Adaptation in a Sea of Uncertainty

Stormwater outfalls, Satellite Beach, FL

July 19, 2016

Photo by Emily Niederman

Sea Level Rise Planning at the Local Level

Jason M. Evans, Ph.D.
Assistant Professor of Environmental Science
Stetson University

May 11, 2017
Sea-Level Rise:
Assessing and Addressing Flooding and Liability for Local Governments
Largo, FL

Sea Grant

STETSON UNIVERSITY

Assertion #1

Climate change adaptation is one of the most complex and daunting challenges ever faced by human civilization.

Media Contact

» Ben Sherman, NOAA, 301-713-3066

» Linda Austin, NOAA CO-OPS, 301-713-2981 ext.126, 301-802-9710 (cell)

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.

Annapolis, Maryland, pictured here in 2012, saw the greatest increase in nuisance flooding in a recent NOAA study. (Credit: With permission from Amy McGovern.)

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 Bamford, 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.

News release on July 28, 2014

Miami Beach

http://s13.therealdeal.com/trd/m/up/2013/07/Miami-flooding-4-13-13.jpg.jpg

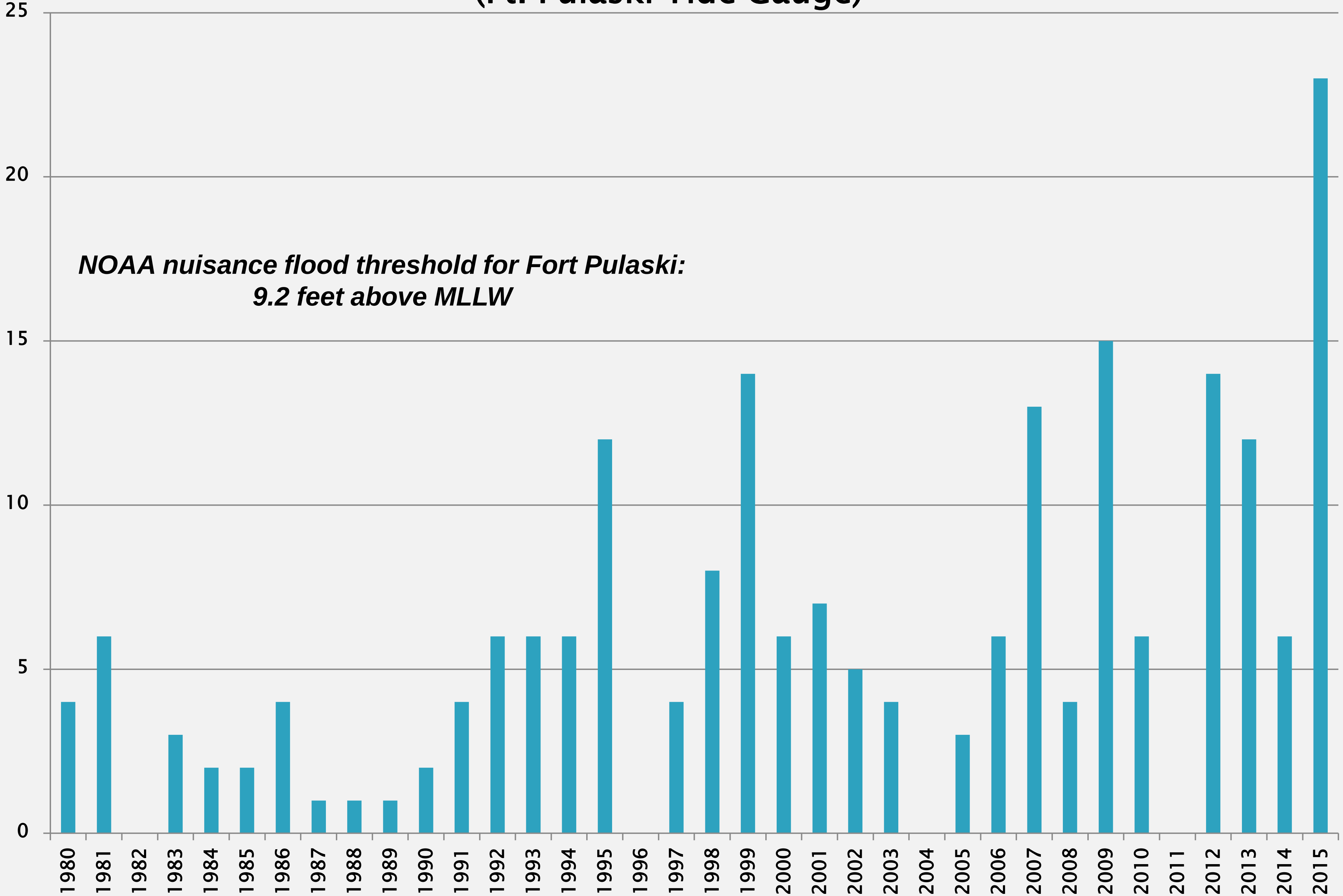
Tidal flooding on Tybee Island, GA
US Highway 80
October 27, 2015

http://sav-cdn.com/sites/default/files/imagecache/superphoto/14845662.jpg

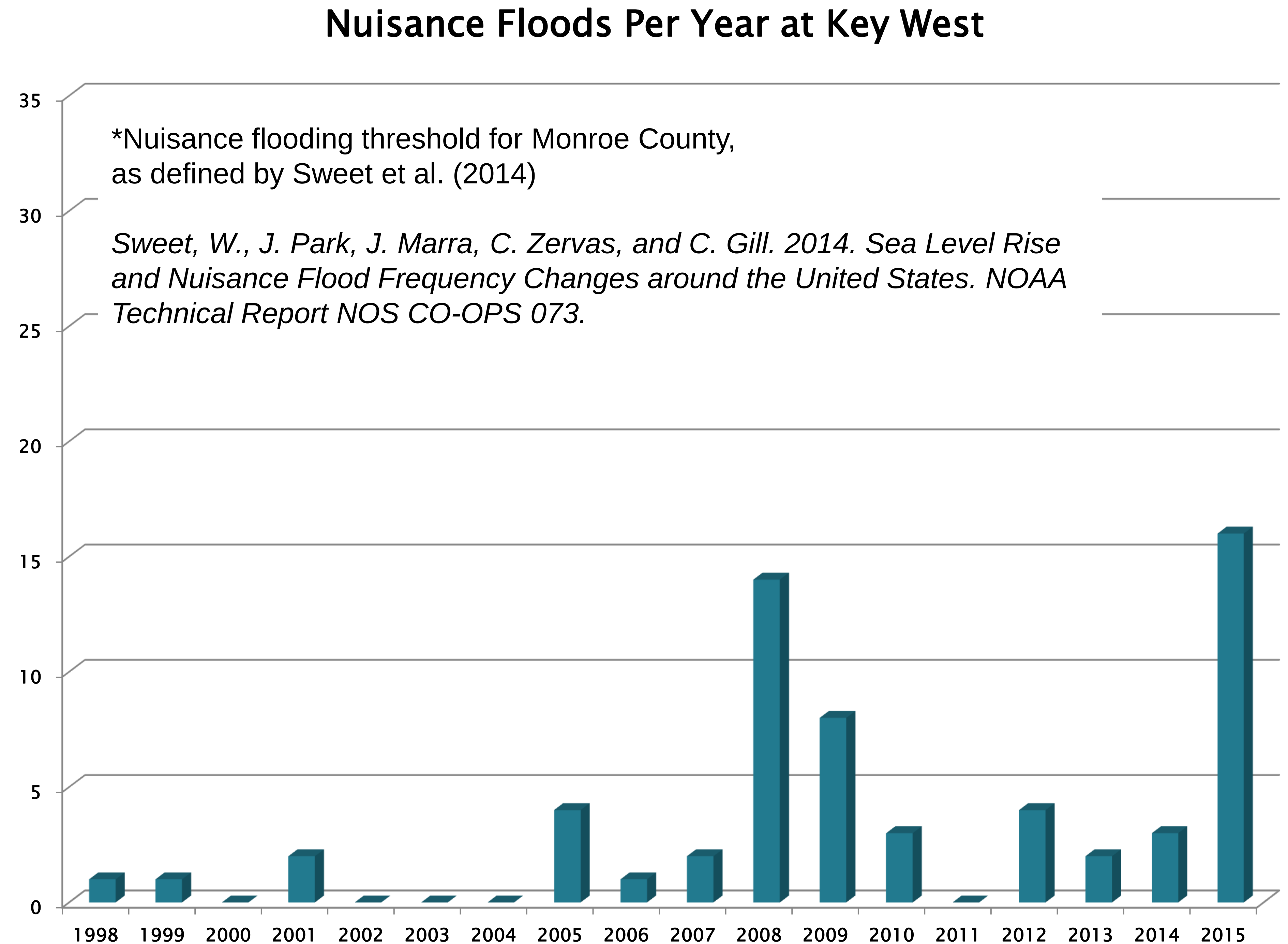
Third highest tide on record (since 1935) for this gauge

