MEMORANDUM

COMMISSIONER XAVIER L. SUAREZ

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TO:	Chairman Jean Monestime Board of County Commissioners Mayor Carlos Gimenez	**DATE:**	March 22, 2016
FROM:	Commissioner Xavier L. Suarez, Esq., District 7	**RE:**	Sea-Level Rise

The purpose of this paper is to ascertain whether the sea is rising at a more exponential rate in South Florida than in the rest of the United States. This paper will be divided as follows:

I. Introduction.
II. Analysis.
III. The related problem of saltwater intrusion.
IV. Planning in Miami-Dade County.
V. Conclusion.

I.

Introduction

I became aware of the sea-level rise issue at various moments and in various capacities:

- As a member of the South Florida Regional Planning Council (SFRPC) for the last three years, where the issue of increased salinity of the South Florida aquifer has been discussed, as well as the fragile condition of Cape Sable in Monroe County.

- As a member of the County Commission, when we were asked to approve a system of circular wells to be used by Florida Power and Light's (FPL) Turkey Point two proposed new nuclear reactors.

- As a member of the Baylink Policy Executive Committee, which is charged with recommending a rail linkage connecting Miami to Miami Beach – the latter of which is experiencing serious flooding during "King Tides."

- As a member of the County Commission, in connection with the consent decree entered into by U.S. District Court Judge Federico Moreno, which requires the county to modify and correct our wastewater system, including treatment plants in places with low grades – notably the one in Virginia Key.

- As chairman of the county's Economic Prosperity Committee, where I have a responsibility to oversee Miami-Dade's economic development and subsidized housing efforts. Clearly, the possibility that we may have serious sea-level rise issues that affect our ability to provide economic development opportunities and affordable housing.

South Florida has been called "ground zero" for sea-level rise due to its massive infrastructure built on a porous aquifer that is level with the ocean. As will be seen, another important factor is South Florida's proximity to the Gulf Stream, which is likely causing a more drastic rise in sea-level than the three generic factors (thermal expansion, melting of ice caps, and tectonic plates that affect ocean depth) alone.

Sea-level rise affects Miami-Dade County's residents' potable water, seacoast construction, transportation systems and wastewater plants. The problem is so serious that certain prominent Miamians are ready to recommend immediate policy changes. For example, Mr. Leonard Abess[1], a prominent environmental advocate, shared with me in a personal interview that he believes the situation is so dire that policymakers should stop analyzing and start increasing the height of building foundations by mandatory regulation, as already done in Key West.[2]

Premised on the above, my staff was asked to review the two distinct sea-level rise forecasts and analyze whether the sea is rising at a more exponential rate in South Florida compared to the rest of the United States. Is it conceivable that Miami is experiencing, what was said in a recent article of the *New Yorker*, ten times the sea-level rise of the rest of the nation?

After having spent countless hours reading articles and interviewing experts, we now proceed to the analysis.

II.

Analysis

It is widely accepted that global sea-level rise is the result of (1) an increased volume of water caused by an increase in temperature; (2) an increased volume of water caused by the melting of polar ice caps; and (3) the changing depth of the ocean floor caused by the movement of tectonic plates.

Let us examine the discrepant forecasts more completely, beginning with the historical 100-year trend.

