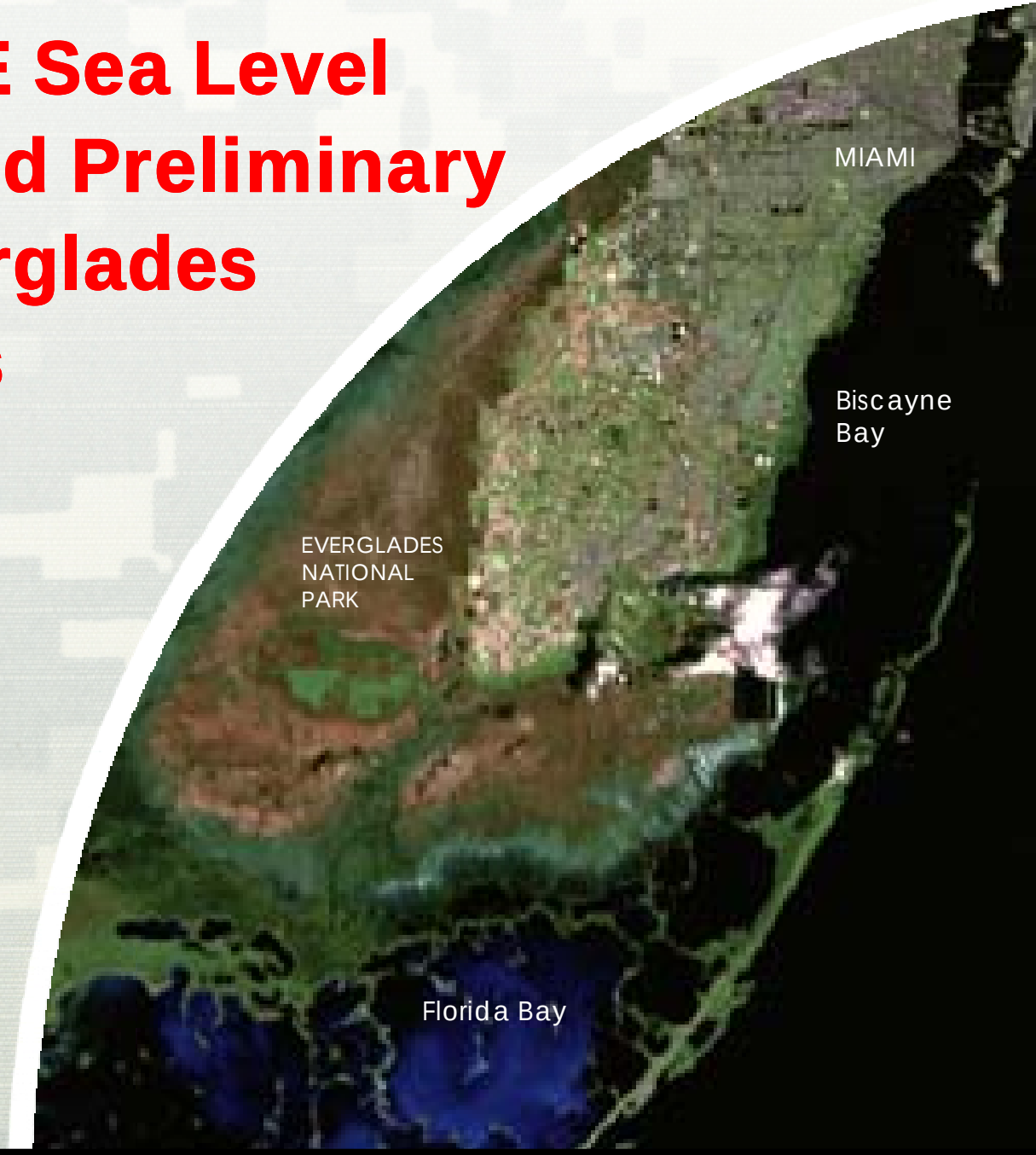
An Update on USACE Sea Level Change Guidance and Preliminary Applications for Everglades Restoration Projects

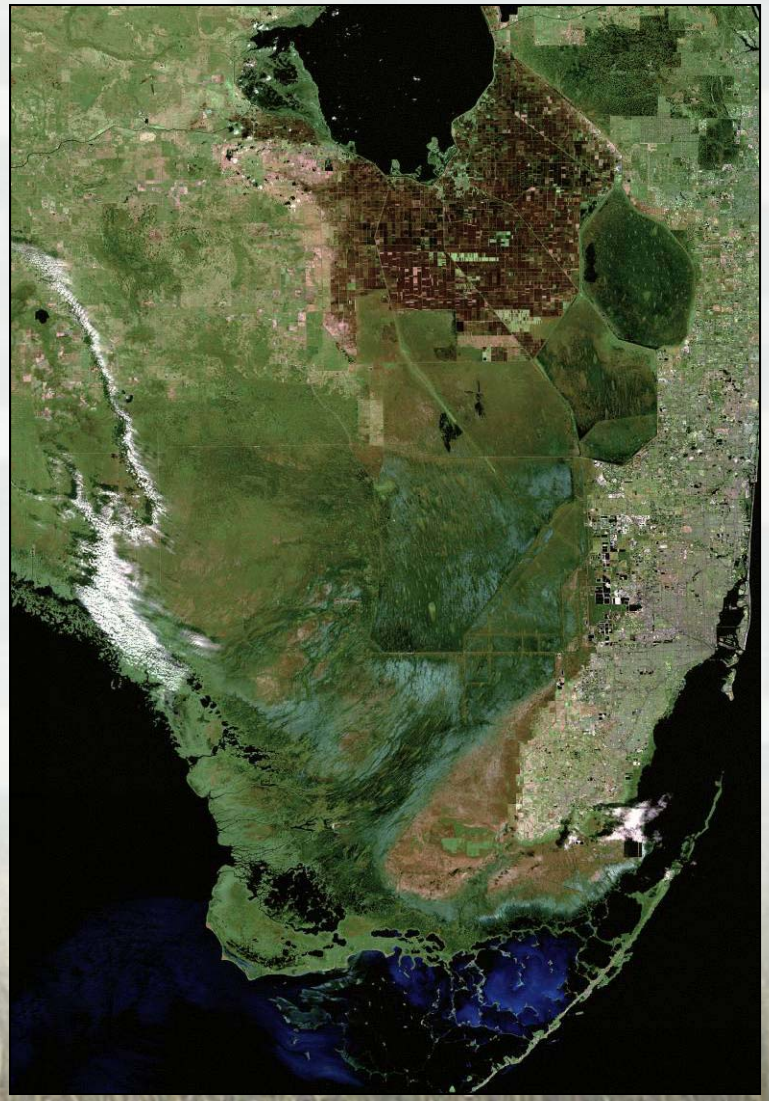
Glenn Landers,
Mark Shafer, Dan Vogler,
Kris Esterson, Bill Gallagher,
Idris Dobbs and Russ Weeks
Climate Change Studies
Everglades Division
Jacksonville District

July 14, 2010
Greater Everglades Ecosystem Restoration Conference

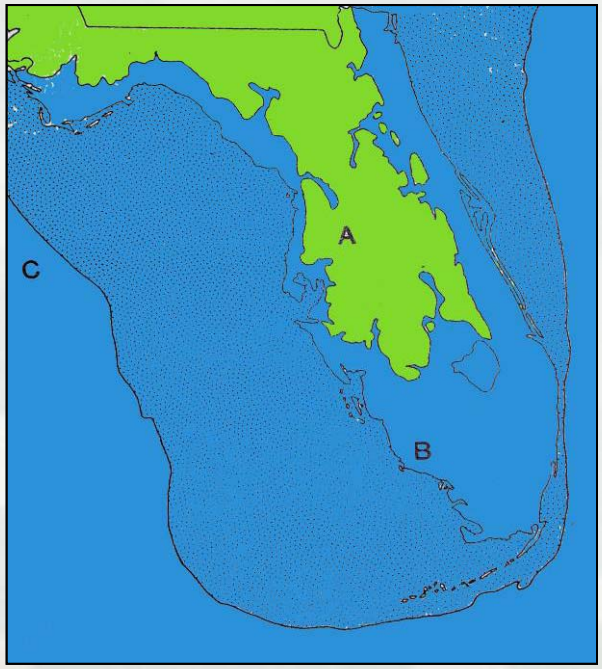


Presentation Outline

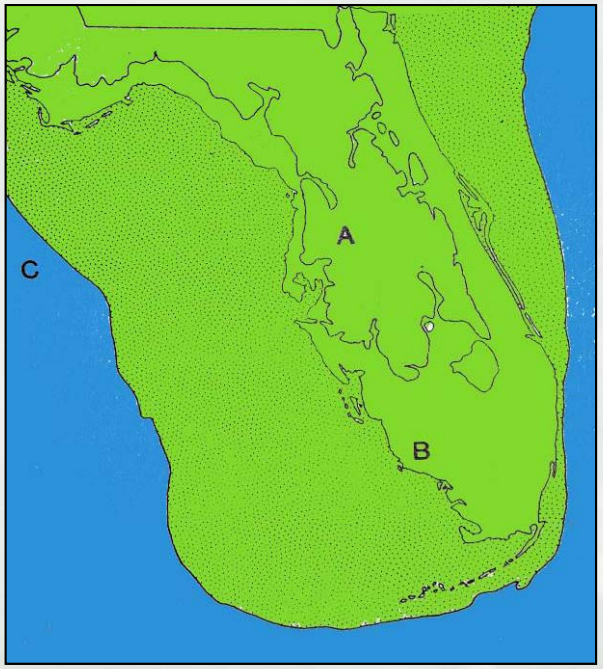
- Geologic Info on Sea Level Change through Time
- New Corps Engineering Circular (EC) 1165-2-211 on Sea Level Change (SLC)
- SLC Considerations for Everglades Restoration and South Florida
- Initial SLC Impacts Assessments for C-111SC and BBCW
- Next Steps For Climate Change Adaptation Planning



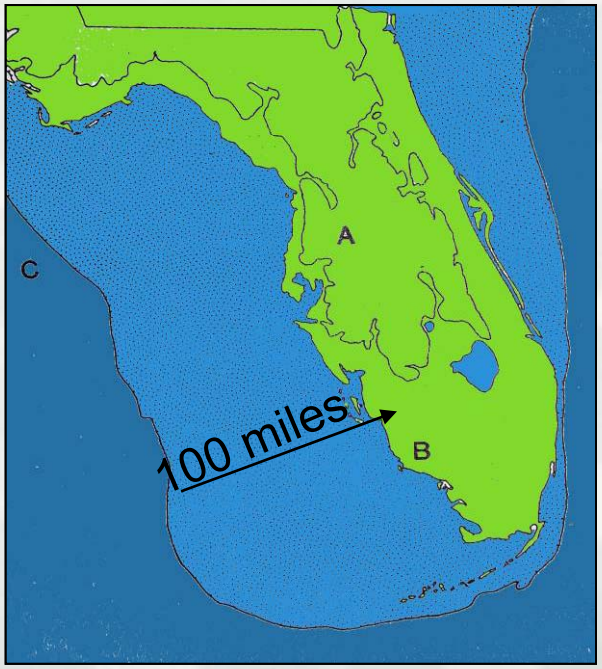
Florida Through Time – Sea Level Change Happens!



120,000 years ago
+ 6 meters (20')*



18,000 years ago
- 120 meters (420')

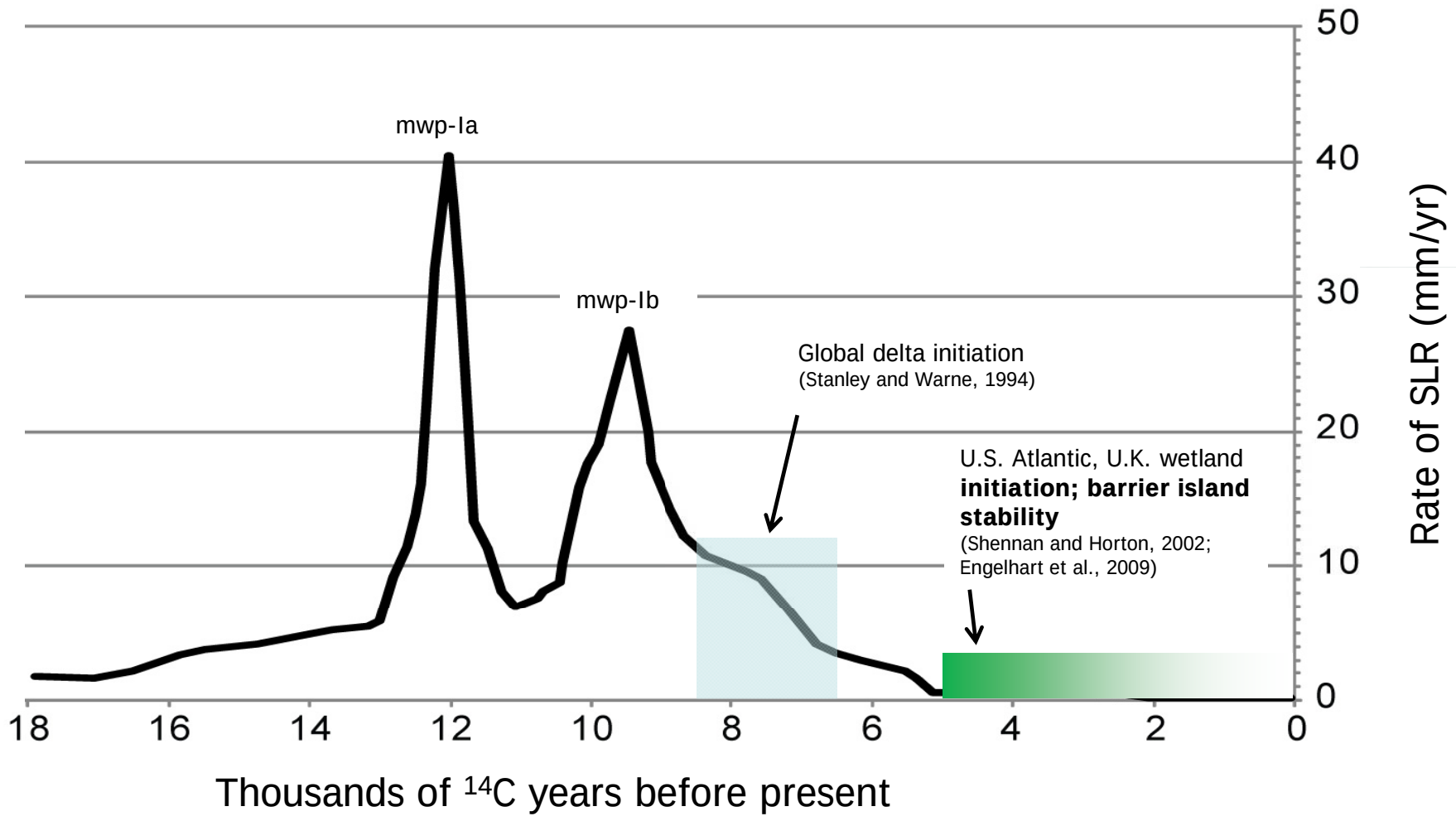


Today

*~ 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

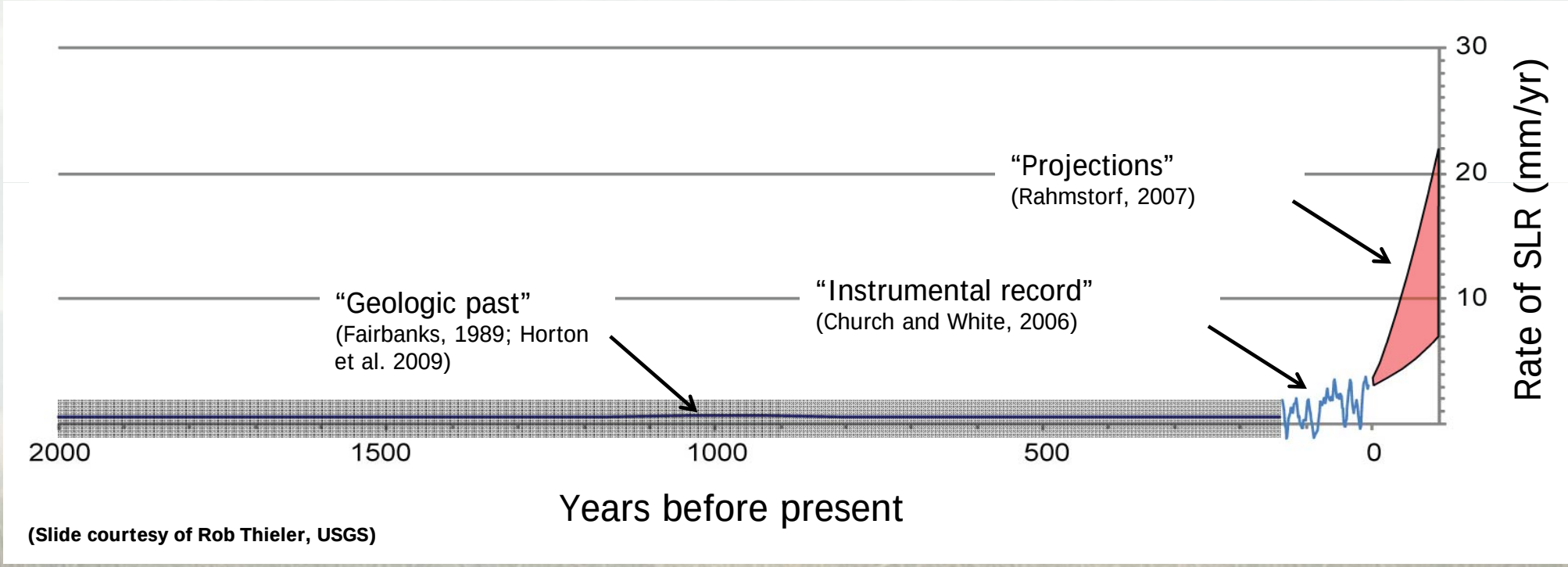
Sea-level rise rates since the Last Glacial Maximum



