Sea Level Rise Concerns and Risk Informed Decision Making for Florida

Northeast Florida Regional Council

January 16, 2013 Jacksonville, FL

Glenn B. Landers, P.E.

Planning and Policy Division
Jacksonville District

Presentation Outline

- USACE National Program on Global Change
- Climate Change Concerns for Florida
- Sea Level Change (SLC) through Geologic Time
- USACE SLC Guidance
- Florida SLC concerns and examples
- Risk Informed Planning and Decision Making
- Discussion

USACE Mission Areas

- Navigation
  - Breakwaters and Jetties
  - Harbors
  - Navigation Channels and Ocean Disposal Sites
- Hydropower
- Reservoir Regulation; Water Supply
- Coastal Storm Damage Reduction
  - Beach fills
  - Shoreline protection structures
- Flood Damage Reduction
  - Dams, levees, floodwalls
- Ecosystem Restoration
- Emergency Response
- Recreation
- Regulatory

Climate change has the potential to impact all USACE mission areas

Procedures to Evaluate Sea Level Change Impacts, Responses, and Adaptation

Civil Works Technical Letter Team

USGS (Robert Thieler, Nate Plant, Jeff Williams)
NOAA (Steve Gill, Billy Sweet, Kristen Tronvig, Carolyn Lindley)
Navy (Tim McHale, Shun Ling)
Bureau of Reclamation (Mike Tansey)
FEMA (Mark Crowell , Tucker Mahoney)
NPS (Rebecca Beavers, Maria Honeycutt, Jodi Eshleman)
US Naval Academy (Dave Kriebel)
FHWA (Kevin Moody)
Moffatt & Nichol (John Headland)
HR Wallingford, UK (Jonathan Simm, Peter Hawkes)
University of Southampton, UK (Robert Nicholls)

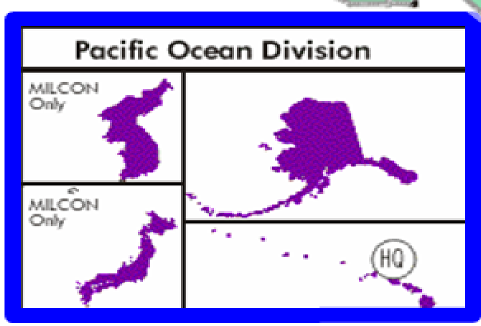
Heidi Moritz, NWP
Team Lead for Engineering
Bernie Hargrave, NWS
Jeffrey Dillon, NWS

Tom Kendall, SPD

Mike Mohr, LRB

John Winkelman, NAE
Jeff Gebert, NAP
Larry Cocchieri, NAD and PCX
Chris Spaur, NAB

Henri Langlois, IWR
Team Lead, Planning
Jeff Arnold, IWR
Brian Harper, IWR
Rolf Olsen, IWR
Kate White, IWR
Andy Garcia, HQ



Mike Wutkowski, SAW

Matt Schrader, SAJ
Glenn Landers, SAJ
Mark Shafer, SAJ

Susan Rees, SAM
Dennis Mekkers, SAM
Patrick O'Brien, MVD

Julie Rosati, ERDC
Kevin Knuuti, ERDC

Justo Pena, SWG

Tom Smith, POH
Crane Johnson, POA

SLC CWTL is part of an integrated programmatic effort - some elements are shown here

IPET/HPDC Lessons Learned Implementation Team (FY06…)

Responses to Climate Change (FY10 -14)

Global Change Sustainability (FY11-20)

Nationwide Datum Standard EC, ER, EM, Comprehensive Evaluation of Project Datums

Engineer Circular 1165-2-211

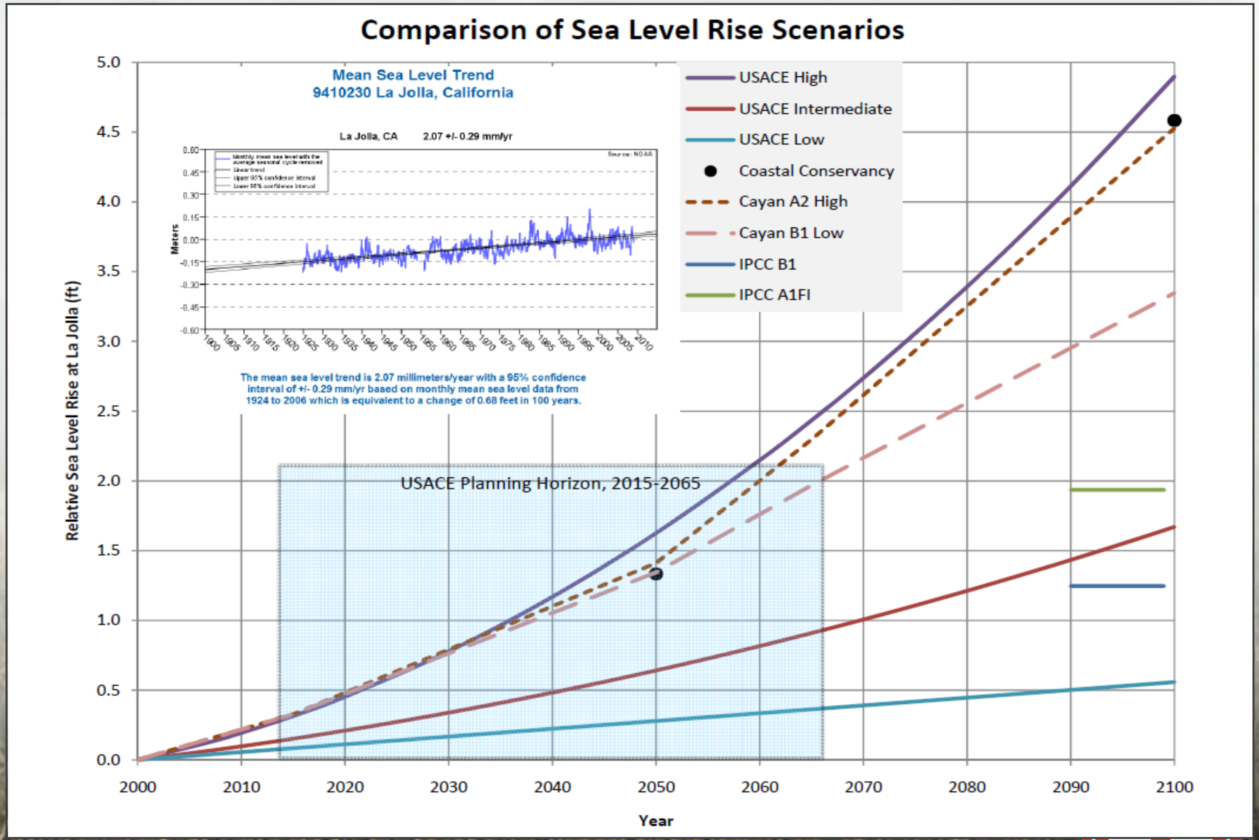
Engineer Circular 1165-2-212

Sea-Level Change Civil Works Technical Letter

Comprehensive Evaluation of Projects With Respect to Sea Level Change

EC 1165-2-212 Incorporating Sea Level Change Considerations in Civil Works Programs

- Three estimates of future SLC must be calculated for all Civil Works Projects within the extent of estimated tidal influence:
  - Extrapolated trend
  - Modified NRC Curve I
  - Modified NRC Curve III
- Requires creativity, funds to evaluate options



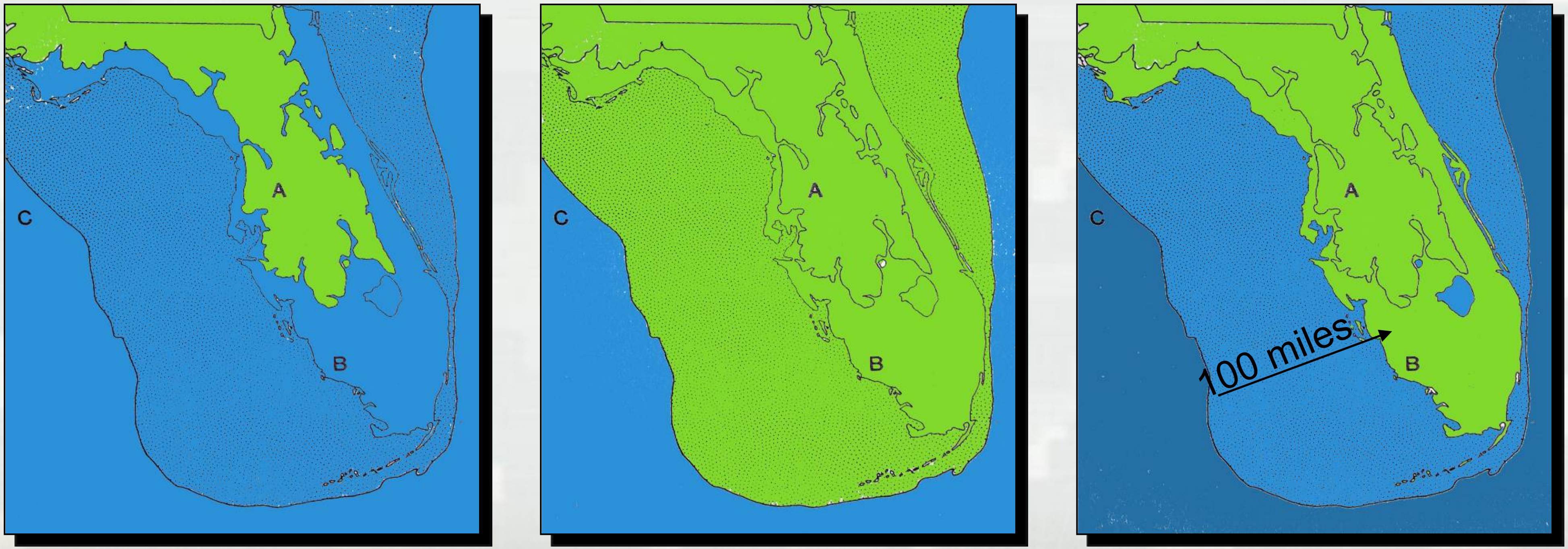
SLC Civil Works Technical Letter

- Utilize **national interdisciplinary team** within Corps and include outside agency experts, addressing **full range of Corps missions and project types**
- Convey to the field the **level of detail** required as a function of project type, planning horizon, and potential consequences
- Identify the **potential for adaptation** throughout project life or project phasing
- Develop a **road map that lays out the engineering and planning procedur**e for full range of projects
- Develop **region-by-region information** and examples
- Include tools that can be used to address **sensitivity and communicate risk**

Climate Change Concerns for Florida

- **Sea Level Rise**
  - Salinity changes in coastal bays, plus tidally influenced creeks and rivers
  - Shoreline retreat with natural habitat changes/losses
  - Increasing flood frequency and depth in coastal areas
  - Saltwater intrusion in water supply wells, OR higher canal stages and flood risks
  - Uncertainties and risks in rate and depth of sea level rise
- **Warmer Temperatures**
  - Evaporation losses up; water supply down
  - Stresses on plant, animal, and marine ecosystems
  - Changes in growing season and migratory patterns
  - Changes in water quality
- **Hydrologic Pattern Changes**
  - Potential for less frequent and more intense rain events
  - Potential increased tropical storm intensity or frequency

Florida Through Time – Sea Level Change Happens!



