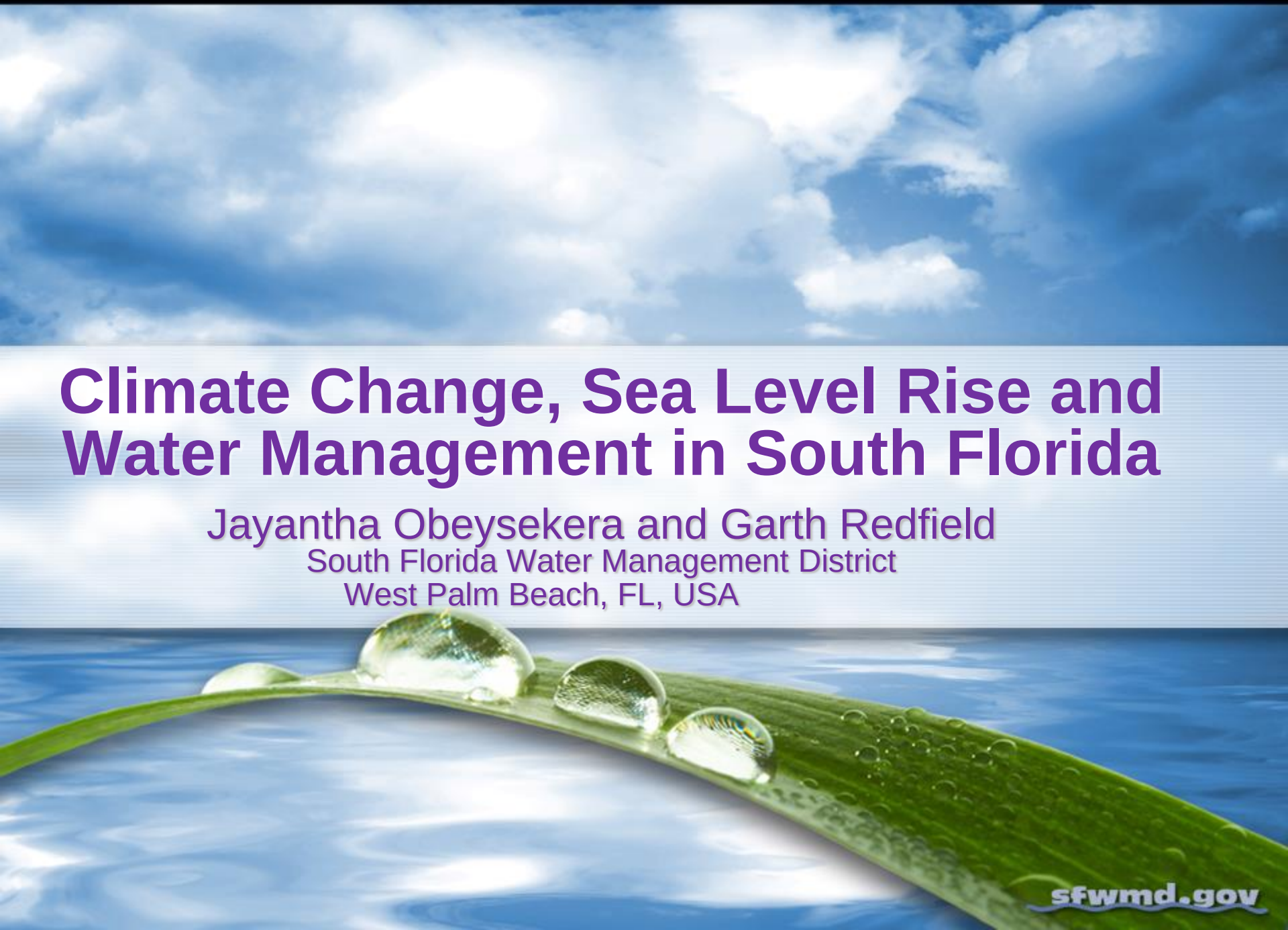
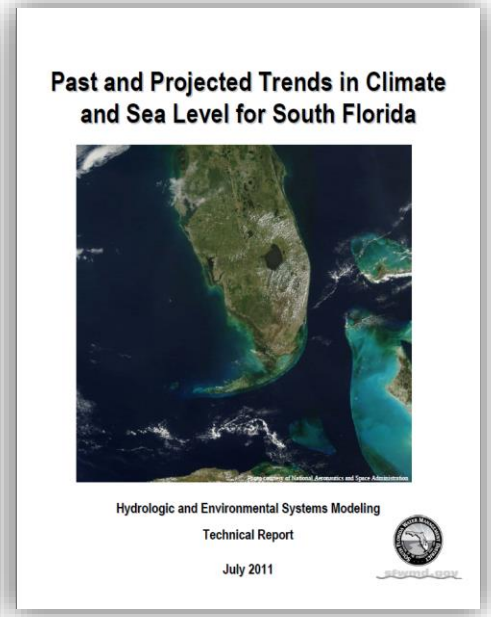