(Slide courtesy of Rob Thieler, USGS)

(SLR rate based on Fairbanks, 1989)

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



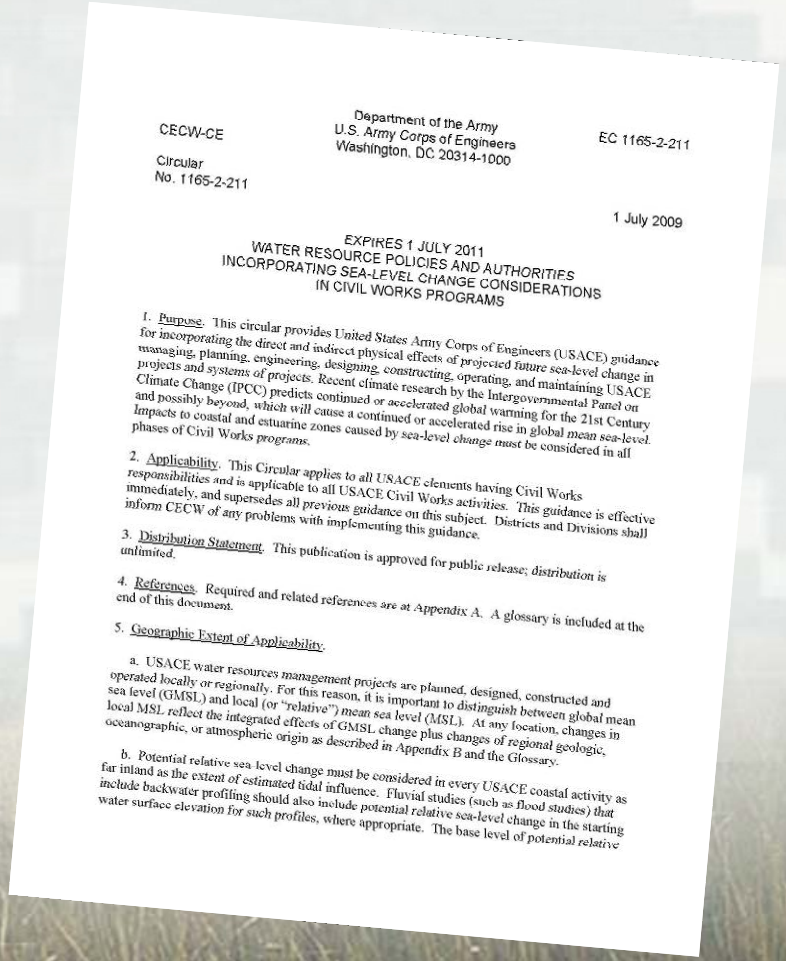
(Slide courtesy of Rob Thieler, USGS)

Climate Change Concerns for South Florida Ecosystem Restoration

- **Sea Level Rise**
  - Salinity changes in coastal bays
  - Shoreline retreat with natural habitat changes/losses
  - Increasing flooding 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

New Corps Guidance on Incorporating Sea Level Change Considerations

- EC 1165-2-211 became effective July 1, 2009
- Applies to all phases of Corps Civil Works activities as far inland as extent of new tidal influence
- Specifically does NOT apply to regulatory activities
- Will expire July 1, 2011
- A more complete replacement document is now being prepared



CECW-CE

Department of the Army
U.S. Army Corps of Engineers
Washington, DC 20314-1000

EC 1165-2-211

Circular
No. 1165-2-211

1 July 2009

EXPIRES 1 JULY 2011

WATER RESOURCE POLICIES AND AUTHORITIES
INCORPORATING SEA-LEVEL CHANGE CONSIDERATIONS
IN CIVIL WORKS PROGRAMS

1. Purpose. This circular provides United States Army Corps of Engineers (USACE) guidance for incorporating the direct and indirect physical effects of projected future sea-level change in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects. Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated global warming for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea-level. Impacts to coastal and estuarine zones caused by sea-level change must be considered in all phases of Civil Works programs.

2. Applicability. This Circular applies to all USACE elements having Civil Works responsibilities and is applicable to all USACE Civil Works activities. This guidance is effective immediately, and supersedes all previous guidance on this subject. Districts and Divisions shall inform CECW of any problems with implementing this guidance.

3. Distribution Statement. This publication is approved for public release; distribution is unlimited.

4. References. Required and related references are at Appendix A. A glossary is included at the end of this document.

5. Geographic Extent of Applicability.

a. USACE water resources management projects are planned, designed, constructed and operated locally or regionally. For this reason, it is important to distinguish between global mean sea level (GMSL) and local (or "relative") mean sea level (MSL). At any location, changes in local MSL reflect the integrated effects of GMSL change plus changes of regional geologic, oceanographic, or atmospheric origin as described in Appendix B and the Glossary.

b. Potential relative sea level change must be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence. Fluvial studies (such as flood studies) that include backwater profiling should also include potential relative sea-level change in the starting water surface elevation for such profiles, where appropriate. The base level of potential relative

Incorporating Relative Sea Level Change Projections into Project Planning and Design

- Project planning and design must consider how sensitive and adaptable 1) natural and managed ecosystems and 2) human systems are to climate change
- Develop Relative SLC curves and evaluate alternatives using "low," "intermediate," and "high" rates of sea level change at 20, 50, and 100 years from forecast project completion
  - Low – historic rate of change
  - Intermediate – Modified NRC Curve I (updated 1987 equation)
  - High – Modified NRC 1987 Curve III (updated 1987 equation)
- Also consider most recent IPCC projections

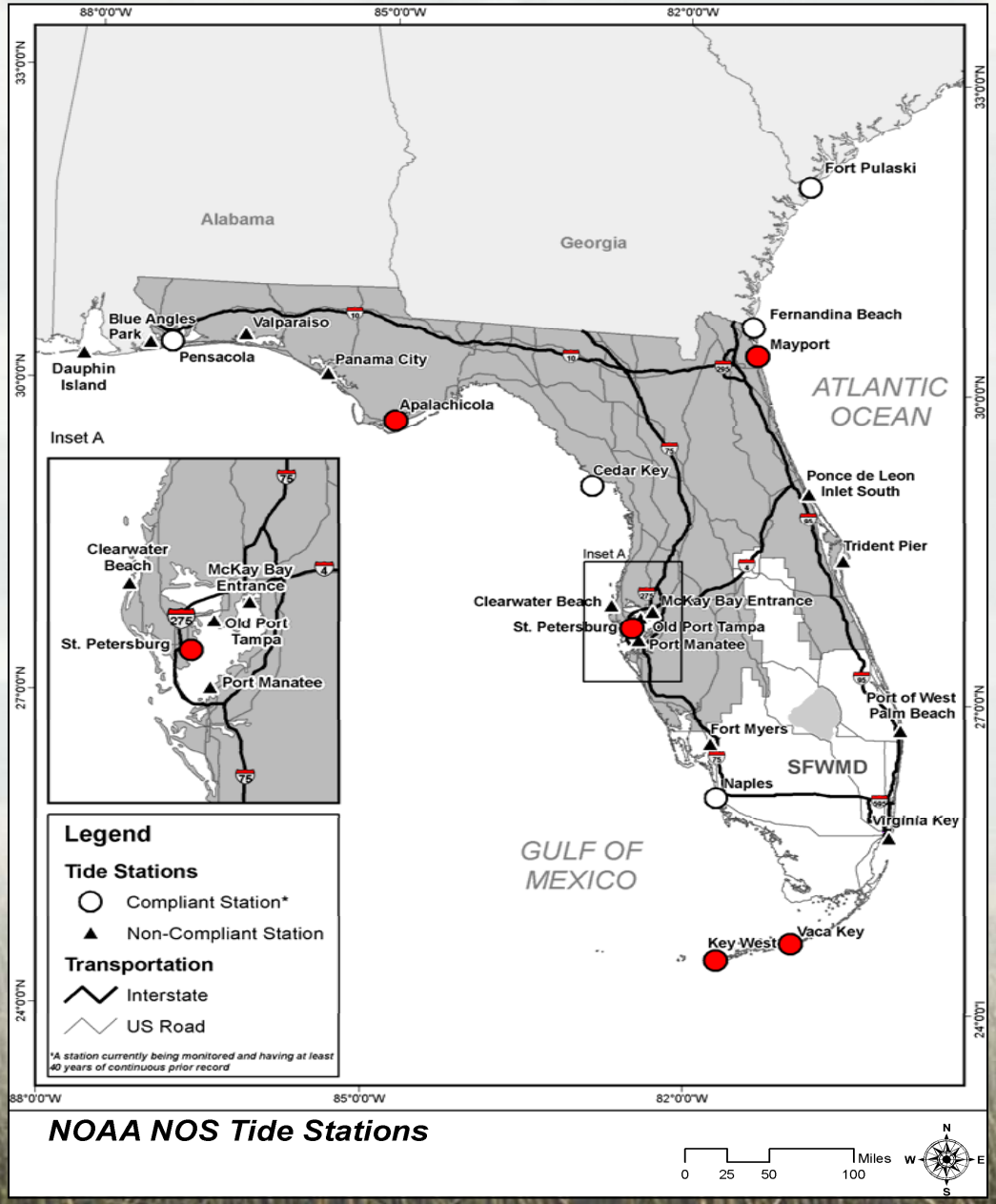
Approach

- Recognize we can't predict the future without uncertainty
- Be prepared to implement flexible planning and engineering adaptations accounting for a range of possible changes
- Must be able to recognize meaningful changes that may require additional response → multiple plausible scenarios
- Determine level of detail and accuracy required with respect to potential risks and consequences
- Differentiate "planning" vs "engineering" issues but also determine where they overlap

Climate Change Adaptation

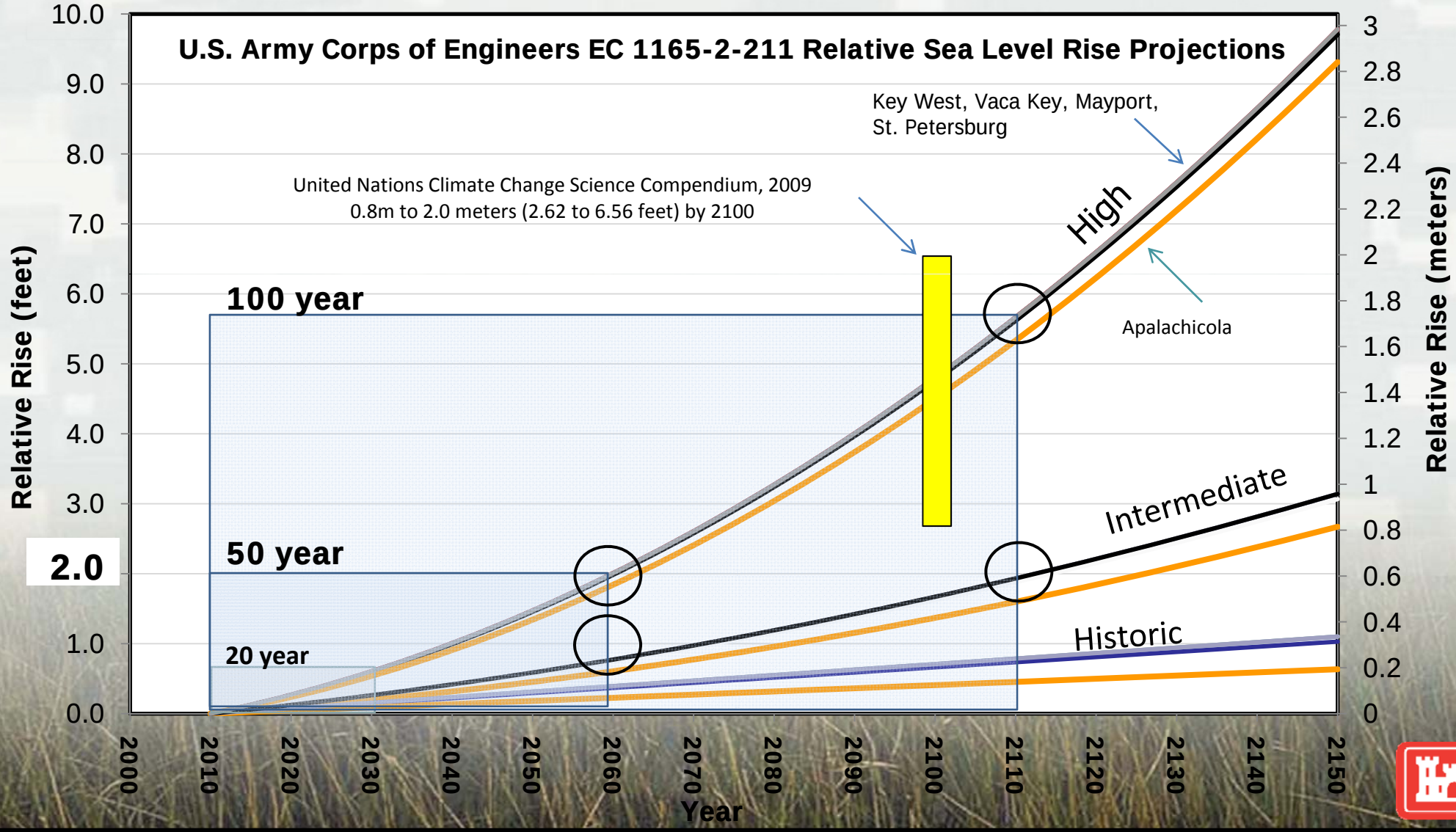
- Objectives are to enhance resilience or reduce vulnerability to observed or expected changes in climate
- Move from an equilibrium – or stationary – paradigm to one of constant evolution that recognizes the dynamic nature of physical and socio-economic processes
- Approach includes the use of rigorous adaptive management, where decisions are made sequentially over a longer planning horizon
- Sharing knowledge and lessons learned is essential for effective climate change adaptation and to prevent duplication of effort

