of property rights issues and municipal jurisdiction associated with the avoidance of areas at risk for climate hazards including sea level rise; b) An evaluation of the current land supply-demand methodology to consider and address, as appropriate, the risk associated with infrastructure investments in flood prone areas; and c) An evaluation of the CDMP long-term time horizon in relation to addressing projected long-range climate change impacts. Recommendations from the analysis shall address appropriate changes to land use designations and zoning of impacted properties, and development standards, among other relevant considerations. • Policy LU-3F: By 2017, Miami-Dade County shall develop a Development Impact Tool or criteria to assess how proposed development and redevelopment project features including location, site design, land use types, density and intensity of uses, landscaping, and building design, will help mitigate climate impacts or may exacerbate climate related hazards. The tool would also assess each development's projected level of risk of exposure to climate change impacts, such as inland flooding. • Policy LU-3K: By 2017, Miami-Dade County shall determine the feasibility of designating areas in the unincorporated area of the County as Adaptation Action Areas as provided by Section 163.3177(6)(g)(10), Florida Statute, in order to determine those areas vulnerable to coastal storm surge and sea level rise impacts for the purpose of developing policies for adaptation and enhance the funding potential of infrastructure adaptation projects. • The Unified Sea Level Rise Projection for Southeast Florida was updated in 2015 by the Compact's Sea Level Rise Work Group, comprised of regional technical experts. It provides excellent, locally-tailored guidance about sea level rise that can be expected over the next 100 years.			
E2. Initiate an additional long-term CCATF advisory board committee composed of representatives from federal, state, and local environmental agencies (including Miami-Dade County DERM, WASD, Cooperative Extension), the Miami-Dade County Department of Health, local colleges and universities, and community leaders to address potential human infectious disease changes and increases that may accompany climate change and to make technical and funding recommendations to the Miami-Dade County Board of County Commissioners.	No	No	Partially

- The County has worked with staff in the Epidemiology, Disease Control, and Immunization Services Program of the Miami-Dade Health Department (MDCHD), to begin analyzing potential climate change-related public health impacts such as infectious disease changes and heat-related illnesses.
- The Florida Public Health Institute conducted a Health Impact Assessment (HIA) to comprehensively assess, through a health lens, the 110 recommendations put forth by the Southeast Florida Regional Climate Change Compact's Regional Climate Action Plan (RCAP). The Health Impact Assessment explores the effects that climate change, sea level rise and heat waves may have on the health of this region and the distribution of those effects throughout the population to inform a holistic approach while minimizing negative health outcomes. The HIA described the health impacts to the 5.6 million residents from Broward, Miami-Dade, Palm Beach and Monroe Counties. This assessment will help decision-makers better understand the local health impacts climate change may have on the residents of four Southeast Florida counties so that decisions can be better informed.
- The Health Impact Assessment, published in March 2014, is titled "Minimizing the Health Effects of Climate Change in the South Florida Region" and is available online at http://www.southeastfloridaclimatecompact.org/wp-content/uploads/2014/09/REVISED-HIA-Final-Report-101514-1.pdf.
- The public health implications of climate change will continue to be a key initiative of the next iteration of GreenPrint. For example, the potential implications of sea level rise on septic tanks will be a key area of focus.

E3. The County shall form an interdisciplinary, community-wide working group, including the media and institutions of higher education, which (a) focuses on public education and information regarding climate change and adaptation and (b) assesses public opinion regarding these subjects.	No	Yes	Partially

- The Office of Resilience is working through the Southeast Florida Regional Climate Change Compact (Compact) and institutions of higher education affiliated with the Florida Climate Institute to continually expand and enhance public education around climate change, its local impacts, and opportunities to lessen local vulnerabilities.
- The Office of Resilience, in partnership with the Compact partners, has worked with Yale University to assess public opinion regarding climate change.
- The Cultural Cognition Project at Yale Law School, led by Dr. Kahan has published two reports on public opinion and the communication of climate change in SE Florida.
- Their first report, released in 2013, measured climate-change risk perceptions and attitudes toward government action to protect Florida from sea level rise and extreme weather impacts. The study also explored how different forms of information were likely to affect support for the Compact. This study found residents of the Compact counties were strongly supportive of governmental efforts to protect SE Florida from sea level risk and adverse weather. This report provided valuable insights as to how to engage (rather than polarize) a diversity of community groups who were still unfamiliar with the Compact.
- The second report, published in November 2014, focused on characterizing the two distinct science communication environments. The Yale researchers found there was one environment that was widely supportive of collective use of best available science to protect the region from adverse impacts and was less influenced by the political identification of the respondent. This report provided recommendations in terms of how the Compact and its members communicate to the public and how to best use ambassadors to communicate the relevant information in a way that does not polarize listeners based on their personal cultural affiliations. One important conclusion of this research was that there was widespread divergence between local residents' professed belief in global climate change and their attitudes toward local climate impacts. Despite diversity in respondents' attitudes toward climate change, there was overwhelming consensus that local government officials should address the area's vulnerabilities to climate impacts through appropriate land use regulations and infrastructure improvements.