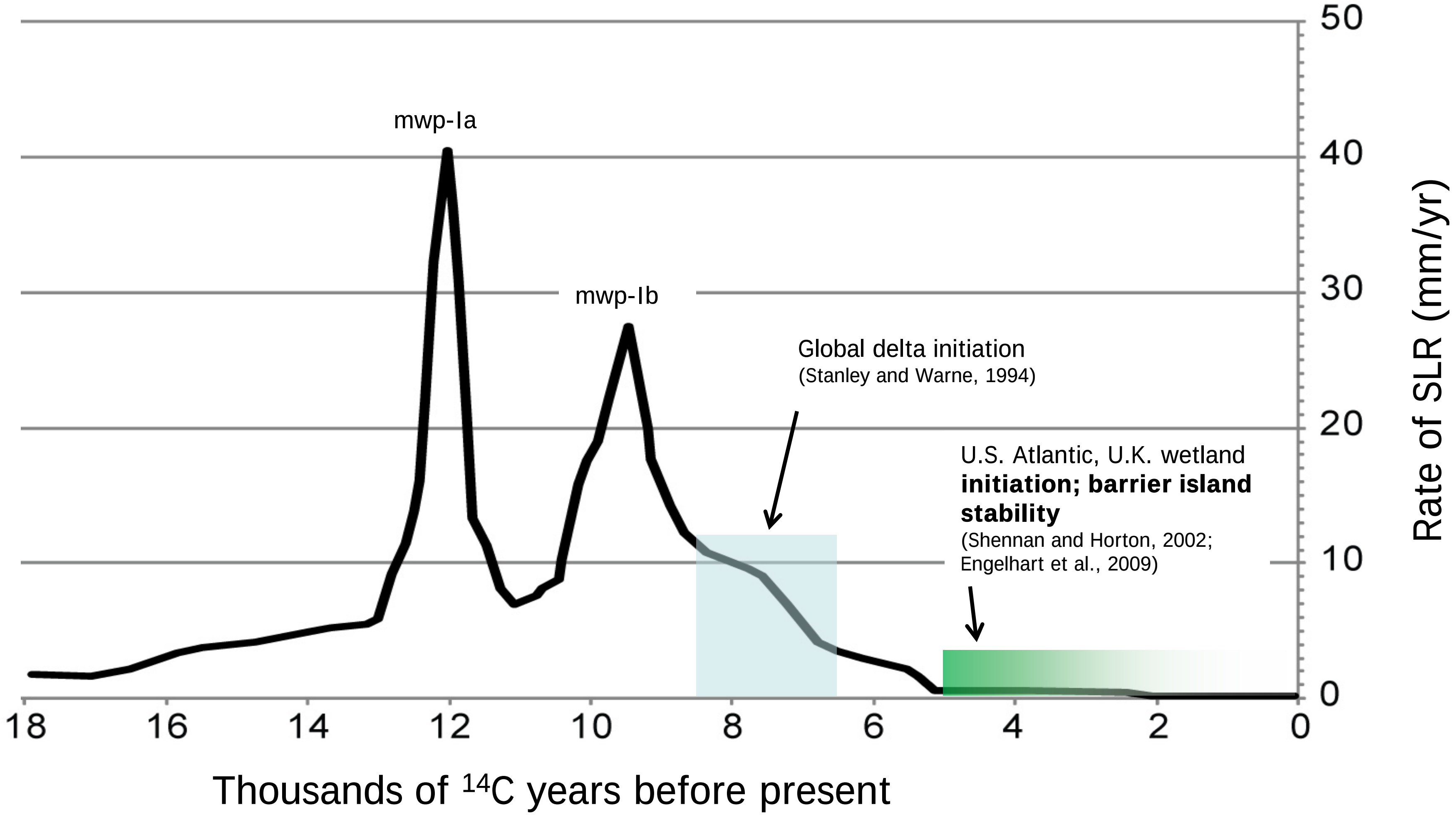
120,000 years ago	18,000 years ago	Today
+ 6 meters (20')*	- 120 meters (420')	

*~ ½ from Greenland

*~ ½ from Antarctica

Credit: Dr. Harold R. Wanless; University of Miami, Department of Geological Sciences; co-chair of Miami-Dade Climate Change Task Force

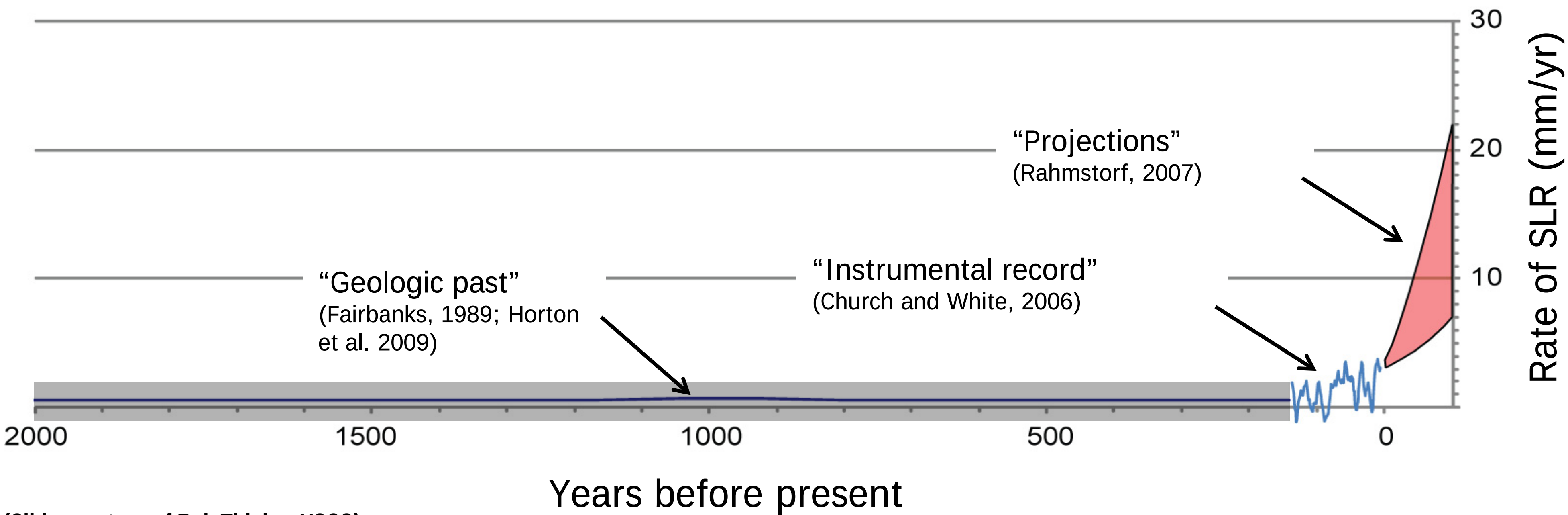
Rates of Sea-level rise since the Last Glacial Maximum



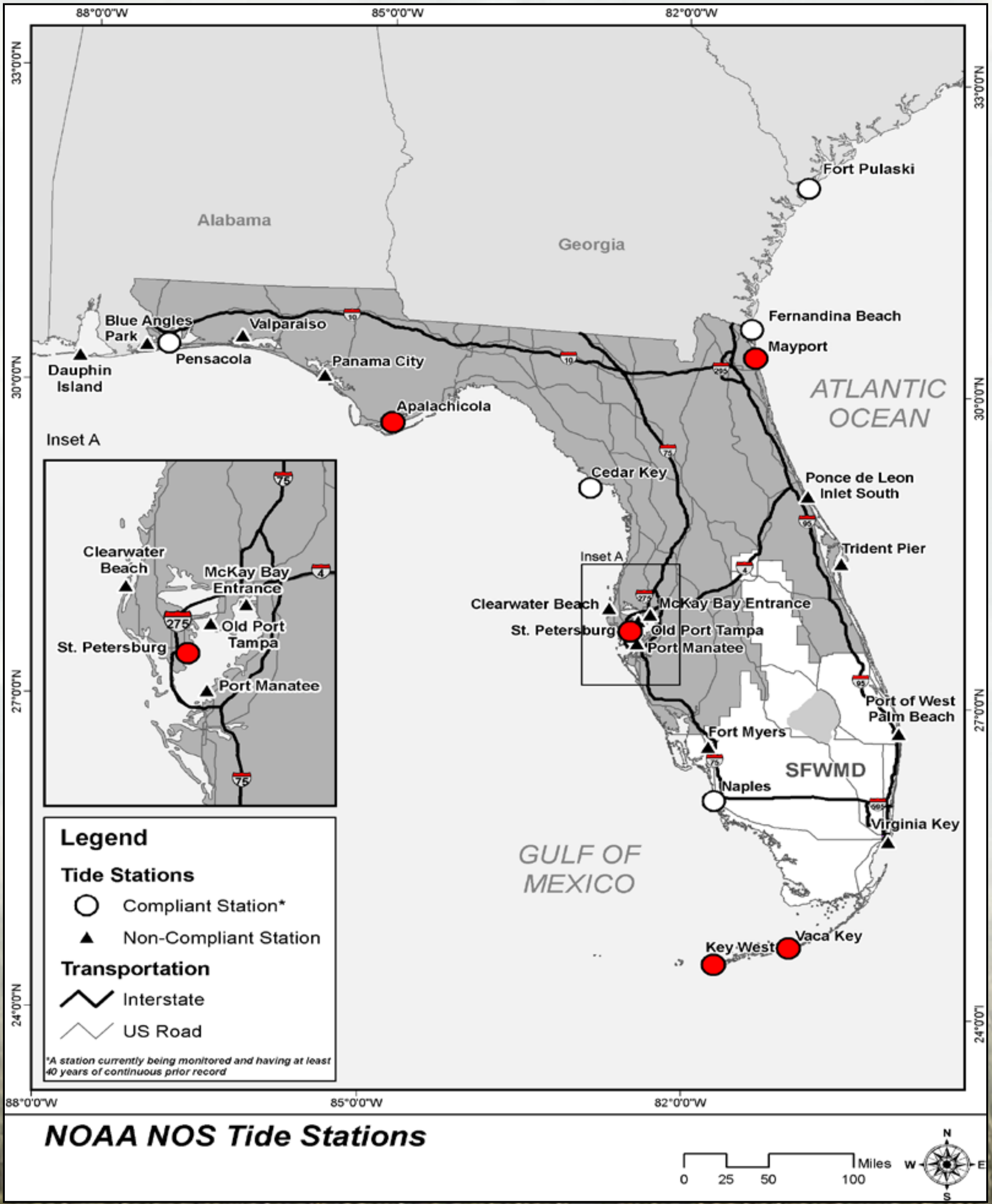
(Slide courtesy of Rob Thieler, USGS)