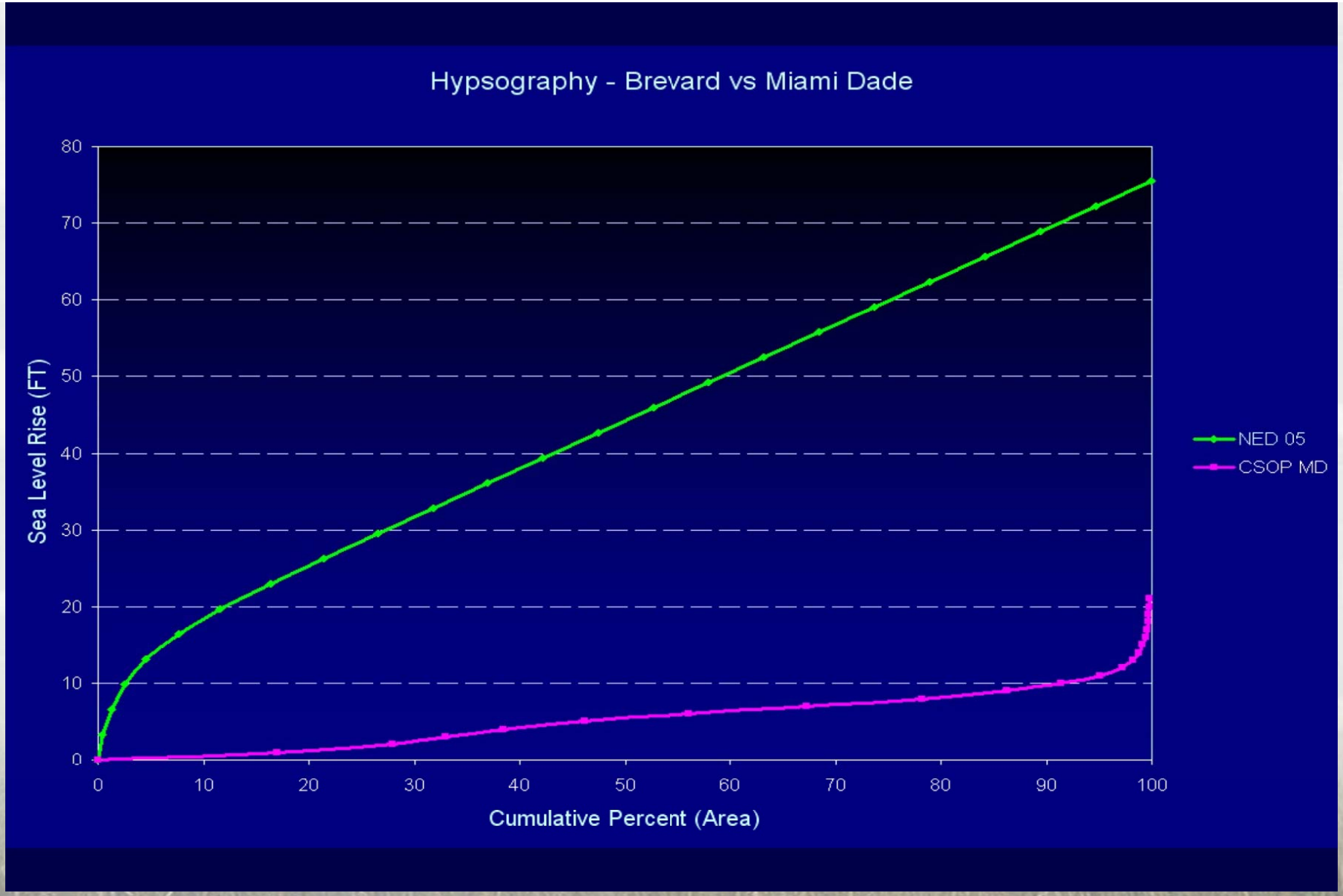
NOAA Tide Stations in Florida



- **Key West has the longest non-continuous U.S. tide station record with 130+ years.**
- **Per EC1165-2-211, 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.**
- **There are also other currently monitored NOAA tide stations in Florida with less than 40 year or non-continuous records.**
- **Most of Florida is very stable geologically, so sea level change is similar around the state.**

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



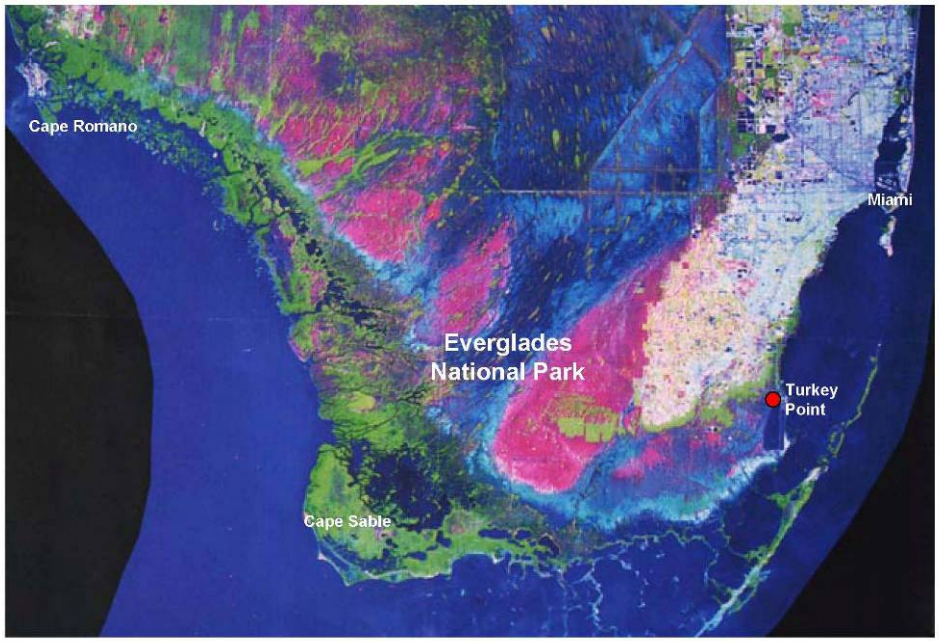


Credit: Peter W. Harlem, Florida International University, Southeast Environmental Research Center

Sea Level Rise in South Florida

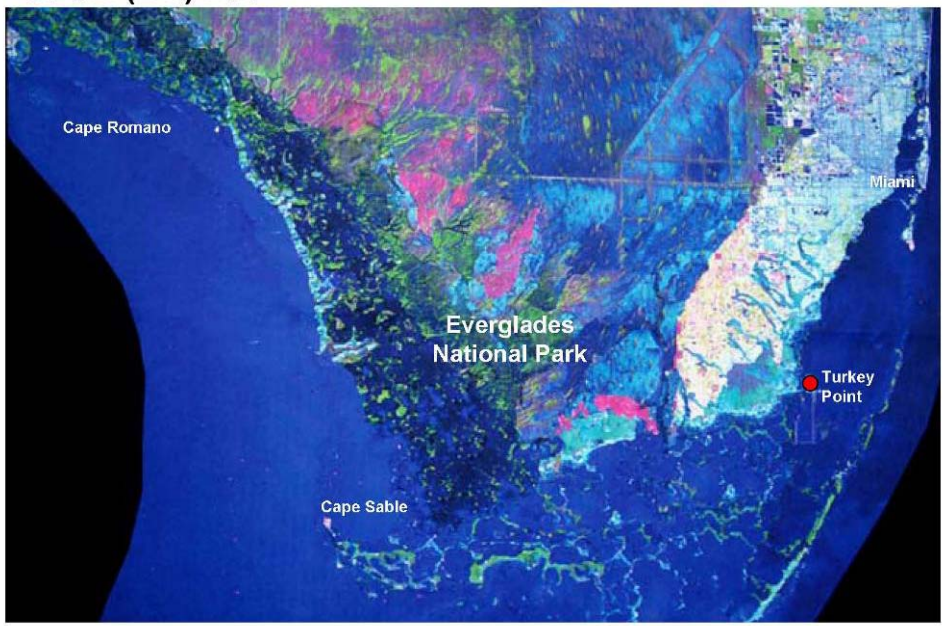
- A little less than 1 foot during the past century measured at Key West
- A 2 foot rise would have significant effects

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

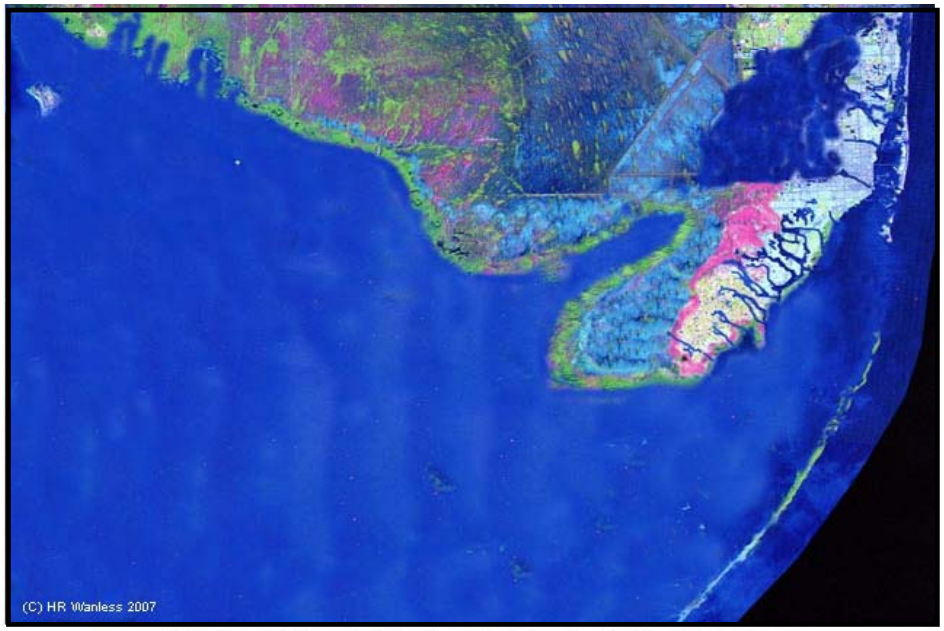


Credit: Dr. Harold R. Wanless; University of Miami, Department of Geological Sciences;
co-chair of Miami-Dade Climate Change Task Force

Sea Level Rise in South Florida

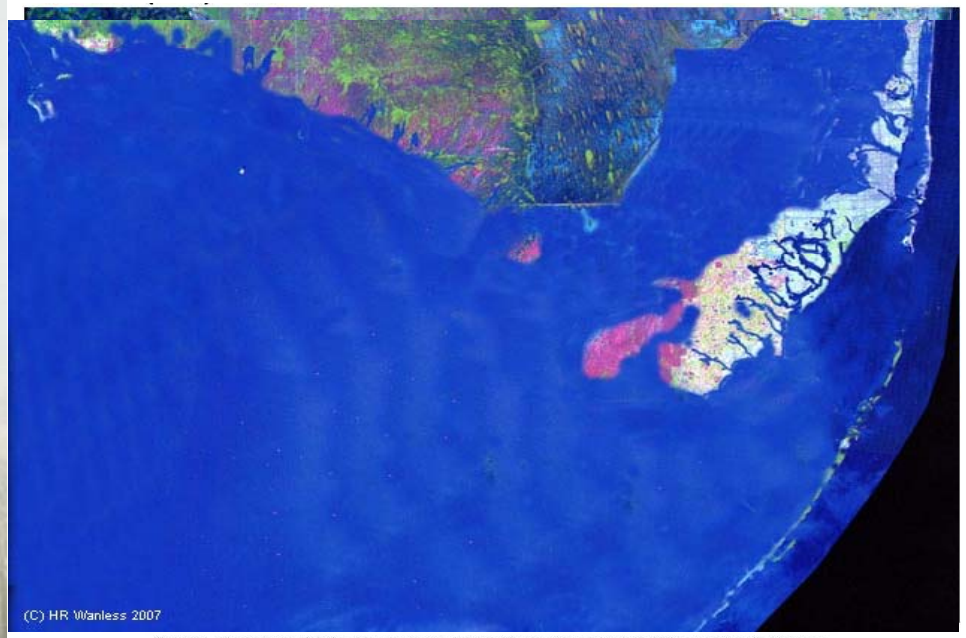
- A little less than 1 foot during the past century measured at Key West
- A 4-5 foot rise would have dramatic impacts

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

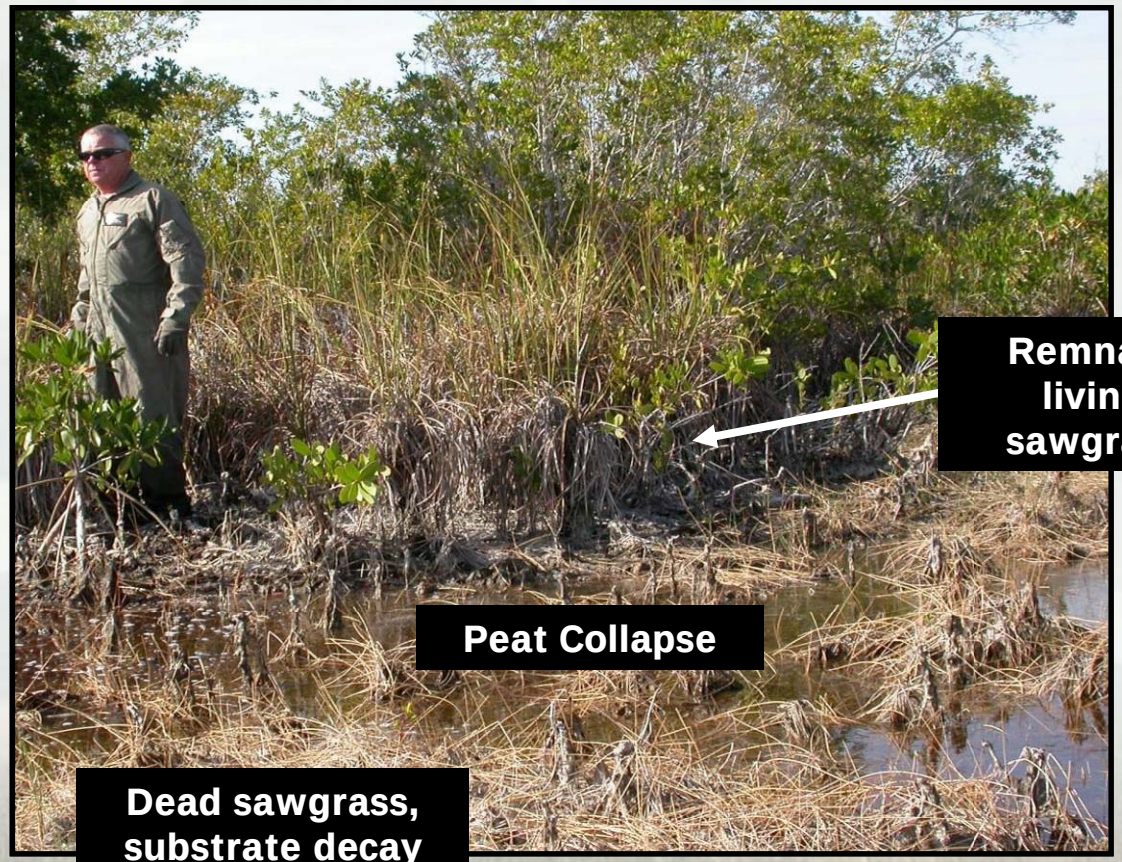


Credit: Dr. Harold R. Wanless; University of Miami, Department of Geological Sciences; co-chair of Miami-Dade Climate Change Task Force

Everglades National Park

Sixty percent of Everglades National Park is less than 3 feet above MSL

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

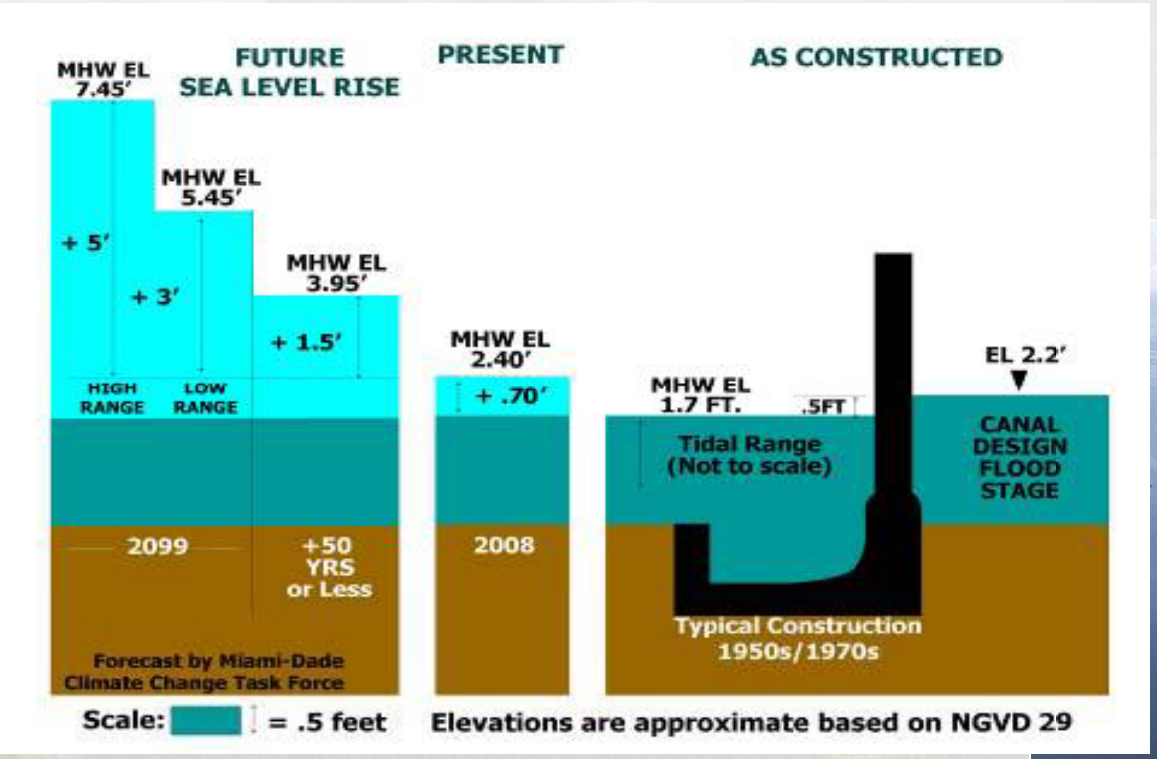
Everglades restoration will increase freshwater flows to natural areas and may delay some future habitat changes