Only exceeded by tropical storm surges

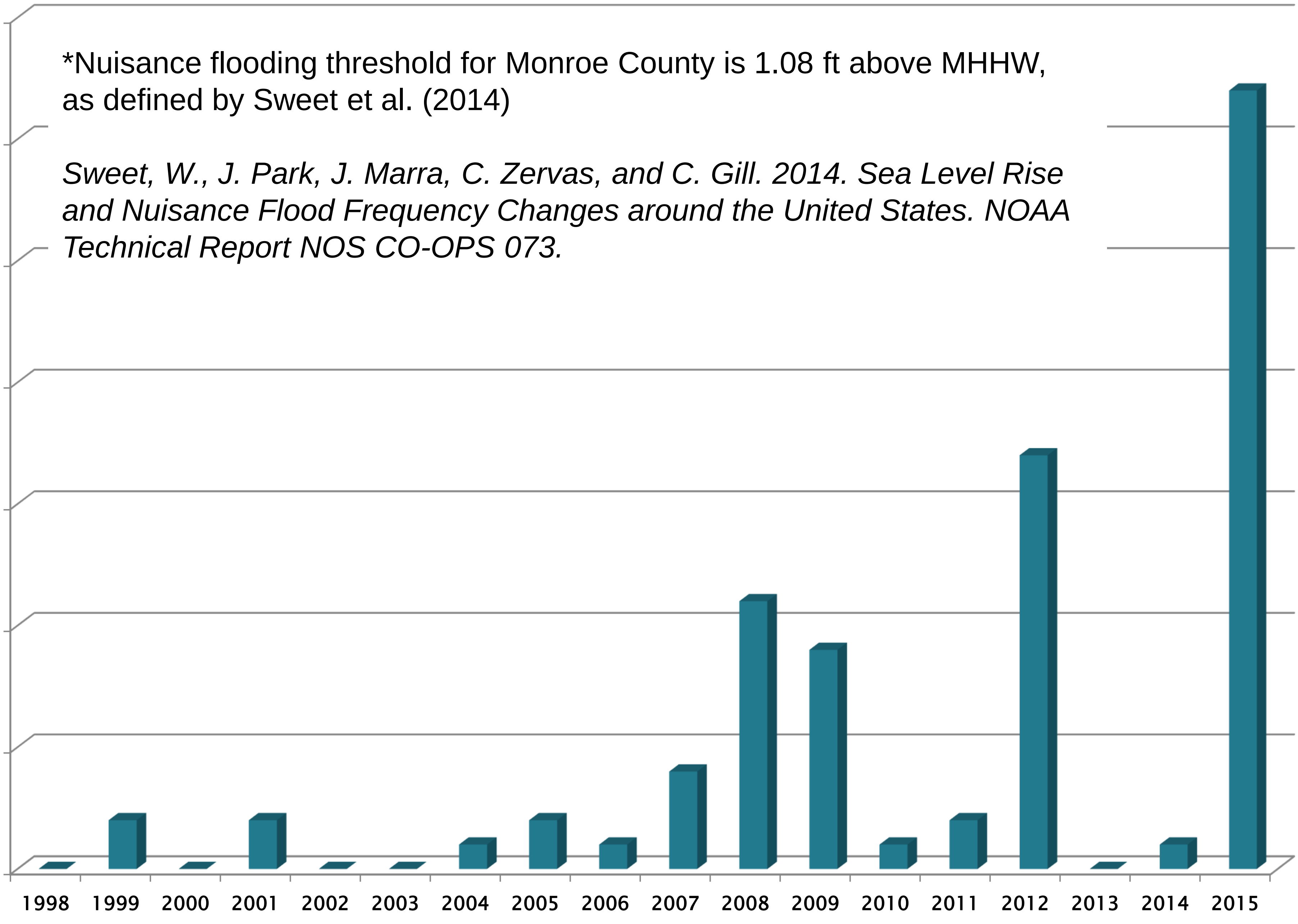
Nuisance Floods by Year at Tybee Island, GA
(Ft. Pulaski Tide Gauge)



Data Source: https://tidesandcurrents.noaa.gov/stationhome.html?id=8670870


Nuisance Floods Per Year at Key West
*Nuisance flooding threshold for Monroe County,
as defined by Sweet et al. (2014)
Sweet, W., J. Park, J. Marra, C. Zervas, and C. Gill. 2014. Sea Level Rise and Nuisance Flood Frequency Changes around the United States. NOAA Technical Report NOS CO-OPS 073.
0
5
10
15
20
25
30
35
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

Nuisance Floods Per Year at Vaca Key (Marathon, FL)



Assertion #2

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

nature climate change

LETTERS

PUBLISHED ONLINE: 14 MARCH 2016 | DOI: 10.1038/NCLIMATE2961

Millions projected to be at risk from sea-level rise in the continental United States

Mathew E. Hauer[1*], Jason M. Evans[2] and Deepak R. Mishra[3]

Sea-level rise (SLR) is one of the most apparent climate change stressors facing human society[1]. Although it is known that many people at present inhabit areas vulnerable to SLR[2,3], few studies have accounted for ongoing population growth when assessing the potential magnitude of future impacts[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[5]. Furthermore, our population projection approach can be readily adapted to assess other hazards or to model future per capita economic impacts.

