

Impacts of Sea Level Rise on Florida's Domestic Energy and Water Infrastructure

Dr. Leonard Berry's Testimony

To

The United States Senate Committee on Energy and Natural Resources

April 19th, 2012

Washington D.C.



My name is Dr. Leonard Berry. I am the Director of the Florida Center for Environmental Studies, Distinguished Professor of Geosciences at Florida Atlantic University (FAU) and the Co-Director of the Climate Change Initiative at FAU.

Introduction

Florida is a special case for sea level rise; it is very flat with millions of people living along the coast. A large portion of the population relies on subsurface water which is being compromised by salt water intrusion due to the porous limestone underlying much of Florida. Sea level rise is also complicated by the threat of hurricanes and storm surge. Water management in Florida is highly organized, but will need major adjustments to accommodate our changing circumstances. Most adaptation responses will require a substantial increase in energy usage, which will test our already limited resources.

People and Sea Level Rise

Florida has a population of nearly 19 million people and this is projected to double in the next 50 years. Approximately 14 million people live along the coast. Most of our coastal assets are in low elevation areas where water supplies, roads, storm sewers, power grids and other infrastructure are at risk from storm surges and flooding at high tide. In view of the current sea level rise projections, the areas most at risk include: the Florida Keys, coastal and inland Miami-Dade County (the City of Miami is the 7th largest city in the country), coastal and inland portions of Broward County, the Florida Everglades, and the cities, Fort Lauderdale, Cape Canaveral, Charlotte Harbor, Cedar Key, and Pine Island Sound. All of these have elevations below two feet (Annex C).

Florida has recorded 5-8 inches of sea level rise in the past 50 years, and this intensifies existing water management issues. Future projections suggest 3-7 inches of additional rise by 2030 and 9-24 inches by 2060 (Figure 1).

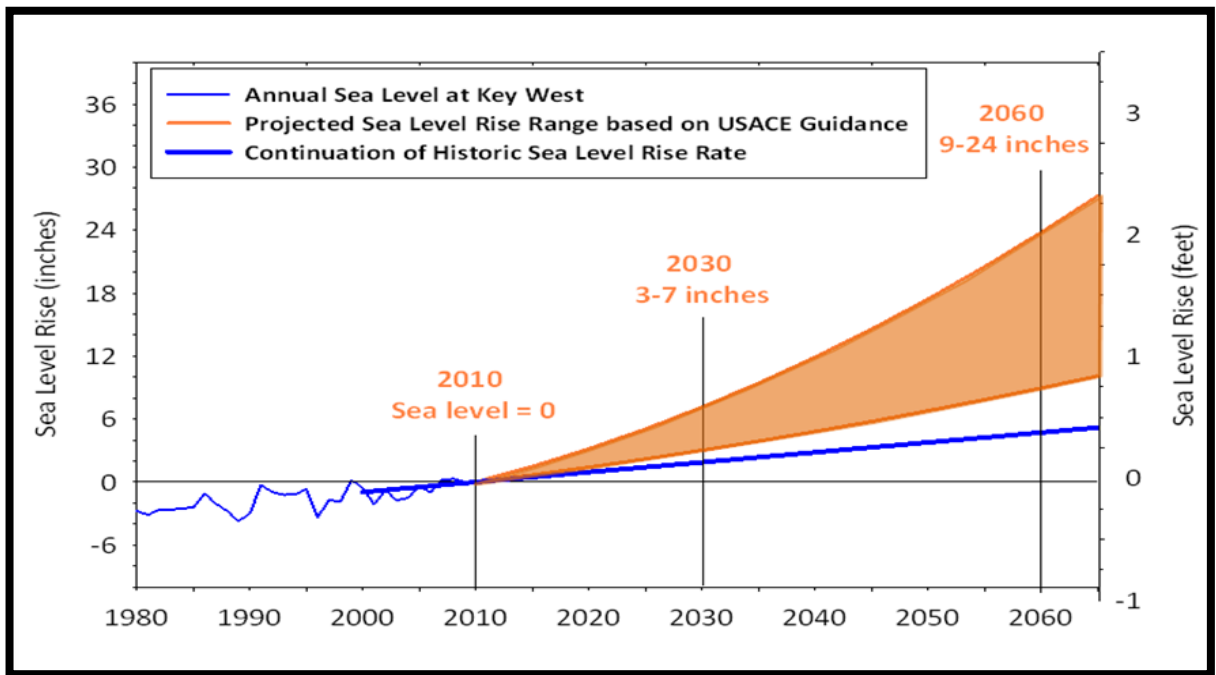


Figure 1: Southeast Florida sea level rise projections for regional planning purposes. This projection is calculated using the US Army Corps of Engineer’s guidance (USACE 2009) intermediate and high curves to represent the lower and upper range for projected sea level rise. The historic Key West tidal data shows current trends. The recent rate of sea level rise from tidal data is extrapolated to show how historic rates compare to projected rates.