Flood Damage Concerns

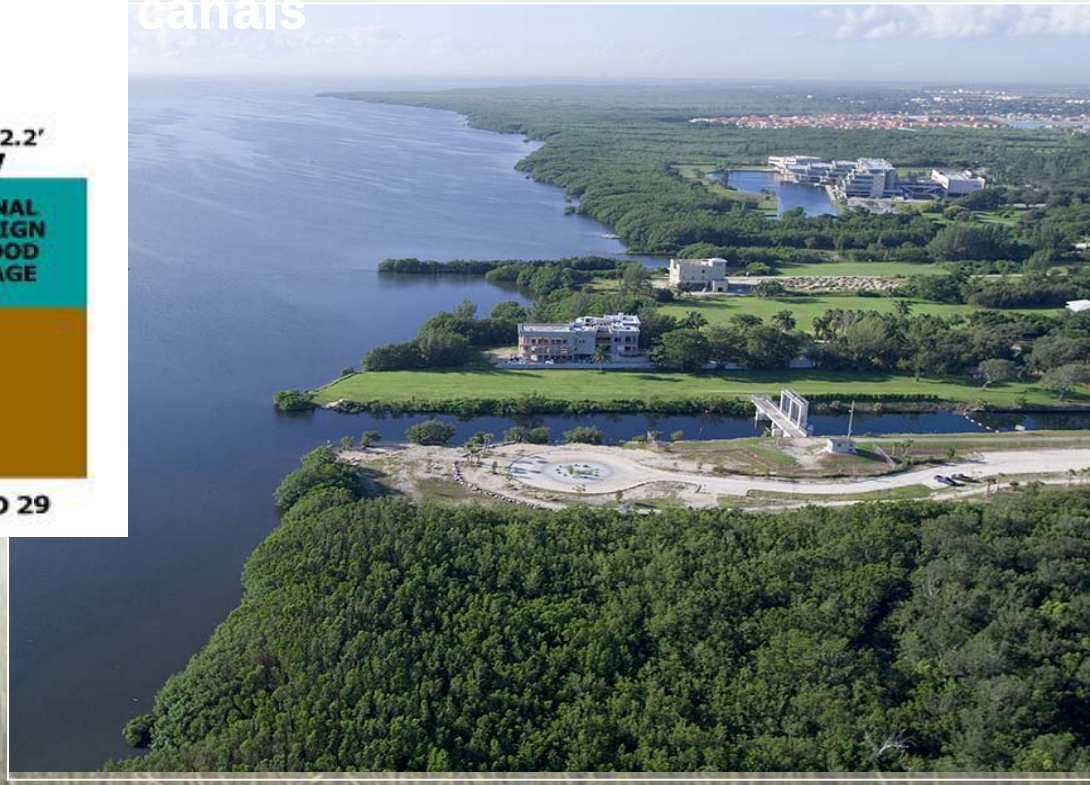
Sea level rise will reduce effectiveness of gravity drainage canals

The population of South Florida is 6.5 million and growing

Flood Damage Concerns



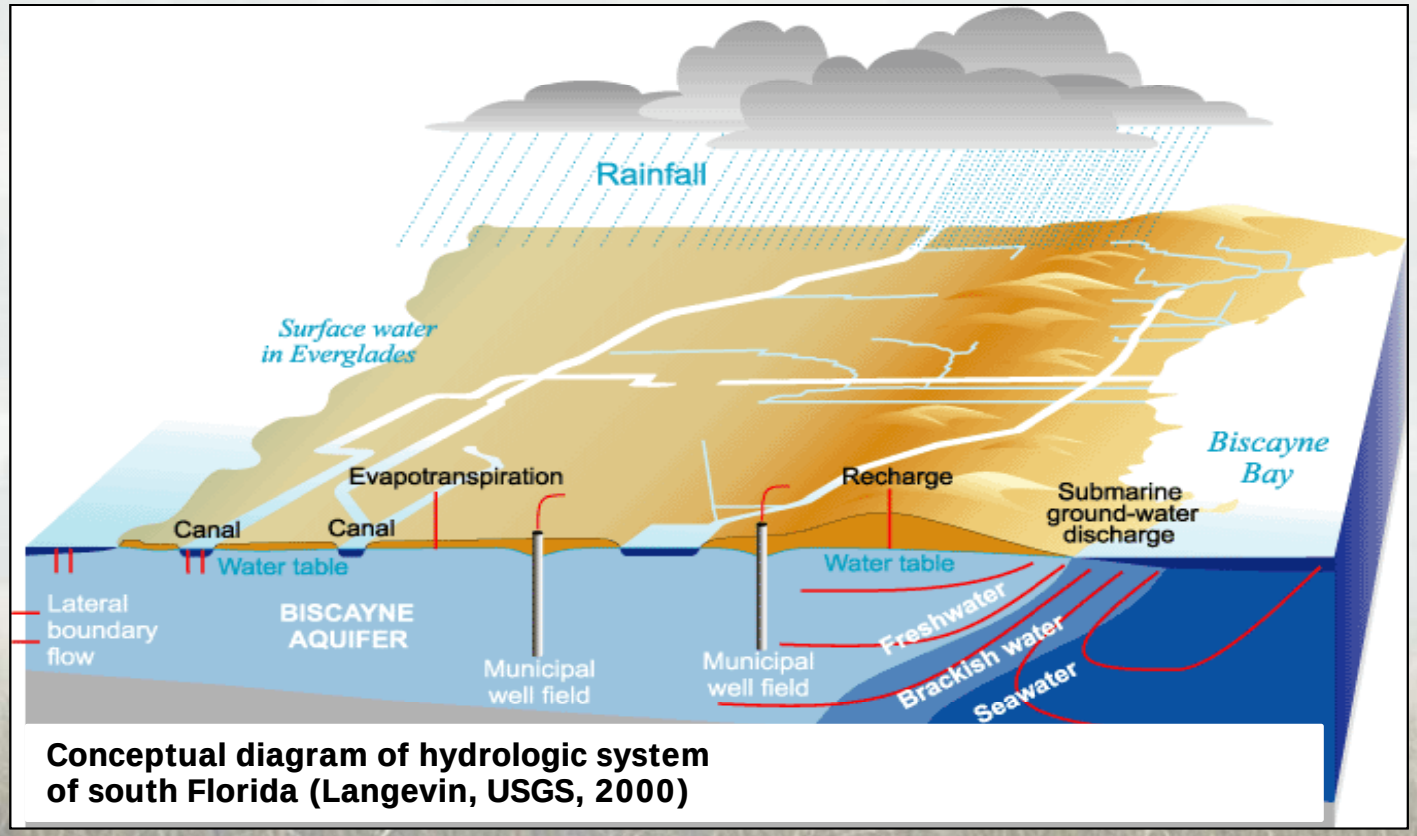
Sea level rise will reduce effectiveness of gravity drainage canals



The population of South Florida is

6.5 million and growing

Water Supply Concerns

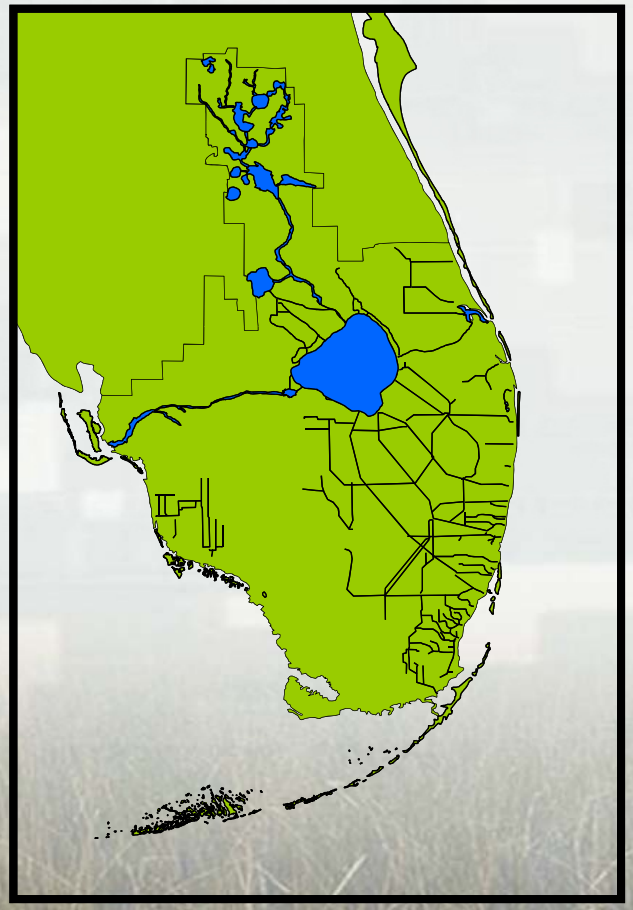


Conceptual diagram of hydrologic system of south Florida (Langevin, USGS, 2000)

- Shallow wells are the primary source of drinking water for south Florida communities
- Will local canal stages be allowed to rise in step with sea level rise?
- Continued sea level rise w/o rising canal stages will allow saltwater intrusion into water wells and create a need for alternative freshwater sources

Water Supply Concerns

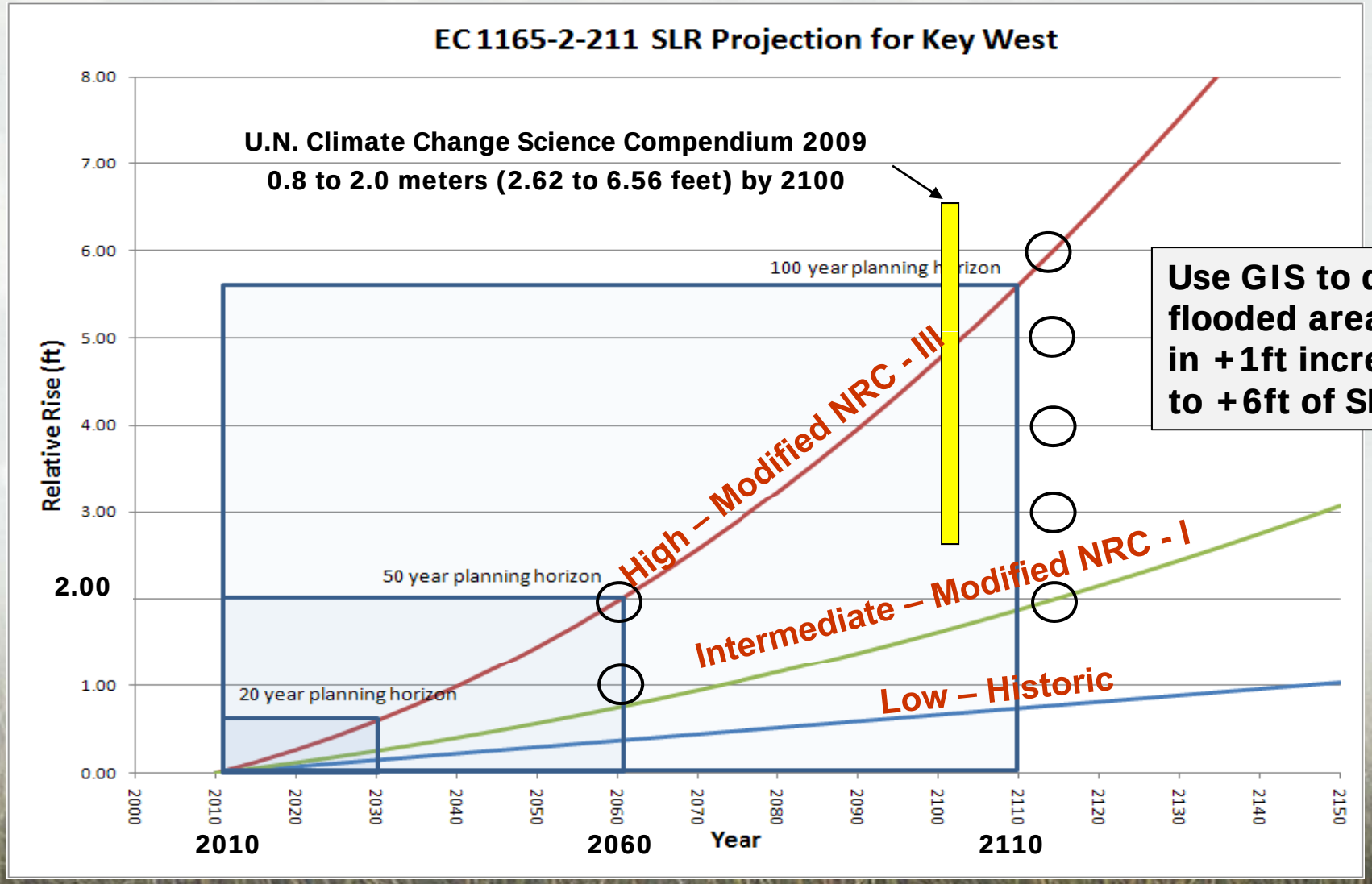
Kissimmee River Basin and Lake Okeechobee