(SLR rate based on Fairbanks, 1989)

Past, present, and potential future rates of sea-level rise



(Slide courtesy of Rob Thieler, USGS)



NOAA Tide Stations in Florida

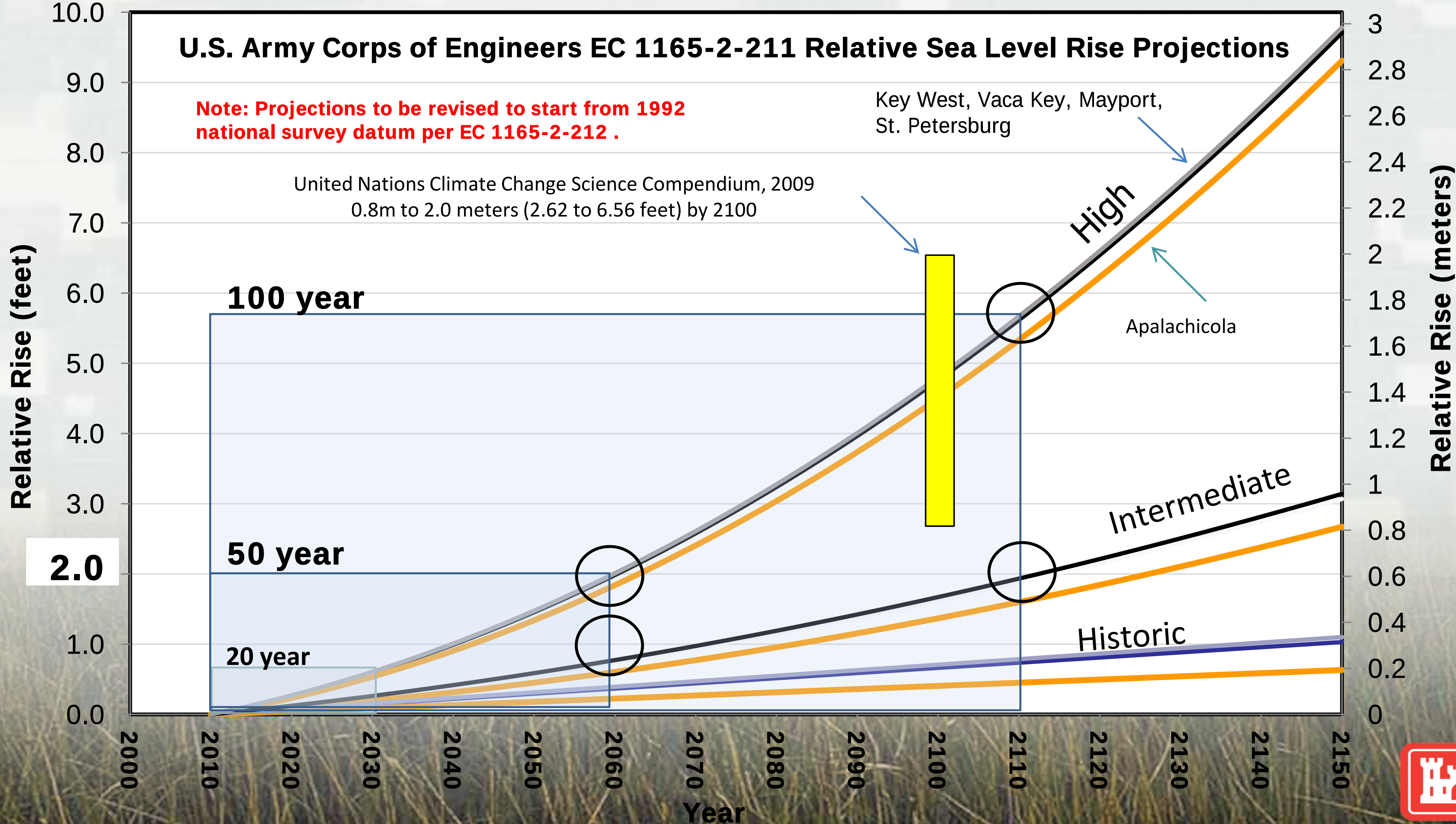
- **Per USACE EC1165-2-212, a Compliant Tide Station is a station currently being monitored and having at least 40 years of continuous prior record.**

- **Compliant Tide Stations in Florida are: Key West, Vaca Key, Naples, St. Petersburg, Cedar Key, Apalachicola, Pensacola, Mayport and Fernandina Beach.**

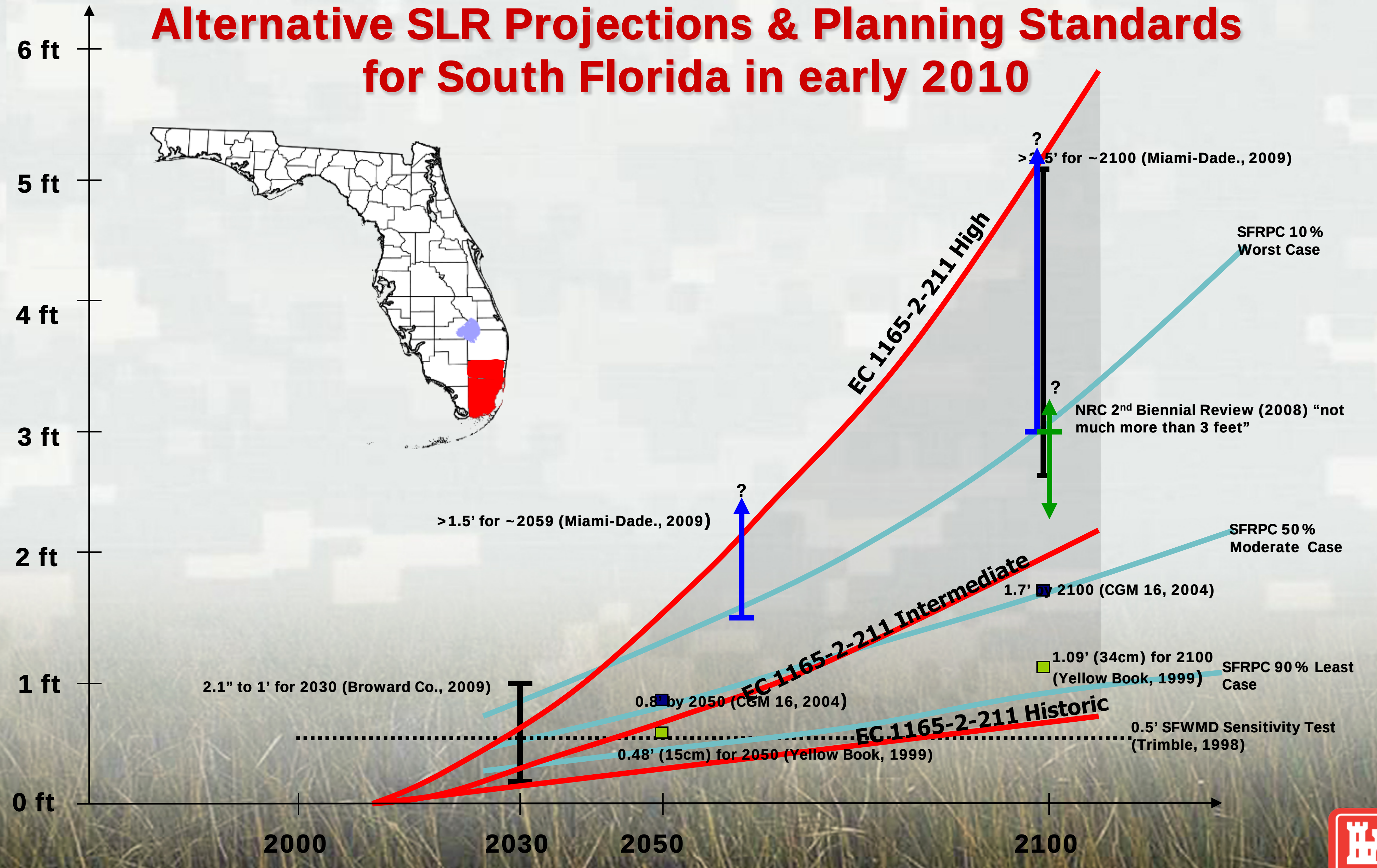
- **Most of Florida is relatively stable geologically, so sea level change is similar around the state.**

- **For USACE sea level change projections at compliant NOAA Tide Stations nationwide: http://corpsclimate.us/ccaceslcurves.cfm**

Planning Scenarios for Sea Level Change Impacts Assessment and Adaptation Studies in Florida