Florida Geology and Sea Level Rise

The porous limestone underlying much of Florida resembles Swiss cheese and makes the state particularly vulnerable to sea level rise. Due to this geological structure, building barriers to prevent sea level rise is often impractical and financially prohibitive. The coast is also vulnerable to periodic tropical storms and hurricanes with related storm surge: Hurricane Andrew had storm surges above 17 feet. Every increment of sea level rise adds to the devastation of storm surge. The combination of sea level rise, intense rainfall, and storm surge creates the on-going potential for major flooding.

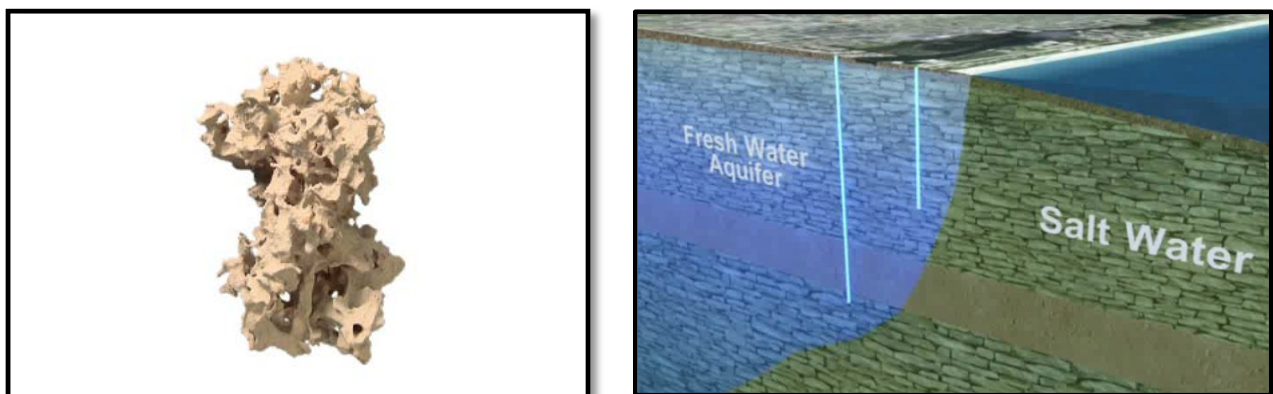


Figure 2: Swiss cheese-like limestone rock sample commonly found in South Florida (left) and the conceptual depiction of how sea level rise may accelerate saltwater intrusion affecting freshwater wellfields.

Impacts Already Identified

Sea level rise is already creating multiple complications in Florida.

1) Coastal Flooding:

Even though Florida has experienced only a few inches of sea level rise, we are already seeing flooding at high tide due to the backup of drainage systems. This new phenomena occurs regularly at lunar high tides and is an indicator of future problems as sea level continues to rise.



Figure 3: Miami Beach - Low Tide



Miami Beach - Peak-High Tide

2) Flood Control Issues in Miami-Dade County:

Sea levels were lower when South Florida's flood gates were constructed in the 1950s and 1960s. With the few inches of sea level rise that we've seen in the past decades, several of these flood gates are unable to discharge storm water at their design capacity during high tides.

There is already a multi-million dollar need to retrofit or rebuild many South Florida flood gates and a recent report finds that only six more inches of sea rise may cripple almost half the area's flood control capacity.



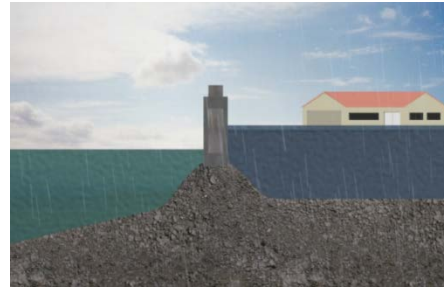
When it rains in South Florida



Excess water flows out to tide through dozens of water control structures along our coasts (an average of 1.7 billion gallons per day)



However, with sea levels rising...



...our flood control structures can no longer function effectively.

Figure 3: Conceptual depiction of the potential impact of sea level rise on coastal flood gates during storms and the increased threat of flooding inland due to insufficient discharge capacity.

3) Salinization of Aquifers

Many coastal wellfields that withdraw freshwater from the productive Biscayne limestone aquifer are located along the coastal belt of the Lower East Coast. These wellfields are extremely vulnerable to saltwater intrusion due to rising sea level and drinking water extraction

For example, because of sea level rise and salt water intrusion into fresh water wells, officials in the City of Hallandale Beach are spending \$16 million to upgrade their storm water system and to move the city's entire drinking water supply westward. City officials understand that this is a temporary solution to a problem that will worsen in the coming decades.