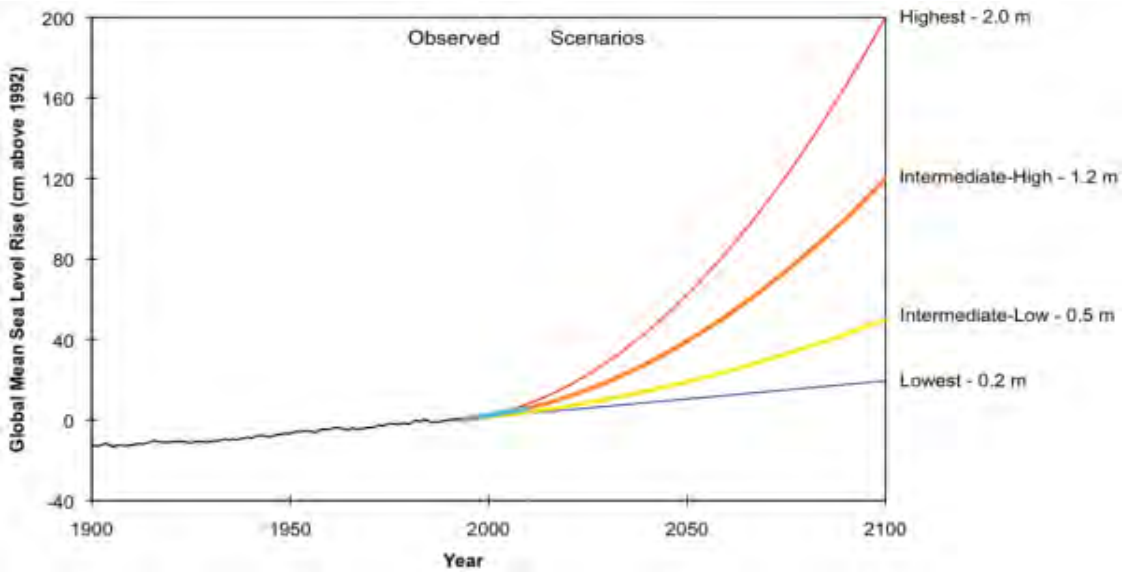
Forecast #1: Standard 100-year trend, Global Measurements based on National Oceanic and Atmospheric Administration (NOAA)/US Army Corps of Engineers.

[1] Mr. and Mrs. Leonard Abess funded the University of Miami "Leonard & Jayne Abess Center for Ecosystem Science and Policy

[2] Bates, Todd B. "Sea-level Rise in 20th Century Was Fastest in 3,000 Years, Rutgers-led Study Finds." Rutgers Today. 22 Feb. 2016. Web. <news.rutgers.edu/news/sea-level-rise-20th-century-was-fastest-3000-years-rutgers-led-study-finds/20160217#.VuBwmkZppfY>.

The NOAA (and its predecessors) has been collecting oceanographic and atmospheric information from all over the world since 1807. The NOAA has found that sea levels have risen about 6 inches in the 20th century[3] and have published four predictive scenarios, as seen below. The scenarios predict a rise of at least 8 inches and perhaps as much as 6.6 feet by 2100[4].

NOAA's Global Mean Sea Level Rise Scenarios



- The lowest sea level change scenario (0.2 meters, equivalent to 8 inches) is based on historic rates of observed sea level change. This scenario should be considered where there is a high tolerance for risk (e.g. projects with a short lifespan or flexibility to adapt within the near-term).
- The intermediate-low scenario (0.5 meters is equivalent to 1.6 feet) is based on projected ocean warming.
- The intermediate-high scenario (1.2 meters is equivalent to 3.9 feet) is based on projected ocean warming and recent ice sheet loss.
- The highest sea level change scenario (2 meters equivalent to 6.6 feet) reflects ocean warming and the maximum plausible contribution of ice sheet loss and glacial melting. This highest scenario should be considered in situations where there is little tolerance for risk.

The federal government has encouraged the use of intermediate/high predictions as the national standard via the oversight of the Environmental Protection Agency (EPA). However, Congress has not mandated any regulatory reform to prepare for sea-level rise.

Forecast #2: Exponential Rise, as Measured in Recent Decades in South Florida.