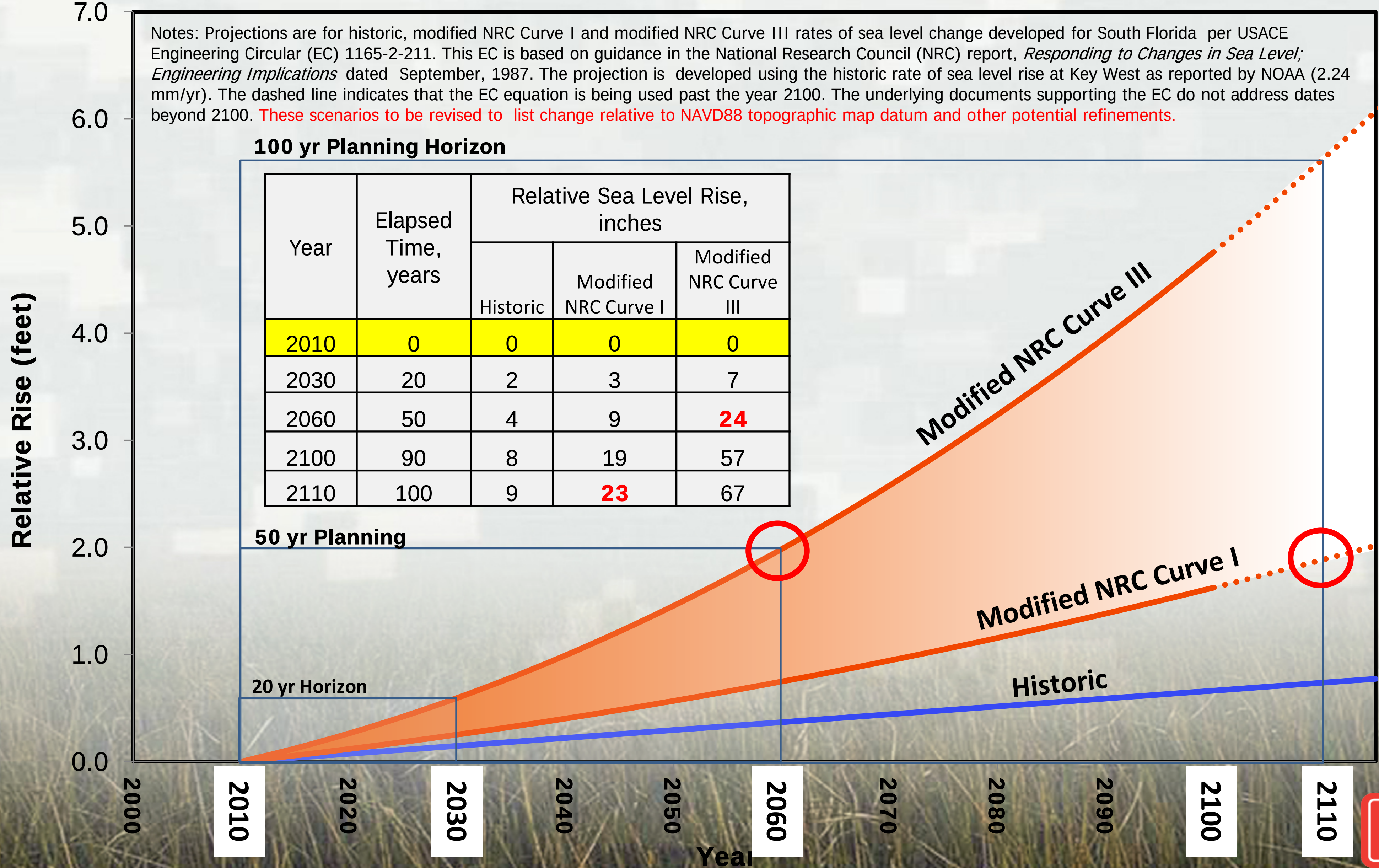


Alternative SLR Projections & Planning Standards for South Florida in early 2010



Relative SLR Scenarios for South Florida (similar for NE FL)

Notes: Projections are for historic, modified NRC Curve I and modified NRC Curve III rates of sea level change developed for South Florida per USACE Engineering Circular (EC) 1165-2-211. This EC is based on guidance in the National Research Council (NRC) report, *Responding to Changes in Sea Level; Engineering Implications* dated September, 1987. The projection is developed using the historic rate of sea level rise at Key West as reported by NOAA (2.24 mm/yr). The dashed line indicates that the EC equation is being used past the year 2100. The underlying documents supporting the EC do not address dates beyond 2100. These scenarios to be revised to list change relative to NAVD88 topographic map datum and other potential refinements.

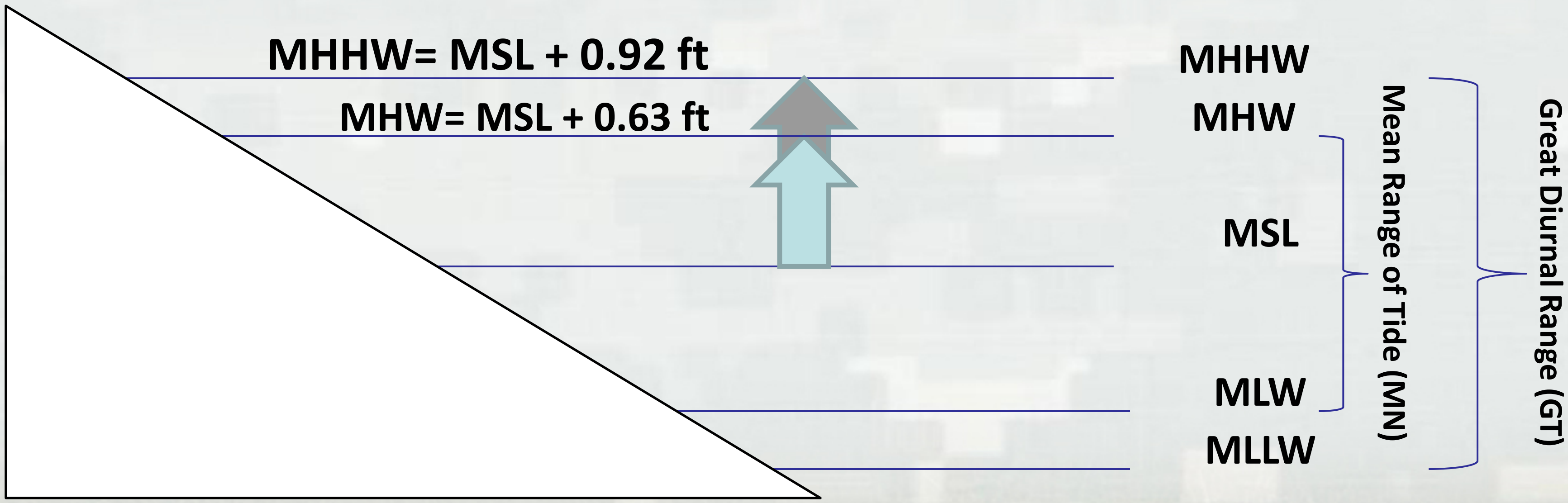


Year	Elapsed Time, years	Relative Sea Level Rise, inches		
		Historic	Modified NRC Curve I	Modified NRC Curve III
2010	0	0	0	0
2030	20	2	3	7
2060	50	4	9	**24**
2100	90	8	19	57
2110	100	9	**23**	67

Tidal Datums

Elevations at Key West, FL

in NAVD 88 Relative to NTDE 1983-2001



Great Diurnal Range (GT)- The difference in height between mean higher high water and mean lower low water.

Mean Range of Tide (MN)- The difference in height between mean high water and mean low water.

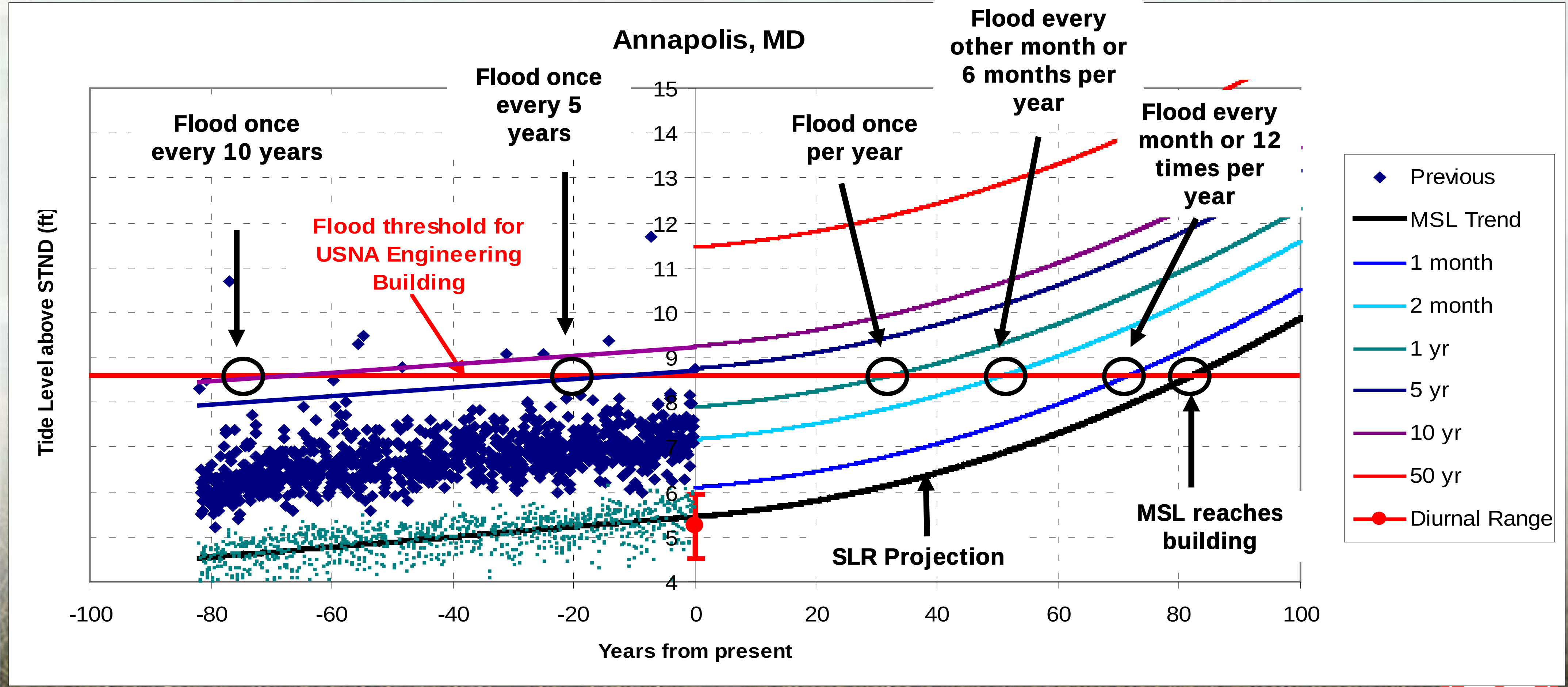
Coastal Flood Risk Frequency

- Future changes in coastal flood risks depend on:
  - Amount and rate of relative sea level rise
  - Storm tide elevation and frequency
  - Flood threshold or “stage” elevation at which damages occur
- Rising relative sea level will allow future storm tides to:
  - Reach higher elevations than past storms
  - Exceed flood stage more frequently than past storms
- Future storm damages will occur to geographic areas not previously impacted by elevated sea levels

Credit: Dr. David L. Kriebel, PE, U.S. Naval Academy, kriebel@usna.edu

Consider SLR plus Storm Events

Sea Level Rise Scenario + Average Frequency of Flooding

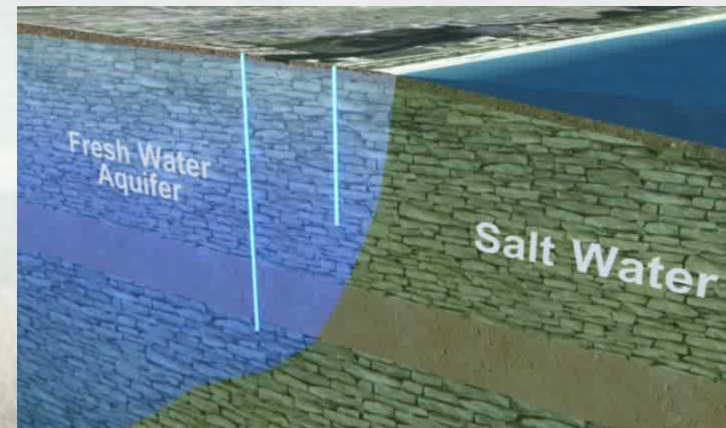


Credit: Dr. David L. Kriebel, PE, U.S. Naval Academy, kriebel@usna.edu

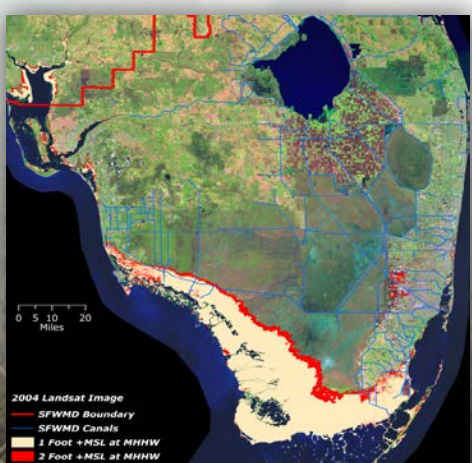
SLR Impacts

- **Direct Impacts**
  (SLR + waves or storm surge)