Future Projected Impacts

- 1) Water Management – Much of the coastal flood protection infrastructure designed and built by the U.S. Army Corps of Engineers 50 years ago will lose its design capacity if the projected sea level rise for South Florida becomes a reality.
- 2) Vulnerable Real Estate - There are 4,315 square miles of vulnerable areas that include agricultural land, developed land, forests, mangroves, marsh and tidal flats, other swamp and forested wetlands, pastures, sandy beaches, scrub, grasslands, prairies, and sandhills. Also included are the southern parts of Everglades National Park, billions of dollars of residential real estate, hundreds of schools, hospitals, and hotels, as well as two nuclear reactors and hundreds of hazardous material sites.
- 3) Transportation Readjustment – A recent study emphasized the need for a detailed assessment of the implications for roads and other transportation taking into account 2060 projections for sea level rise. Local studies of South Florida and the West Central Coast show that some communities and major metropolitan areas such as Fort Lauderdale will lose parts of their transportation networks at this level of sea level rise.
- 4) Coastal well contamination – Coastal well contamination will extend further inland as sea level rise continues.

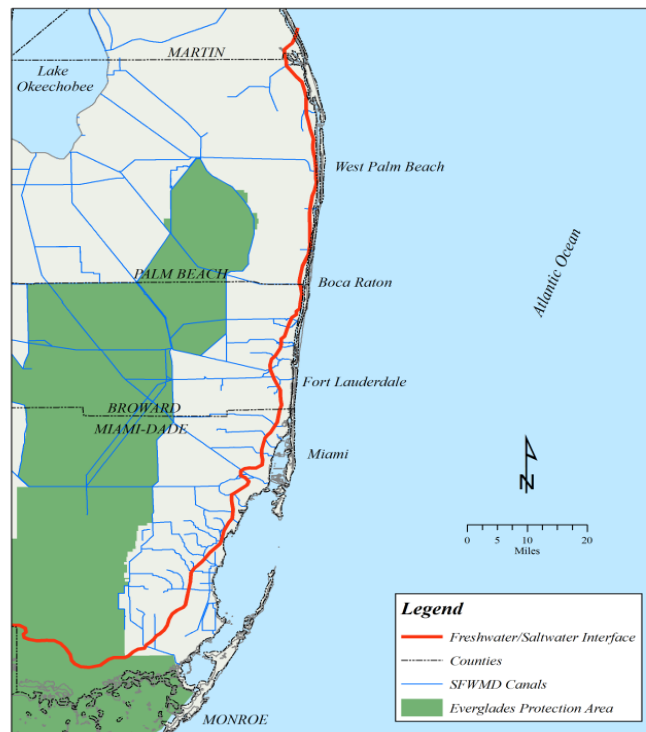


Figure 4: Saltwater Intrusion along the coast of South Florida (red line). Many wellfields and their protection areas are close to the saltwater intrusion zone potentially salinizing the freshwater wellfields in the future.

Most coastal communities in South Florida depend on wellfields that tap underground freshwater aquifers for their water supply. Saltwater intrusion into these aquifers is due to the current sea level and concentrated coastal development already threatens the region’s water supply. Between the years 1995 and 2000, a compilation of data resulted in an approximate location of the freshwater/saltwater interface on the Lower East Coast (Figure 4). The heavily populated area from the Florida Keys to Palm Beach County is considered especially vulnerable. Many coastal wellfields which withdraw freshwater from the productive Biscayne aquifer are located along the coastal belt of the Lower East Coast and will be highly vulnerable if saltwater intrusion is accelerated due to rising sea level. A more detailed analysis is needed to identify the impact of projected sea level rise on selected utility wellfields that are at risk of saltwater intrusion.

Implications for Energy, Water, and Resource Management

Water is already heavily managed in Florida with extensive canal systems. These will need major retrofitting and reconceptualizing as sea level rises. Energy needs will grow rapidly with additional pumping needed both for water supply and drainage, desalinization (which is considerably energy intensive), and with increased cooling needs due to higher temperatures.

Power demands for additional water treatment cannot be supplied by the current grid infrastructure or installed capacity. The results of the current water/energy nexus evaluation suggest the possibility of conflicts over water supplies in the near future. To reduce this potential, resolution of water rights, water quality, and other laws will be important.

Due to the projected increase of energy demands, Florida will need to continue to explore alternative as well as traditional energy sources. There is widespread, long term potential in alternative energy sources such as solar energy, biofuels, and harnessing the readily accessible Gulf Stream as an ocean energy resource.

INITIAL ESTMATES OF ENERGY ADAPTATION AND COSTS

Trigger	Implementation Strategy	Cost
Immediate 0-0.5 foot sea level rise by 2030	Install stormwater pumping stations in low lying areas to reduce storm water flooding (requires study to identify appropriate areas, sites and priority)	Start at \$1.5 to 5 million each, number unclear without more study
	Water conservation	Start at \$30 million + \$1 million/year
	Armoring the sewer system (G7 program)	\$12.5 million start, plus annual cost allocation
0.5–1 foot Sea Level Rise 2031-50	Additional reclaimed water production	Over \$25 million depending on permit requirements
	Aquifer recharge/salinity barriers	Up to \$200 million depending on permit requirements
1 – 2 foot Sea Level Rise 2043-78	Desalination	\$45-50 million to convert + wells (\$750,000 per MGD)
	Control flooding west of the coastal ridge	Start at \$1.5 to 5 million each, number unclear without more study – at least a dozen would be need - \$25 million

Table 1: Initial Estimates of Energy Adaptation and Costs (source: personal communication with Dr. Frederick Bloetscher, Florida Atlantic University.)