Sea-level rise is widely recognized as one of the most likely and socially disruptive consequences of future climate change[2]. Scenarios of future SLR at the year 2100 range from a low of 0.3 m to a high scenario of 2.0 m associated with collapse of polar ice sheets[3]. Understanding the specific locations at risk of SLR impacts is a high priority in climate change research[6] and adaptation planning[7,8].

Although there is growing worry and debate that climate change could cause widespread human migration over the next century[2,9,10], relatively few studies have attempted to merge climate change scenarios with population growth trends and projections in high-risk areas (however, see ref. 11). Notably, several previous studies

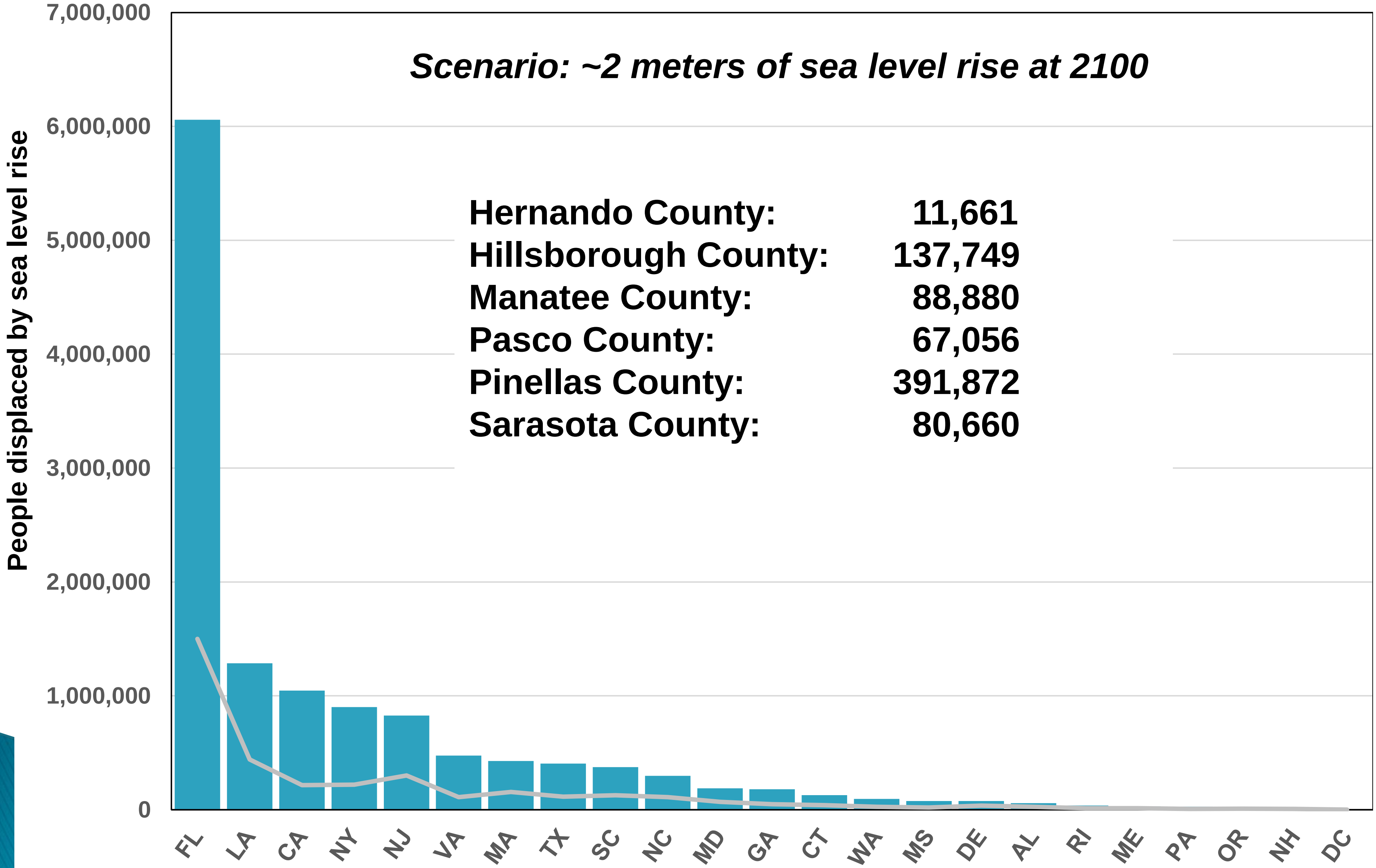
data (that is, elevation and associated flood risk) with small-area population projections developed with a modified version of the Hammer method[17,18] in a dynamic flood hazard model. By spatially and temporally aligning small-area population projections from coastal states in the continental United 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: How many people are 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 District of Columbia[19]. These data sets simulate expected changes in the mean higher high water (MHHW) mark on areas that are hydrologically connected to coastal areas, without taking into account additional land loss caused by other natural factors such as erosion. Notably, the state of Louisiana was not included in the data set at the time of analysis owing to local hydrologic complexities associated with coastal levees and accelerated land subsidence; however, we have recreated NOAA's hydrologic connectedness approach for Louisiana using USGS's National Elevation Dataset (NED) (Methods).

We used a linear/exponential extrapolation approach for

Population growth = Underestimation of problem



Assertion #2

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

This is understandable – even appropriate – given uncertainty about the future over such a long time-horizon.

"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

Garden Shed or Nuclear Power Plant?