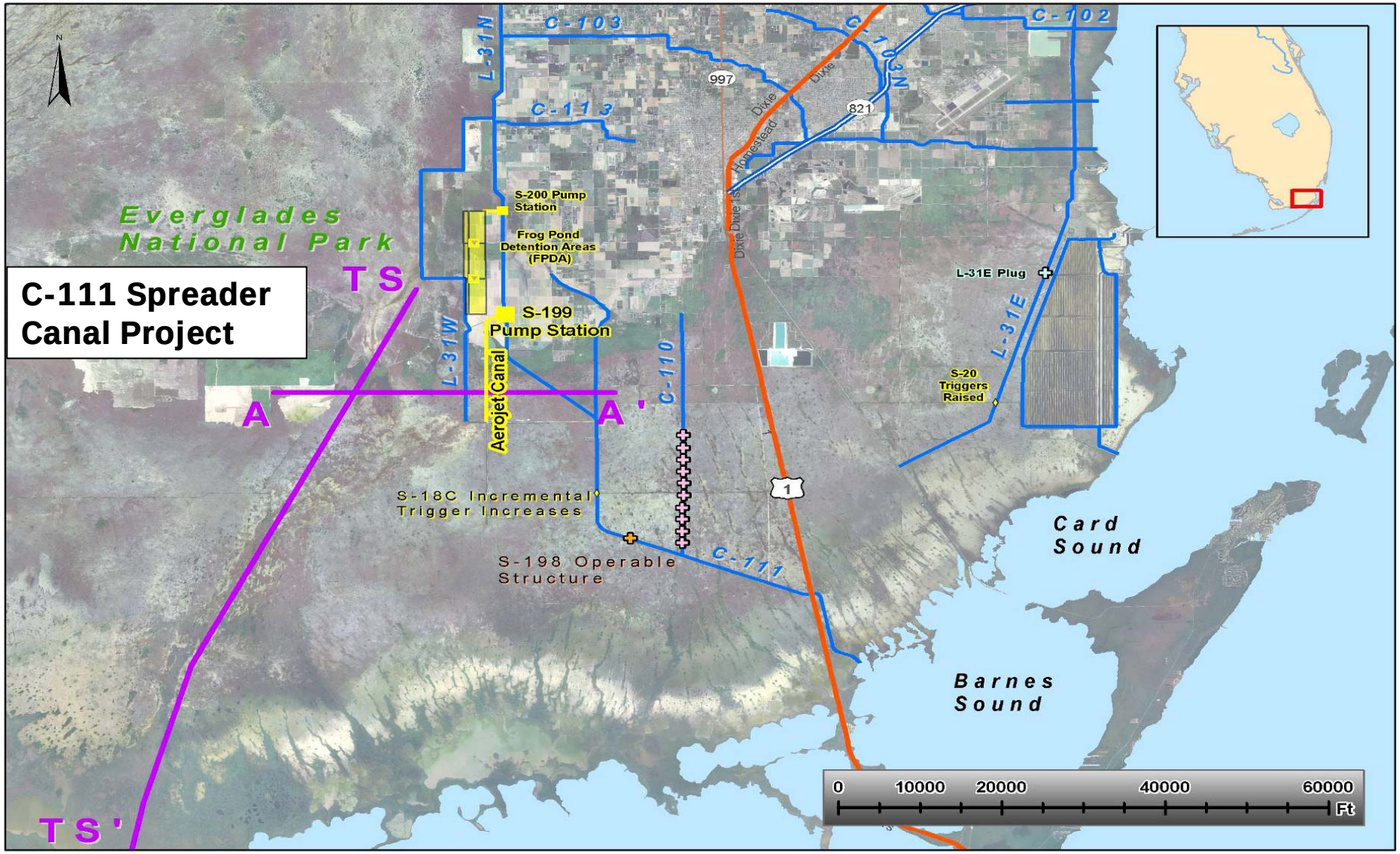
Lake Okeechobee Drought

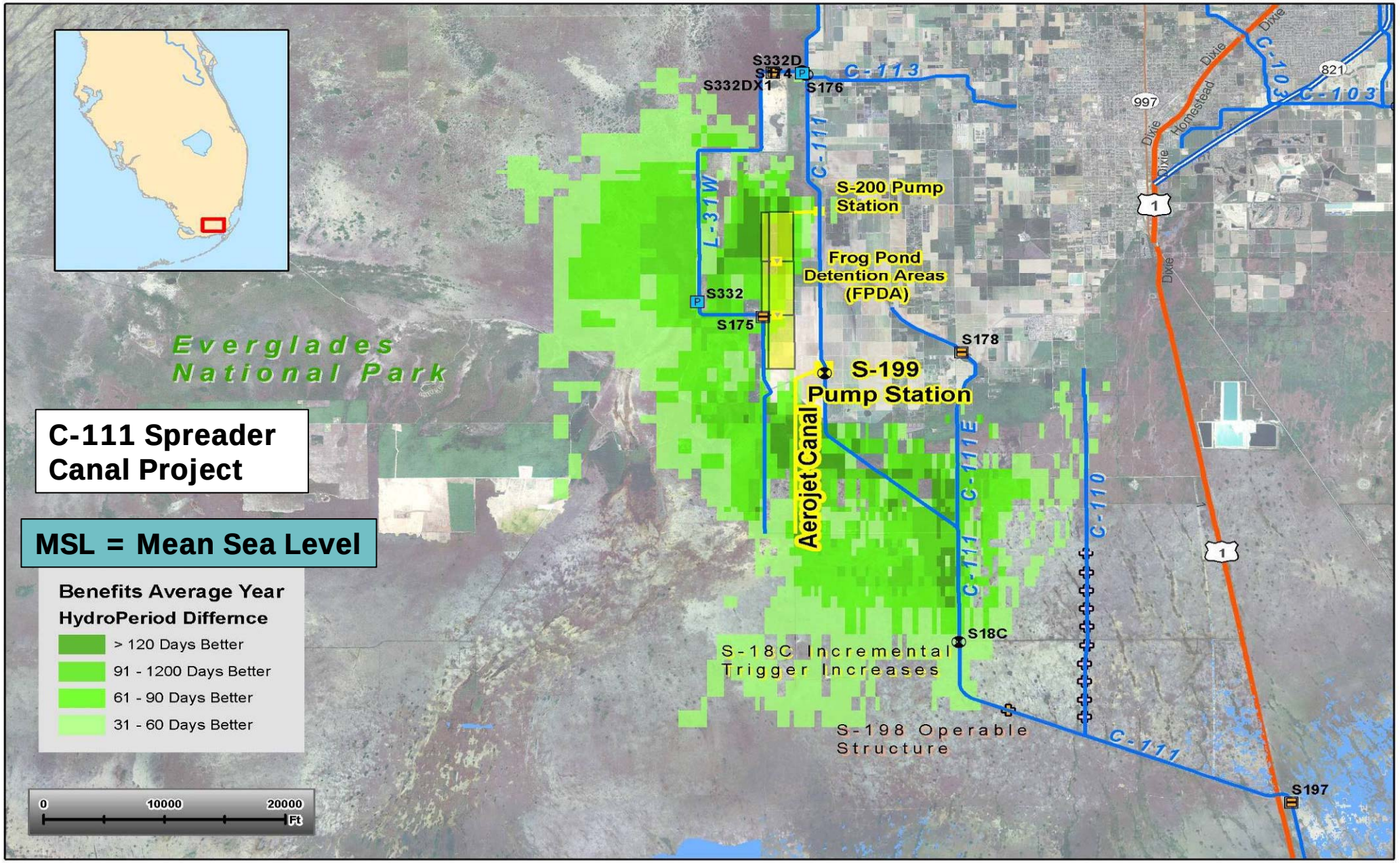
- **Sea level rise may increase demand for water to maintain higher canal stages near the coast**
- **Saltwater intrusion into water supply wells or climate change impacts on rainfall patterns and evaporation will increase water storage needs**

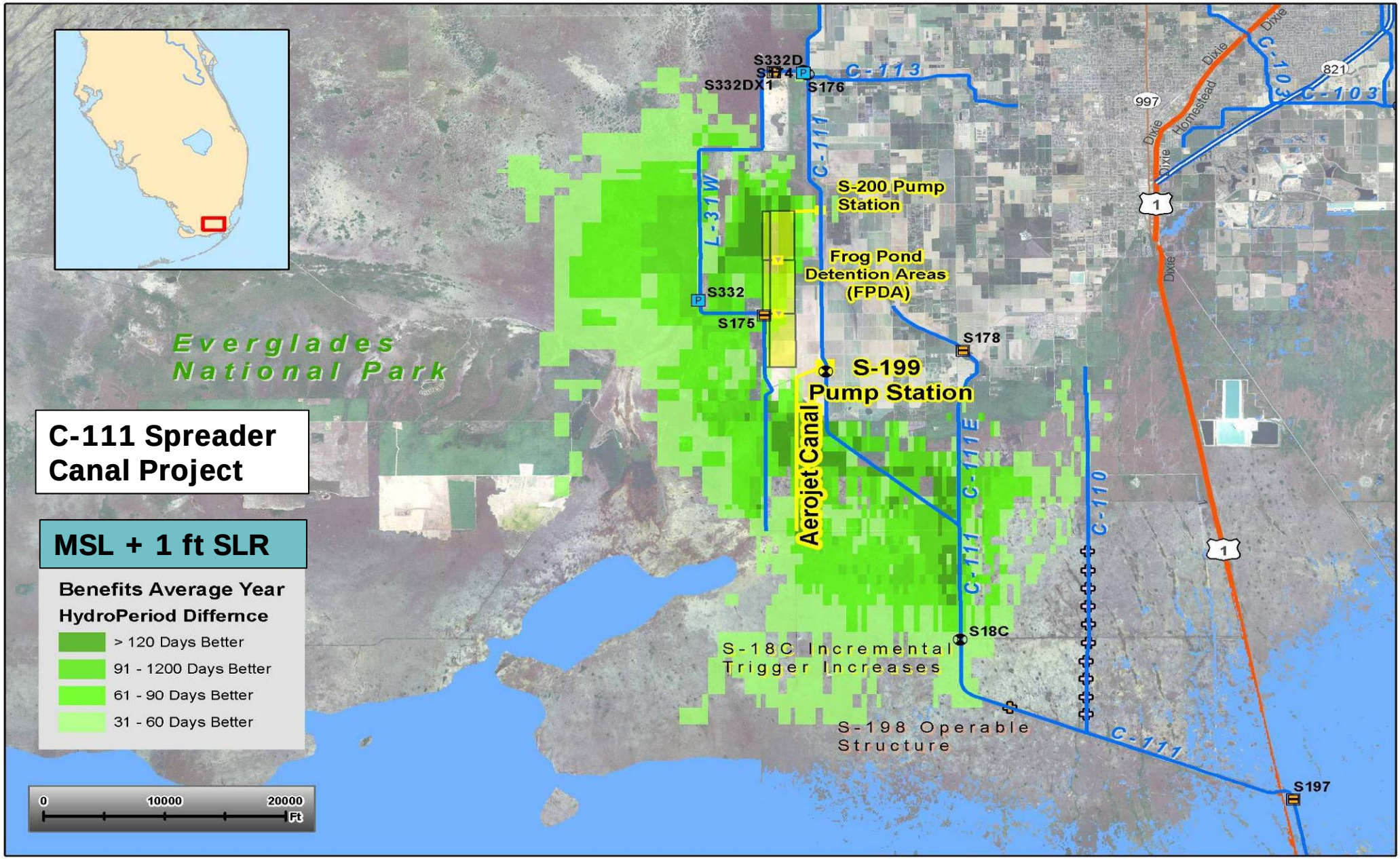
Scenarios for Sea-Level Rise

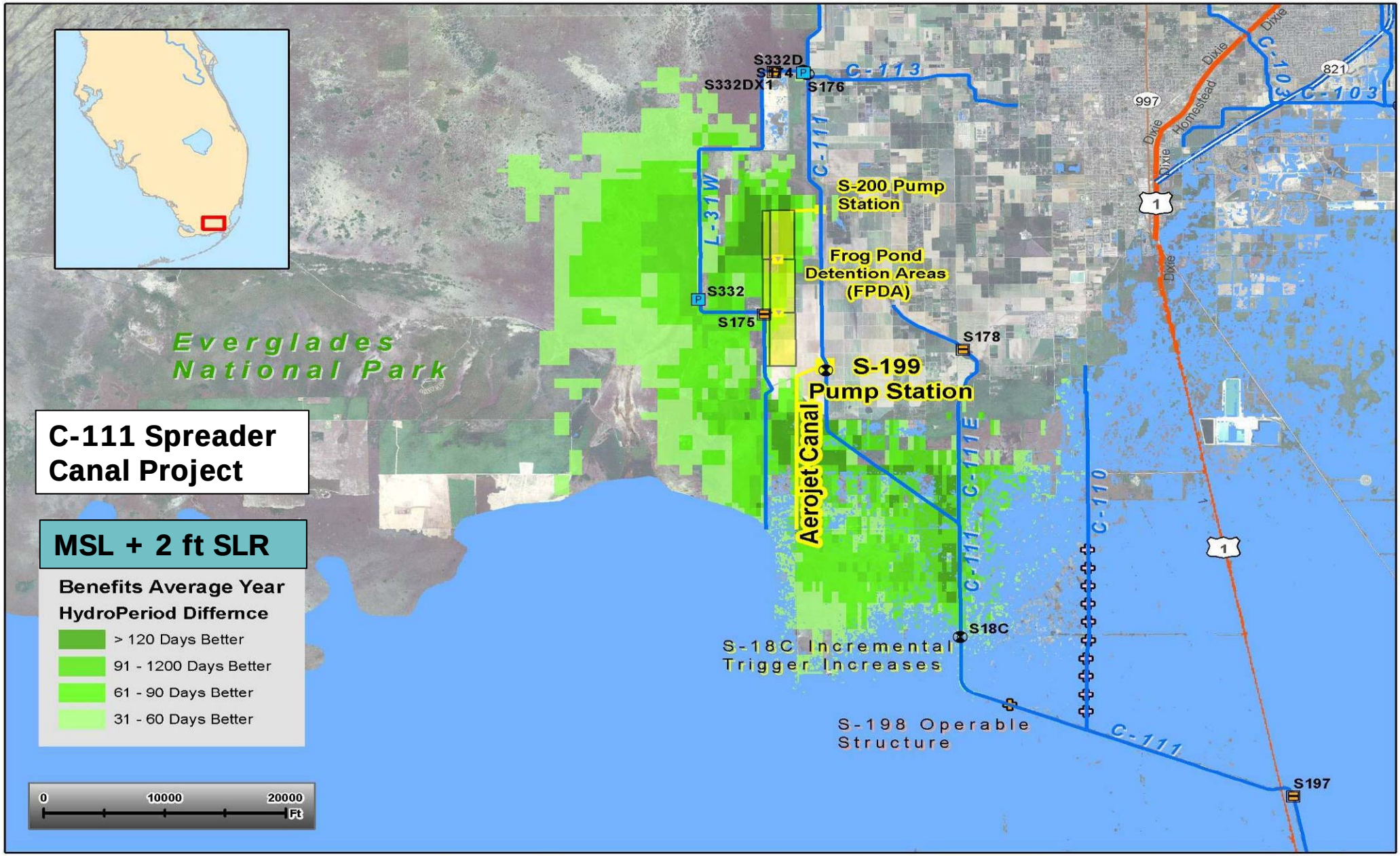


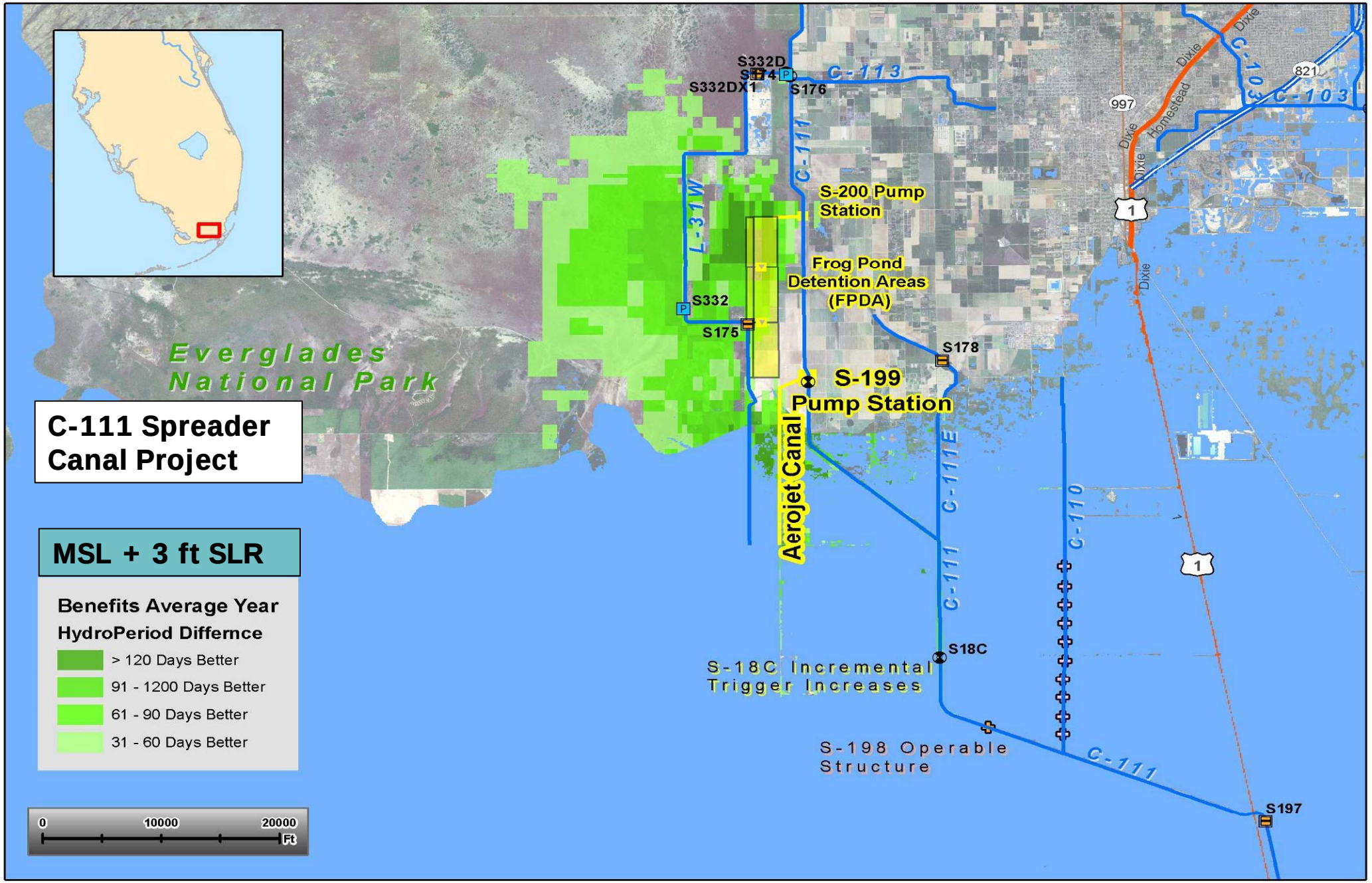
Use GIS to develop flooded area maps in +1ft increments to +6ft of SLC.