Responses

Many of Florida’s decision makers are aware of these problems and are beginning to respond to them.

1) Organizations

Counties and cities are organizing to respond to sea level rise at the local level. The Southeast Florida Climate Change Compact is a unique partnership of four diverse counties and was formed precisely for the purpose of responding regionally to the impacts of sea level rise and other climate related phenomena. This organization has a detailed action plan and needs statement that is summarized in Annex A. One important contribution of this group is that they have identified the need for special adaptation action areas. Legislation incorporating this language was passed by the Florida legislature and signed into law in 2011. Federal adoption of similar legislation would not only benefit Florida but also other states vulnerable to sea level rise.

Coastal cities such as Punta Gorda, Florida, have invested in detailed adaptation plans to monitor and respond to sea level rise. Regional planning councils across the state have undertaken initiatives that will in part address sea level rise issues. Florida's Department of Economic Opportunity has established a multi-agency, multi-disciplinary focus group to address sea level rise future planning. The South Florida Water Management District is conducting extensive hydrological modeling and scenarios, along with collaborating with other organizations and agencies.

2) Research and Education

The Florida State University System is undertaking significant research programs and state and local projects on sea level rise monitoring and adaptation. These include the Florida State University System's Climate Change Task Force, the National Science Foundation-funded Coastal Areas Climate Change Education Partnership, the CLEO institute, the Resilient Tampa Bay Project, and a large-scale NASA/Florida Atlantic University project. The Florida Climate Institute is currently expanding to multiple universities and will continue and build upon the previously mentioned research and projects. Several state and federal agencies have on-going sea level rise studies, these agencies include: the Florida Department of Transportation, the Florida Department of Economic Opportunity, the Florida Division of Emergency Management, US Fish and Wildlife, NOAA, US Army Corps of Engineers, National Park Service, the US Geological Survey (USGS), the South Florida Water Management District and the Florida Department of Environmental Protection. The USGS and other agencies have on-going programs on the implications of sea level rise and Everglades' restoration. A major summit on the risk and response of sea level rise in Florida is scheduled for June 2012 (Annex B).

3) Data Gathering and Monitoring

There is an on-going need for a thorough vulnerability assessment, particularly for communities affected by sea level rise. Comprehensive data gathering is necessary. Monitoring environmental changes is vital to understanding the impacts of sea level rise. The USGS, in coordination with other local agencies, will need to establish a region-wide, formal saltwater intrusion monitoring network. Federal agencies will also need to develop and implement computer models to understand and predict both saltwater intrusion and flooding under future sea level rise scenarios.

The Cost of Inaction

It is important to note that:

1. For every dollar spent on hazard mitigation, society saves four dollars in the long term
2. When the mitigation efforts have been on flooding hazards, it is a five to one return on investment
3. The largest return on investment occurs when mitigation projects focus on reducing business interruption from loss of utilities. Most of Florida's utility infrastructure is underground, situated directly on the coast, and at risk.
4. Building resilience now will pay off tomorrow.
5. New coastal infrastructure and large scale, long term restoration projects (i.e. Everglades Restoration) may not be successful and may be a waste of resources and time if sea level rise is not accounted for in the planning and implementation.
6. There will be long-term societal costs as people move from their homes to inland areas.

What Should We Be Doing Now

1. We need to further identify areas and communities at special risk using the State of Florida Adaptation Action Area legislation. Efforts should be made to align Federal legislation with these critical state level policies.
2. There is an urgent need to incorporate sea level rise projections into all infrastructure and water management plans, including the Everglades Restoration. We can evaluate and better understand the value and utility of restoring freshwater flow. We need increased monitoring activities, including additional National Water Level Program Networks (NWLON), which will be important in understanding and tracking changes in sea level rise for the state. Establishment of a state-wide saltwater intrusion monitoring network is also recommended.
3. We should be identifying future energy needs, including the cost of adaptation, for the coming decades, and moving towards traditional and alternative energy forms to meet these needs.
4. In addition, we need to utilize our past response to extreme events to create more sustainable community systems. Florida emergency management is already successfully working towards such initiatives.

Conclusion

The impacts of sea level rise are already a reality in South Florida and, as sea level rise continues, they will further impact all parts of Florida. The actions outlined above need to be taken now to increase our resilience and prepare for and minimize these impacts. People and organizations on the ground are already responding. We are delighted that, through this hearing, the US Senate is also responding. The people of Florida are already concerned about sea level rise as local awareness through major efforts has increased significantly. A larger role for the Federal Government is clearly warranted.

