RECLAIMING THE FUTURE

SCIENCE, ENGAGEMENT AND HOPE IN OUR STATE OF WATERY PERIL

Jason M. Evans, PhD
Volusia Water Symposium
October 26, 2018
DEFINITIONS OF “RECLAIM”

From Merriam-Webster:

1. To recall from wrong or improper conduct; reform
2. To rescue from an undesirable state
3. To obtain from a waste or by-product
4. To demand or obtain the return of
(a) The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. In order to achieve this objective it is hereby declared that, consistent with the provisions of this Act–

(1) it is the national goal that the **discharge of pollutants** into the navigable waters be **eliminated by 1985**

(2) it is the national goal that wherever attainable, an interim goal of water quality which provides for the **protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water** be achieved by July 1, 1983

(3) it is the national policy that the **discharge of toxic pollutants** in toxic amounts be **prohibited**

(6) it is the national policy that a major research and demonstration effort be made to develop technology necessary to **eliminate the discharge of pollutants** into the navigable waters, waters of the contiguous zone, and the oceans

(7) it is the national policy that programs for the control of nonpoint sources of pollution be developed and implemented in an expeditious manner so as to enable the **goals of this Act to be met through the control of both point and nonpoint sources of pollution**.

https://www3.epa.gov/npdes/pubs/cwatxt.txt
AND YET HERE WE ARE...

Martin County, FL, 2016

AND YET HERE WE ARE...

Lake Okeechobee

Maps courtesy
Richard P. Stumpf, Ph.D.
NOAA
(Derived from Copernicus
Sentinel-3 data from
EUMETSAT)
richard.stumpf@noaa.gov
AND YET HERE WE ARE…

AND YET HERE WE ARE...

Indian River Lagoon fish kill, 2016

AND YET HERE WE ARE...

Satellite Beach residents warned to avoid sewage spill

Jim Waymer, FLORIDA TODAY  Published 12:50 p.m. ET Feb. 2, 2018 | Updated 1:53 p.m. ET Feb. 2, 2018

Nearly 1 million gallons of sewage was just dumped into Florida's Indian River Lagoon

Posted By Larissa Hamblin on Tue, Jul 31, 2018 at 12:27 pm


Raw sewage spills into canals, ponds around Satellite Beach

Dan Billow  Reporter

AND YET HERE WE ARE...

Southwest Coast *Karenia brevis* concentrations
09/18/2018 – 09/25/2018

*Karenia brevis* cell abundance is shown here overlaid on ocean color satellite images (showing normalized fluorescence line height, or nFLH, an index of chlorophyll a) from 09/25/2018, provided by the Integrated Red Tide Information System (IRIS) at http://optics.marine.usf.edu/projects/iris.html. The hotter colors in the image show higher levels of chlorophyll a, and the grey represents cloud cover.

NOTE: Sampling efforts for other areas are not depicted on this map.

*Karenia brevis* (cells/liter)
- not present/background (0-1,000)
- very low (>1,000-10,000)
- low (>10,000-100,000)
- medium (>100,000-1,000,000)
- high (>1,000,000)
AND YET HERE WE ARE…

Statewide *Kareния brevis* concentrations
10/09/2018 – 10/16/2018

*Kareния brevis* cell abundance is shown here overlaid on ocean color satellite images (showing normalized fluorescence line height, or nFLH, an index of chlorophyll a) from 10/16/2018, provided by the Integrated Red Tide Information System (IRIS) at http://optics.marine.usf.edu/projects/iris.html. The hotter colors in the image show higher levels of chlorophyll a, and the grey represents cloud cover.

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- medium (>100,000-1,000,000)
- high (>1,000,000)
“In general, *Karenia* spp. demonstrated a strong need for additional exogenous N supplies…” (Paerl et al. 2008, pg. 150)
HOW DID WE GET HERE?

Values → Institutions → Behaviors → Values

Outcomes (Socio-Physical Reality)
VALUES?