- **Flood Drainage**
  (increased frequency, depth and/or duration of interior areas flooding)



- **Water Supply**
  (**saltwater intrusion**)



- **Natural System**
  (coastal ecosystems and **rapid peat loss**)

(SFWMD, 2011)
(FAU, 2008)

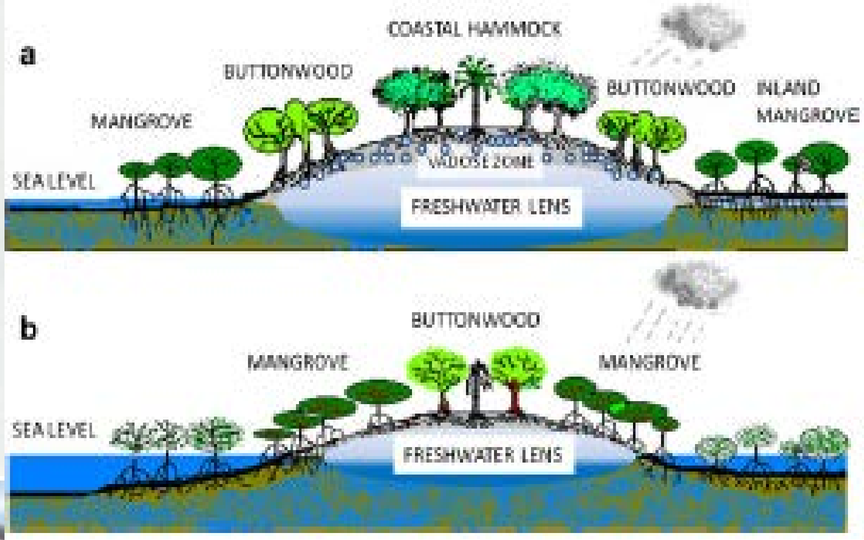
SLR Impacts

DIRECT IMPACTS

Hollywood, Florida – 2007

Hollywood, Florida - 1-meter sea level rise
Data Source: LIDAR and USGS 10M NED

INUNDATION OF BARRIER ISLANDS AND COASTAL INFRASTRUCTURE



COASTAL FLOODING & ECOSYSTEM CHANGES

BEACH EROSION

(FAU, 2008)
(SAHA, FIU, 2011)

SLR Impacts

- <u>FLOOD DAMAGE REDUCTION</u>
  reduced discharge from coastal structures

Figure 37 – Typical coastal flood/salinity control structure of the sluice gate type. (SFWMD)

Figure 38 - S-13 Pump station located on C-11 canal at US441 and Orange Drive in Davie, FL. It has a rated capacity of 540 cfs, and can pump approximately 14.5 million gallons per hour (SFWMD, 2007).

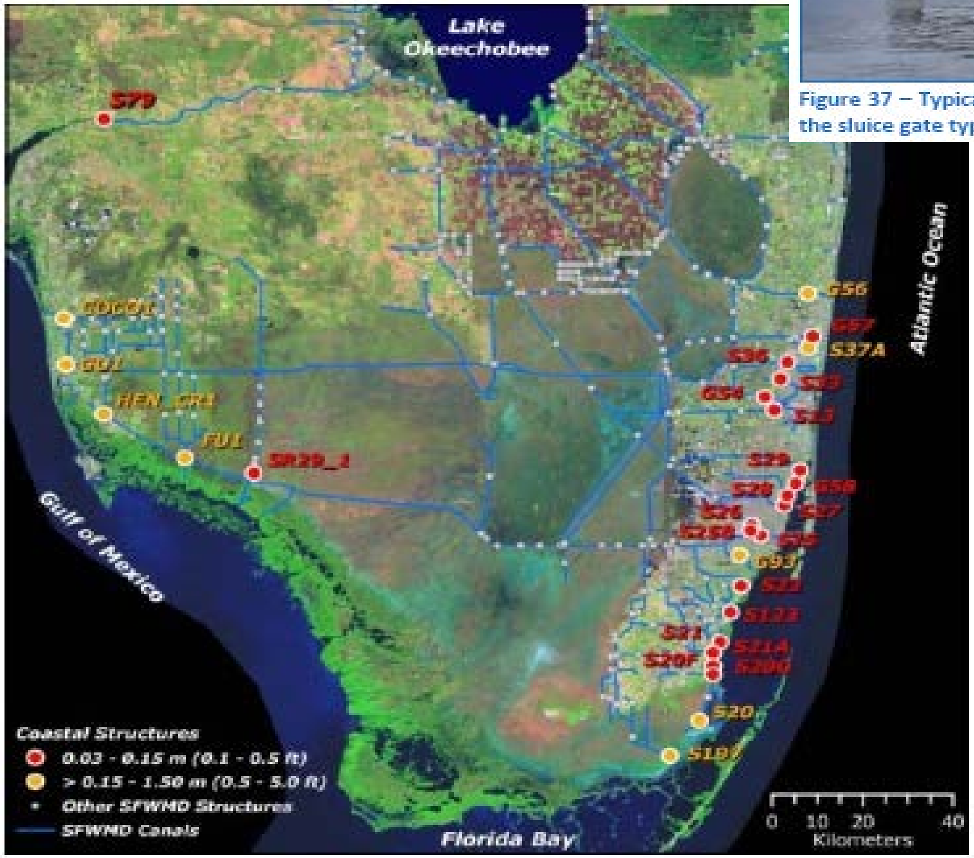
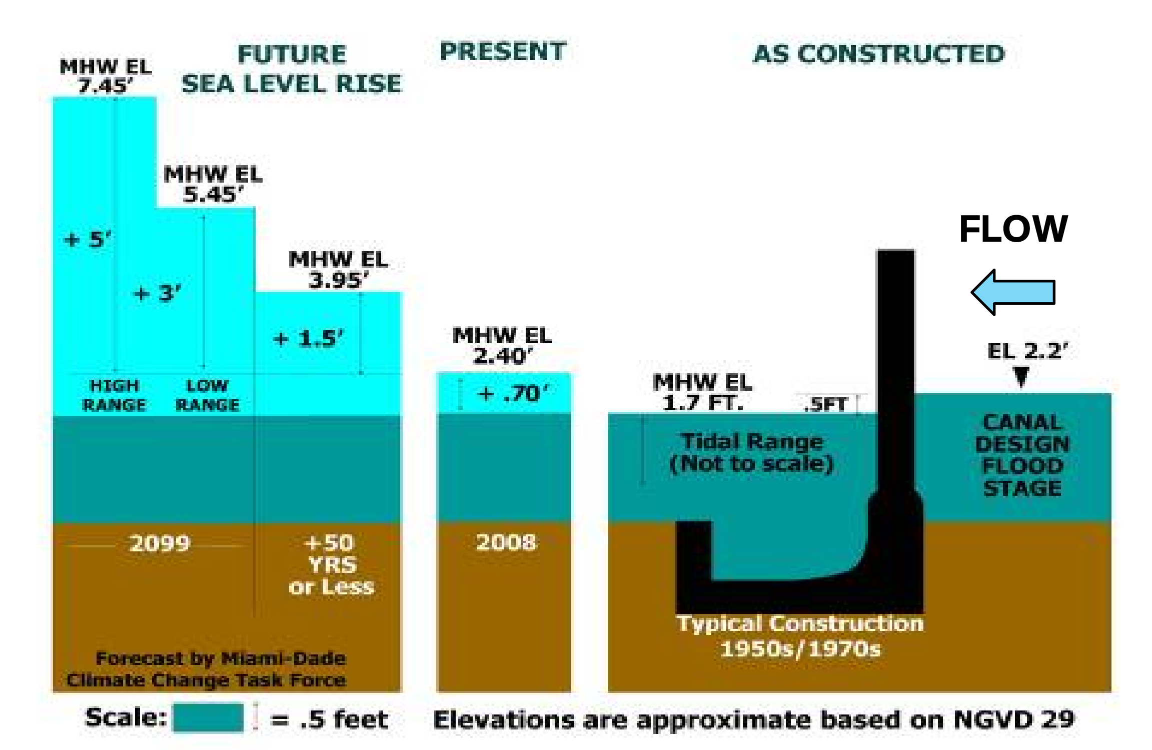


Figure 69. Coastal structures that may lose flow capacity in response to a 15 cm (6 inch) increase in sea level.