Additional Resources and References:

Florida Center for Environmental Studies: <http://www.ces.fau.edu/>

Florida Climate Institute: <http://floridaclimateinstitute.org/>

South Florida Water Management District: <http://www.sfwmd.gov>

Four County Compact: <http://www.southeastfloridaclimatecompact.org/>

Climate Central: <http://www.climatecentral.org/>

University of South Florida, Resilient Tampa Bay: <http://sgs.usf.edu/rtb/index.php>

ANNEX A

Southeast Florida Sea Level Rise Concerns for Federal Consideration

Based on the findings of the Final Recommendations of the Interagency Ocean Policy Task Force (July 2010), a National Priority Objective in an Area of Special Emphasis is to “Strengthen resiliency of coastal communities ...and their abilities to adapt to climate change impacts and ocean acidification.” Southeast Florida is highly vulnerable to the effects of climate change, especially sea level rise. In order to effectively address sea level rise issues, the Southeast Florida Regional Climate Compact Counties have identified a number of concerns for federal assistance related to adaptation policies, adaptation funding and technical needs.

Southeast Florida Regional Climate Change Compact 2012 Joint Legislative Program Statements on Sea Level Rise

SUPPORT - greater incorporation of adaptation strategies in the development of state climate and energy policies, legislation, and appropriations priorities.

SUPPORT - legislation which complements and enhances the utilization and implementation of Adaptation Action Area comprehensive plan designation in law for areas that experience coastal flooding and that are vulnerable to the related impacts of sea level rise. (See expanded language below under Broward County Legislative Program).

SUPPORT - programs and efforts that provide technical assistance and funding to local governments to aid the integration of adaptation planning in local comprehensive plans.

SUPPORT - funding for adaptation planning and investments (see attached letter) in the areas of water management, water supply, transportation and other projects that provide hazard mitigation and serve to reduce immediate and long-term risks (of sea level rise) to infrastructure.

SUPPORT - policies, legislation and funding that will provide for the complete implementation of the Comprehensive Everglades Restoration Plan as fundamental to Everglades Restoration, but also the vitality of local water resource management efforts given the overall contributions of the Everglades to regulated water storage and aquifer recharge which will become increasingly important under variable climate conditions and in the face of sea level rise.

SUPPORT - greater recognition of the role of Everglades Restoration in planning for economic and environmental sustainability, climate adaptation, including the impacts of sea level rise and extreme weather, such as droughts and floods.

2012 Broward County Legislative Program

SUPPORT: Federal legislation that would create and fund a national infrastructure bank or other new infrastructure funding source to finance projects needed by state and local governments to adapt to the impacts

of climate change and the growing regional needs for improved infrastructure with emphasis on investments in areas such as water management, water supply, transportation and other projects that provide hazard mitigation and serve to reduce risks to urban infrastructure from extreme weather events and rising sea levels.

SUPPORT: Specific recognition of an “Adaptation Action Area” through designation in federal legislation for those regions, such as Southeast Florida, that are uniquely vulnerable to climate impacts, including sea level rise, for the purpose of prioritizing funding for infrastructure needs and adaptation planning, This specifically includes support for the inclusion of Adaptation Action Area language with the Army Corps of Engineers (USACE) and the Environmental Protection Agency (EPA), enabling at-risk regions to develop long-term plans for adaptation.

Technical Needs Identified in Compact Work Group Discussions

- Continued technical support from federal agencies. The Compact acknowledges the significant role and contributions of federal agency partners in local and regional planning efforts relating to water supply, water resource management, and sea level. These collaborations have served to substantially advance programmatic efforts and the Compact with the applied expertise and resources of the USACE, NOAA, USGS, and EPA staff in local and regional offices. Continued support is need to develop technical tools and aid in the implementation of the Southeast Florida Regional Climate Change Action Plan.
- Improved and expanded hydrologic modeling for the region to understand the impacts of sea level rise with scenario testing for adaptation infrastructure improvements. Particular areas of vulnerability and analysis will include sea level rise, drainage and flood control infrastructure, changing precipitation patterns, impacts on groundwater levels, surface water management, and saltwater intrusion and its influence on potable wellfields and water supplies. The USGS is currently working on this type of modeling in select pilot areas of South Florida.
- Installation of additional National Water Level Observation Network (NWLON) stations. NOAA conducted an assessment of tidal stations along the Florida Coast and identified the need for additional NWLON stations and subordinate gages. This additional monitoring equipment will be important in understanding and tracking changes in sea level rise for the region.

Inventory of infrastructure at risk: While NOAA, USGS, USACE and others have aided the region in the development of inundation maps, vulnerability assessments are impeded by the lack of complete and accurate geographic information system (GIS) coverages for select infrastructure, such as historical and cultural resources. Funding is needed to create these coverages to determine impacts associated with sea level rise and storm surge.