E4. The Task Force recommends that the County bring together all agencies and entities involved in economic development and planning in order to develop a unified and comprehensive response to the challenges of climate change, housing, economic development, and quality of life.	No	No	Partially

- Just as climate and the weather affect nearly all of our infrastructure and many aspects of our daily life, climate change will similarly touch upon our quality of life, economic development, housing and other systems in both predictable and unforeseen ways. It will likely be difficult to develop a fully unified and comprehensive response to all of these changes; however, several parallel initiatives have already begun to address these challenges.
- Through the Southeast Florida Regional Climate Change Compact the County and municipal agencies have been involved in developing and implementing the Regional Climate Action Plan.

• Several agencies within the County government have been involved and continue to be involved with implementing the County's sustainability plan, GreenPrint, which includes the County's Climate Action Plan.			
E5. The CCATF recommends the following in reference to green jobs and the economy:			
E5 1. The County should sign the Local Government Green Jobs Pledge (attached).	No	No	Yes
• BCC approved in 2009 the Mayor to sign the pledge via Resolution R-747-09 and the pledge was signed by Mayor Alvarez on September 2009. http://www.miamidade.gov/govaction/matter.asp?matter=091372&file=true&yearFolder=Y2009 • Creating green jobs is an initiative within the Vibrant Economy section of GreenPrint and the Office of Resilience is continuing to work closely with the Beacon Council to determine the most effective methods to promote sustainable business practices and job growth here locally. • The County is actively participating in the "One Community One Goal Program" target industry strategic plan (2012-2017). Part of this plan addresses creating of jobs, training and diversification of the local economy.			
E5 2. The County should establish a full Green-collar Jobs Task Force. This committee should promote green jobs and building a local green economy as follows: establish a local action plan for Miami-Dade County, identify goals and opportunities, and identify key partners, both governmental and NGO's, for sharing best practices and resources.	Partially	No	Partially
• Creating green jobs included in Initiative 100 within GreenPrint's Vibrant Economy goal area. • The Office of Resilience has proposed to the Economic Development Council to develop a white paper defining green jobs, how they will be tracked, exploring opportunities and progress made to date. • The Mayor has been an active proponent on the One Community One Goal program which promotes the development of jobs, including green jobs in our community. • Miami-Dade County is working closely with the Beacon Council which also promotes the development of green jobs, among many programs. • In addition, the County established the Chairman's Council for Prosperity Initiatives (CCPI) in 2015 to work on increasing employment opportunities, reducing barriers to homeownership, and reducing transportation costs.			
E6. The CCATF recommends that Miami-Dade County initiate efforts for a county-wide assessment of local public knowledge and opinion on climate change. The effort should: review and assess existing data on local public knowledge and opinion related to climate change (both mitigation and adaptation), and supplement available data through additional polling, attitude research, and other appropriate information gathering methods.	No	No	Yes
• Through the Southeast Florida Regional Climate Change Compact the County has been working with Yale University's Cultural Cognition Project to track and assess local public knowledge and opinions related to climate change. • As described previously in E.3 above, the two studies conducted by Yale specifically addressed residents' divergent opinions in relation to climate change mitigation (divided along cultural identity lines) and adaptation (widely supported regardless of personal political or cultural associations). • These efforts should be periodically updated and refined and the staff within the Office of Resilience has continued a dialogue with Yale University to identify priorities for future studies.			
E7. The CCATF recommends that Miami-Dade County take the following steps to facilitate a county-wide education outreach program on climate change to educate the general public: Step I - review and assess existing entities (such as internal County departments, Miami-Dade County Environmental Education Providers consortium, local colleges and universities, etc.) that could provide education on climate change; Step II - coordinate relevant entities identified through Step # I in order to share information gathered as a result of County-wide Assessment of Local Public Knowledge and Opinion on Climate Change (as outlined in #1); Step III - direct funding and resources to relevant entities identified through Step # I	No	No	Partially