(Heimlich, FAU, 2009)
(SFWMD, 2011)

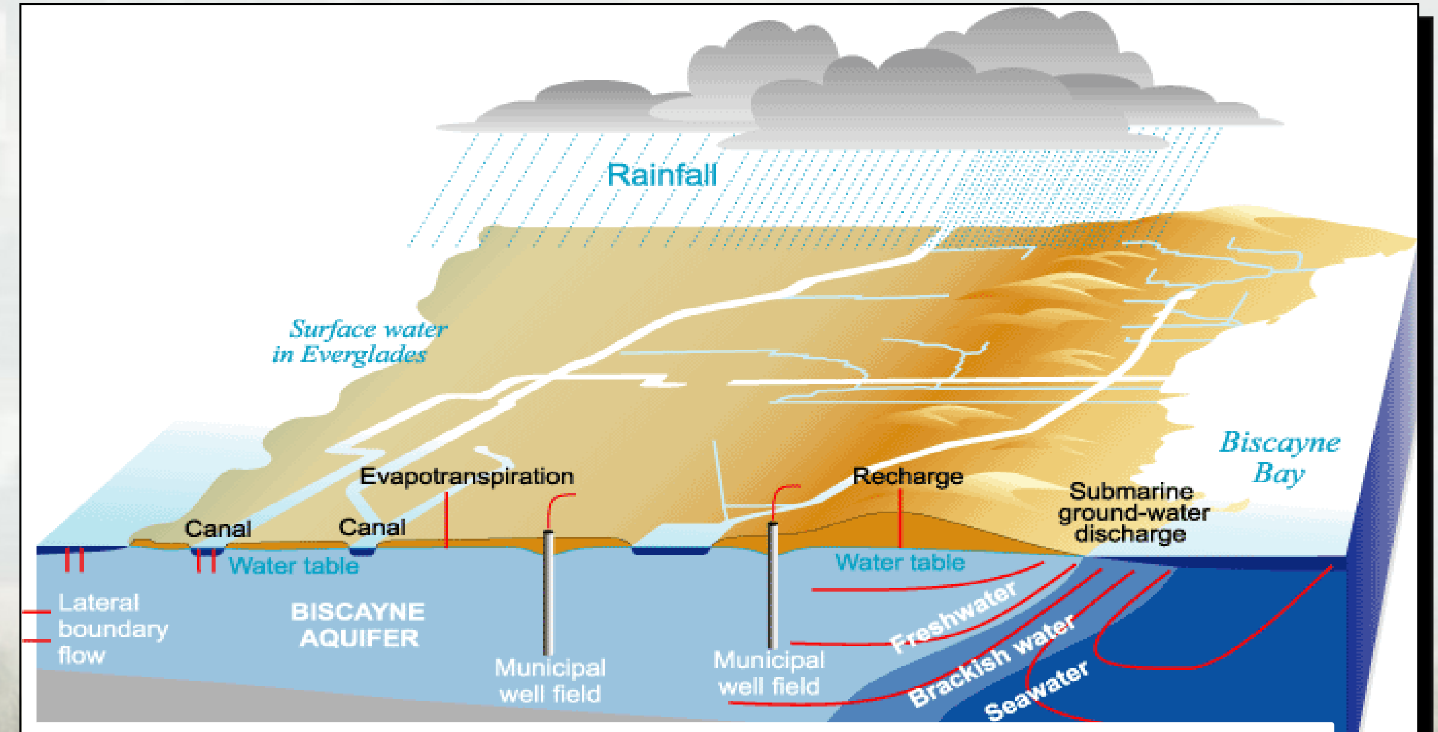
Flood Drainage Concerns



Sea level rise will reduce effectiveness of gravity drainage canals

The population of South Florida is 6 million and growing

Flood Risk vs Water Supply Concerns

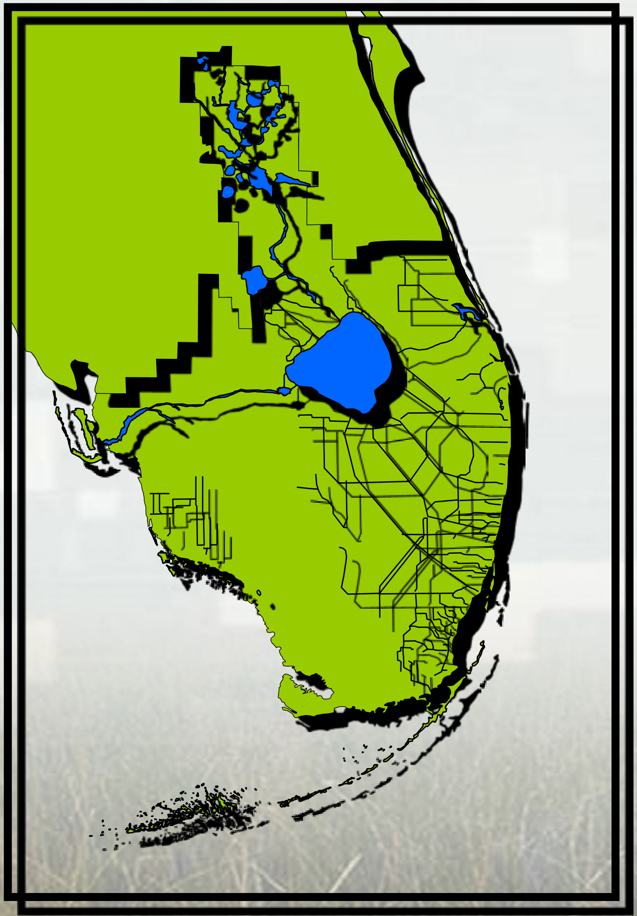


Conceptual diagram of hydrologic system of south Florida (Langevin, USGS, 2000)

- Shallow wells are the primary source of drinking water in South Florida communities
- Continued sea level rise will cause saltwater intrusion into wells and create a need for new freshwater sources
- --- OR ---
- Protecting water supply wells with higher canal stages will increase flooding in many low elevation communities

Water Supply Concerns

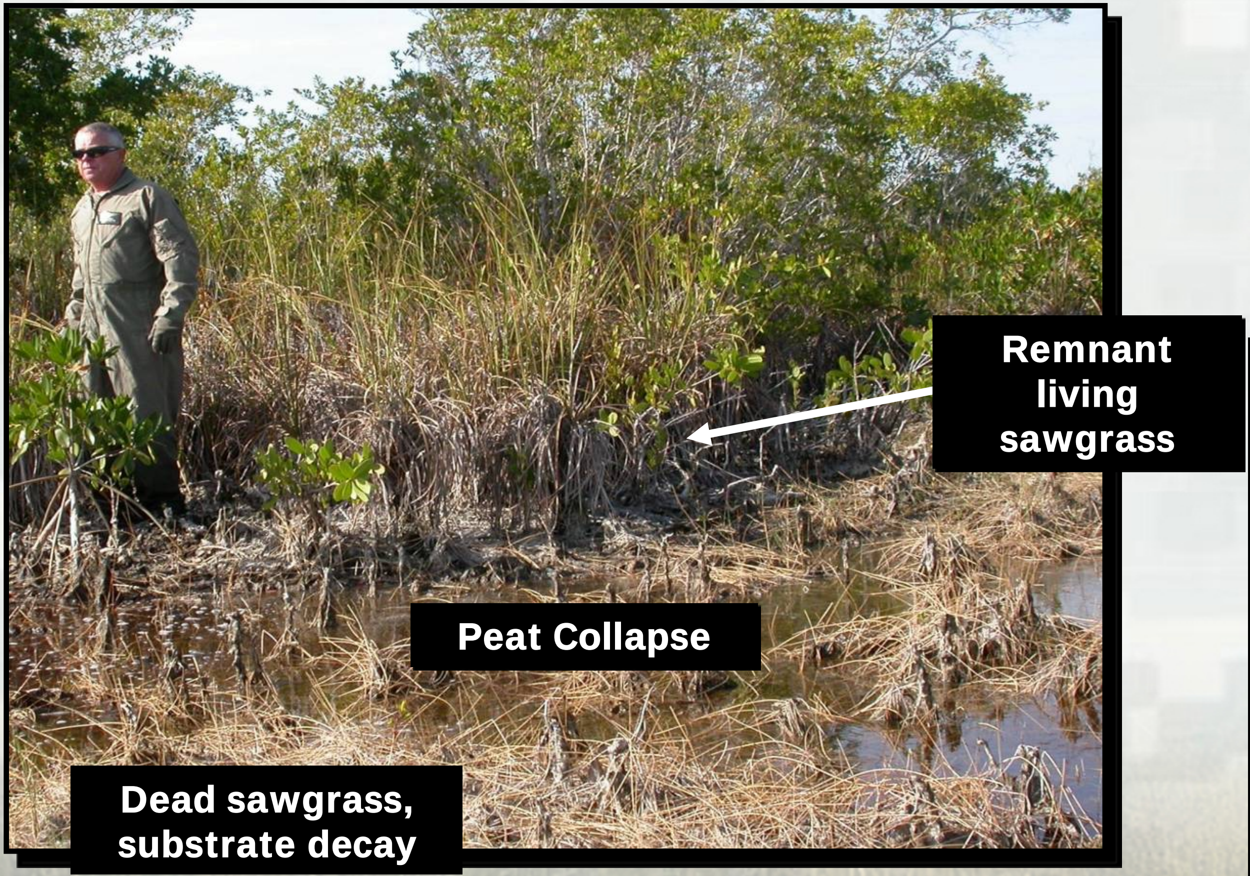
Kissimmee River Basin and Lake Okeechobee



Lake Okeechobee Drought

- Potential saltwater intrusion into coastal water supply wells, plus climate change impacts on rainfall patterns and evaporation will increase water supply demands and water storage needs

Effects on Natural Areas



Saltwater inundation leads to peat collapse and decline of freshwater wetlands habitat

Photo Credit: Dr. Harold R. Wanless;
University of Miami, Department of Geological Sciences;
co-chair of
Miami-Dade Climate Change Task Force

Everglades restoration will increase freshwater flows to natural areas and may delay some future habitat changes