“Risk-based” scenario planning for sea-level rise…

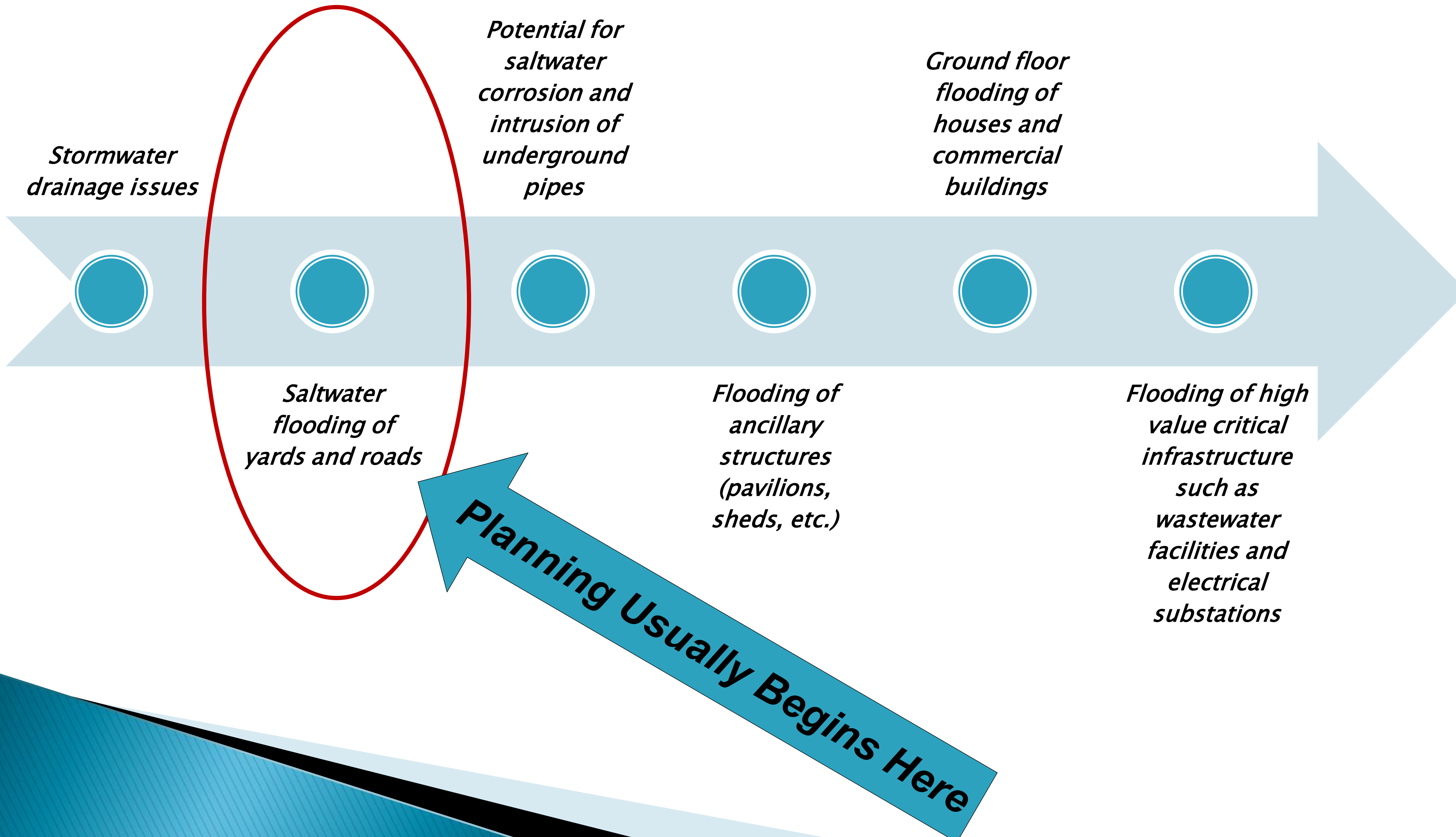
http://www.homebase.co.uk/cmsresource/image/42316/landscape_ratio3x2/440/300/563f6a641d7134842bc93d991c4fa65a/zj/how-to-erect-a-shed---header-image.jpg

https://nuclear.gepower.com/content/dam/gepower-nuclear/global/en_US/images/hero-images/Nine-Mile-Point-Nuclear-Plant-cropped.jpg

Assertion #3

People start to really take notice when roads start flooding on a sunny day.

General Timeline of Sea Level Rise Impacts on the Built Environment



Tidal flooding on Tybee Island, GA
US Highway 80
October 27, 2015

http://sav-cdn.com/sites/default/files/imagecache/superphoto/14845662.jpg

Third highest tide on record (since 1935) for this gauge

Only exceeded by tropical storm surges

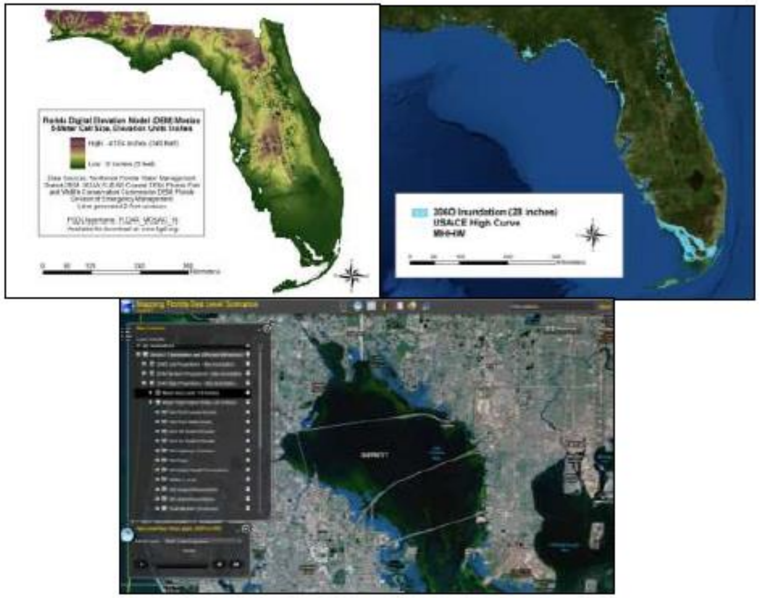
September 29, 2015

Photo credit: Greg Corning, provided by Monroe County staff

Based on FDOT Sea Level Rise Sketch Tool *

Developed by University of Florida

DEVELOPMENT OF A GEOGRAPHIC INFORMATION SYSTEM (GIS) TOOL FOR THE PRELIMINARY ASSESSMENT OF THE EFFECTS OF PREDICTED SEA LEVEL AND TIDAL CHANGE ON TRANSPORTATION INFRASTRUCTURE