C-111 Spreader Canal Project
Everglades National Park
T S
T S '
A
A '
L-31N
L-31W
L-31E
C-103
C-113
C-102
C-103N
C-110
C-111
997
821
Dixie
Homestead
Dixie Dixie 1st
S-200 Pump Station
Frog Pond Detention Areas (FPDA)
S-199 Pump Station
Aerojet Canal
L-31E Plug
S-20 Triggers Raised
S-18C Incremental Trigger Increases
S-198 Operable Structure
Card Sound
Barnes Sound
1
0
10000
20000
40000
60000
Ft
L-31E Plug
C-110 Plugs
S-18C
S-198
S-199
S-20
S-200
Weir
Frog Pond DA
Aerojet Canal
Cross Sections


C-111 Spreader Canal Project
MSL = Mean Sea Level
Benefits Average Year HydroPeriod Differnce
> 120 Days Better
91 - 1200 Days Better
61 - 90 Days Better
31 - 60 Days Better
0
10000
20000
Ft
Everglades National Park
S332D
S332DX1
S176
C-113
C-111
L-31W
S-200 Pump Station
Frog Pond Detention Areas (FPDA)
S332
S175
S178
S-199 Pump Station
Aerojet Canal
C-111E
C-110
S18C
S-18C Incremental Trigger Increases
S-198 Operable Structure
S197
997
Dixie
Homestead
C-103
821
1
L-31E Plug
C-110 Plugs
S-18C
S-198
S-199
S-20
S-200
Weir
Frog Pond DA
Aerojet Canal
MSL Limit


C-111 Spreader Canal Project
MSL + 1 ft SLR
Benefits Average Year
HydroPeriod Differnce
> 120 Days Better
91 - 1200 Days Better
61 - 90 Days Better
31 - 60 Days Better
0
10000
20000
Ft
Everglades National Park
S332D
S332D1
S332DX1
S176
C-113
C-111
L-31W
S-200 Pump Station
Frog Pond Detention Areas (FPDA)
S332
S175
S178
S-199 Pump Station
Aerojet Canal
C-111E
C-110
S18C
S-18C Incremental Trigger Increases
S-198 Operable Structure
C-111
S197
C-103
821
997
Homestead
Dixie
1
L-31E Plug
C-110 Plugs
S-18C
S-198
S-199
S-20
S-200
Weir
Frog Pond DA
Aerojet Canal
MSL Limit + 1' SLR

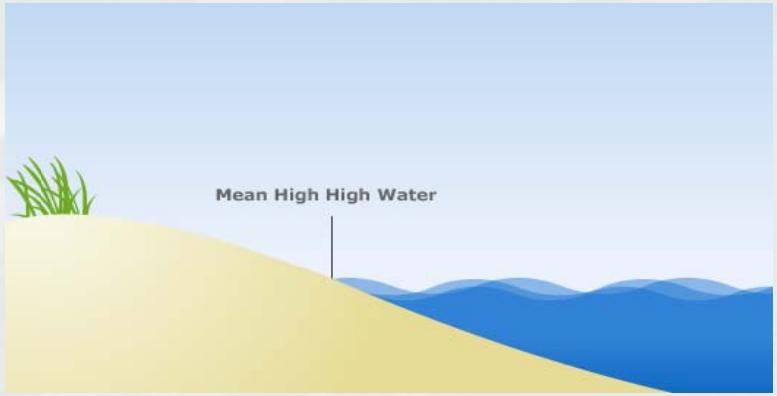

C-111 Spreader Canal Project
MSL + 2 ft SLR
Benefits Average Year
HydroPeriod Differnce
> 120 Days Better
91 - 1200 Days Better
61 - 90 Days Better
31 - 60 Days Better
0
10000
20000
Ft
Everglades National Park
S332D
S332
S332DX1
S176
S175
S178
S197
S18C
C-113
C-111
L-31W
C-111E
C-110
C-103
S-200 Pump Station
Frog Pond Detention Areas (FPDA)
S-199 Pump Station
Aerojet Canal
S-18C Incremental Trigger Increases
S-198 Operable Structure
Dixie
Homestead
997
821
1
L-31E Plug
C-110 Plugs
S-18C
S-198
S-199
S-20
S-200
Weir
Frog Pond DA
Aerojet Canal
MSL Limit + 2' SLR

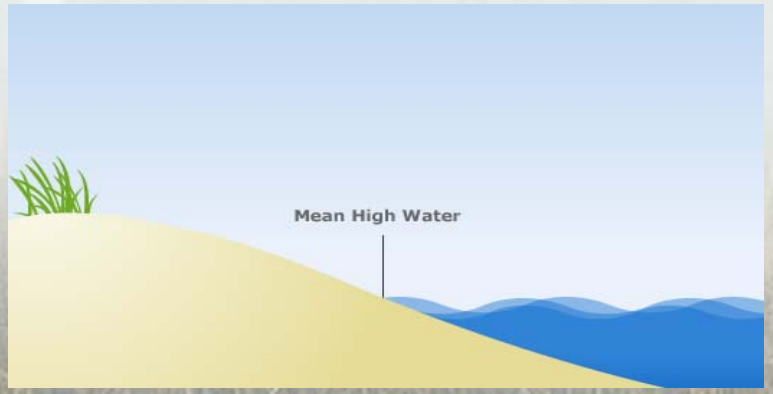

C-111 Spreader Canal Project
MSL + 3 ft SLR
Benefits Average Year
HydroPeriod Differnce
> 120 Days Better
91 - 1200 Days Better
61 - 90 Days Better
31 - 60 Days Better
Everglades National Park
S332D
S332
S332DX1
S176
C-113
C-111
L-31W
S-200 Pump Station
Frog Pond Detention Areas (FPDA)
S332
S175
S178
S-199 Pump Station
Aerojet Canal
C-111E
C-110
C-111
S18C
S-18C Incremental Trigger Increases
S-198 Operable Structure
S197
Dixie
Homestead
997
821
C-103
1
0
10000
20000
Ft
L-31E Plug
C-110 Plugs
S-18C
S-198
S-199
S-20
S-200
Weir
Frog Pond DA
Aerojet Canal
MSL Limit + 3' SLR

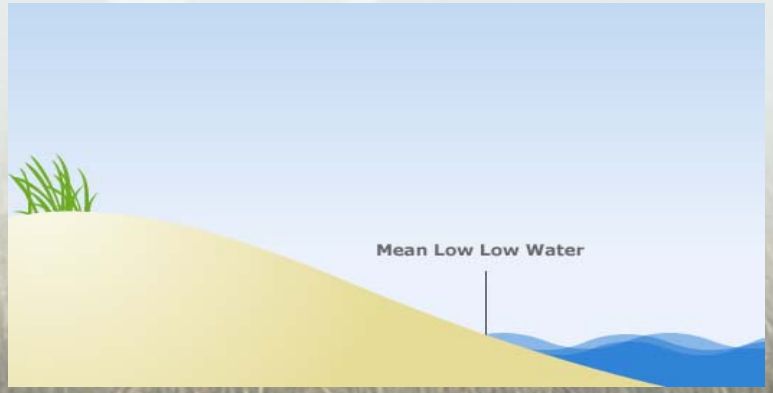
C-111 Spreader Canal Project
SLR Effects on Restoration Benefits

	After 20 Years	After 50 Years	After 100 Years
Low			
Freshwater Wetlands	No effect	Not significant	Minor (10% reduction)
Nearshore Salinity	No effect	Not significant	Location shift
Intermediate			
Freshwater Wetlands	No effect	Minor (10% reduction)	Significant (33% reduction)
Nearshore Salinity	Minimal location shift	Location shift	Location shift
High			
Freshwater Wetlands	Minor (<10%)	Significant (33% reduction)	All lost
Nearshore Salinity	Location shift	Location shift	Location shift & losses

shoreline.noaa.gov/apps/bounddeterm.html

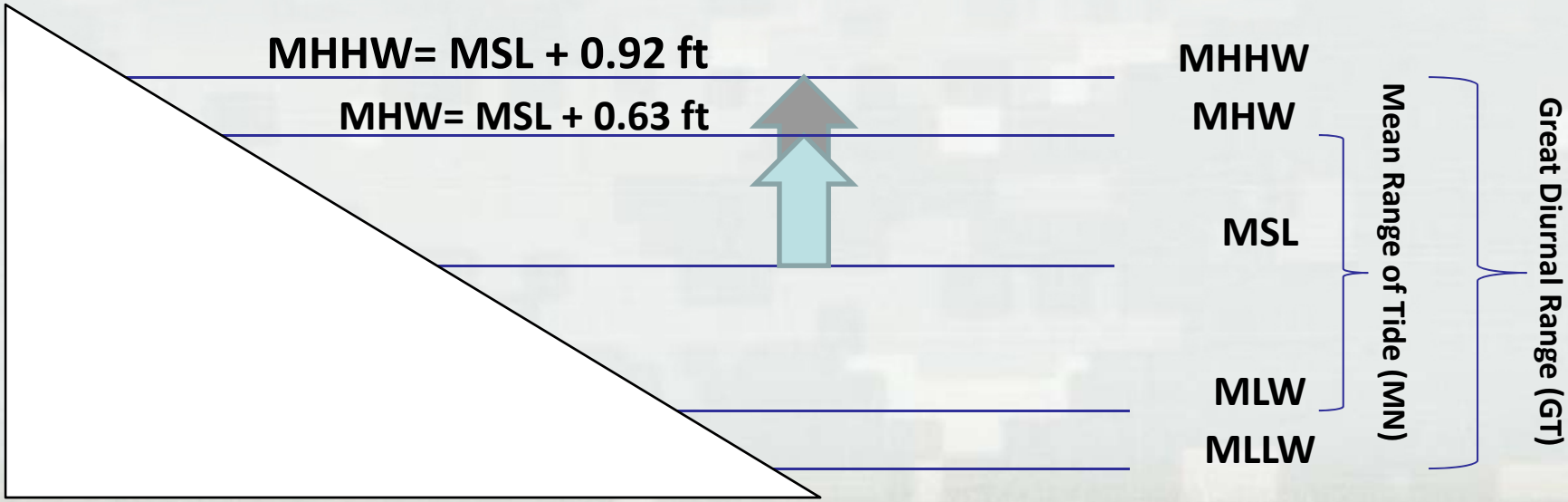






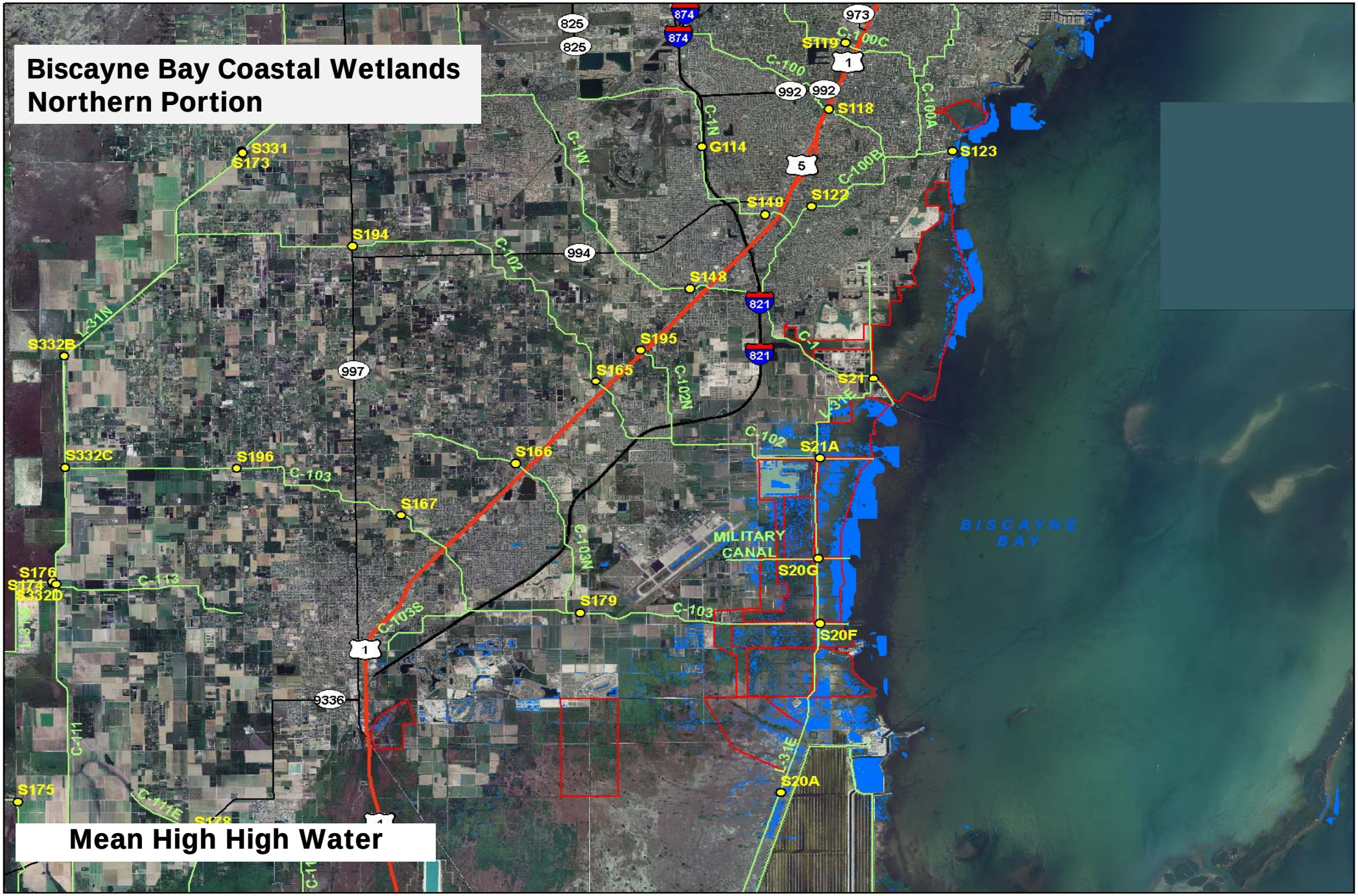
Tidal Datums for Key West

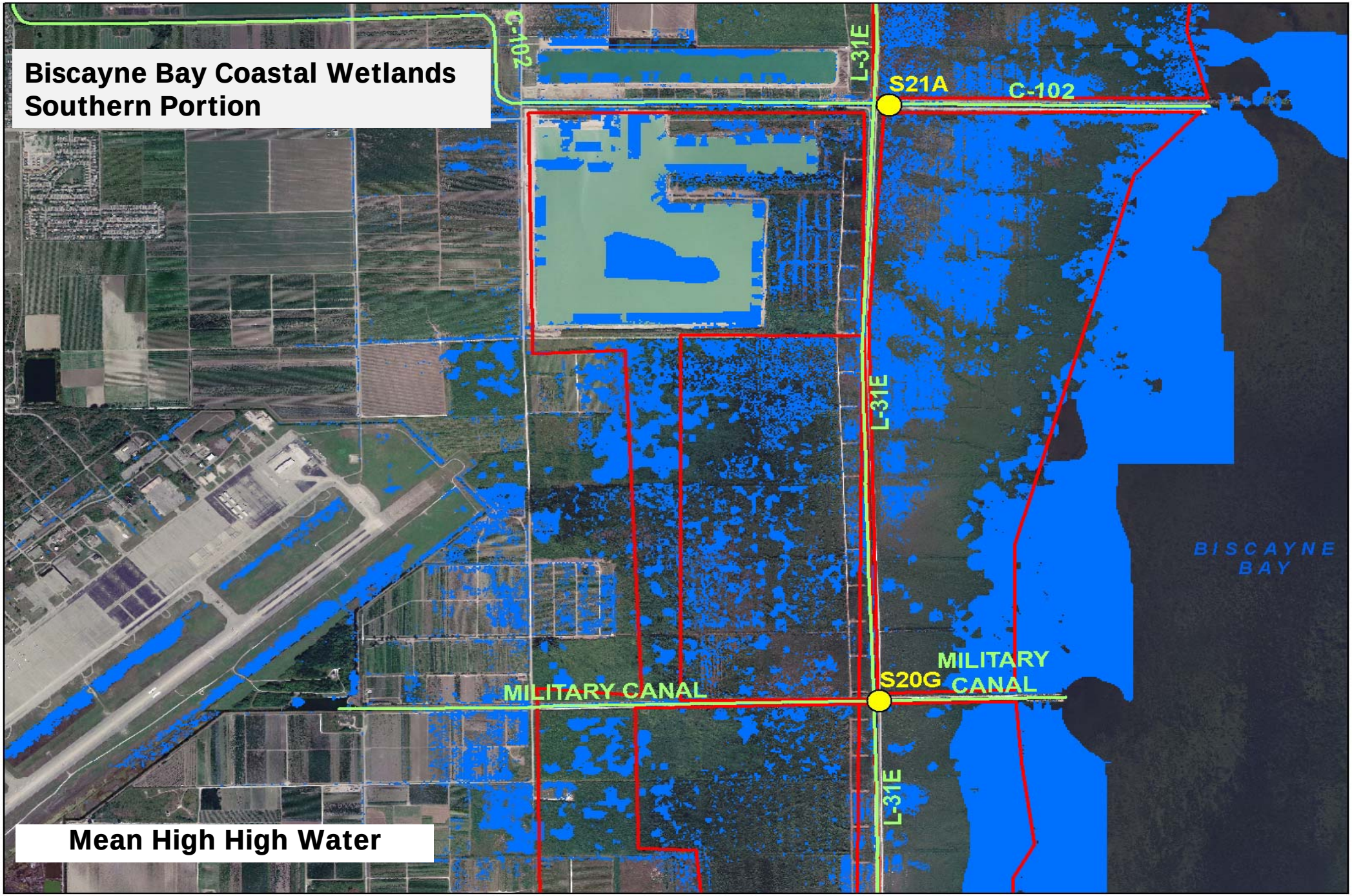
Elevations in NAVD 88 Relative to NTDE 1983-2001