Climate Change, Sea Level Rise and Water Management in South Florida

Jayantha Obeysekera and Garth Redfield
South Florida Water Management District
West Palm Beach, FL, USA

Climate Change and Water Management

- Growing interest and concern in last decade for impacts on water and environmental management
- Monitoring of climate science, especially on variability & sea level rise
- Outreach presentations to many organizations
- Produced two reports:



Climate Change and 'Commitment'

- Long-term change in climate beyond natural cycles
  - Climate change is like moving the whole stage in a theatre where climate cycles and natural variability are playing on stage
- Climate change '*commitment*'
  - Changes in response to an external forcing that continue to change even if the forcing stops increasing or is constant
  - Jury is still out on how committed we are and what reductions are needed to reverse course

Climate Change: A Societal Context

TAME PROBLEMS
Well-defined, simple

WICKED PROBLEMS
Complex, contradictory

High or low societal impact

MESSY PROBLEMS
Poorly defined mixtures

WICKED MESSY PROBLEMS
Climate Change

Welcome to Environmental Management!

Climate Projection Uncertainties

Natural Variability

General Circulation Model

GCM (IPCC, 2007)

- BCM2
- CGHR
- CGMR
- CNCM3
- CSMK3
- ECHCG
- FGCM1
- GFCM20
- GFCM21
- GIAOM
- INCM3
- IPCM4

Model Uncertainty

Downscaling

Statistical

Dynamical

Statistical: Constructed Analogues (CA); Bias Correction and Spatial Disaggregation (BCSD); Weather Generators

Dynamical: Regional Climate Models (RCMs)

Ice Sheet Dynamics

Scenarios

Scenario Uncertainty

B1	A1T	B2	A1B	A2	A1FI
1.1-2.9 (°C)	1.4-3.8 (°C)	1.4-3.8 (°C)	[illegible] (°C)	2.0-5.4 (°C)	2.4-6.4 (°C)
0.18-0.38 (m)	0.20-0.45 (m)	0.20-0.43 (m)	0.21-0.48 (m)	0.23-0.51 (m)	0.26- 0.59 (m)

Climate Change Prediction Highly Uncertain

- Multiple mechanisms
- Massive scale
- Very complex modeling
- Opposing processes
- Shifting baselines

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

P. C. D. Milly,[1]* Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Climate Change & Water Management

Climate Change Drivers

Natural Cycles
Inter-annual (e.g. El Nino and La Nina) to Multi-decadal (e.g. AMO*), and Glacial