FDOT Contract# BDK75 977-63
September 2013
Final Report

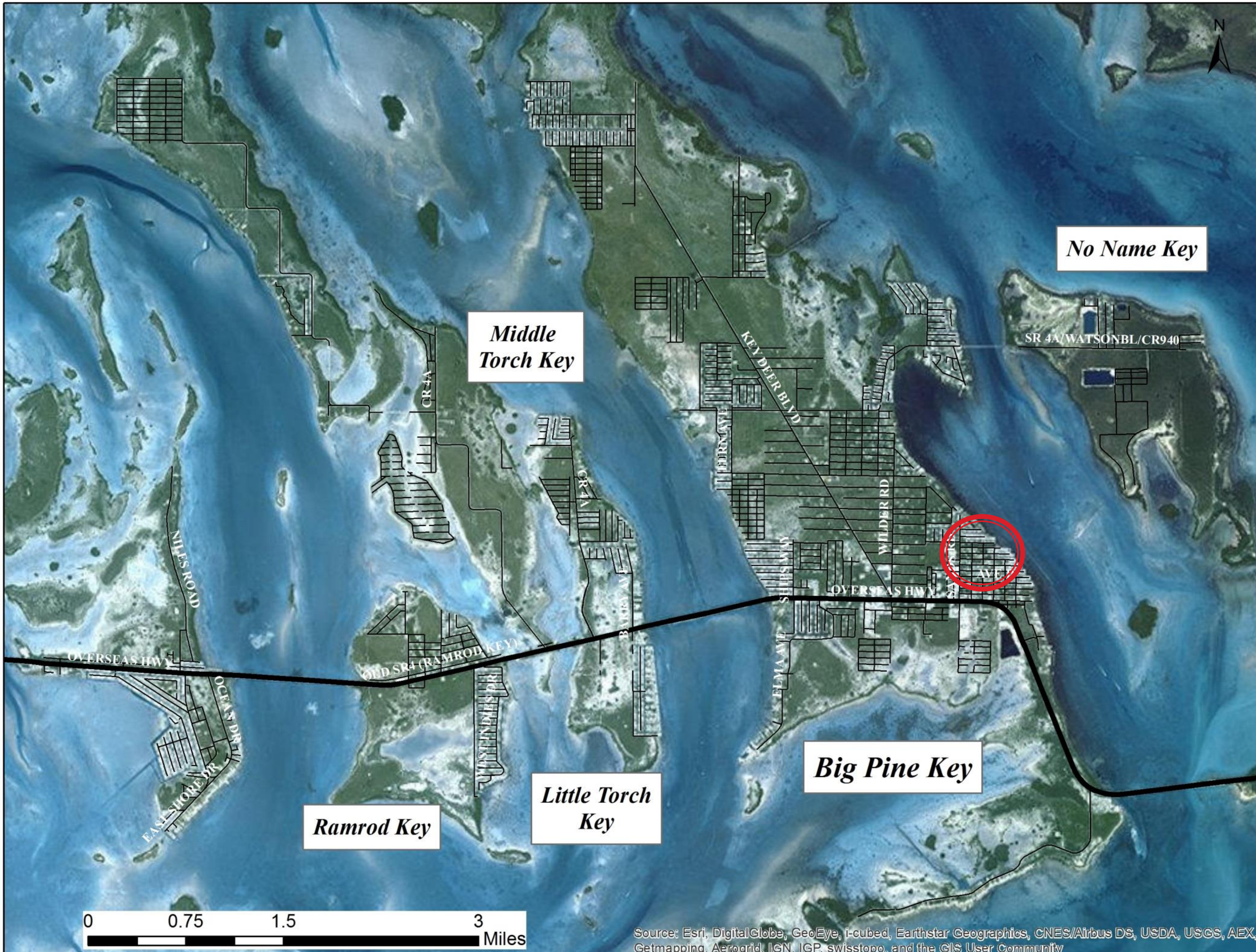
UF UNIVERSITY of FLORIDA

Prepared by
Alexis Thomas
Dr. Russell Watkins
The GeoPlan Center
Department of Urban & Regional Planning
University of Florida

Funded by
Florida Department of Transportation

http://sls.geoplan.ufl.edu/documents-links/

**General planning assessment tool requires additional data for use in site-level decisions*

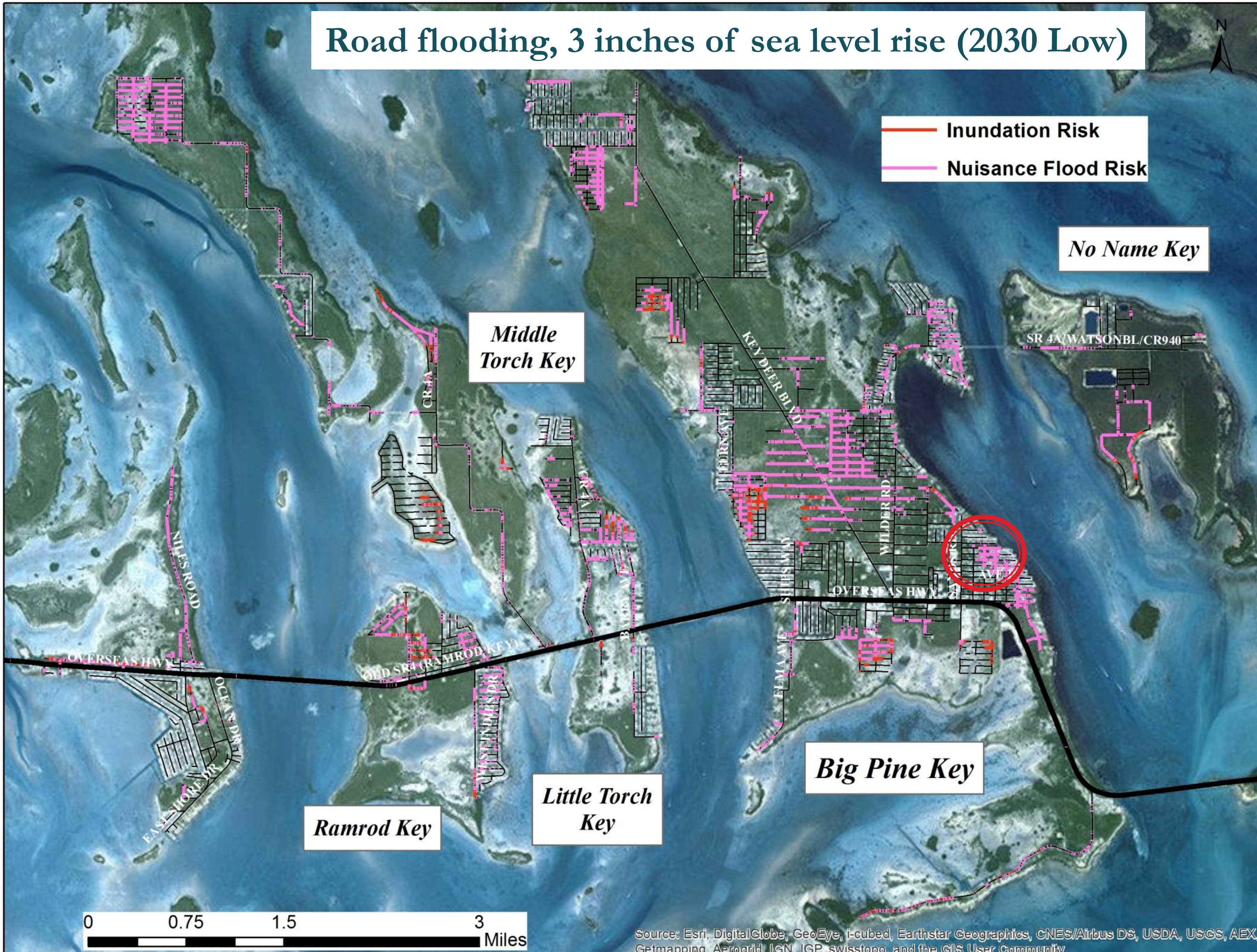


N
No Name Key
SR 4A/WATSONBL/CR940
Middle
Torch Key
KEY DEER BLVD
CR 4A
CR 4A
WILDER RD
AVE
OVERSEAS HWY
OVERSEAS HWY
NILES ROAD
OCEAN DR
EAST SHORE DR
OLD SR4 (RAMROD KEY)
ELMA AVE
Big Pine Key
Little Torch
Key
Ramrod Key
0
0.75
1.5
3
Miles
Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