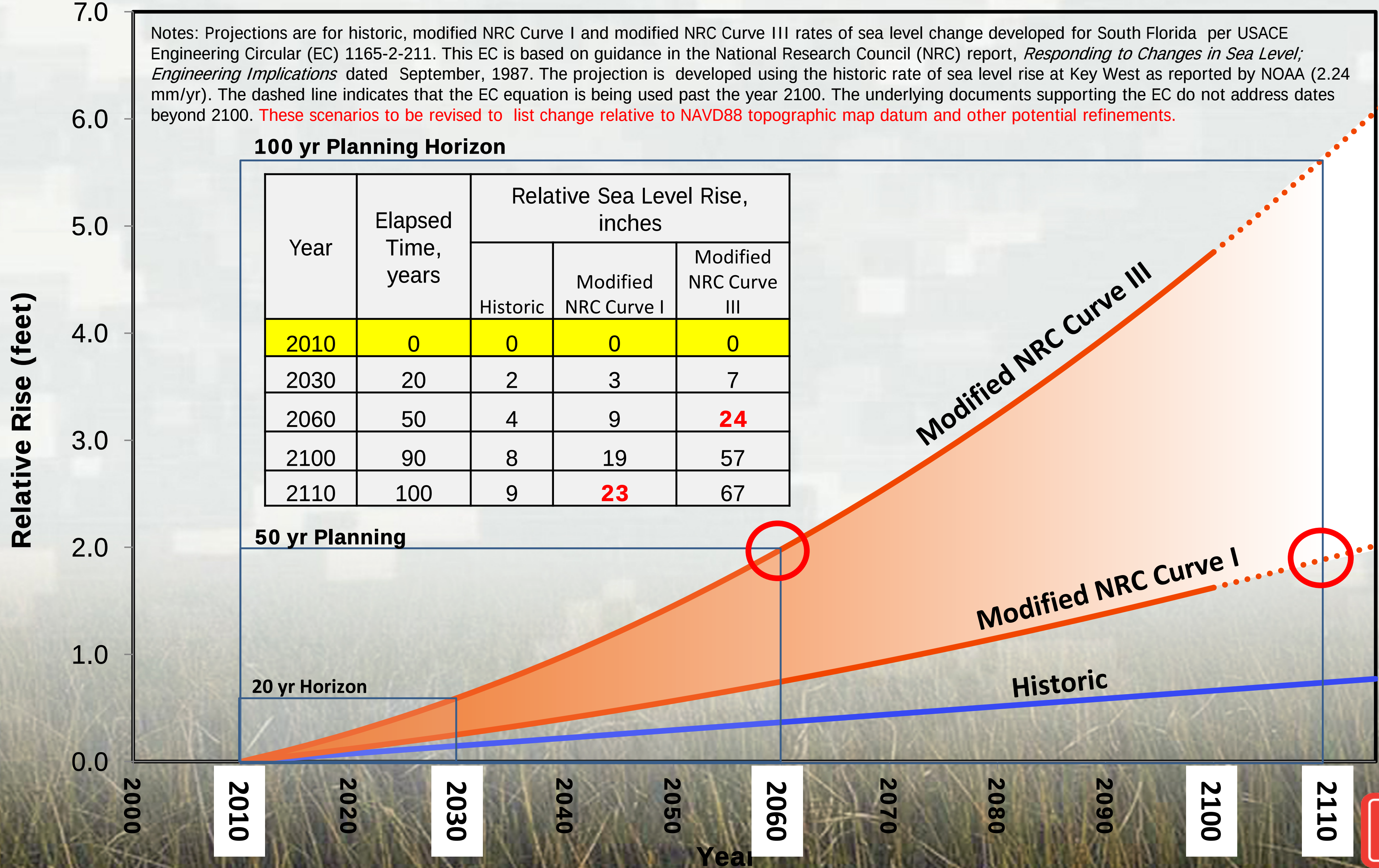
Risk

- Risk is a measure of the probability and consequence of uncertain future events
- Risk includes
  - Potential for gain (opportunities)
  - Exposure to losses (hazards)

Relative SLR Scenarios for South Florida (similar for NE FL)

Notes: Projections are for historic, modified NRC Curve I and modified NRC Curve III rates of sea level change developed for South Florida per USACE Engineering Circular (EC) 1165-2-211. This EC is based on guidance in the National Research Council (NRC) report, *Responding to Changes in Sea Level; Engineering Implications* dated September, 1987. The projection is developed using the historic rate of sea level rise at Key West as reported by NOAA (2.24 mm/yr). The dashed line indicates that the EC equation is being used past the year 2100. The underlying documents supporting the EC do not address dates beyond 2100. These scenarios to be revised to list change relative to NAVD88 topographic map datum and other potential refinements.

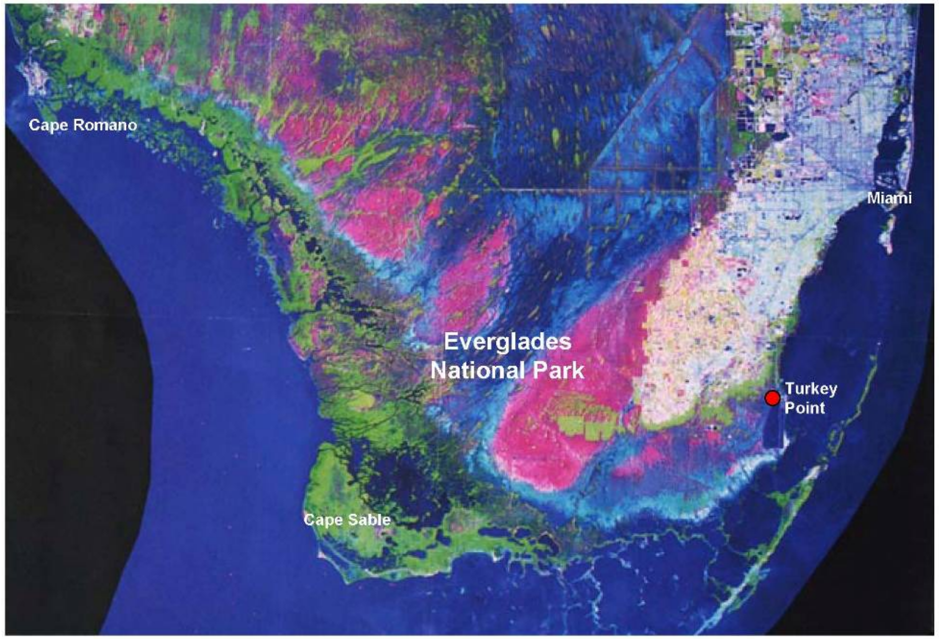
Year	Elapsed Time, years	Relative Sea Level Rise, inches		
		Historic	Modified NRC Curve I	Modified NRC Curve III
2010	0	0	0	0
2030	20	2	3	7
2060	50	4	9	**24**
2100	90	8	19	57
2110	100	9	**23**	67



Sea Level Rise in South Florida

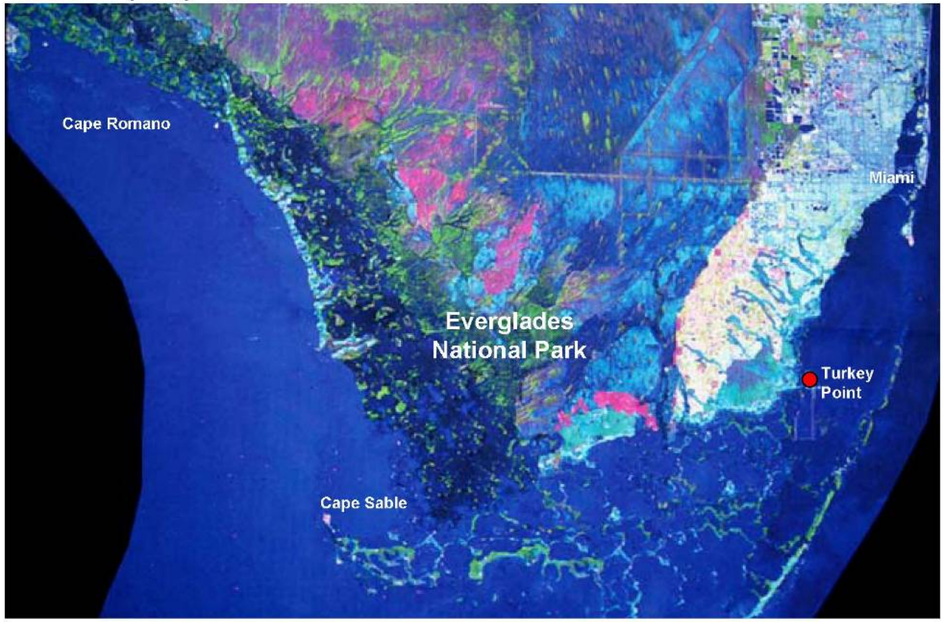
- A little less than 1 foot during the past century measured at Key West
- A 2 foot rise would have significant effects

South Florida 1995



Credit: Dr. Harold R. Wanless; University of Miami, Department of Geological Sciences; co-chair of Miami-Dade Climate Change Task Force

+60 cm (2 ft) rise

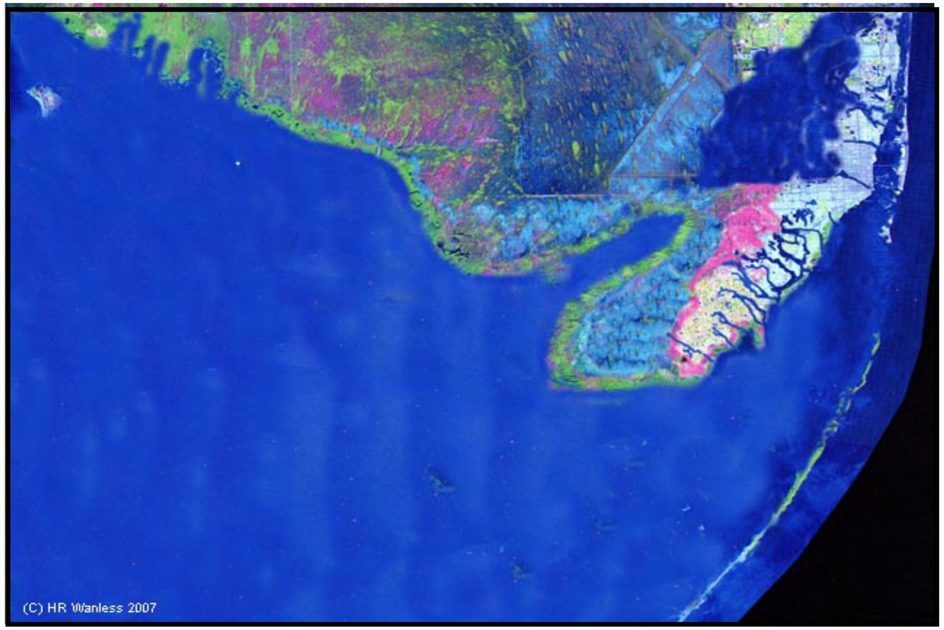


Credit: Dr. Harold R. Wanless; University of Miami, Department of Geological Sciences; co-chair of Miami-Dade Climate Change Task Force

Sea Level Rise in South Florida

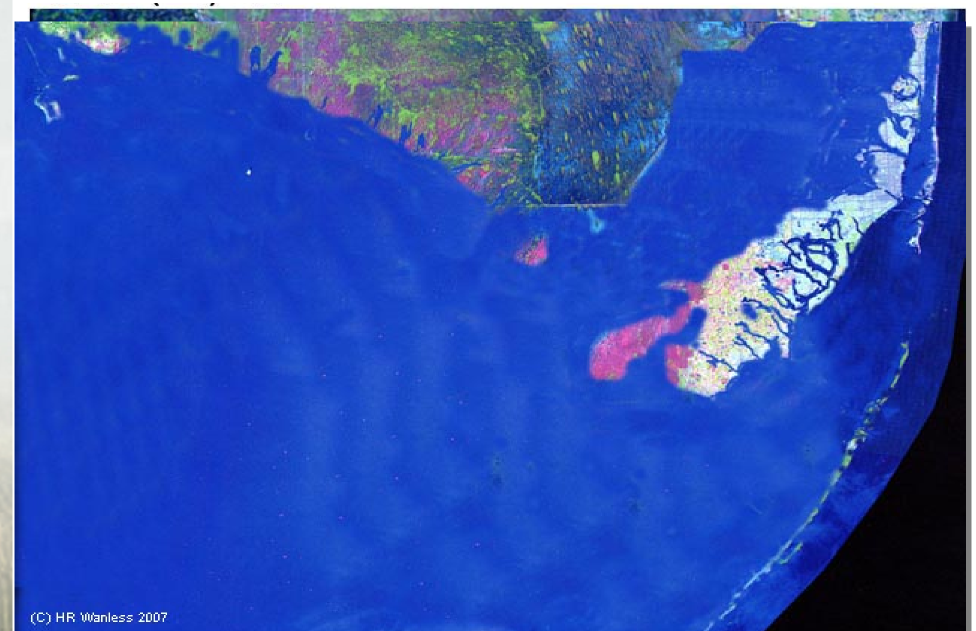
- A little less than 1 foot during the past century measured at Key West
- A 4-5 foot rise would have dramatic impacts