ALMOST EVERYONE BELIEVES THAT CLEAN WATER IS IMPORTANT

Water Issues in Georgia: A Survey of Public Perceptions and Attitudes about Water

Originally published in April 2011
https://secure.caes.uga.edu/extension/publications/files/pdf/B%201385_2.PDF

Prepared by
Jason Evans, Carl Vinson Institute of Government, University of Georgia
Jon Calabria, College of Environment and Design, University of Georgia
Warren Brown, Carl Vinson Institute of Government, University of Georgia
Alice Miller Keyes, Georgia Environmental Protection Division
Mark Risse, Department of Biological and Agricultural Engineering, College of Agricultural and Environmental Sciences, University of Georgia

Very similar results found when the same survey was given to Florida residents.
http://edis.ifas.ufl.edu/fe841
ARE THESE CORE VALUES REFLECTED IN OUR INSTITUTIONS AND BEHAVIORS?

Florida Water Districts Wring Out $700 Million in Budget

From the News Service of Florida:
THE CAPITAL, TALLAHASSEE, August 24, 2011......Having kicked sugar and cut up the credit card, water management districts submitted a budget proposal that is $700 million leaner without jeopardizing critical water supply and Everglades restoration efforts, state officials and a key environment group said Wednesday.

Seminole residents protest 'obscene' proposed water rate hikes

Orlando Sentinel, February 2017

Proposed stormwater fee draws criticism from Collier County residents

The Collier County Commissioners have proposed a new fee that could be added to resident's property taxes, leaving some angry.


Application rates of 2 lbs of nitrogen per 1000 square ft between 2-6 times per year...

Results in between 174 – 523 lbs of nitrogen per acre per year.

By way of comparison, U.S. corn growers used about 144 lbs of nitrogen per acre per year in 2014.
GULF OF MEXICO HYPOXIC ZONE

https://www.motherjones.com/environment/2016/06/gulf-mexico-braces-monsterous-dead-zone/
Code of Ordinances of the County of Volusia

Chapter 50, Article VII, Florida Friendly Fertilizer Use

Sec. 50-520. Findings.

As a result of impairment to surface waters caused by excessive nutrients, and as a result of increasing levels of nitrogen in the surface and ground water within the aquifers and springs, the county council hereby determines that the use of fertilizers creates a risk to contributing to adverse effects on surface and ground water. Accordingly, the county council hereby finds that management measures contained in the most recent edition of the Florida-Friendly Best Management Practices for Protection of Water Resources by the Green Industries are required.

Sec. 50-521. Purpose and intent.

This article regulates the proper use of fertilizers by any applicator; requires proper training of commercial and institutional fertilizer applicators; establishes training and licensing requirements; establishes a prohibited application period; and specifies allowable fertilizer application rates and methods, fertilizer free zones, low maintenance zones, and exemptions. This article requires the use of best management practices, which provide specific management guidelines to minimize negative secondary and cumulative environmental effects associated with the misuse of fertilizers. These secondary and cumulative effects have been observed in and on natural and constructed stormwater conveyances, rivers, creeks, canals, springs, lakes, estuaries and other water bodies. Collectively, these water bodies are an asset critical to the environmental, recreational, cultural and economic well-being of county residents and the health of the public in general. Overgrowth of algae and vegetation hinder the effectiveness of flood attenuation provided by natural and constructed stormwater conveyances. Regulation of nutrients, including both nitrogen and phosphorus contained in fertilizer, will help improve and maintain water and habitat quality.

Also includes a plan to monitor nutrient concentrations from stormwater outfalls into coastal waters – i.e., getting a better handle on how urban stormwater contributes to nutrient loading.

https://ffl.ifas.ufl.edu/
A first principle of engaged science in the twenty-first century...