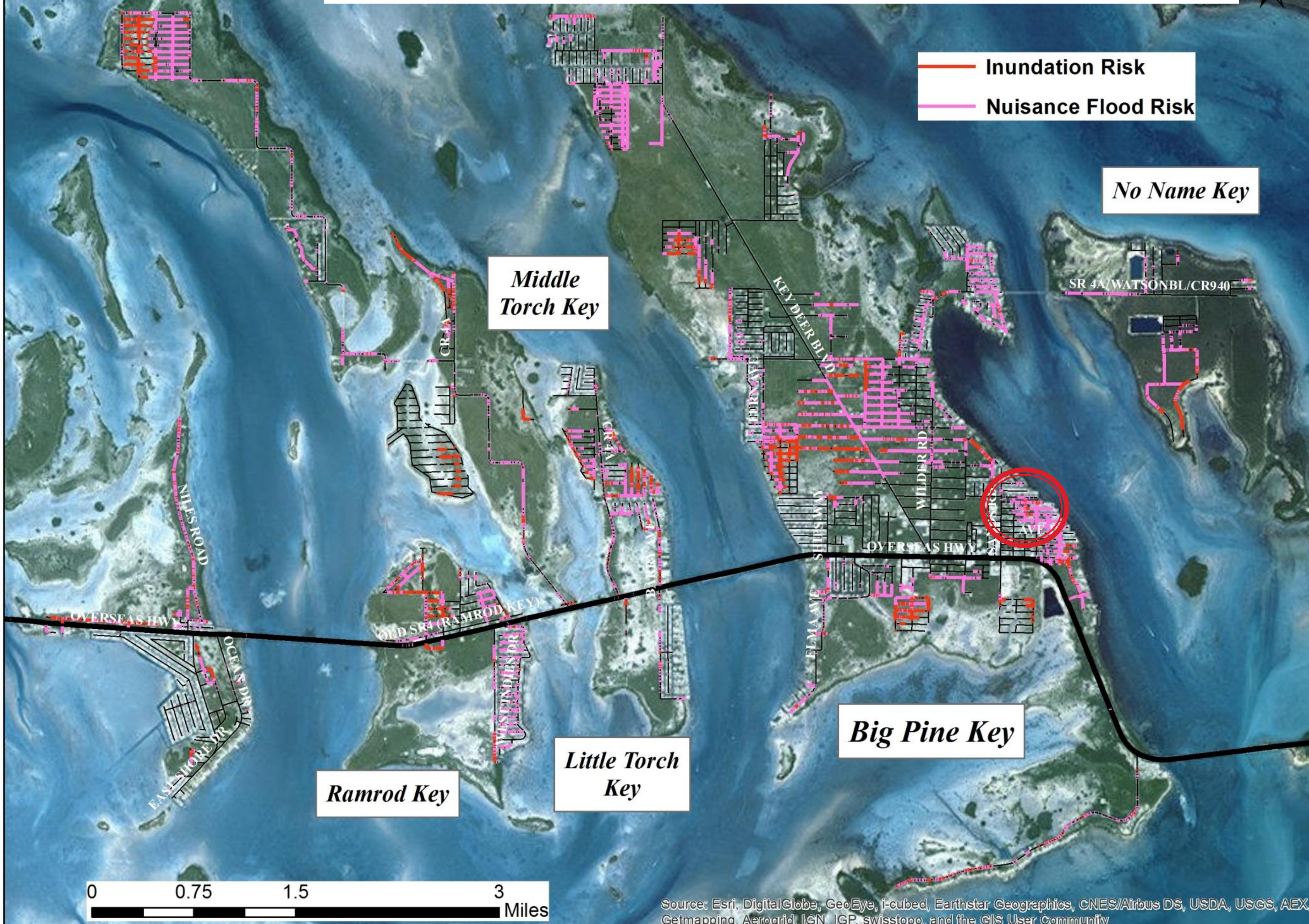
September 29, 2015

Photo credit: Greg Corning, provided by Monroe County staff

Road flooding, 3 inches of sea level rise (2030 Low)



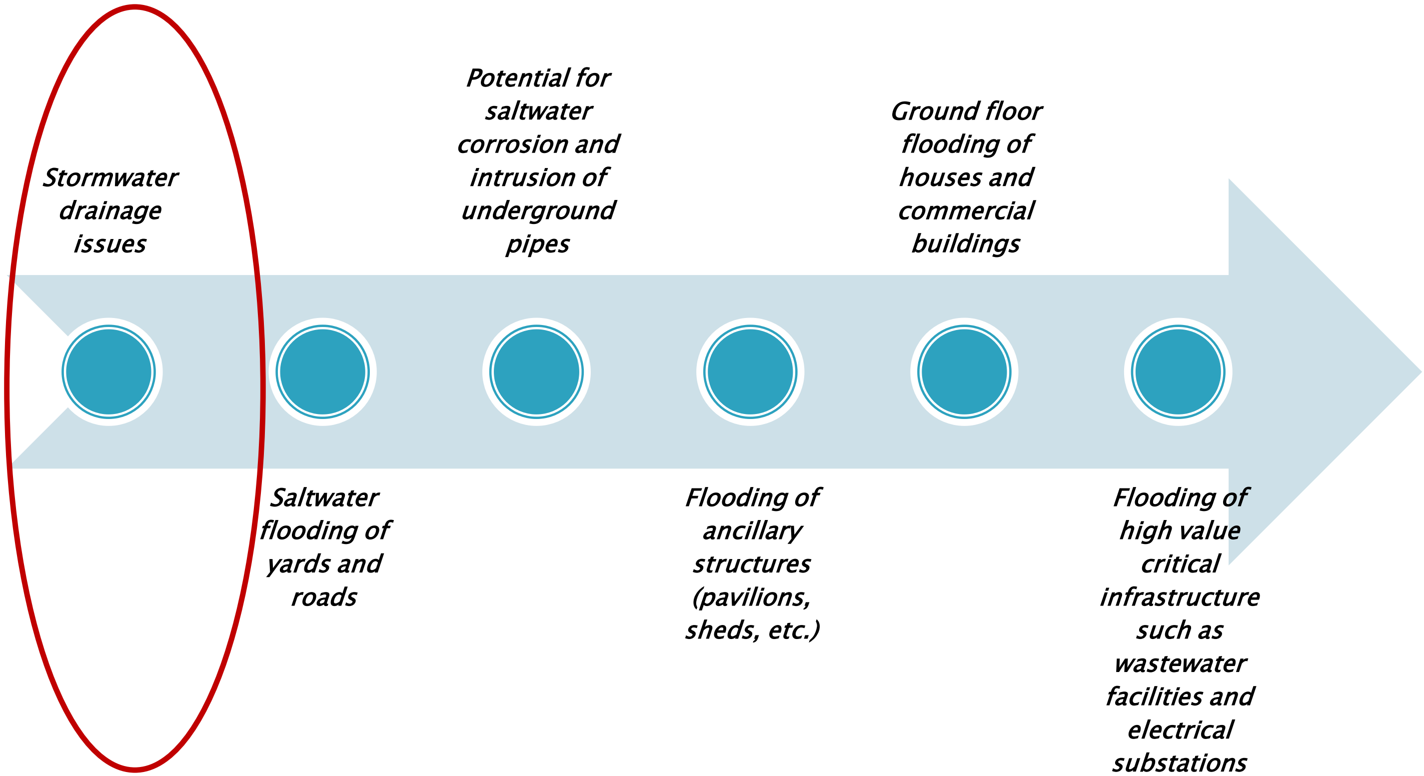
Road flooding, 7 inches of sea level rise (2030 High)