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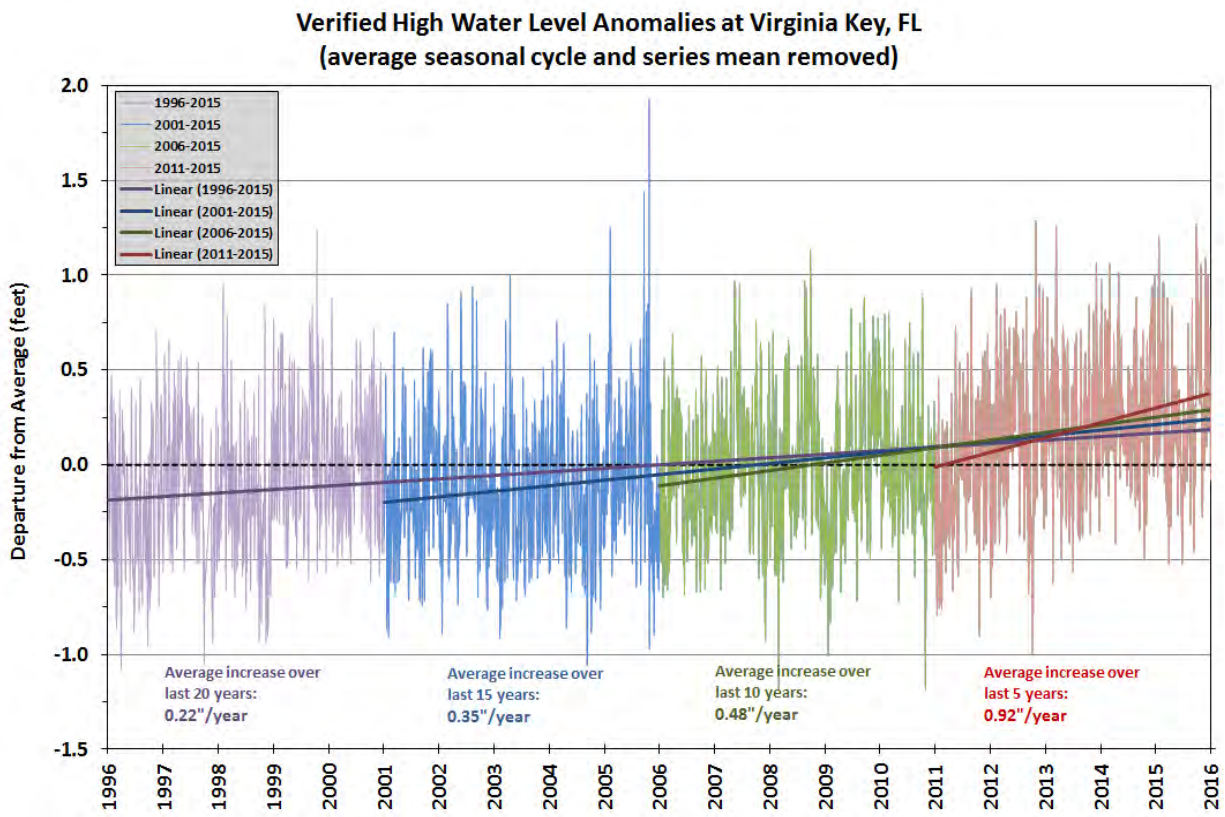
[3] Bates, Todd B. "Sea-level Rise in 20th Century Was Fastest in 3,000 Years, Rutgers-led Study Finds." Rutgers Today. 22 Feb. 2016. Web. <news.rutgers.edu/news/sea-level-rise-20th-century-was-fastest-3000-years-rutgers-led-study-finds/20160217#.VuBwmkZppfY>.

[4] Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti, R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss. 2012. Global Sea Level Rise Scenarios for the US National Climate Assessment. NOAA Tech Memo OAR CPO-1. 37 pp.

The first NOAA sea-level measurement gauge was installed in Virginia Key, Miami, Florida in 1994. Since then, other gauges have been installed in Lake Worth Pier, Naples and Fort Myers.