Congress of the United States
Washington, DC 20515

May 13, 2011

The Honorable Rodney Frelinghuysen
Chairman
House Appropriations Committee
Subcommittee on Energy and Water
2362-B Rayburn House Office Building
Washington, DC 20515

The Honorable Pete Visclosky
Ranking Member
House Appropriations Committee
Subcommittee on Energy and Water
1016 Longworth House Office Building
Washington, DC 20515

Dear Chairman Frelinghuysen and Ranking Member Visclosky:

As you begin work on the Fiscal Year 2012 Energy and Water Appropriations bill, we respectfully request you to include language with the Army Corps of Engineers enabling at-risk, multi-county regions impacted by rising sea levels to develop long-term plans for adaptation.

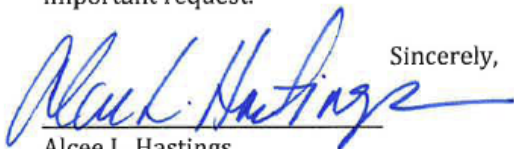
Scientists around the world and within our most respected institutions note an alarming level in sea level rise, possibly by several feet over the next century. This will inundate low-lying coastal zones, impacting hundreds of millions of people worldwide and tens of millions of Americans here at home. Our states and local communities are just beginning to grapple with the possible effects of what this kind of massive, permanent flooding will mean. It is critical that local leaders be given the necessary tools to start planning now, so that our communities will have enough time to prepare for these life-altering effects.

We request that the following language be inserted into the Army Corps of Engineer's Operations & Maintenance account, or whichever account you feel is most relevant:

"Funds will be used to study, define and designate several "Adaptation Action Areas," which are at-risk, multi-county, regions of the country, uniquely vulnerable and significantly impacted by rising sea level."

We hope that this language will enable regional groups to begin effectively strategizing and planning for adaptation to sea level rise. We thank you for your consideration of this important request.

Sincerely,



Alcee L. Hastings
Member of Congress



Ted Deutch
Member of Congress



Debbie Wasserman Schultz
Member of Congress



Frederica Wilson
Member of Congress

ANNEX B

Sea Level Risk and Response Summit – The Future of Florida and the Coast June 20, 21 & 22, 2012 - Boca Raton Marriott, Florida

INTRODUCTION

This Summit will result in raising an awareness and visibility of sea level rise and climate change issues to make them a central agenda item for the future of Florida and to emphasize how local and regional actions can be translated to other regions in the U.S. and abroad. Furthermore, this Summit will result in highlighting the “now” of sea level rise and showcase the myriad of activities taking place in Florida and the organizations that are mobilizing to address the issue to a national and global audience. In addition, the Summit will produce specific recommendations to local, state and federal agencies presented in a report summary and a website where visual aids and publications will be used to educate summit participants before and after the summit.

FORMAT AND PURPOSE

The Center for Environmental Studies (CES) at Florida Atlantic University, the Florida Sea Grant Program, and the United States Geological Survey will hold a Sea Level Rise Risk and Response Summit June 20th through June 22nd. The organizers have collaborated with a diverse group of experts in designing the program, goals and outcomes. The Summit will take place in Boca Raton, Florida and seek to bring in an audience of up to 300.

The purpose of this summit is three-fold: Highlight the interrelationships between sea level rise, limestone geology, and water management in Florida; share the ongoing responses and adaptation planning of agencies, institutions, and civic society to sea level rise; and compare the Florida situation and response with other vulnerable localities in the US and worldwide. This summit will focus on the complex sea level rise issues in Florida and provide examples from other coastal regions within the US and internationally.