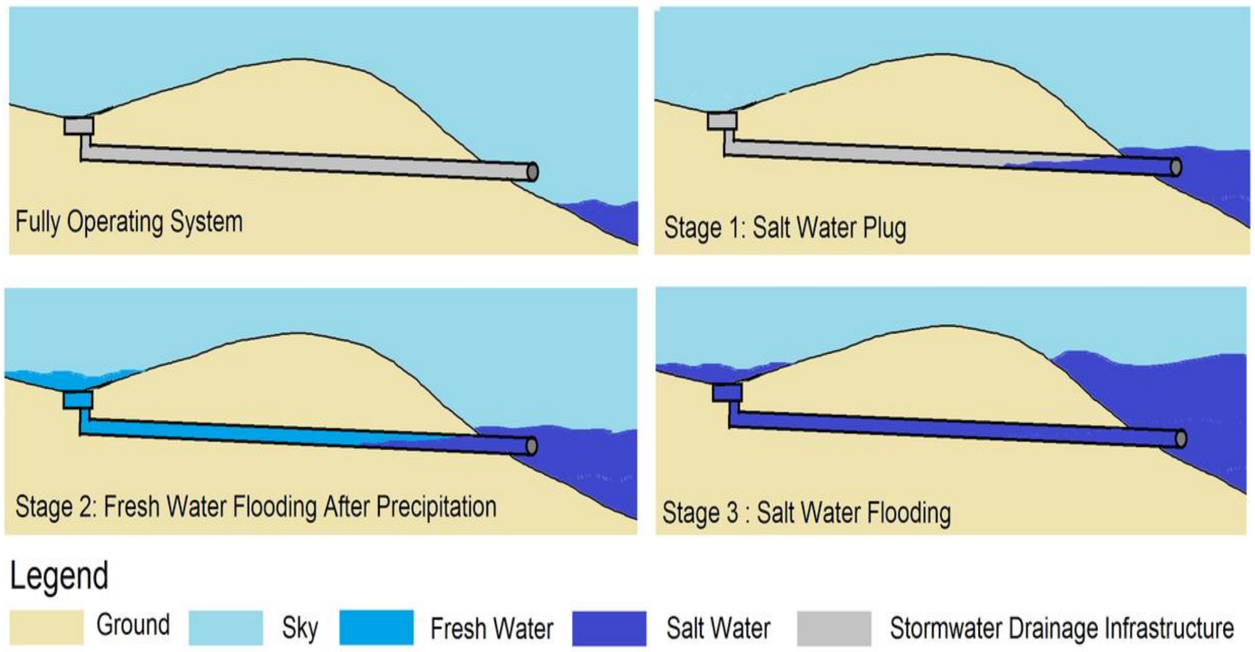
Assertion #4

Almost all coastal communities in the coastal southeast, even those not yet seeing dramatic direct saltwater flooding from king tides, are already being impacted by various stormwater drainage issues and failures.