*Climate change is one of the most complex and daunting challenges ever faced by human civilization.*
WHAT DOES CLIMATE CHANGE MEAN FOR FLORIDA

Climate change models have been somewhat unclear about the following impacts for much of Florida over the next several decades:

1) Drought
2) Extreme rainfall
3) Extreme heat*
4) Freeze frequency and severity
5) Hurricane frequency (although storms are likely to be wetter and stronger)
It's A Record: Hottest September Ever

By LISA PEAKES • OCT 2, 2018

http://wusfnews.wusf.usf.edu/post/its-record-hottest-september-ever
Toxic Algae Blooms Occurring More Often, May Be Caught in Climate Change Feedback Loop


SEA-LEVEL RISE IS AN EXISTENTIAL CLIMATE CHANGE ISSUE FOR MUCH OF FLORIDA...
NOAA: ‘Nuisance flooding’ an increasing problem as coastal sea levels rise

Study looks at more than 60 years of coastal water level and local elevation data changes

July 28, 2014

Eight of the top 10 U.S. cities that have seen an increase in so-called “nuisance flooding”—which causes such public inconveniences as frequent road closures, overwhelmed storm drains, and compromised infrastructure—are on the East Coast, according to a new NOAA technical report.

This nuisance flooding, caused by rising sea levels, has increased on all three U.S. coasts, between 300 and 925 percent since the 1960s.

The report, Sea Level Rise and Nuisance Flood Frequency Changes around the United States, also finds Annapolis and Baltimore, Maryland, lead the list with an increase in number of flood days of more than 920 percent since 1960. Port Isabel, Texas, along the Gulf coast, showed an increase of 547 percent, and nuisance flood days in San Francisco, California increased 364 percent.

“Achieving resilience requires understanding environmental threats and vulnerabilities to combat issues like sea level rise,” says Holly Barnford, Ph.D., NOAA assistant administrator of the National Ocean Service. “The nuisance flood study provides the kind of actionable environmental intelligence that can guide coastal resilience efforts.”

“As relative sea level increases, it no longer takes a strong storm or a hurricane to cause flooding,” said William Sweet, Ph.D., oceanographer at NOAA’s Center for Operational Oceanographic Products and Services (CO-OPS) and the report’s lead author. “Flooding now occurs with high tides in many locations due to climate-related sea level rise, land subsidence and the loss of natural barriers. The effects of rising sea levels along most of the continental U.S. coastline are only going to become more noticeable and much more severe in the coming decades, probably more so than any other climate-change related factor.”

The study was conducted by scientists at CO-OPS, who looked at data from 45 NOAA water level gauges with long data records around the country and compared that to reports of number of days of nuisance floods.
MIAMI BEACH, APRIL 2013

Big Pine Key, FL

September 29, 2015

Photo credit: Greg Corning, provided by Monroe County staff
Nuisance Floods Per Year at Vaca Key (Marathon, FL)

*Nuisance flooding threshold for Monroe County is 1.08 ft above MHHW, as defined by Sweet et al. (2014)

At the time, was the third highest tide on record (since 1935) for this gauge – only exceed by tropical storm surges

Subsequently exceeded by Matthew (2016) and Irma (2017) surges
Data Source: https://tidesandcurrents.noaa.gov/stationhome.html?id=8670870
TYBEE ISLAND, GA: NOVEMBER 14, 2012

**FIGURE 4.6:** STORMWATER DRAIN WITH SALTWATER DISCHARGE DURING KING TIDE, NOVEMBER 14, 2012

**FIGURE 4.7:** SALTWATER FLOODING OF YARDS AND STREETS FROM STORMWATER DRAIN DISCHARGE DURING KING TIDE, NOVEMBER 14, 2012
Stages of Stormwater Infrastructure Failure due to Sea Level Rise

Legend
- Yellow: Ground
- Light Blue: Sky
- Blue: Fresh Water
- Dark Blue: Salt Water
- Gray: Stormwater Drainage Infrastructure

Fully Operating System
Stage 1: Salt Water Plug
Stage 2: Fresh Water Flooding After Precipitation
Stage 3: Salt Water Flooding