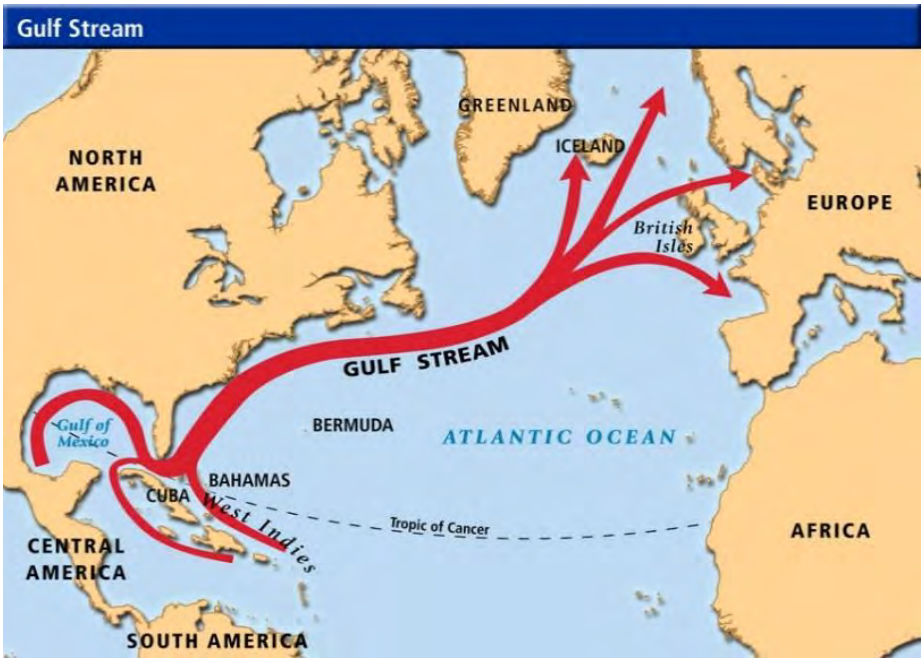
To date, the NOAA (via the sea-level gauge tube anchored and contained on the dock of the University of Miami's Rosenstiel School of Marine and Atmospheric Science (RSMAS)) has found that sea levels have risen in South Florida at an average of 0.21 inches per year since 1996, with a trend of approximately 0.36 inches per year over the past few years. In RSMAS Senior Research Associate Brian McNoldy's blog entry "Water, water, everywhere: Sea level rise in Miami," McNoldy predicts that South Florida will experience an even more alarming rise by the end of the century. (Note that even at 0.21 inches per year, the expected sea level increase in 85 years would be 2.5 feet, or enough to cover a goodly portion of our coastal areas).

Whatever the magnitude, it is clear that South Florida is experiencing a unique exponential rise in sea-level. Therefore, it is important to at least attempt to reconcile the distinct forecasts above.

In discussions with South Miami Mayor Philip K Stoddard[5], it was brought to my attention that the RSMAS figures of rapid-rise (as much as ten times higher than the 100-year trend) are measured in buoys that might reflect the effect of the Gulf Stream, which is estimated to have increased as much as one foot in recent years.

[5] Dr. Stoddard is also a Florida International University Professor of Biological Sciences and a Whitehouse appointee of the Governance Coordinating Committee of the National Ocean Council.

The Gulf Stream (as pictured below) is a powerful, warm current of water that passes by the tip of South Florida and flows north along the eastern coastline of the United States. The current then flows across the Atlantic Ocean toward Greenland, where cold water from the glaciers cools the current and slows it down by reverse pressure of the melting ice caps.



As Brian McNoldy explains it, recent measurements indicate that the Gulf Stream has been slowing down for the past few years. "The quicker that river in the ocean moves, the more water is being evacuated away from the coast." [6] Conversely, when it slows down, the water backlogs and builds up on the shorelines due to a law of fluid dynamics known as Bernoulli's Principle.[7]

It is not clear whether the changes in the speed and height of the Gulf Stream will continue to fluctuate or become a permanent factor uniquely affecting South Florida's sea-level rise. For the moment, policymakers must confront the issue as to how to prepare for and regulate new development based on the assumption that sea level is rising quicker in South Florida than in the rest of the world.

III.