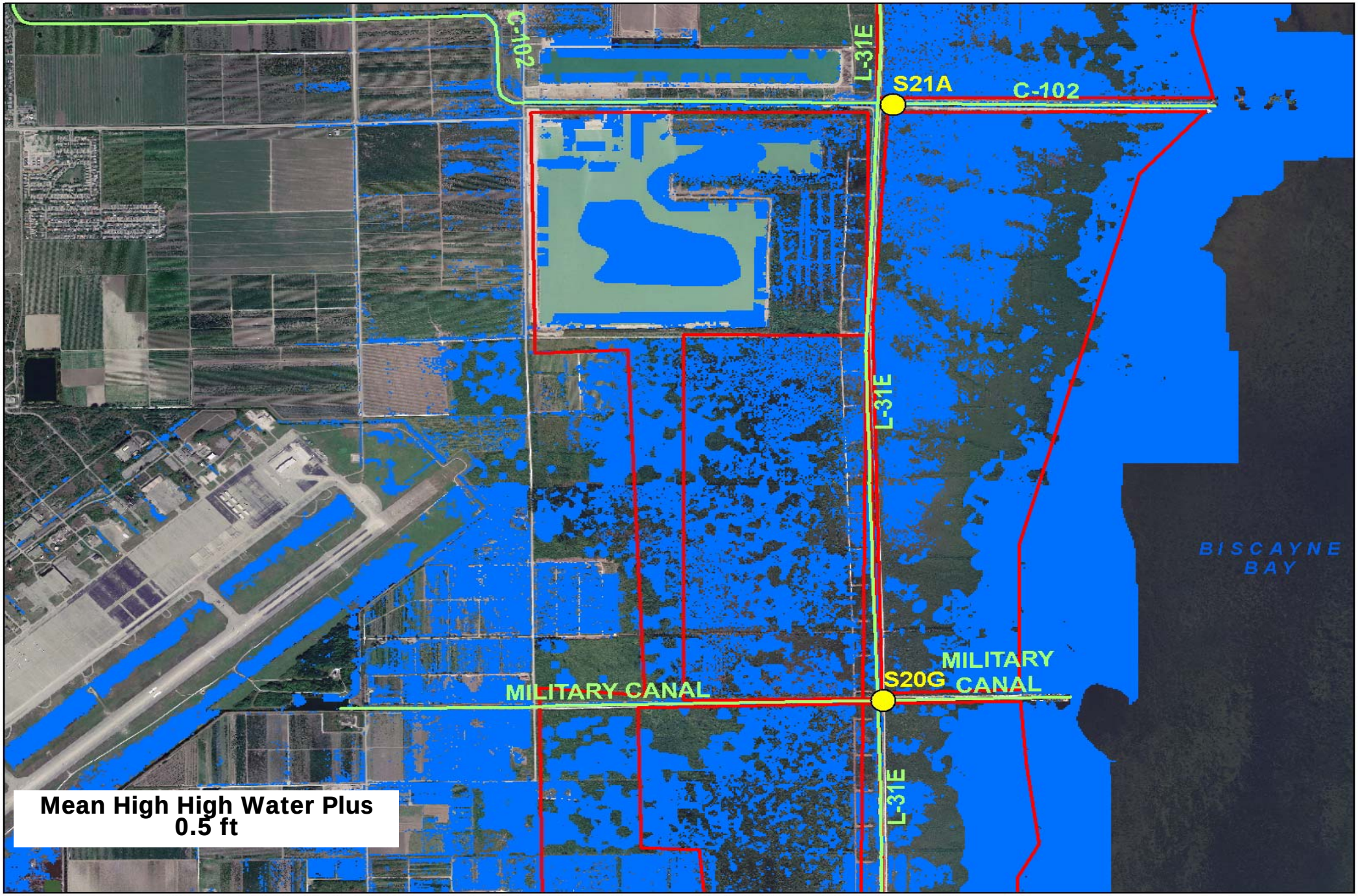


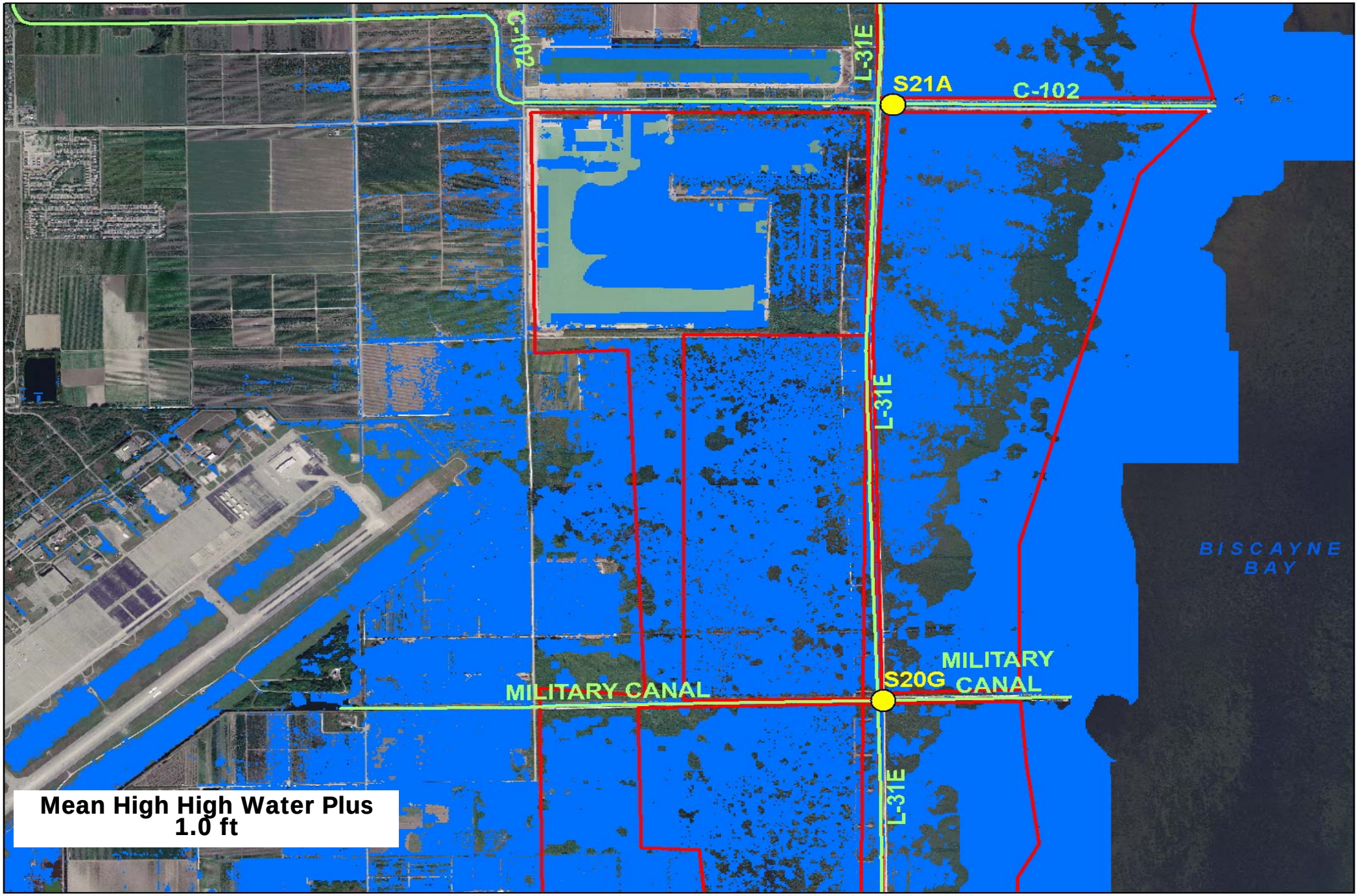
Great Diurnal Range (GT)- The difference in height between mean high high water and mean lower low water.

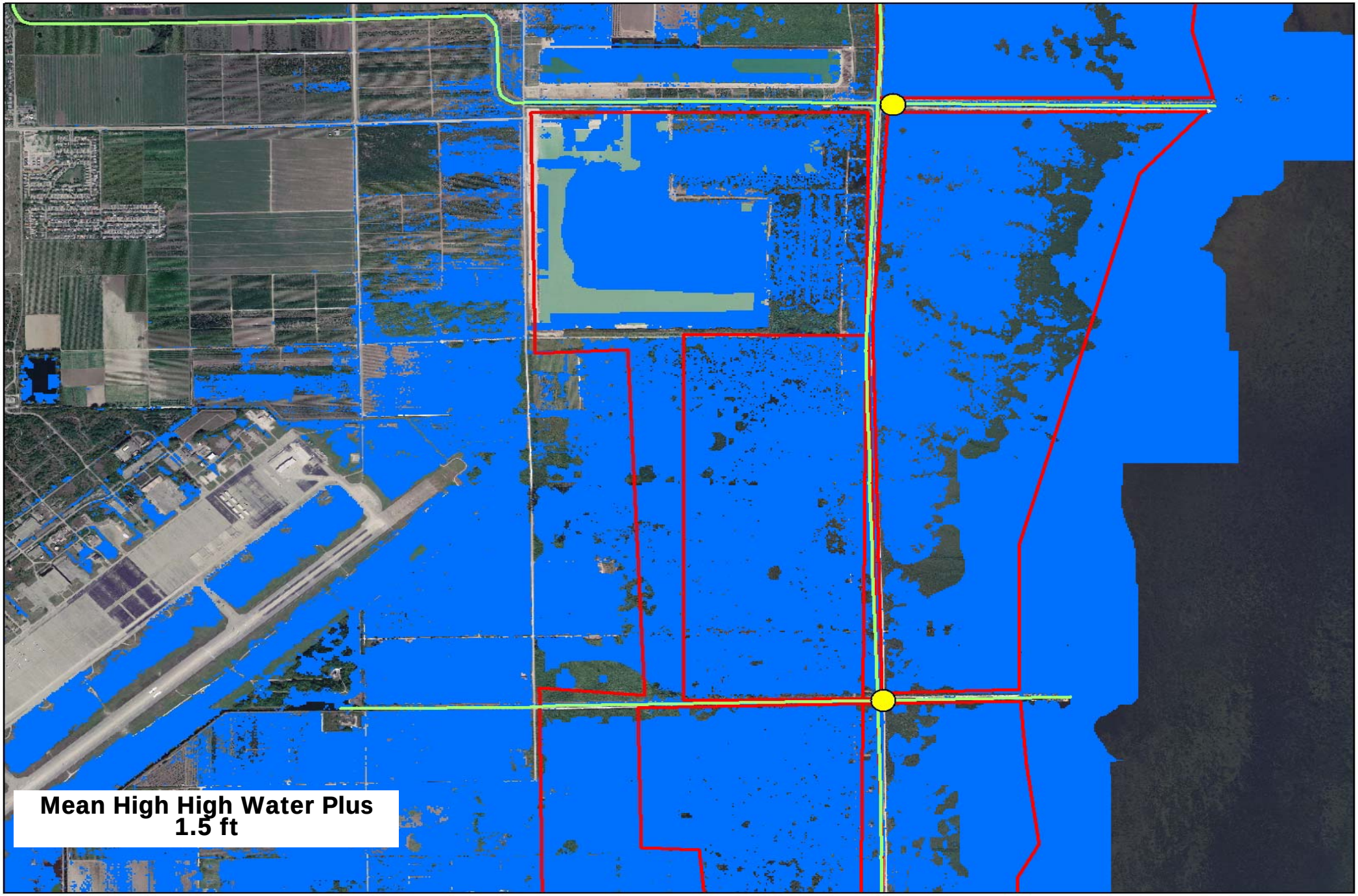
Mean Range of Tide (MN)- The difference in height between mean high water and mean low water.

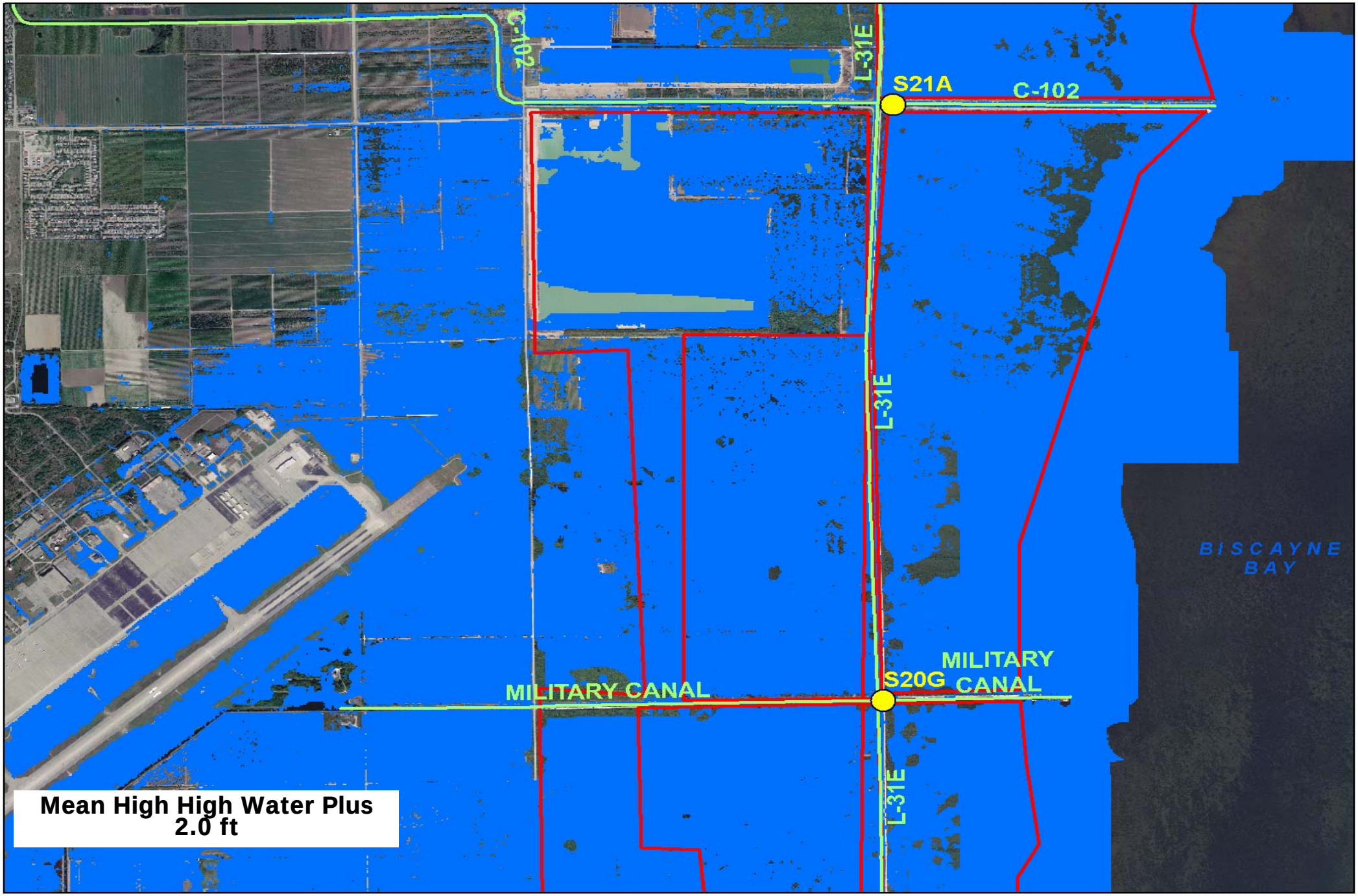

Biscayne Bay Coastal Wetlands
Northern Portion
Mean High High Water
S331
S173
S194
S332B
S332C
S196
S167
S176
S174
S332D
S175
S178
S119
S118
G114
S123
S149
S122
S148
S195
S165
S166
S21
S21A
S20G
S20F
S20A
S179
MILITARY
CANAL
BISCAYNE
BAY
C-100C
C-100
C-100A
C-100B
C-1N
C-1
C-102
C-102N
C-103
C-103N
C-103S
C-113
C-111
C-111E
L-31N
L-31E
825
874
973
992
994
997
821
1
5
9336