Figure by Emily Niederman, Stetson University (Class of 2017)
**WE EXPECT SEA-LEVEL RISE TO ACCELERATE**

**Unified Sea Level Rise Projection**
(Southeast Florida Regional Climate Change Compact, 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>IPCC AR5 Median (inches)</th>
<th>USACE High (inches)</th>
<th>NOAA High (inches)</th>
</tr>
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<tr>
<td>2030</td>
<td>6</td>
<td>10</td>
<td>12</td>
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<tr>
<td>2060</td>
<td>14</td>
<td>26</td>
<td>34</td>
</tr>
<tr>
<td>2100</td>
<td>31</td>
<td>61</td>
<td>81</td>
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The graph shows the projected increase in sea level rise in inches relative to mean sea level from 1992 to 2100. The bars represent the range of projections from IPCC AR5, USACE, and NOAA for different time periods.
BUT....

Very few development decisions being made today in vulnerable coastal communities are considering the consequences of future sea-level rise.
Millions projected to be at risk from sea-level rise in the continental United States

Mathew E. Hauer\textsuperscript{1*}, Jason M. Evans\textsuperscript{2} and Deepak R. Mishra\textsuperscript{3}

Sea-level rise (SLR) is one of the most apparent climate change stressors facing human society\textsuperscript{1}. Although it is known that many people at present inhabit areas vulnerable to SLR\textsuperscript{2,3}, few studies have accounted for ongoing population growth when assessing the potential magnitude of future impacts\textsuperscript{4}. Here we address this issue by coupling a small-area population projection with a SLR vulnerability assessment across all United States coastal counties. We find that a 2100 SLR of 0.9 m places a land area projected to house 4.2 million people at risk of inundation, whereas 1.8 m affects 13.1 million people—approximately three times larger than indicated by current populations. These results suggest that the absence of protective measures could lead to US population movements of a magnitude similar to the twentieth century Great Migration of southern African-Americans\textsuperscript{5}. Furthermore, our population projection approach can be readily adapted to assess other hazards or to model future per capita economic impacts.

Data (that is, elevation and associated flood risk) with small-area population projections developed with a modified version of the Hammer method\textsuperscript{17,18} in a dynamic flood hazard model. By spatially and temporally aligning small-area population projections from coastal states in the continental United States (US) to 2100, we are able to assess who could be at risk from future SLR.

This approach addresses two fundamental questions concerning the vulnerability of future coastal populations in the United States: What are the areas potentially at risk of impact from SLR? and What areas in the US are likely to experience the greatest population exposure to SLR? Accordingly, our results can be used to inform local adaptation infrastructure and growth management strategies, alerting officials to the areas where interventions and policies are most needed.

We assess the populations at risk of SLR by using the National Oceanic and Atmospheric Administration’s (NOAA) 0 m through 1.8 m (6 feet) SLR data sets for twenty-two coastal states and the
POPULATION GROWTH = UNDERESTIMATION OF PROBLEM

# of People Displaced, by State

High sea level rise scenario

Hauer, Evans, & Mishra (2016)
LONG-TERM DECISIONS WITH UNCERTAINTY....

Very few development decisions being made today in vulnerable coastal communities are considering the consequences in a worst-case scenario at 2100.

Uncertainty over such a long time-horizon problematizes making hard decisions today.
“Scientists have very high confidence that global mean sea level will rise at least 8 inches and no more than 6.6 feet by 2100.”

NOAA REPORT, DEC. 2012
Wanda Evans
88 Years Old

Isaac Evans-Levine
88 Years Old in 2100
BIG DIFFERENCE BETWEEN LOW AND HIGH SCENARIO

Unified Sea Level Rise Projection
(Southeast Florida Regional Climate Change Compact, 2015)

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~6.1 million people affected statewide in FL

~1.2 million people affected

So how much will the sea rise?
2 feet above present (0.6 meters)
4 feet above present (1.2 meters)
6 feet above present (1.8 meters)
Recent modeled estimates suggest at least 35 feet of sea-level rise within the next 2,000 years if carbon dioxide emission trajectories continue through 2100.
Anders Levermann <anders.levermann@pik-potsdam.de>

Tue 3/15/2016 1:36 PM

Drs Hauer, Evans and Mishra,
cc Dr Howlett

sorry for being so bland, but I saw your recent paper in Nature Climate Change and was more than surprised to see the reference list. Missing one relevant study is not a crime, but you have missed so many that it is not excusable really. I am cc-ing Dr Howlett to let the chief editor of Nature CC know that there has been a serious gap in your review process here.