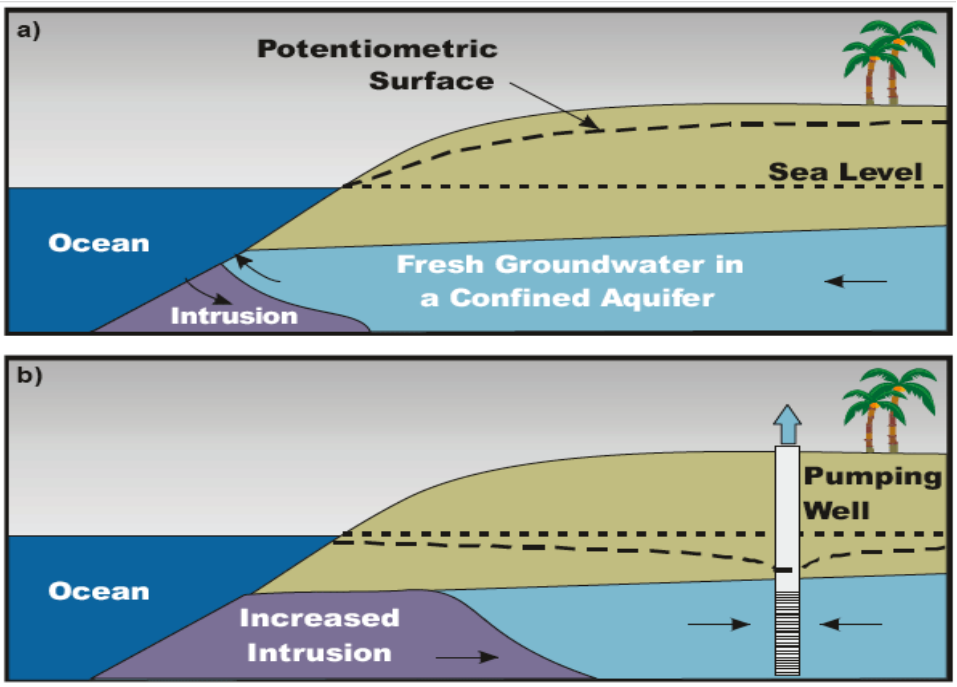
The related problem of saltwater intrusion

I have also asked my staff to analyze the effect of sea-level rise on saltwater intrusion into the South Florida aquifer. The issue of saltwater intrusion comes up in the context of sea-level rise because South Florida's topography is very close to the water table. As the sea level rises, it tends to penetrate into the aquifer either by back-flow into the canals

[6] McNoldy, Brian. Personal Interview. 15 Feb. 2016. Marine & Atmospheric Sciences at the Rosensteil School in Key Biscayne, FL.,

[7] Bernoulli's Principle states that for an inviscid flow of a non-conducting fluid, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy.

or mixing with the storm water outfalls. The issue of outfalls is treated later in connection with a special section on Miami Beach.



Saltwater intrusion can be aggravated by increased pressure from the ocean side (Experts refer to it as "increased head"). It can also be aggravated by localized conditions[8] in which large amounts of fresh water are pumped out for specific purposes, such as cooling nuclear reactors. (In a subsequent section, we will describe this phenomenon as it affects the Turkey Point Power Plant, in both its existing and planned nuclear reactors.)

The most comprehensive analysis of how saltwater interfaces with the aquifer is performed on an ongoing basis by Peter Kwiatkowski, South Florida Water Management District Water-shortage Incident Commander. The sketch below reflects the movement of the interface from 1984 to 2011. Mr. Kwiatkowski has recently reported that "there have been no major changes in saltwater interface position from 2009 to 2014." His other conclusions are as follows:

- "Interface is dynamic – Some inland and seaward movement is observed
- Saltwater intrusion is occurring, emphasizing the importance of continued monitoring (laterally and vertically) and wellfield management
- Additionally, localized monitoring may be required at select wellfields to protect water supplies"

[8] Dr. Virginia Walsh, Miami-Dade County hydrology engineer, has identified certain wellfields that are more susceptible to saltwater intrusion based on some recent USGS groundwater modeling.

As explained in the last of the three observations listed above, localized effects can be much more serious than the regional situation - which prompts us to analyze in depth some of the most serious local conditions.

Localized Effect and King Tides.

It is important to understand that sea levels are measured and reported in terms of yearly averages. To those average levels, sporadic (heavy rain) or seasonal ("King Tides") occurrences must be added. If the current trends of high tides and storm water continue and the overall water temperature increases causing thermal expansion, then, over time, all of the groundwater system will be sorely tested.