Human Induced
Land use changes
Greenhouse gases

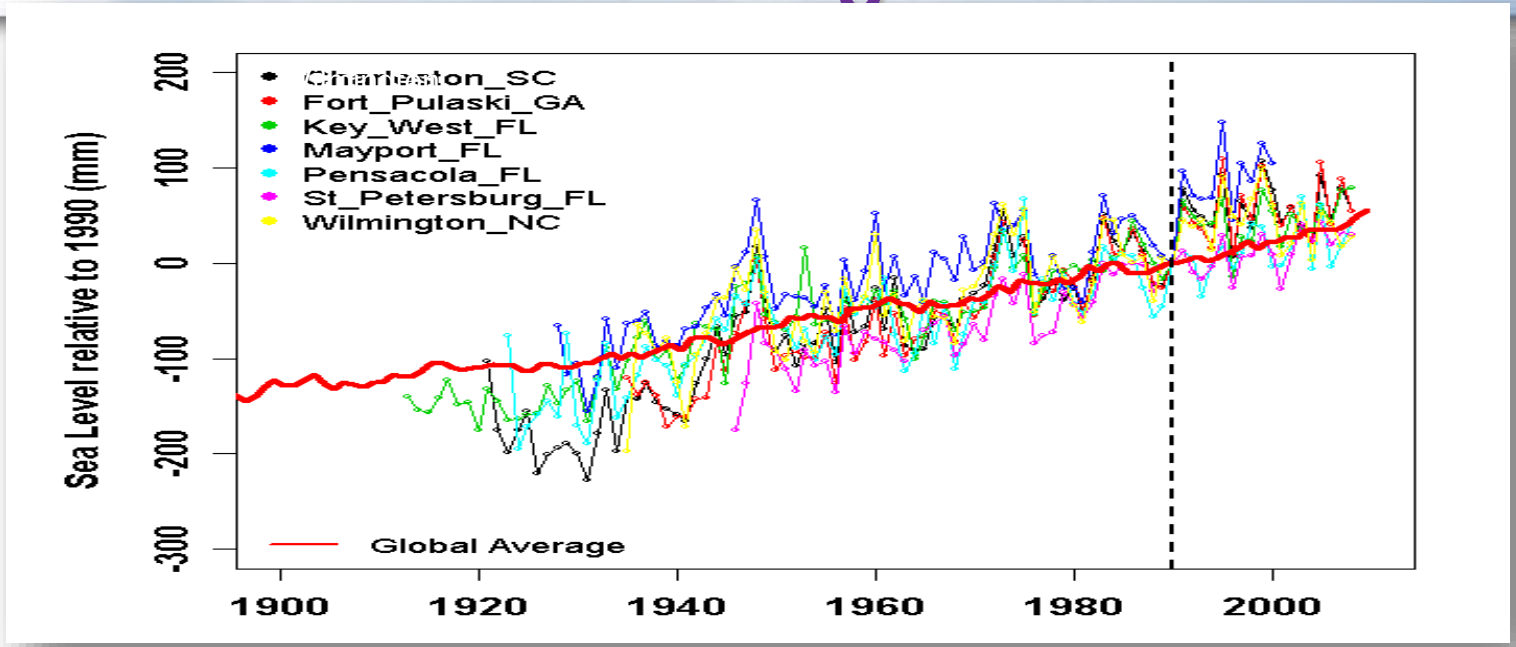
Quartet of change: Stressors

- **Rising Seas**
- **Temperature**
- **Rainfall, floods, and droughts**
- **Tropical Storms & Hurricanes**

Water Management Impacts

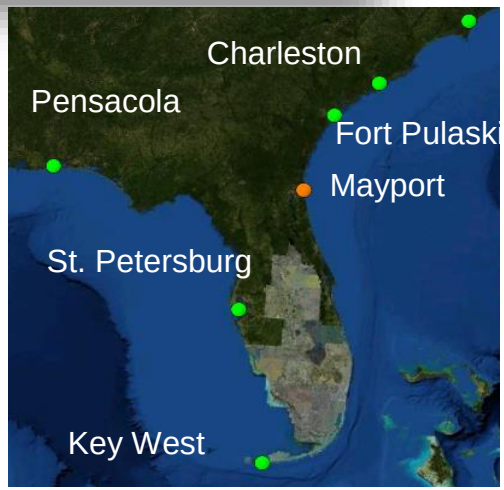
- **Direct landscape impacts (e.g. storm surge)**
- **Water Supply (e.g. droughts, saltwater intrusion)**
- **Flood Control (e.g. urban flooding, hurricanes)**
- **Natural Systems (e.g. ecosystem impacts, both coastal and interior)**

Exposure: Rising Seas
Tide Gauge Data



Relative Sea Level (height above a local datum) depends on:

- **Global Mean Sea Level**
- **Vertical Land Movement (uplift/subsidence)**
- **Regional Variability**