This really is a major issue. In addition to the fact that you only use semi-empirical sea-level projections without even discussing the IPCC projections or any other process-based projections.

I appreciate that you have computed this, but I am sorry to say that this is not the kind of standard one is to expect from Nature Climate Change. I will only mention my own studies now, but you have missed much more, while at the same time referenced much stuff that was not necessary.
The last time that atmospheric CO2 concentrations reached over 400ppm was approximately 3.2 MYA, during the Pliocene epoch.

Global sea level during that time was approximately 35-50 meters (~115 – 164 feet) higher than it is right now.
12 feet above present (3.7 meters)
25 feet above present (7.6 meters)
HOW HIGH WILL THE SEA RISE?

http://www.climatescienceandpolicy.eu/wp-content/gallery/csep/plio_2.jpg
HOW HIGH WILL THE SEA RISE?
50 feet above present
(15.2 meters)
125 feet above present (38.1 meters)
175 feet above present (53.3 meters)
BUT BACK TO WHERE WE ARE TODAY…
WHAT ARE YOU GOING TO BUILD?

“Risk-based” scenario planning for sea-level rise…
THINKING IT THROUGH SOME MORE:
HOW AND WHEN ARE WE GOING TO CLEAN UP THE MESS? (OR WILL WE?)

Holland Island,
Chesapeake Bay
WHAT ARE COMMUNITIES DOING?

$500 million in Miami Beach alone for pumps, stormwater upgrades, and elevating roads over the past 3-4 years.
Emily rain pounds South Florida and Beach pumps fail without power

BY JOEY FLECHAS, SAMANTHA J. GROSS AND BROOKE HENDERSON
jflechas@miamiherald.com
AUGUST 01, 2017 9:11 PM

As remnants of Tropical Storm Emily dumped several inches of rain across Miami-Dade County on Tuesday afternoon, stormwater pumps in Miami Beach were found to have one crucial shortcoming: no backup generators in case of, well, a power outage during a storm.

The Sunset Harbour neighborhood saw flooding amid heavy rains Tuesday that knocked out power for a time, leaving two pumps meant to drain the area offline for about 50 minutes—a glaring weakness not yet addressed by the city’s upgraded drainage system.

“We’re going to be installing permanent generators,” Beach spokeswoman Tonya Daniels said Tuesday after the flood.

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Miami Beach king tides flush human waste into bay, study finds

BY JENNY STALETOVICH
jstaletovich@miamiherald.com
MAY 16, 2016 7:12 PM

Massive pumps that flush floodwater from Miami Beach into Biscayne Bay during seasonal king tides are dumping something else into the bay: human waste.

A study that looked at tidal floodwater and water discharged from the island’s new pumps during the 2014 and 2015 king tides found live fecal bacteria well above state limits. In one case, levels were more than 600 times the limit. While some of the fecal matter was dog
Miami Beach will have to replace parts of its Indian Creek Drive seawall after it was discovered certain sections were unpermitted and noncompliant with county and state regulations. Alex Harris - aharris@miamiherald.com

MIAMI BEACH

Oops. Miami Beach built a seawall without a permit and may have to tear it down


Fired Miami Beach engineer who skirted environmental regulations won’t lose his license

Mowry “either had a blatant disregard for the requirements of the environmental regulatory agencies or developed an adversarial relationship with regulatory agencies and residents.” city attorney

WHAT ABOUT THE DUTCH?