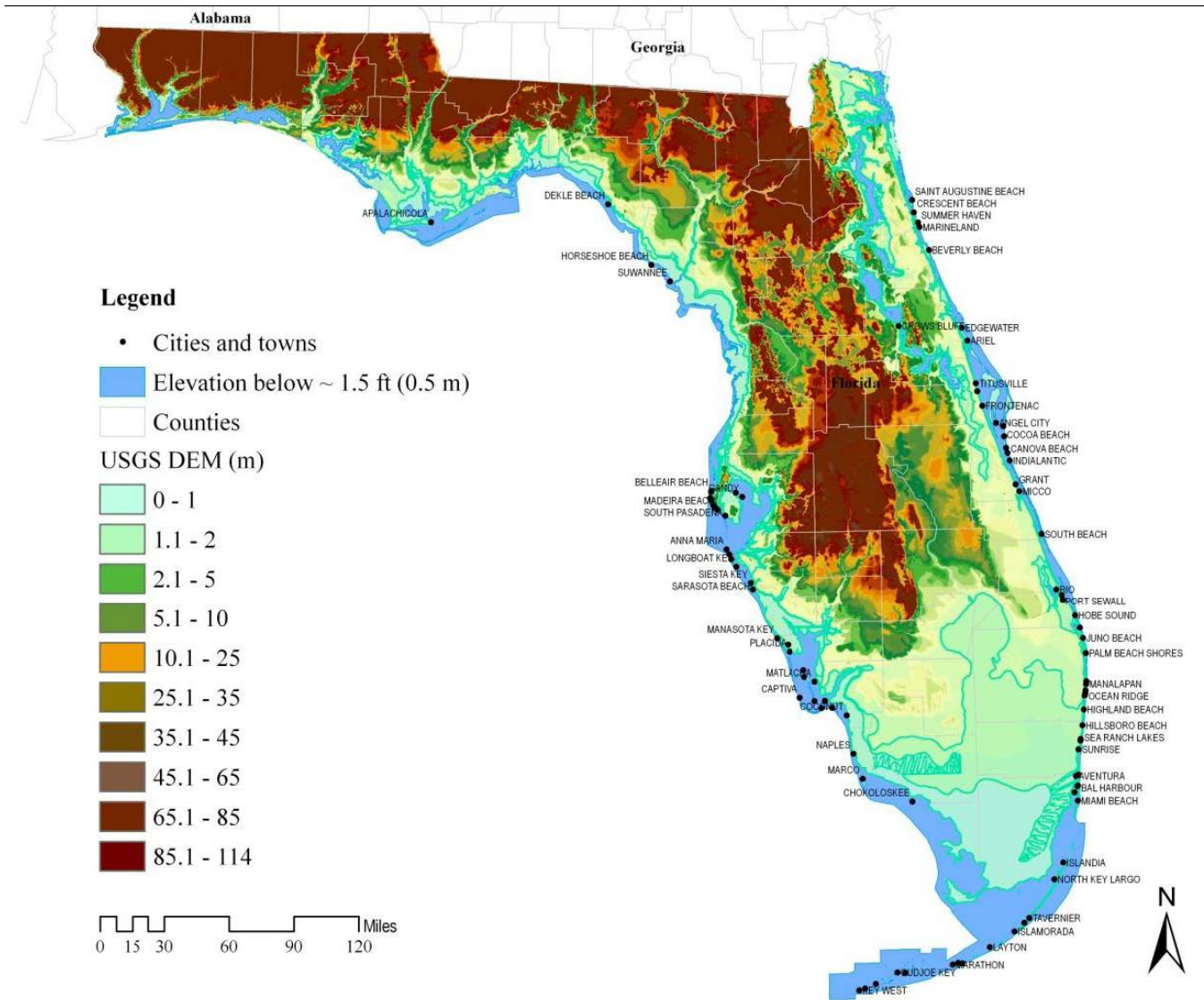
GOALS AND OBJECTIVES

The goals are to make a diverse audience of Summit attendees aware of the myriad of adaptation activities currently underway in the region and beyond. From this shared awareness, there will be a plan to continue a process of cooperation and coordination of adaptation responses. The primary objective is to present an awareness and understanding of the effects of sea level rise on the built environment and other social and societal issues and to explore adaptation and mitigations practices and policies that could be used to offset negative impacts. Other objectives include:

- Highlighting current and ongoing sea level rise and climate change research initiatives from academia, regional planning, state and federal projects taking place in Florida.
- Share methods and lessons learned with other states/regions to improve planning, decision making and adaptation.
- Provide scientific information to enable effective decision making to enable effective decision making to address the threats and opportunities posed by climate and sea level rise (similar to US Global Change Research Program goal).
- Identify concerns, compatibilities and links between social and economic issues, underserved populations, and the built environment with regards to sea level rise, salt water intrusion and water supply issues.

www.ces.fau.edu/SLR2012

ANNEX C



Additional Resources, Collaborations, and Research

1) Department of Transportation Research: Development of a Methodology for the Assessment of Sea Level Rise Impacts on Florida's Transportation Modes and Infrastructure

In Florida, low elevations can make transportation infrastructure in coastal and low-lying areas potentially vulnerable to sea level rise (SLR). Because global SLR forecasts lack precision at local or regional scales, SLR forecasts or scenarios for parts of the state have been prepared using varying tools and approaches. However, Florida still lacks a consensus on the appropriate methodology to forecast potential, adverse impacts. Also, a comprehensive analysis of transportation infrastructure potentially at risk in Florida from SLR has not been conducted.

In this project, Florida Atlantic University researchers analyzed findings, including data sources and methodologies used to forecast SLR. They recommended data sources and methods for forecasting SLR and related impacts in Florida and investigated integrating SLR forecasts with FDOT information systems to identify at-risk infrastructure. Using the Weiss Overpeck 1-meter (~3 ft) estimate of SLR to illustrate the methodology, researchers linked mapping software and datasets to create a framework for identifying transportation facilities at risk. Project Manager: Maria Cahill, AICP, FDOT Planning Office, Principal Investigator: Dr. Leonard Berry, Florida Atlantic University www.dot.state.fl.us/research-center, www.ces.fau.edu/climate_change/fdot