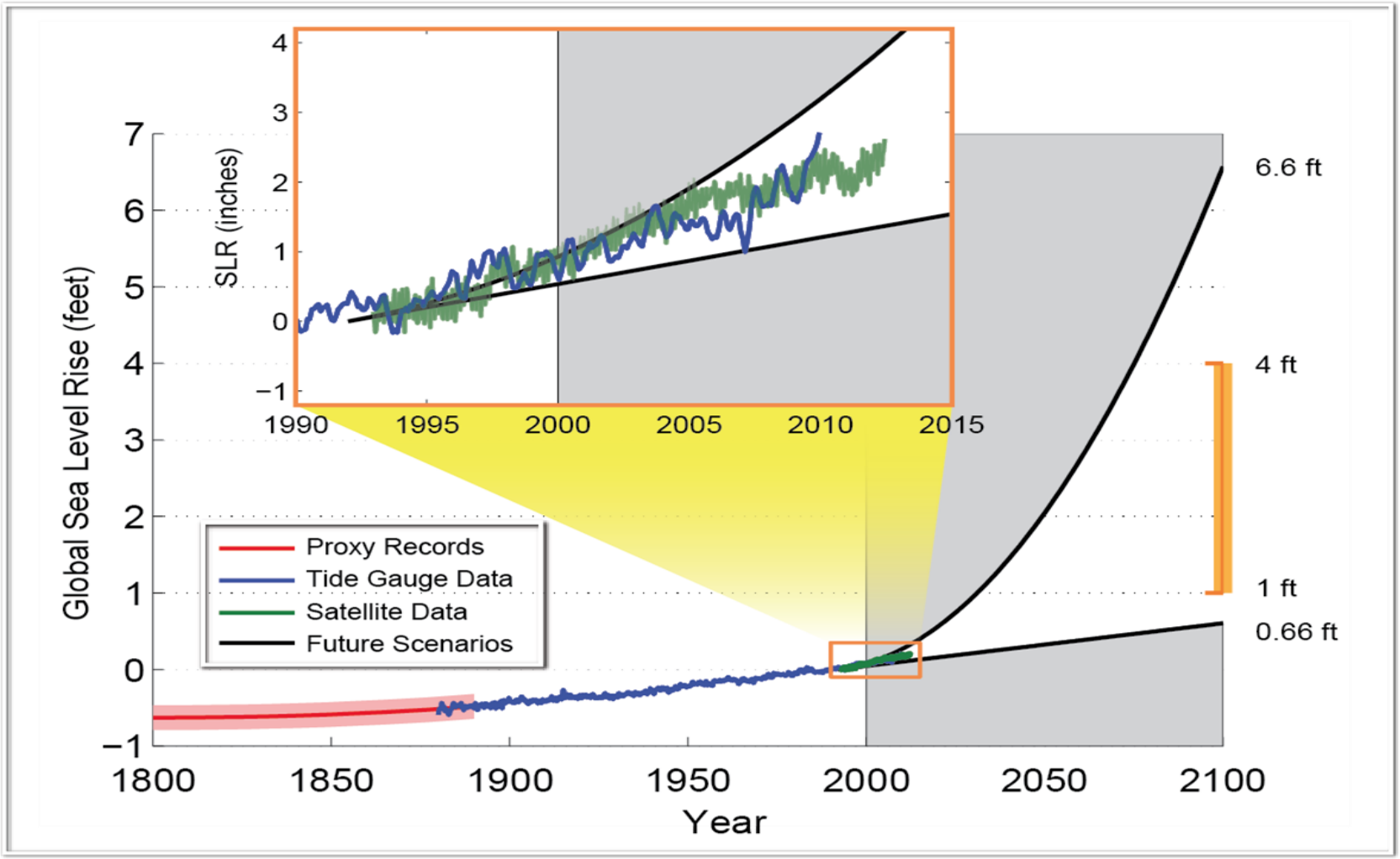


Recent Observations along SE Coast ("Sunny Day Flooding")

Miami-Dade County
Credit: Miami-Dade DERM

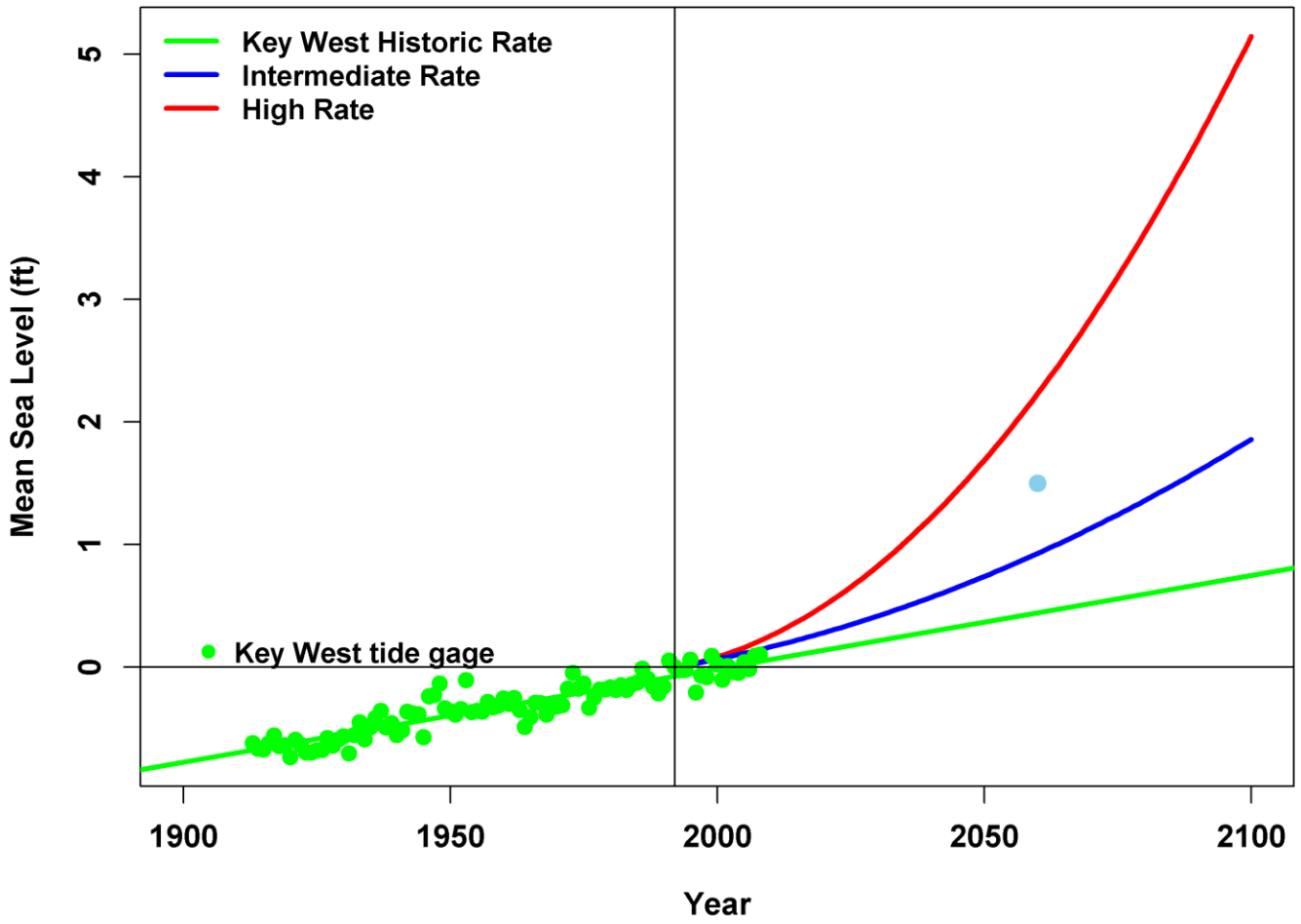
More recent pictures..