- Several educational efforts on climate change have been implemented since the CCATF recommendations were drafted. Many organizations such as CLEO, Catalyst, 350.org, and the Southeast Florida Regional Climate Change Compact focus almost entirely on climate change education in the community and have been very effective at improving public awareness. The County works closely with these organizations and is dedicated to enhancing public outreach efforts around climate change as an initiative in the next version of GreenPrint.
- The Office of Resilience is very actively presenting to a variety of audiences about the impacts of climate change across the community.

Intergovernmental Affairs

Recommendations	GreenPrint	Regional Climate Action Plan	Implemented
F1. Conduct a survey of Miami-Dade County municipalities to gauge their level of knowledge and engagement in climate change issues, learn about their activities, and begin the creation of an intergovernmental, learning network that allows members to work with each other and the County on adaptation / mitigation issues. Once the survey has been completed, engage the cities in a dialogue about the survey findings and work of the Climate Change Advisory Task Force. This dialogue could happen in a number of ways including a meeting with the Miami-Dade League of Cities and/or a convening of Miami-Dade municipal and county leaders in a shared discussion of the issues and information exchange	No	Yes	Partially
• The County is working very closely with several municipalities on climate change, principally through the Municipal Workgroup of the Southeast Florida Regional Climate Change Compact. • An initial survey of municipalities was completed by the South Florida Regional Council and the League of Cities and the final report was published in December 2009. • The Miami-Dade League of Cities and the City/County Managers Association are also engaged in climate change efforts and are coordinating with the city. • A Municipal Green Initiatives Survey was also developed and administered by the Office of Resilience in partnership with the Miami-Dade League of Cities and was completed in 2015. This serves as a tool for benchmarking and promoting climate change and sustainability efforts and for facilitating future collaboration.			
F2. Convene local and state agencies and water and sewer utilities around a discussion of climate change and impacts on water quantity, quality, and availability and implications for infrastructure planning and investment.	Yes	Yes	Yes
• The impact of climate change on water quantity, quality, and availability is a primary focus area of the Southeast Florida Regional Climate Change Compact (Compact) and the Regional Climate Action Plan. • The science surrounding future changes in precipitation, evapotranspiration rates, salt water intrusion, and management of our regional water system are an area of intense research and discussion and strong working relationships exist between the relevant agencies and private entities interested in these resources. • Several substantial research efforts and infrastructure planning and investment programs have been completed by the South Florida Water Management District (District), the Water and Sewer Department (WASD), the U.S. Geological Survey (USGS), and the Storm Utility Design Division within the Regulatory and Economic Resources Department. Together these projects represent a collective investment in order of tens of millions of dollars. • These efforts are on-going and investments are increasing. Monitoring, preparing for, and predicting the impact changing climatic conditions will have on our water resources will continue to be a central focus of the District, RER, and the District's planning. • The County is collaborating with the Compact on a regional project led by the RAND Corporation, known as "Water Management and Adaptation Planning to Address Sea Level Rise and Climate Change in Southeast Florida". This project also includes the USGS, the District, WASD, the South Florida Regional Council, The Nature Conservancy (TNC), and other academic partners which cooperatively developed the scope of work, schedule, and action plan for the study. The project reviewed the region's most pressing water management issues, completed a gap analysis identifying which key decisions currently lack sufficient analytical support, and worked through a prioritization exercise to address those gaps. RAND has previous experience helping policy makers work though complex problems and decision-making processes and has provided research and facilitation support to stakeholders in the Mississippi Delta region. RAND will be able to provide support by helping to analyze and connect several existing models. The exact scope of the project is still being determined as of March 2016. It is anticipated that within the next 12-16 months this project will provide a decision support tool to help the region evaluate the economic implications of various water management regimes and infrastructure investments, as well as different land use patterns. A focus of this research will be integrating economic models to identify ways that the economic exposure of regional assets to storms and flooding risks can be minimized. • These efforts are complimented by a host of other studies conducted by academics through the Florida Climate Institute and other federal, state, and local government entities.			