2) Integrative Collaboration on Climate and Energy (ICCE) Launched by Florida Atlantic University in the spring of 2009, ICCE is a cross-university program creating relevant linkages across disciplines. With Florida Atlantic University as the lead institution ICCE includes more than 80 faculty members in a multitude of climate change-related disciplines. Collectively, we have strong collaborative linkages with local, state and federal governmental and non-governmental organizations, the business community, and public. Other University collaborators include: University of South Florida, Florida Gulf Coast University, and Columbia University. Our partners provide strong support in topical and regional areas. Based on our expertise, deep community connections, and long-held partnerships, we are uniquely positioned to take research-based knowledge and apply it to practical decision-making that focuses on the needs of the region and its people. Furthermore, we know that the work of ICCE will have implications for addressing the climate change issues that will soon be faced by much of the United States and the world. www.ces.fau.edu/climate_change/icce

3) Resilient Tampa Bay 2011

A Knowledge Exchange with Dutch Experts was hosted by the University of South Florida's Patel Center for Global Solutions in Tampa, Florida, on February 21-23, 2011. The three-day workshop was organized in collaboration with local, regional, state, and international entities. More than 150 attendees heard from Dutch and local water experts on resiliency issues relating to Tampa Bay, particularly on urban flooding, storm surge, and sea level rise. Additionally, key stakeholders formed four geo-focal teams to identify vulnerabilities and to make recommendations on resiliency strategies for four defined locations: Tampa Bay, City of Tampa, City of St. Petersburg, and Gulf Beach Communities.

Today, coastal cities around the world face a range of dynamic regional and global pressures. These pressures make coastal cities more vulnerable to flooding, storm surges, coastal erosion, and more. Global change pressures serve as threat multipliers thus increasing existing problems for these cities. The Tampa Bay region is one of these coastal areas that will become more vulnerable in the future; hence the critical need to improve its resiliency. Tampa Bay's key vulnerabilities related to water include:

- Urban flooding events caused by heavy rainfall induce frequent but limited local damage
- Storm surges caused by hurricanes. Occurrence probability is low but as high-impact events, they can lead to catastrophic flooding along the entire coast.

- Sea level rise caused by climate change. As a long-term driver, it will increase existing flooding problems.

The goal of Resilient Tampa Bay 2011 was to exchange ideas on developing resiliency plans for the Tampa Bay region. The challenge was to consider plans that would protect vital infrastructure, improve conditions for economic development, and minimize the impact of hurricanes and other natural disasters. Key issues addressed were:

- Determining the factors that make Tampa Bay vulnerable
- Establishing progress toward improving resiliency in Tampa Bay
- Understanding existing visions and solutions for improving resiliency in Tampa Bay
- Recommending the next steps for improving resiliency in Tampa Bay

As part of an ongoing effort to engage Dutch water experts in addressing resiliency challenges in Tampa Bay, we partnered closely with the Dutch Consulate in Miami and the Dutch Embassy in Washington, D.C., to secure the participation of several Dutch speakers who shared some of their most effective and reliable solutions for flood resiliency. The Patel Center has been instrumental in establishing a dialogue between Dutch water experts and their counterparts in the Tampa Bay region through two previous workshops in June 2009 and November 2009. Resilient Tampa Bay 2011 built upon the momentum created from the prior workshops and will serve as a springboard to launch ongoing resiliency planning efforts in our region.

4) Florida Water Management and Adaptation in the Face of Climate Change

A WHITE PAPER ON CLIMATE CHANGE AND FLORIDA'S WATER RESOURCES

Supported by the State University System of Florida November 2011

The State of Florida will be faced in the coming years with significant challenges and opportunities for managing water in a highly dynamic and changing climate. The impacts of climate change on water resources management will have consequences for the economic sustainability and growth of the state. A strong awareness of climate change impact issues and potential adaptation strategies that could be implemented by the state will increase its resilience over the long-term to uncertain climatic conditions and sea level rise. To that end, a series of white papers have been prepared by State University System (SUS) of Florida Universities to coalesce our understanding of realized and predicted climate change impacts with a focus on various topics. The report presented herein addresses water resources and adaptation issues across the state.

The primary objectives of this report are: (1) to identify Florida's water resources and water-related infrastructure that are vulnerable to climate change; (2) show demographics in the state that are vulnerable to climate change impacts with a focus on water resources and sea level rise; and (3) highlight some of the alternative technologies currently being used to solve water resource supply issues in the state that are likely to expand and be challenged under various scenarios of climate change.

Florida is highly vulnerable to climate change as a result of its expansive shoreline, low elevation and highly permeable aquifers, and the location of high population centers and economic investments close to the coastline. Further, the state receives a high frequency of tropical storm landings that are accompanied by tidal surges that compound the risks of sea level rise. Because the state is highly vulnerable compared to other regions globally, Florida's academic, governmental and non-governmental institutions are developing adaptation strategies and conducting research on climate change. In this white paper, we highlight climate change issues relevant to water management, but also recognize the financial challenges to implement adaptation measures to address climate change solutions. Implementing adaptation measures will require an unprecedented level of resource leveraging and coordination among academic, governmental, non-governmental, and private sector entities. <http://floridaclimate.org/whitepapers/> http://floridaclimate.org/water_management_pdf.php