Projected Range of Sea Level Rise
(National Climate Assessment, 2013)



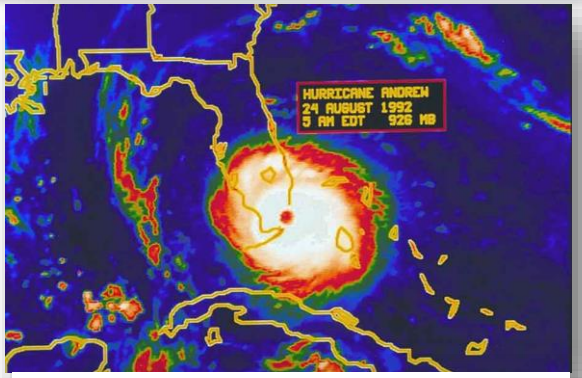
Draft report: http://ncadac.globalchange.gov

US Army Corps of Engineers Guidance

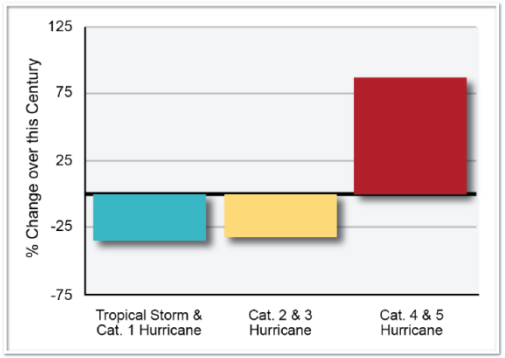


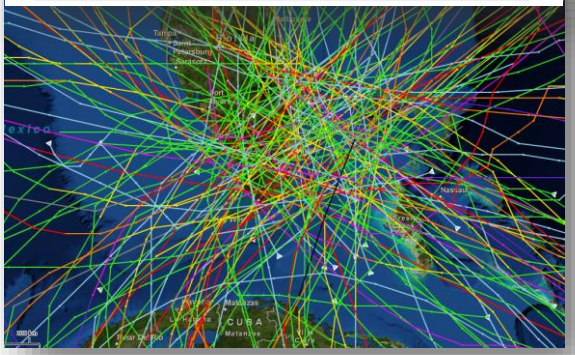
Exposure: Tropical Climate Change

- Tropical cyclones to shift towards strong storms (2-11% intensity increase by 2100)
  - Decrease in global frequency of tropical cyclones (6-34%)
  - Increase in rainfall rate, 20% within 100 km of storm center
- Possible changes in ET, rainfall, cloud cover, temperature, etc……