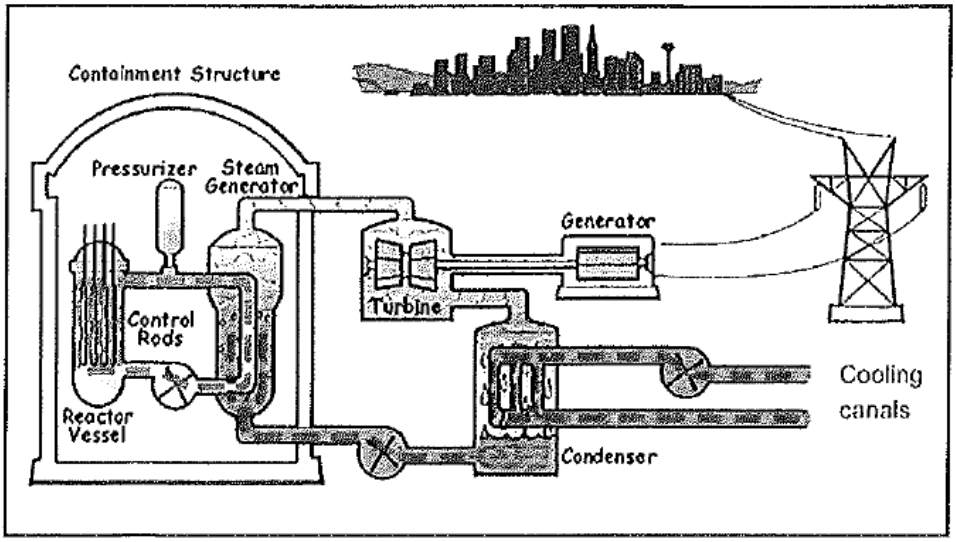
A very important localized effect, as previously mentioned, is the one experienced in the vicinity of FPL's Turkey Point nuclear plant. The nuclear cores must be constantly cooled to avoid meltdowns, and at Turkey Point, fresh water canals are used to circulate water through the plant to lessen the heat of the reactors. (The accompanying sketch illustrates the workings of that cooling system.)

Besides the effect the cooling system has on saltwater intrusion, the vicinity of the nuclear reactor exposes the flowing water to radiation.

As explained in recent press reports, the county through its Department of Environmental Resource Management (DERM) Director and Mayor Carlos Gimenez, has warned of extensive tritium discharges into the cooling canals[9].

[9] Elfrink, Tim. "Turkey Point Nuclear Plant Is Pumping Polluted Water Into Biscayne Bay." Miami New Times. 8 Mar. 2016. Web. 8 Mar. 2016. <http://www.miaminewtimes.com/news/turkey-point-nuclear-

However, the more prevalent concern is the effect that the reactor cooling system has on our supply of fresh water. The next section is devoted entirely to that analysis.



Florida Power & Light Company

Localized problem: FPL's Turkey Point Nuclear Plant (Existing Reactors).

The Turkey Point Nuclear Plant has recently come under increased scrutiny due to elevated levels of salinity (measured as chloride content) in the nearby aquifer.

A rather comprehensive analysis of the problem is found in the March 1 edition of *Community Newspaper* (Brickell edition). Grant Miller states, in rather blunt terms, that "Current operations at the Turkey Point nuclear power plant are a significant threat to the health of Biscayne Bay." Miller further explains that

> *The danger posed by the plant's current operation is twofold. First, the plant generates a plume of hypersaline water which degrades the aquifer and contributes to chloride pollution in the bay. Second, the Industrial Wastewater Cooling Canal System generates large amounts of ammonia and phosphorous, in addition to other contaminants that have been now found leaching out into the bay.*

Mr. Miller goes on to argue that the Turkey Point nuclear plant requires massive amounts of water to cool down their reactors. The reason, he elaborates, is that:

> *The nuclear facility at Turkey Point utilizes a "once-through" cooling system which draws water from Biscayne Bay and runs it through a series of canals hereafter referred to as the Industrial Wastewater Cooling Canal System or "IWCCS." This water is used to cool down the steam supply into a liquid*

plant-is-pumping-polluted-water-into-biscayne-bay-8304252>. A response from FPL's CEO was published as an op-ed in the March 16, 2016, *Miami Herald.*

> *state to be reused in the reactor. When the water in the IWCCS is exposed to the heat of the turbine steam, much of it evaporates. The water taken from the Biscayne Bay is brackish, meaning it contains some salt. When the water in the IWCCS evaporates the salt is left behind, leading to ever saltier or "hypersaline" water. The issue is, that hypersaline water is not staying confined to the IWCCS. A huge plume of incredibly salty water is spilling out from the IWCCS into Biscayne Bay in the east and the Biscayne aquifer in the west.*

FPL's response to the above is that the company has permits to release salt; however, as Grant Miller argues, "those permits only apply within the boundaries of the IWCCS itself." Mr. Miller elaborates that:

> *The release of salt in this manner is specifically prohibited. The logic behind this regulatory regime rests in the assumption that the IWCCS is a closed system, it has never been a closed system. There is an 18-foot interceptor ditch that provides for a hydrologic barrier to the west, but as the water evaporates the heavier saltwater sinks and loads our aquifer and moves swiftly west toward wellfields and into our aquifer. The boundary only works for the first 18 feet.*

Laura Reynolds, leading environmentalist and former head of Tropical Audubon, explains the effect of increased salinity in our ecosystem:

> *This hypersaline environment negatively affects the Biscayne Bay ecosystem by reducing the productivity and diversity of numerous species (including commercially valuable snook, and pink shrimp populations) as well as decreasing overall bio-diversity due to the elimination of less salt tolerant species in affected areas. It also threatens the drinking water supply of Miami-Dade County by loading the aquifer with undrinkable saltwater*.

Policymakers, including this commissioner, worry that additional reactors at Turkey Point are compounding the challenge of fresh water flow through the aquifer and Biscayne Bay. Let's discuss the desirability of the proposed new reactors.

FPL's Turkey Point Nuclear Plant (Proposed Reactors 6 & 7).

Besides the current critical issue presented by Turkey Point's existing reactors, Florida Power and Light has recently applied for the two additional nuclear reactors.

For the last decade, FPL has been seeking the approval of two new nuclear reactors from both the SFRPC and the US Nuclear Regulatory Commission. The FIU Sea Level Solutions Center (SLSC) has been critical of the approvals so far received. The center recently stated:

> We strongly suggest a need for additional study as to the appropriateness of the FPL proposed nuclear reactor technology at this site and the basis for decision-making. There are significant uncertainties in climate warming impacts and a lack of focused study on area of habitable land in south Florida during the operational horizon of the proposed FPL Nuclear Reactors 6 & 7.

The SLSC response concluded with the statement:

> A reevaluation of these matters, along with the long-term outcomes, should be required and SLSC asks the USNRC to reopen the comment period and opportunities for public meetings to obtain new comments after more information is available

I myself was confronted with the issue of the two new reactors in my capacity as a member of the South Florida Regional Planning Council. The context was the 2013 site application. On subsequent review of the approval documents, I realized that, while the new construction would be built in preparation for intense flooding, much of the rest of the power plant was not sufficiently prepared.[10]

Localized Effect: Miami Beach.

If we assume the NOAA projections from 2012 that suggest a rise of 6 ft by the end of the 21st century, a huge percentage of the U.S. population that will have to evacuate their homes due to flooding will be right here in South Florida. The largest population center in close proximity to the ocean is Miami Beach; and it is thus the first to feel the effects of sea level rise.

In order to combat saltwater intrusion in stormwater outfalls, Miami Beach has begun retrofitting "baffle" valves, which are one-way valves that shut down the reverse flow from the ocean back into the stormwater sewer system. Furthermore, seasonal flooding of Miami Beach streets during King Tides has been alleviated through the use of pumps and by raising the level of particularly vulnerable streets, such as Purdy Avenue.