Chapter 1, Article 21 of the Dutch constitution: "It is the concern of the authorities to keep the country habitable and to protect and improve the environment."
The Dutch Can’t Save Us From Rising Seas

Dutch engineers are renowned for their ability to keep cities dry. But their approach doesn’t necessarily translate to an American context.

OCT 17, 2018

BILLY FLEMING
Ian L. McHarg Center, University of Pennsylvania School of Design

City of Satellite Beach City Manager
August 6, 2014

STORMWATER RATES: the Florida Today has an article in today’s paper regarding the need for the County and cites to increase stormwater utility rates for lagoon water quality projects. Stormwater utility rates are used for drainage, flooding, and water quality projects that remove nutrients and pollutants from stormwater before they enter our adjacent water bodies. The article in today’s paper did not mention Satellite Beach. I wanted to inform our residents that our City Council held a workshop on July 25, 2014 regarding stormwater rates and have provided general direction to staff to prepare the necessary documents for final approval on August 20, 2014 (regular City Council meeting at 7pm) to increase our rates from $65 per residence per year, to $85 per residence per year (and possibly $104 per residence per year). This fee is paid on your tax bill, and the increase would represent approximately $1.60 per month. The City has major needs for pipe replacement and we must meet state requirements for the Basin Management Action Plan. You can review the staff presentation to the City Council regarding the state of our stormwater system and the stormwater utility’s financial status on our website:
http://www.satellitebeachfl.org/Pages/CouncilMinutes.aspx
Go to the July 25, 2014 Presentation item under Agendas.

And, of course, please call me if you have any questions: 321-773-4407.
All Florida communities, even those not along the coast, will be dramatically affected by the large-scale social impacts from sea-level rise and coastal flooding.
NATIONAL FLOOD INSURANCE PROGRAM:
~$36 BILLION IN DEBT
EXPOSED COASTAL PROPERTIES: ~$1.1 TRILLION

Flood insurance problem: same houses, over and over

By Jed Rita
September 01, 2016 | 9:50 AM

http://www.marketplace.org/2016/08/31/sustainability/flood-study
LET’S ASSUME A BAD FUTURE SCENARIO…

Where are these people going to go?
# Projections of Flood-Induced Migration to 2100 (High Sea-Level Rise)

Figures and results from Dr. Mathew Hauer, Florida State University

<table>
<thead>
<tr>
<th>Rank</th>
<th>County</th>
<th>SLR In Migration</th>
<th>SLR Out Migration</th>
<th>SLR Net Migration</th>
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<tr>
<td>1</td>
<td>Travis County, TX</td>
<td>810,981</td>
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<td>2</td>
<td>Harris County, TX</td>
<td>325,481</td>
<td>30,000</td>
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<th>SLR Out Migration</th>
<th>SLR Net Migration</th>
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<td>Austin-Round Rock, TX</td>
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<td>Atlanta-Sandy Springs-Roswell, GA</td>
<td>331,048</td>
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</tbody>
</table>
The potential for even faster in-migration to inland regions of central Florida has important implications for the sustainability of water resources and remnant natural ecosystems.
18.8 million people

~2.2 million in metro Orlando counties

University of Florida GeoPlan Center (2016)
33.7 million people

~4.9 million in metro Orlando counties

University of Florida GeoPlan Center (2016)
~2.2 million in metro Orlando counties

Statewide 2010 Baseline
(Total demand by census block in gallons per day per acre)

This map uses a mathematically-generated geometric scale to better visualize the results due to the wide range of values. Each category has roughly the same number of data entries.
~4.9 million in metro Orlando counties

Statewide 2070 Trend
(Total demand by census block in gallons per day per acre)

This map uses a mathematically-generated geometric scale to better visualize the results due to the wide range in values. Each category has roughly the same number of data entries.
We have a moral obligation to engage with the complexity, come to grips with the climate change crisis, and – in the process – reclaim Florida’s water resources for the benefit of current and future generations.