F3. Convene a broader group of local and state agencies around a discussion of their activities related to climate change. Agencies / groups would include, but not be limited to, DOT 4 & 6, DEP, SFWMD, DCA, Health Planning Agencies, Ecosystem Restoration Task Force, etc. In this conversation we will gain a better understanding if there are issues or concerns that we need to be aware of and identify opportunities for collaboration moving forward.	No	Yes	Partially
• The Southeast Florida Regional Climate Change Compact (Compact) has become a very effective forum for discussing climate change activities with municipalities and other stakeholders in the region. • Through the Compact the County is able to work closely with agencies such as the South Florida Water Management District, The Nature Conservancy, The South Florida Regional Council, and public health organizations. • The Institute for Sustainable Communities is currently providing the facilitation and financial support for the Compact which allows the Compact to convene stakeholder groups and facilitate discussions around different climate topics as needed. • For example, the Compact's Shoreline Resilience Work Group is convening representatives from several counties, municipalities, local non-profits, academic institutions, and other regional stakeholders and effectively directing this collaboration to identify potential climate adaptation/ecosystem restoration projects and prioritizing their implementation across the region. This regional collaboration enhances leveraging of limited resources, facilitating advancement of projects.			
F4. Develop a County internet website with up-to-date information about the work of the Miami-Dade Board of County Commissioners, the CCATF, and municipalities with links to information and best practices related to climate change, adaptation and mitigation efforts by individuals and organizations.	No	No	Partially
• The County created a new, user-friendly website (http://www.miamidade.gov/green) highlighting the County's work on sustainability and climate change issues from an enterprise-wide perspective. This page contains information on climate change, energy, recycling, water resources, green government, green buildings and development, transportation, and tips for living green. • The Southeast Florida Regional Climate Change Compact website (http://www.southeastfloridaclimatecompact.org) contains an extensive library of best practices, case studies of adaptation and mitigation efforts underway, links to other national and international efforts as well as a calendar and links to up-coming events related to climate change. This website provides a valuable resource for municipal officials and the region overall.			
F5. Work with the region's children's museums and foundations to create and fund educational exhibits on climate change, green technologies, clean cities, etc.	No	No	Partially
• The County's Office of Resilience is working with local universities, foundations, and community groups to develop and promote climate change related educational materials and events. • In 2014, the Coral Gables Museum and the Florida International School of Architecture prepared an exhibit called "Miami 2100 Envisioning a Resilient Second Century" about planning for climate change and sea level rise in Greater Miami.			
F6. Identify and develop educational materials that can be incorporated into a Miami-Dade Public Schools curriculum on climate change, the environment, and sustainability. The materials should be shared with other educational institutions to facilitate the dissemination of information to Miami-Dade residents.	No	No	Yes
• Miami-Dade County Public Schools (MDCPS) has created a sustainability office. • Sustainability and climate change has been incorporated into Dream in Green's (DIG) Green Schools Challenge program. As part of the Green Schools Challenge specifically, primary and secondary participating schools receive a DIG Guidebook tailored to their level that includes a number of activities for classroom implementation. This provides the opportunity for students to learn about energy and climate change, waste reduction and recycling, water conservation, green transportation, green buildings and green careers. Each activity is closely aligned with the MDCPS Math and Science Pacing Guide and provides students with opportunities to conduct research, analyze and solve problems, and think of solutions to environmental challenges.			