MHHW +120 cm (4 ft) rise



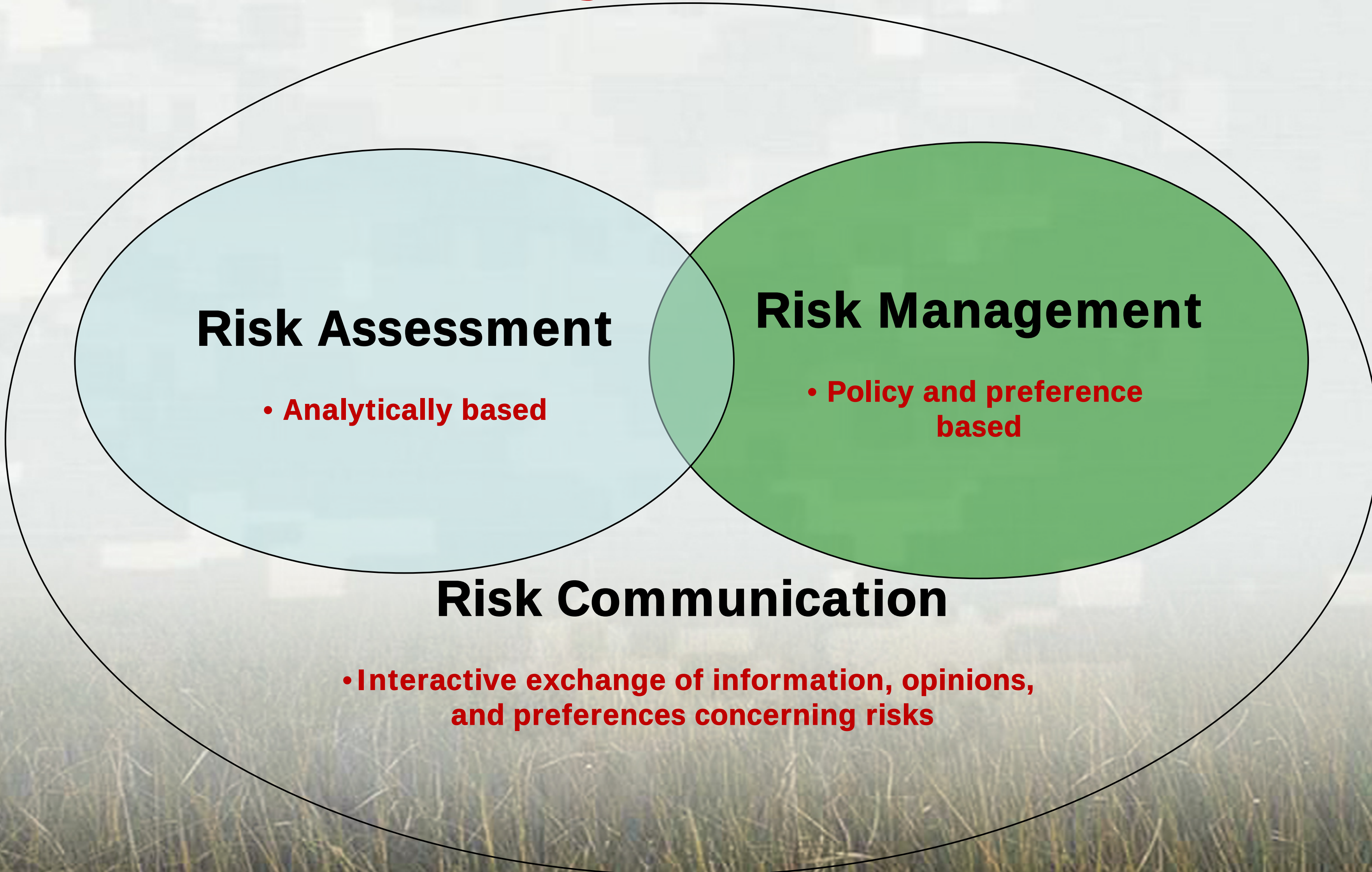
Credit: Dr. Harold R. Wanless; University of Miami, Department of Geological Sciences; co-chair of Miami-Dade Climate Change Task Force

MHHW +150 cm (5 ft) rise



Credit: Dr. Harold R. Wanless; University of Miami, Department of Geological Sciences; co-chair of Miami-Dade Climate Change Task Force

Risk Analysis in Three Tasks



Analyze Risks and Formulate Alternatives

- Formulate with vulnerabilities in mind
- <u>**Reactive**</u> – take action after impacts occur
  - Planned – decide now, implement later (triggers or disaster)
  - Ad Hoc – no decisions until impacts occur
- <u>**Anticipatory/Precautionary**</u> – implement features now
  - E.g. – acquire additional lands for wetland migration; increase design parameters for engineered features
- <u>**Adaptive Management**</u> – sequential decisions and implementation based on new knowledge. Requires ongoing monitoring, funding when needed AND time to implement.
- Timing of action is a key issue

United Kingdom Climate Adaptation Approaches: Precautionary versus managed adaptive

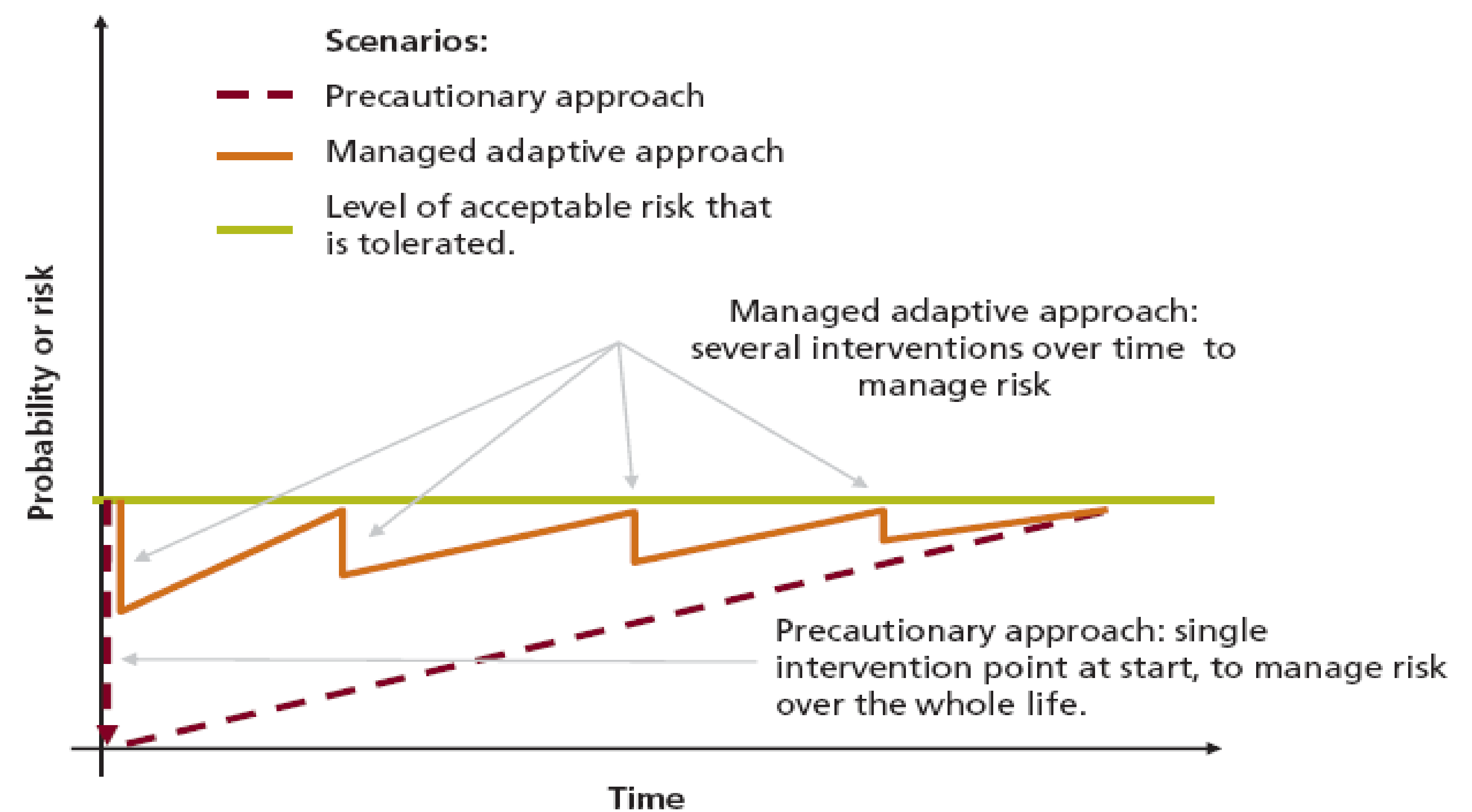


Figure courtesy of Jonathan Simm, HR Wallingford, UK

Risk Management Decision

- Sustainable
- Robust – performs well under wide range of future conditions
- Cost-risk trade-offs
  - Regret-based approach
  - If cost-cost trade-off, no firm rule
  - If trade-off of cost vs. safety, precautionary with respect to safety risk, <u>minimize worst-case outcome</u>

Florida Sea Level Rise Concerns
Take Away Points

- USACE SLR projections are based on guidance from the National Research Council, are site specific and include local uplift or subsidence. Does not address wave and storm surge frequency.
- **SLR <u>PERMANENTLY</u> increases coastal flood frequency**
- Leading Indicators of Sea Level Rise, such as the reduction in polar ice caps, and the recent rapid increases in the rate of glacier melting worldwide forecast significant SLR rate increases
- **<u>Long Term</u> Sea Level Rise Adaptation Strategies** are needed at project, community, watershed, and national scales
- **USACE Watershed Planning Authority** – With local support, might be an option for coordinated interagency regional SLR adaptation planning. Cost share up to 75/25 federal/local.

Ideas for Discussion

- Focus on short AND long term (100 yr+) risk reduction
- Recognize many buildings are remodeled or rebuilt after 50 years
- Shift planning from projects “optimized” for static future conditions to “robust and adaptable systems” that support long term risk reduction plans
- Establish unified sea level rise scenarios for watersheds or other broad areas for coordinated planning purposes
- Remember how the Interstate Highway System changed city development patterns. Build “Framework” Infrastructure (major roads, power, water, sewer, etc.) in low risk areas and strongly encourage private development in these areas.
- Hurricanes and other disasters are opportunities to redevelop in low risk areas. Implement pre-storm relocation agreements.

Thank you!

For additional information, contact:

Glenn.B.Landers@usace.army.mil