Other Localized Effects (Sweetwater):

Sea level rise also combines with heavy rains to cause flooding in Sweetwater and other low-lying areas of the county. The map below illustrates areas that are particularly susceptible to the effects of sea-level rise.

[10] Notice of Filing Stipulation between South Florida Regional Planning Council and Florida Power and Light Company. 7 June 2013.

The City of Sweetwater was built on basin-like, low-laying land and currently experiences intense flooding. The Southeast Florida Climate Compact[11] has recently proposed a hypothetical "resilient redesign" that includes ideas such as using existing golf courses for increased water storage capacity and converting existing trailer parks into alternative adaptive dwelling typology (floating trailer park concept).

IV.

Planning for the Future in Miami-Dade County

The problem we confront is not a recent phenomenon. Various local agencies and jurisdictions have been working toward researching and implementing solutions to the troubling phenomena of sea-level rise since the early nineties.[12] The previously mentioned Compact has been empaneled since January 2010 to "marry" the national historical trend and current empirical data taken in South Florida, and generate predictions specific to the area to coordinate mitigation and adaptation activities across county lines.

Miami-Dade County, in particular, has recently been deeply involved in this issue. The county, at the request of Commissioner Rebeca Sosa, impaneled a committee (Chaired by Clerk of the Board, Harvey Ruvin) in 2012. The recommendations were incorporated into seven resolutions in late 2015.[13]

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[11] Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact). October 2015. Unified Seal Level Rise Projection for Southeast Florida. A document prepared for the Southeast Florida Regional Climate Change Compact Steering Committee. 35 p.

[12] In 1992, the sea-level gauge was moved by NOAA from a buoy in Miami Beach to a fixed dock in Virginia Key. This was the year that news of global climates being on the rise possibly due to increase of carbon emissions became a global concern and George H.W. Bush signed a treaty to implement voluntary goals to reduce greenhouse gas emissions.

In 2015, the Office of Resilience was created by the county to coordinate the effort of government agencies, business groups, and non-profit organizations as we collectively seek to commit to a community-wide resilience and sustainability plan.

I also attended, in the company of Commissioner Daniella Levine-Cava, the recent meeting of the Beacon Council where various groups discussed the latest findings and planned for a summit presently scheduled for April 1, 2016.

It is also worth mentioning that in 2015, the City of Miami implemented its own Sea Level Rise Committee, led by Commissioner Francis Suarez. That committee is focusing on architectural codes, insurance requirements, and an emergency action plan.

V.

Summary and Conclusions

It is clear from measurements taken at Virginia Key that parts of South Florida are experiencing much greater sea-level rise than the rest of the nation. It is likely that the discrepancy is the result of changes in the speed and height of the Gulf Stream. The confluence of the three generic factors (thermal expansion, melting of ice caps, and tectonic plates that affect ocean depth) with the proximity to a changing Gulf Stream, makes South Florida so unpredictable that even the most knowledgeable experts are unable to forecast with much scientific certainty the future of a phenomenon that has been measured during the past 20 years.

Therefore, it is incumbent upon policymakers in South Florida to do two things: (1) continue measuring and evaluating sea-level rise for at least the next ten years; and (2) while those measurements are being made and other climate change data are being obtained, prepare to make adjustments to the building codes if it is found that the accelerated rates are a permanent feature of our geology and weather.

The phenomenon of saltwater intrusion must be separately and aggressively tackled by emphasizing the importance of continued monitoring (laterally and vertically) and wellfield management. The South Florida Water Management District, the South Florida Regional Planning Council, and the county and city governments must impose additional monitoring requirements that measure salinity in wellfields and in the vicinity of Turkey Point nuclear plant. Due to the fact that this phenomenon could intensify - in an exponential way - governments' regulatory agencies must be ready to take more drastic action, including imposition of a moratorium wherever a localized effect seriously affects the environment.

Xavier L. Suarez
Miami-Dade County Commissioner
District 7

cc: Miami-Dade County Office of Resiliency