• The first large-scale 'green' program launched by MDCPS was the energy conservation rebate program which was announced in 2009. The primary goals of the initiative were: to reduce energy consumption by an average of 10 to 15 percent from year to year; to achieve significant cost efficiencies for the District annually and positively impact the carbon footprint; and to reward school sites that beat their energy target for their efficiency and stewardship by returning to them a significant percent of any 'over and above' savings. • The Miami-Dade School District has been able to achieve an energy consumption reduction (2009-2012) of approximately 50 million KWH and conservation related cost savings of over $10 million for that period. • The program has greatly elevated the importance and immediate benefits of environmental consciousness and stewardship at the individual school level. The program has been suspended the 2015-2016 academic year due to the extensive amount of renovation work going on at schools in Miami-Dade County as part of the bond program. The energy usage database and targets are being recalibrated to obtain new baselines.			
F7. The CCATF recommends that Miami-Dade County develop as quickly as possible an Action Plan identifying the "who, what, when, where, and how" that will further the objectives identified in the Board of County Commissioners' December 1, 2009 resolution in support of the Southeast Florida Regional Climate Change Compact (Compact) and related activities. Taking immediate action to further the activities highlighted in the Compact and BOCC Resolution will help elevate the importance of mitigating greenhouse gas emissions and adapting to the potential impacts of climate change in Miami-Dade County and the Region. The CCATF recommends that these actions be taken well in advance of the 2010 Climate Summit to allow for stakeholder participation and regional discussion.			
F7 1. 1. Common measures of success and benchmarks;	Yes	Yes	Partially
• The Compact has not formally adopted common measures of success; however, by a number of measures the Compact is exceeding the initial expectations. For example the Compact was recognized as a Climate Action Champion by the Federal Government. • In the spring of 2015 President Obama recognized the work of the Compact saying, "Five years ago, local leaders…Republicans and Democrats, formed the bipartisan Compact – an agreement to work together to fight climate change. And it's become a model not just for the country, but for the world." • The Compact has also won awards from ICLEI and the National Association of Counties.			
F7 2. Acknowledgement of the need to create uniform standards and regulations to minimize confusion and business costs associated with conducting business in different parts of the region and to encourage business activity and competition; and	No	Yes	Partially
• Through the Compact the county and municipal governments are able to coordinate and harmonize policy responses to climate change and therefore increase the uniformity of standards and regulations and create a more predictable regulatory environment. • One example of this type of coordination is the development of the Unified Sea Level Rise Projection for Southeast Florida, which increases the predictability of the regulatory environment and future standards. • Another example of this is the Go Solar Florida Initiative funded by a grant from the U.S. Department of Energy. Go Solar is a consortium that received grant funding from the U.S. Department of Energy and is comprised of Alachua, Broward, Miami-Dade, Monroe, Orange, and St. Lucie Counties as well as the City of Venice, Florida Atlantic University, and the Florida Solar Energy Center. The goals of this consortium are to standardize permitting procedures for solar photovoltaic rooftop systems in order to reduce typical permitting times and lower costs, standardization of design, enhancing the availability of financing options, and expanding uniform net metering and interconnection standards.			
F7 3. A comprehensive outreach strategy that will engage the wide range of stakeholders, acknowledge differing views, and work to reach consensus on a shared course of action moving into the future.	No	Yes	Partially
• As described above (recommendation E3) the Compact has been extensively involved in engaging a wide range of stakeholders and has worked to broadly educate regional leaders on climate change issues. • The development of the Regional Climate Action Plan was completed with the sustained input of many diverse groups. The Plan was written with the help of representatives from numerous federal, state, and county agency partners as well as representatives from academia, non-profits, and the private sector. This process drew on the deep diversity of expertise with representatives from design consultants, hydrologists, planners, environmental scientists, transportation planners, engineers, architects, and community based organizations. These stakeholders brainstormed issues including the scope of the Regional Climate Action Plan, criteria to select priority issues, defining regional versus local efforts, areas of expertise needed in			