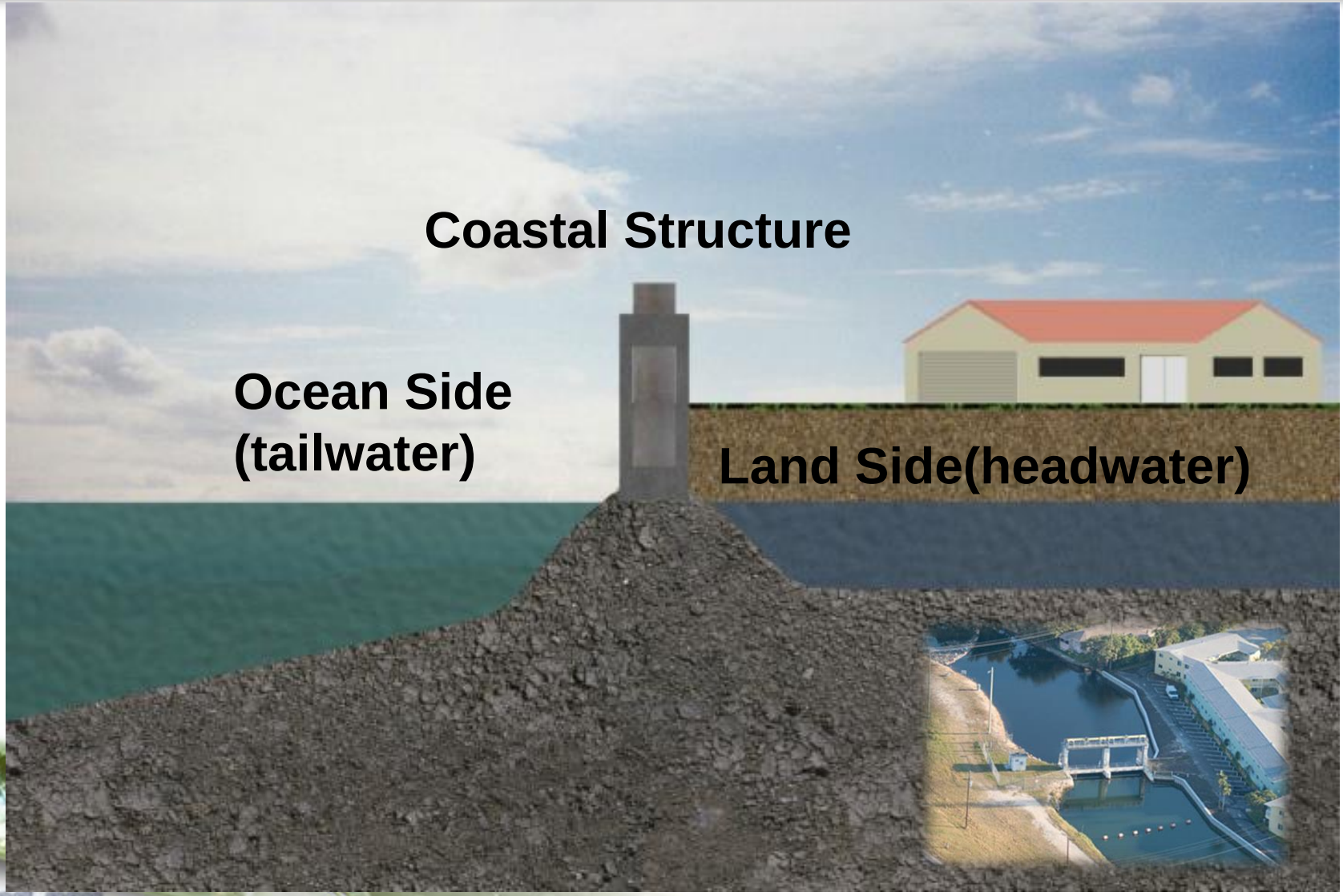


Projected Changes in Atlantic Hurricane Frequency by Category



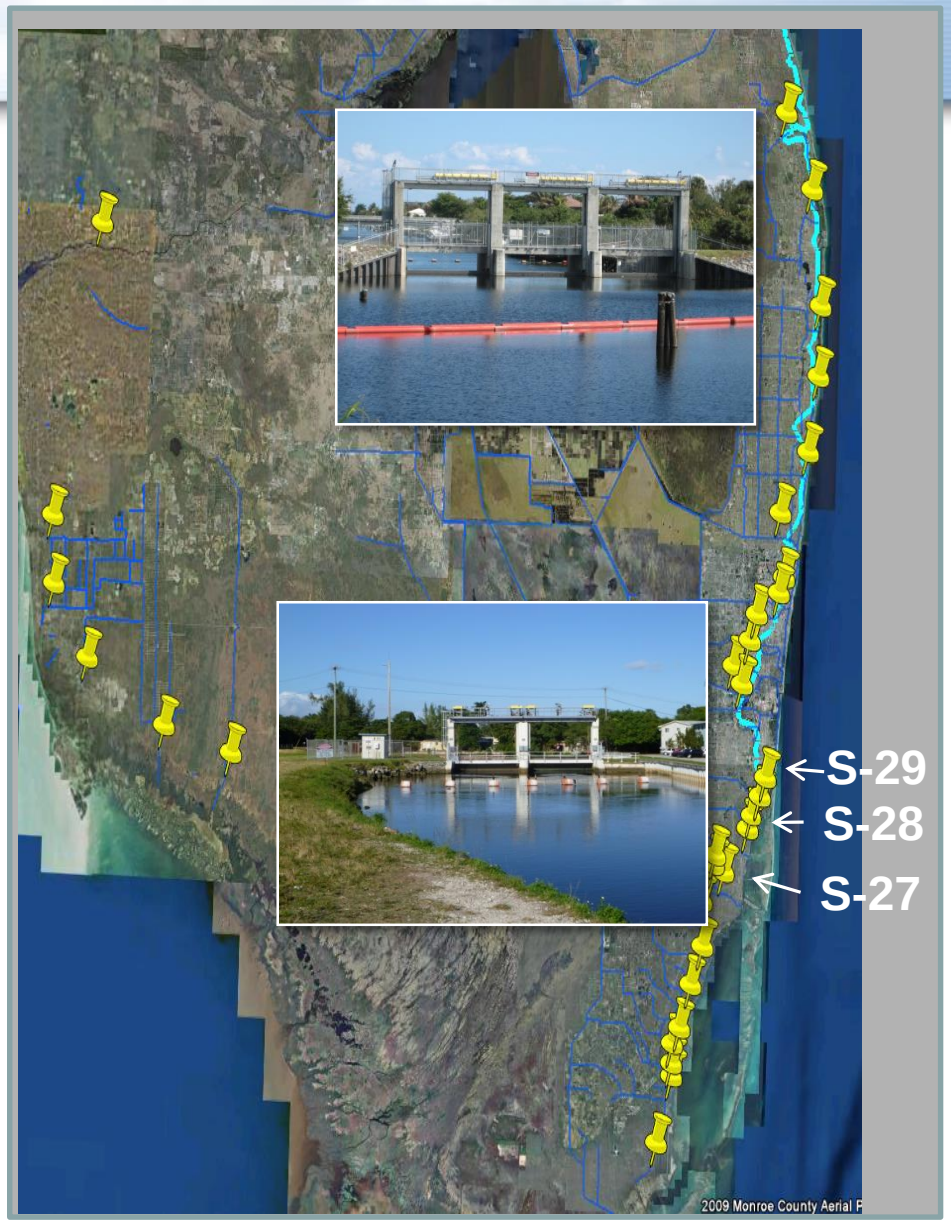


Exposure: Flood Protection



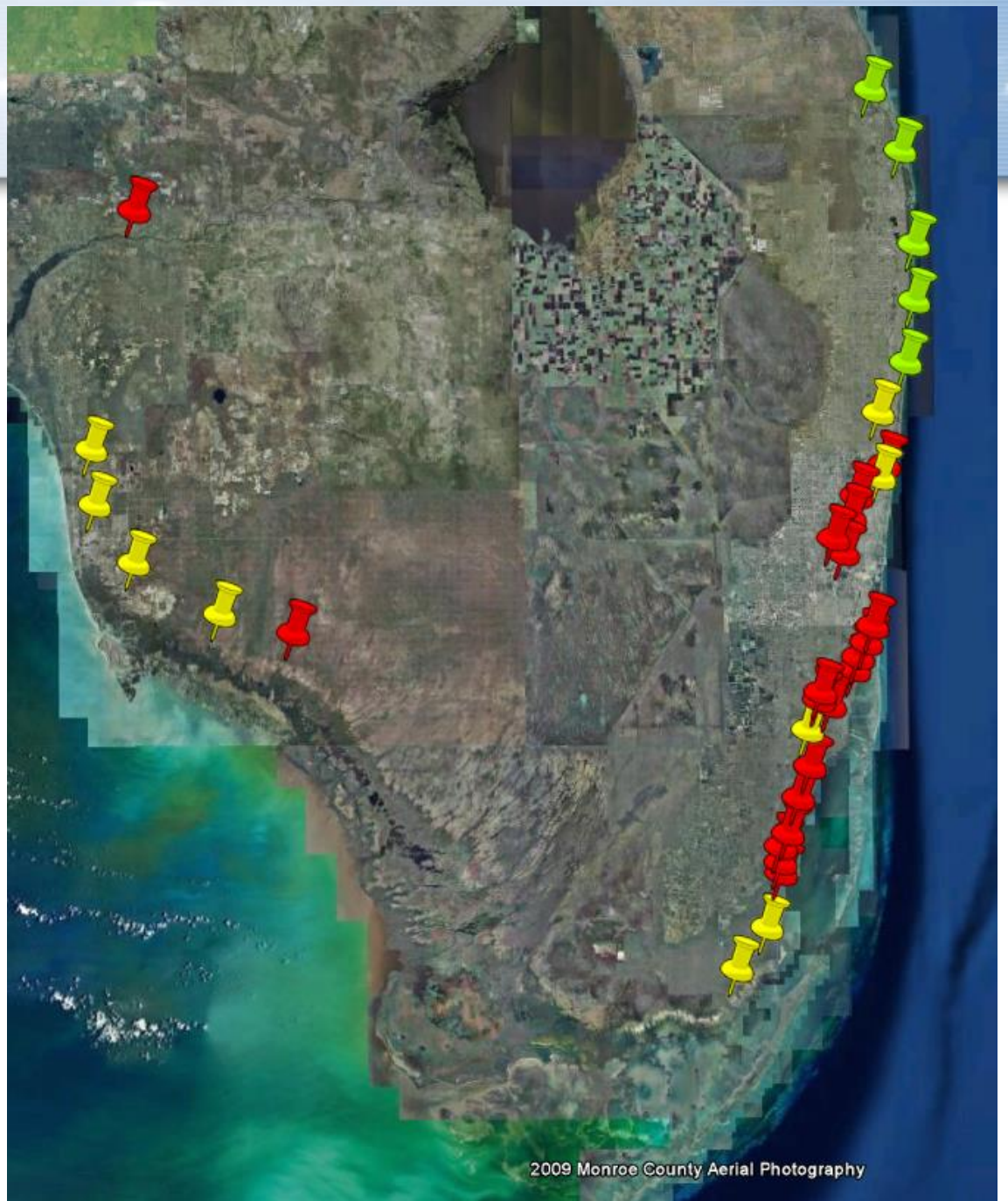