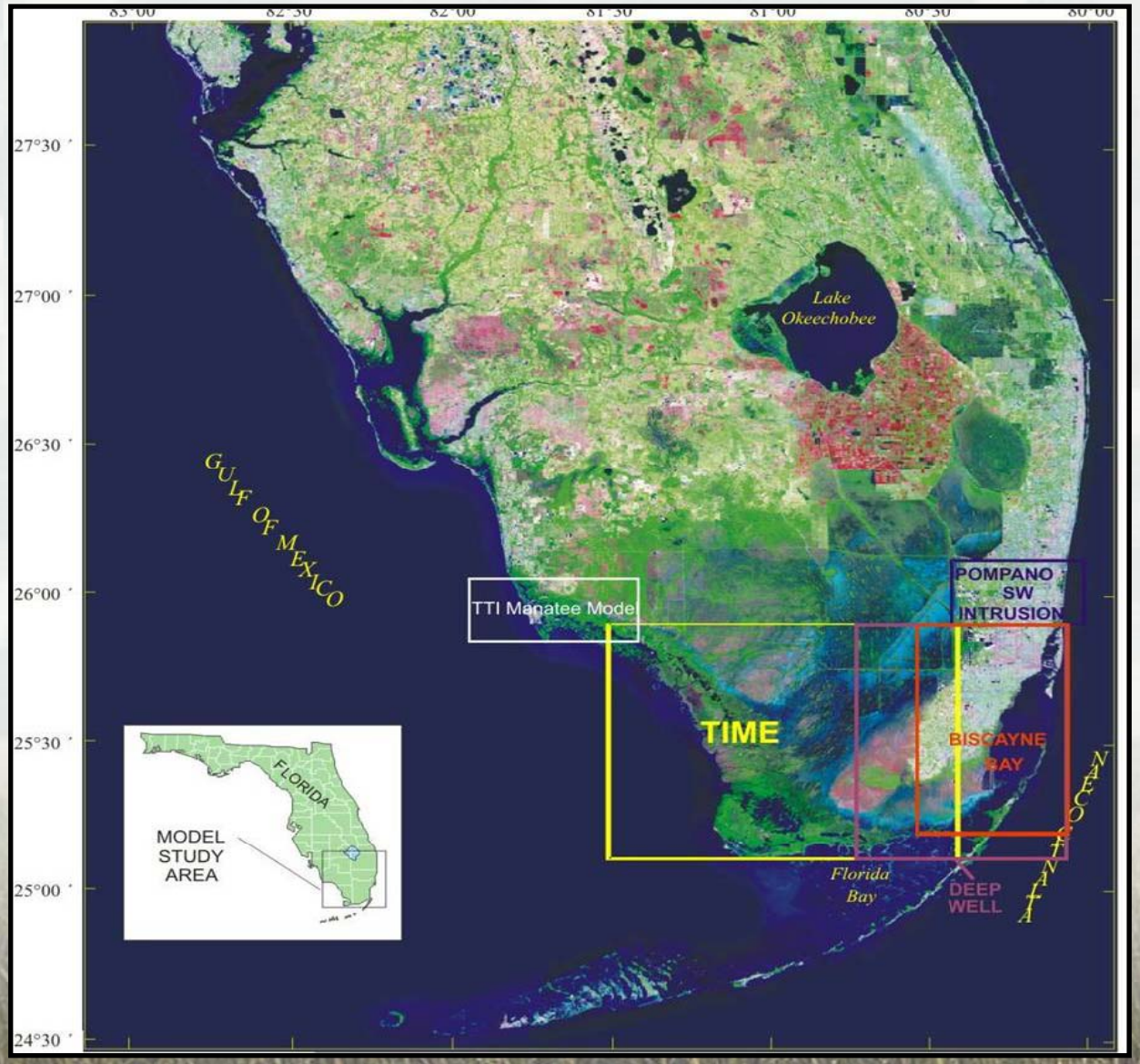

Biscayne Bay Coastal Wetlands
Southern Portion
C-102
L-31E
S21A
C-102
L-31E
BISCAYNE
BAY
MILITARY CANAL
S20G
MILITARY
CANAL
L-31E
Mean High High Water


C-102
L-31E
S21A
C-102
L-31E
BISCAYNE BAY
MILITARY CANAL
S20G
MILITARY CANAL
L-31E
Mean High High Water Plus 0.5 ft


C-102
L-31E
S21A
C-102
L-31E
BISCAYNE BAY
MILITARY CANAL
S20G
MILITARY CANAL
L-31E
Mean High High Water Plus 1.0 ft


Mean High High Water Plus
1.5 ft


C-102
L-31E
S21A
C-102
L-31E
BISCAYNE BAY
MILITARY CANAL
S20G
MILITARY CANAL
L-31E
Mean High High Water Plus 2.0 ft



Model Development

For South Florida Climate Change Adaptation Studies

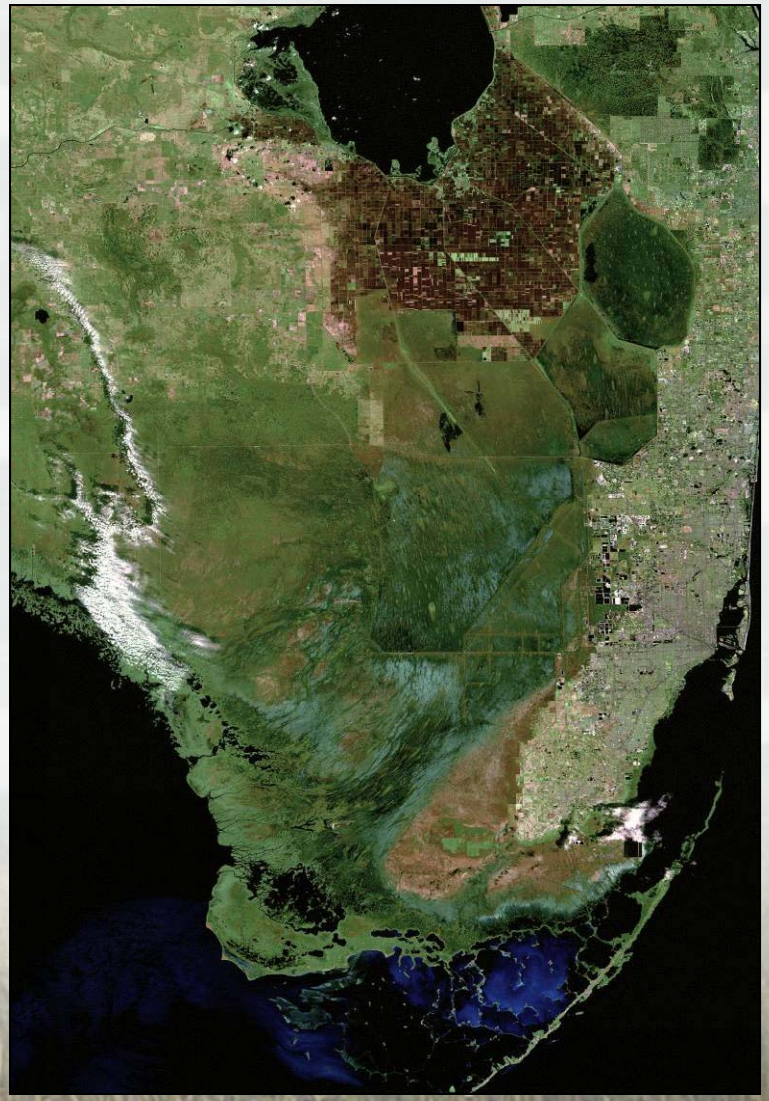
Regional models must be modified or developed to evaluate potential climate change related variations in rainfall, evapotranspiration and tropical storms.

Local models with one foot topographic contours must be developed or enhanced to evaluate potential sea level rise and salt water intrusion impacts in natural and developed coastal areas.

Conversion to **NAVD88** is needed.

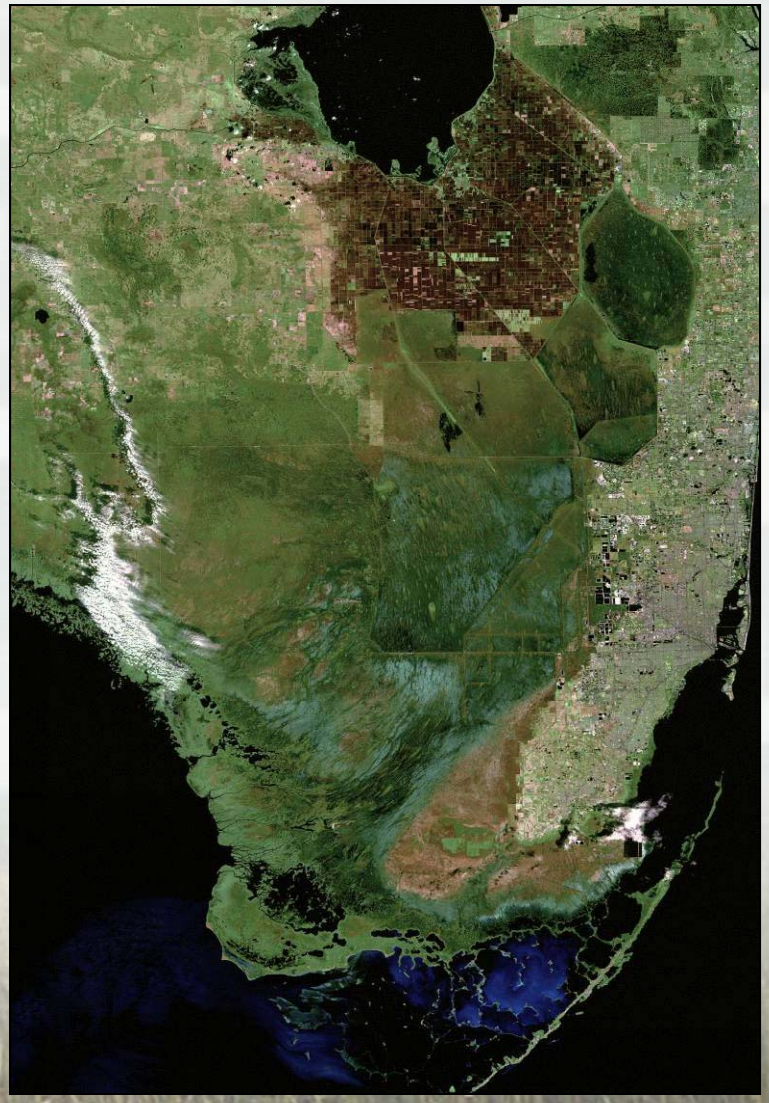
Next Steps - CERP

- Complete Draft CGM16 on SLR
- Coordinate Draft CGM16 with CERP Partners and COE national team preparing SLC ETL
- Continue Initial SLR Impacts Assessments for CERP coastal projects
- Summarize Initial SLR Impacts Assessments in CERP Tech Rpt 1
- Continue Model Development for More Detailed Future Studies



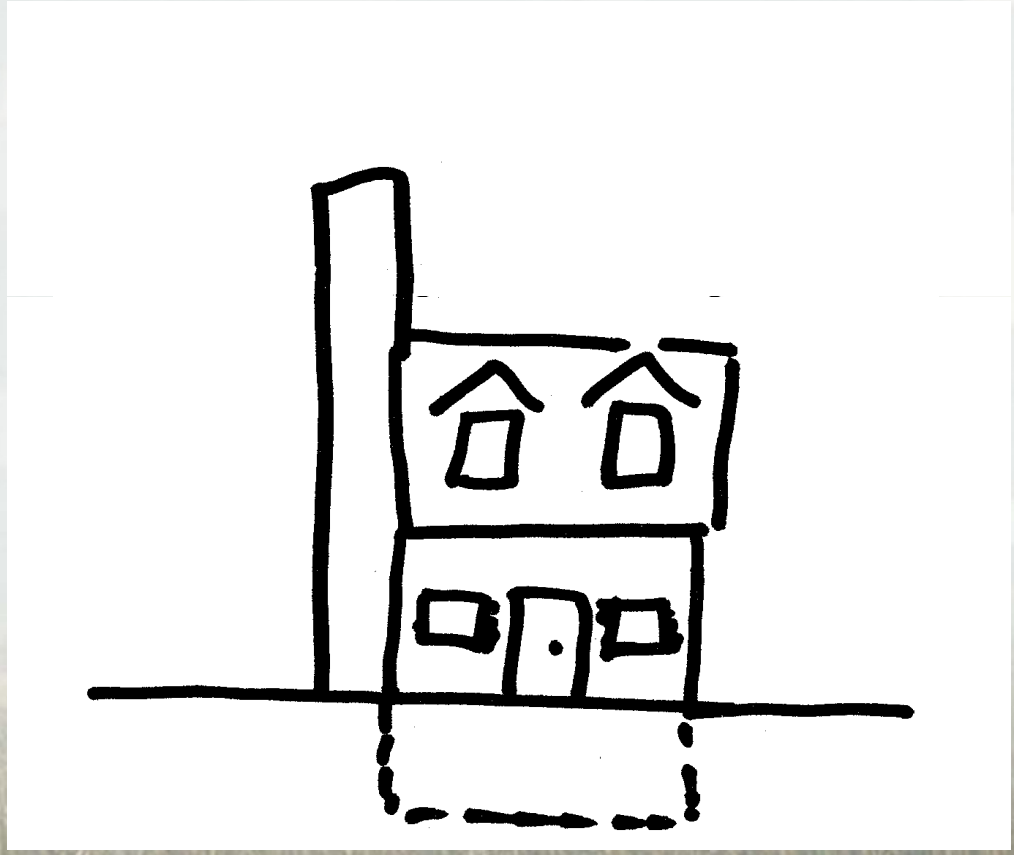
Next Steps - USACE

- Per WRDA 2007, update USACE Principles and Guidelines for Water Resources Projects. National Research Council (NRC) review comments due Nov 2010.
- A national interagency team is preparing a new Engineering Technical Letter (ETL) on Sea Level Change due in 2011.
- NRC to review and possibly update their 1987 guidance on SLR. Target completion Dec 2011.
- CEQ Climate Adaption Task Force



Building Guidance

1. Site Prep: Datum
   - EC 1110-2-6065/6070, Comprehensive Evaluation of Project Datums
   - Engineer Regulation 1110-2-8160, Policies for Referencing Project Elevation Grades to Nationwide Vertical Datums
   - Draft EM in progress
2. Foundation: Sea Level
   - EC 1165-2-211, Incorporating Sea-Level Change Considerations in Civil Works Programs
3. Next Step: Impacts, Responses, Adaptation
   - This ETL
4. Add on Later: Tides, Waves, Storms, etc



Procedures to Evaluate Sea Level Change Impacts, Responses, and Adaptation
Engineering Technical Letter Team

External Experts
USGS
NOAA
Navy
FHWA
HR Wallingford, UK
University of Southampton, UK

Mike Mohr, LRB

Heidi Moritz, NWP
Team Lead for Engineering

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

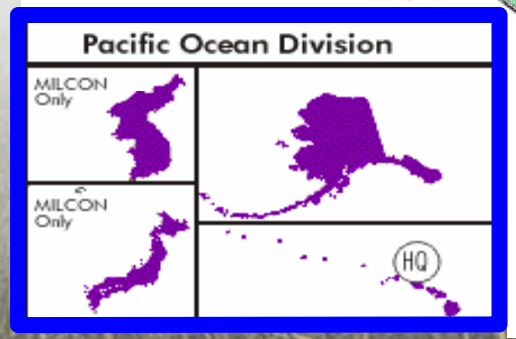
John Furry, HQ

Henri Langlois, IWR
Team Lead for Planning

Stu Townsley, SPD

Lauren DeFrank, IWR

Mike Wutkowski, SAW



Matt Schrader, SAJ
Glenn Landers, SAJ

Susan Rees, SAM
Dennis Mekkers, SAM

Justo Pena, SWG

Julie Rosati, ERDC
Andy Garcia, ERDC

Tom Smith, POH
Crane Johnson, POA

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

Everglades Restoration Climate Change Concerns

Key Take Away Points

- Uncertainties and RISKS exist regarding climate change, particularly future rate and depth of sea level rise
- National Academy of Sciences 2008 report on restoration progress stated that climate change should be a reason to accelerate Everglades restoration, not a reason for delays
- Everglades Restoration will help delay climate change impacts in natural and developed areas
- More work needed to assess impact of sea level rise and climate change on the restoration effort
- CERP PIRs to address Climate Change Adaptation Strategies for enhanced long term sustainability

For additional information, contact:

Glenn Landers

U.S. Army Corps of Engineers
Jacksonville District

Glenn.B.Landers@usace.army.mil