issue-specific work groups, and how best to separate issue areas into groupings. This Plan has effectively created a shared course of action for the Compact county and municipal governments.			
F8. The CCATF recommends that the County collaborate with and encourage its regional partners in the development of uniform message on climate change as part of a regional outreach and education campaign. Such a campaign should include the use of high profile media and other appropriate outlets to raise general awareness of climate change in Southeast Florida. This regional message on climate change can be supplemented with county-specific information as needed to educate Miami-Dade County residents on the potential impacts of climate change and make the connection between mitigation, adaptation, and policy changes in the County's climate change and sustainability initiatives.	No	Yes	Partially
• The Compact and its County and municipal partners have worked extensively to develop a uniform message on climate change and engage decision makers, the business community and the general public around climate change. • Recognizing that significantly more can be done in this regard to raise the visibility of the issue and improve the communication surrounding the solutions, the Compact has applied for grant funding to support a new full-time position to work on education and outreach.			
F9. The Office of Resilience, in partnership with the Miami-Dade County League of Cities, should develop a local government outreach program to raise awareness about climate change science and potential climate change impacts on Miami-Dade County and possible mitigation and adaptation strategies. Local governments should be encouraged to identify a point of contact who will serve as an agency liaison to the County in issues of climate change and sustainability.	No	Yes	Partially
• The Office of Resilience coordinates with and participates in activities of the Municipal Workgroup which was created in 2015 by the Southeast Florida Regional Climate Change Compact. • While one aim of the Municipal Workgroup is to raise awareness about climate change science and its impacts, the primary purpose of the group is to facilitate the implementation of the Regional Climate Action Plan. • The Municipal Workgroup has created a peer-to-peer network where best practices, common challenges, and information can be shared between colleagues to accelerate the implementation of solutions. • The municipal workgroup meets regionally 3-4 times a year and hosts periodic workshops on climate change and other related topics pertinent to implementation of the Regional Climate Action Plan.			
F10. To enhance coordination between the County and its municipalities and make it easier to incorporate "green technologies" in both residential and commercial settings, the CCATF recommends the following:			
F10 1. To enhance understanding among code officials and design professionals of what green technologies and innovative approaches are currently allowed in the code, request that the Florida Building Code Commission consider a statewide augmentation of continuing education requirements for Engineers and Architects.	Partially	No	Partially
• Through the award of the Energy Efficiency and Conservation Block Grant (EECBG) the County was able to review building and zoning codes and permitting process in order to draft recommendations for changes that will foster green building design and remodeling, including renewable installations. This report is published on the County's website http://www.miamidade.gov/green/library/diagnosis-and-recommendations-2011-21-07.pdf. • The County also has monthly meetings with the building officials and Office of Resilience staff have presented at some of these meetings. Other speakers have also presented on innovative technologies, best practices, and other sustainability topics. • As part of GreenPrint, the County adopted a goal to work with local Board of Rules and Appeals and other stakeholders to maintain the Florida Energy Code and to better define and set forth responsibilities of each trade in order to improve compliance with and enforcement of the Code.			

• Every three years, the County's Office of Resilience and Code Administrative Division work together to obtain scholarship funding from ICLEI - Local Governments for Sustainability to allow building officials to attend U.S. International Code Council Final Action Hearings that decide the energy code for a majority of the United States. At the Final Action Hearings, County staff serve as voting delegates to influence national building and other code policy, which in turn influences state and local codes. The conference takes place only every three years.			
F10 2. Request that the Office of Code Compliance develop checklists that can be used as guidelines for Building Officials and Design Professionals to further the uniform application of codes.	No	No	Partially
• The Office of Building Code Compliance developed a "Renewable Energy Uniform Permit Submittal Guidelines" and checklist in May of 2009. The guidelines can be found at https://www.miamidade.gov/building/library/memos/interpretations/2009-05-28-renewable-energy.pdf. • With the GoSolar program the County is working on e-permitting system for solar PV installations. • A form was created by BORA committee for improving compliance with The Energy Code. • GreenPrint includes an initiative to develop a report which provides recommendations on ways to increase compliance with Energy Code. The report was completed and made available to all Building Officials, please see above B17.2. • The Board of Rules and Appeals (BORA) issued recommendations which are mandatory but allow building officials discretion when complying with the recommendations. The recommendations were distributed to Building Officials in 2014.			
F11 The CCATF recommends that the Board of County Commissioners encourage the convening of a regional discussion around the opportunities and challenges posed to the Region's businesses and economy by potential climate change related impacts. Key partners in a regional discussion include, but are not limited to, the region's economic development organizations, county economic development officials, Chambers of Commerce, key business organizations representing existing and emerging industries in Southeast Florida, Enterprise Florida, and the South Florida and Treasure Coast Regional Planning Councils.	No	No	Yes
• The Office of Resilience is working closely with the Beacon Council, the Building Owners and Managers Association, the South Florida Regional Council, and the Miami Chamber of Commerce to begin discussions with the region's business leaders about increasing the region's economic resilience and preparedness for climate change and sea level rise. • These conversations have begun through a series of targeted discussions with industry leaders, including hosting a series of roundtable discussions related to the insurance implications of climate change and sea level rise and the long-term risk management strategies that could be implemented in Miami-Dade County. • The Office of Resilience is also helping design educational tracks at large conferences and speaking regularly at meetings about climate change. • The County is fully engaged in the Beacon Council's "One Community One Goal" initiative which aligns well with many of the County's priorities and initiatives. • The County is formally participating in the Southeast Florida Regional Climate Change Compact.			