General Timeline of Sea Level Rise Impacts on the Built Environment



Stages of stormwater failure with sea-level rise



Graphic by Emily Niederman, Stetson University

SW Tybee Island: November 14, 2012

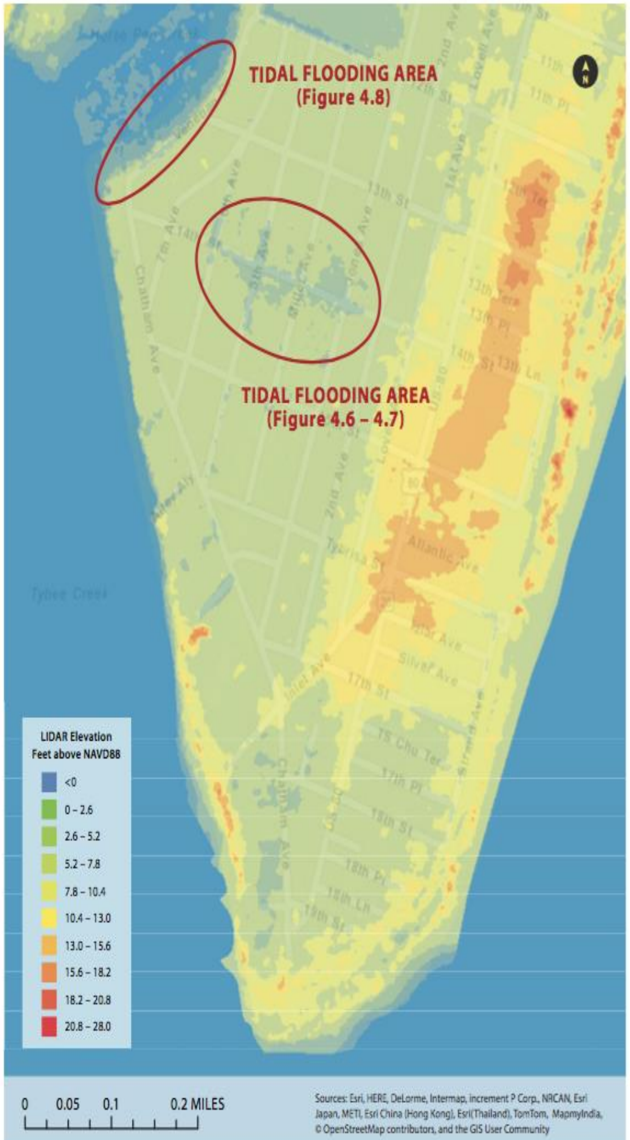


FIGURE 4.6: STORMWATER DRAIN WITH SALTWATER DISCHARGE DURING KING TIDE, NOVEMBER 14, 2012

FIGURE 4.7: SALTWATER FLOODING OF YARDS AND STREETS FROM STORMWATER DRAIN DISCHARGE DURING KING TIDE, NOVEMBER 14, 2012

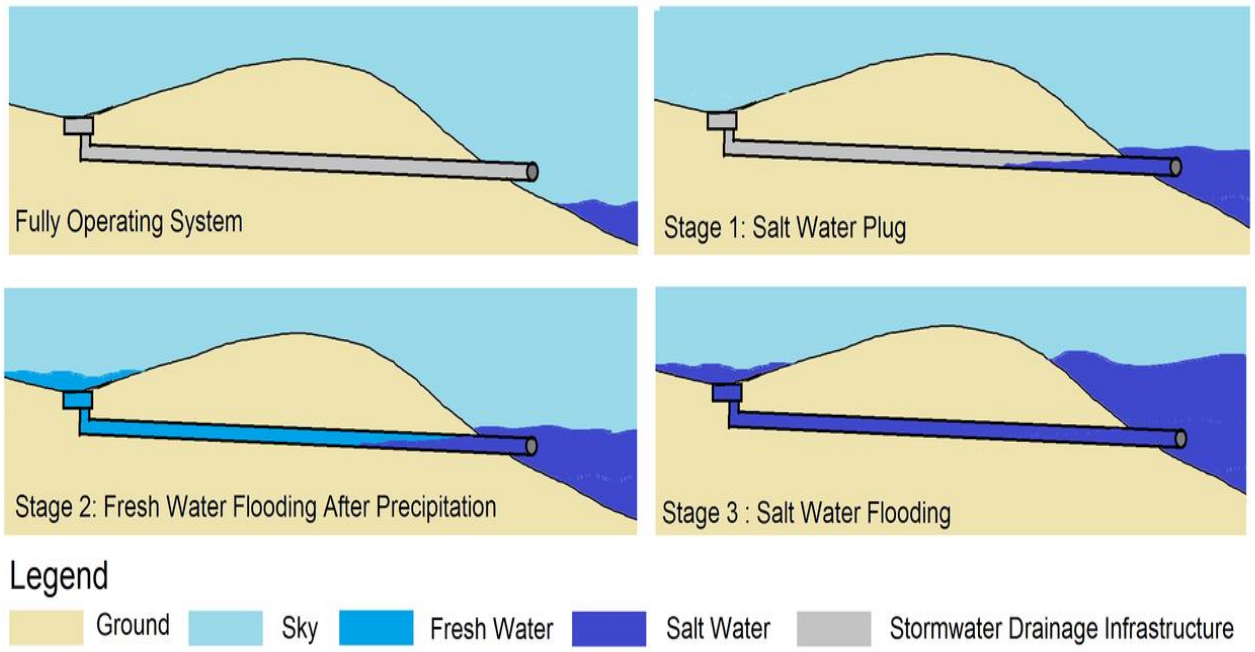
SW Tybee Island: Local Government Action

Action: Stormwater backflow preventers and pipe enlargement

~$3 Million Investment

L BACKFLOW PREVENTERS, NEAR INTERSECTION OF 14TH ST. AND VENETIAN DR.

Stages of stormwater failure with sea-level rise



Graphic by Emily Niederman, Stetson University

Stages of stormwater adaptation

1) Systematically documenting stormwater drainage failures, s
2) Digital mapping of
   a) Outfall and infall po
   b) Pipe extents
   c) Invert elevations
3) Near-term retrofit
   a) Backflow preventers
   b) Decrease run-off co connectivity
4) Long-term retrofit
   a) Increase pipe sizes
   b) Green infrastructure
   c) Pumps

More expensive further down the list!

Long-term and dedicated funding mechanisms very much implied

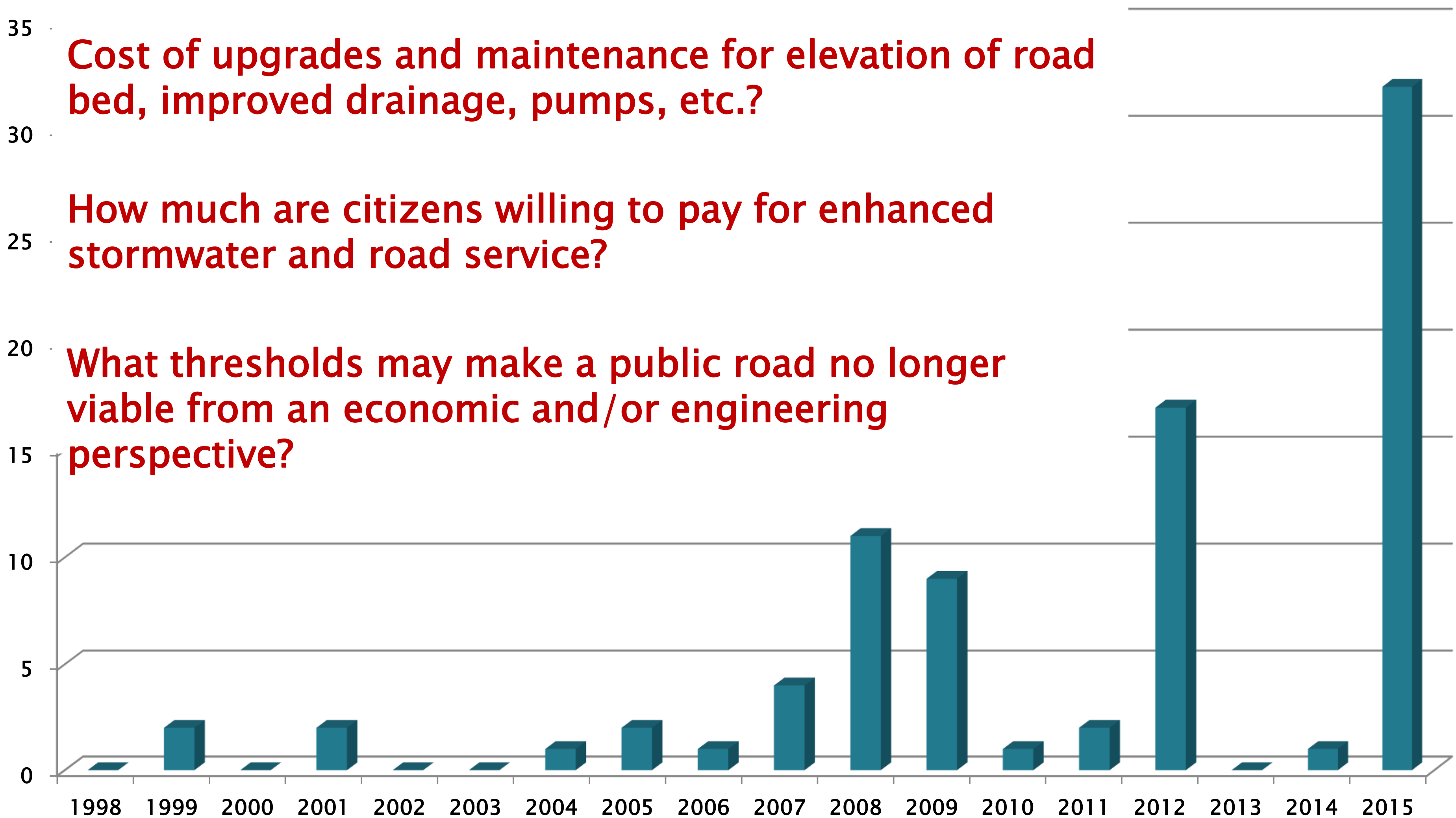
Modeling: More Accurate by the Day Policy Framing: Much More Difficult

What is an appropriate level of service for maintaining stormwater and roads under sea level rise?

Cost of upgrades and maintenance for elevation of road bed, improved drainage, pumps, etc.?

How much are citizens willing to pay for enhanced stormwater and road service?

What thresholds may make a public road no longer viable from an economic and/or engineering perspective?



Thanks and acknowledgments

Monroe County, FL BOCC and staff

Tybee Island, GA City Council and staff

Satellite Beach, FL City Council and staff

University of Florida GeoPlan: Crystal Goodison

University of Georgia: Mathew Hauer, Jill Gambill, Dr. Mark Risse, , Dr. Charles Hopkinson, Maddie Russell

Stetson University undergraduates: Emily Niederman, Justin Baumann, Zella Conyers, Alex Clark, Enric Cordoba, George Winsten

Sea Grant Florida Sea Grant Georgia The Nature Conservancy Protecting nature. Preserving life.™ Erin L. Deady, P.A. Islamorada Village of Islands Monroe County Green Keys! Stetson University