Review of Coastal Infrastructure

- Salinity Control Structures provide a barrier for saltwater intrusion and flood control
- South Florida system nearing design life
- 5 year and 10-year capital improvement budgets
- Analyze frequency and duration of flooding, impacts on downstream areas
- Coordination with local governments on local flooding

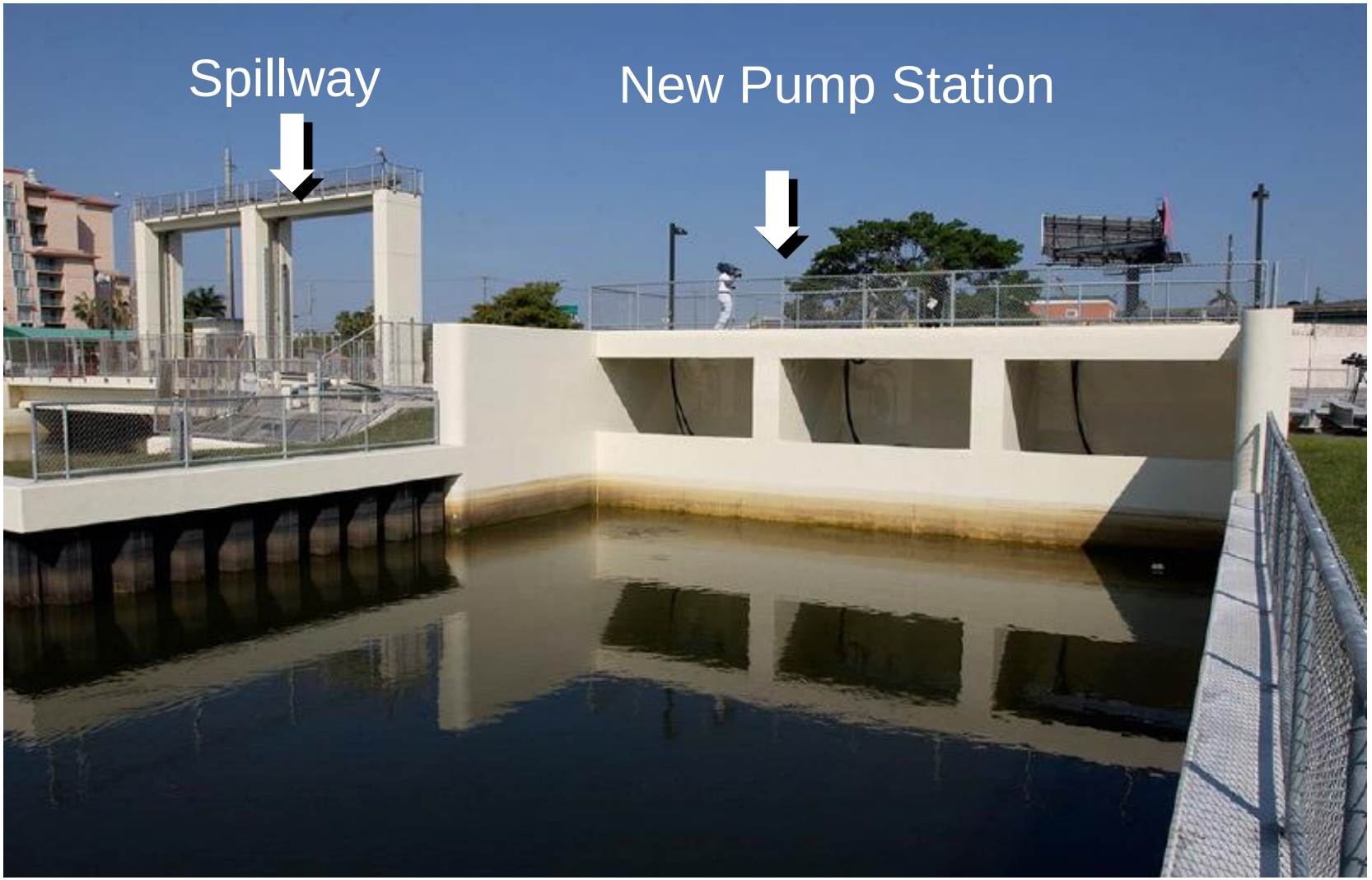


Potential Coastal Exposure

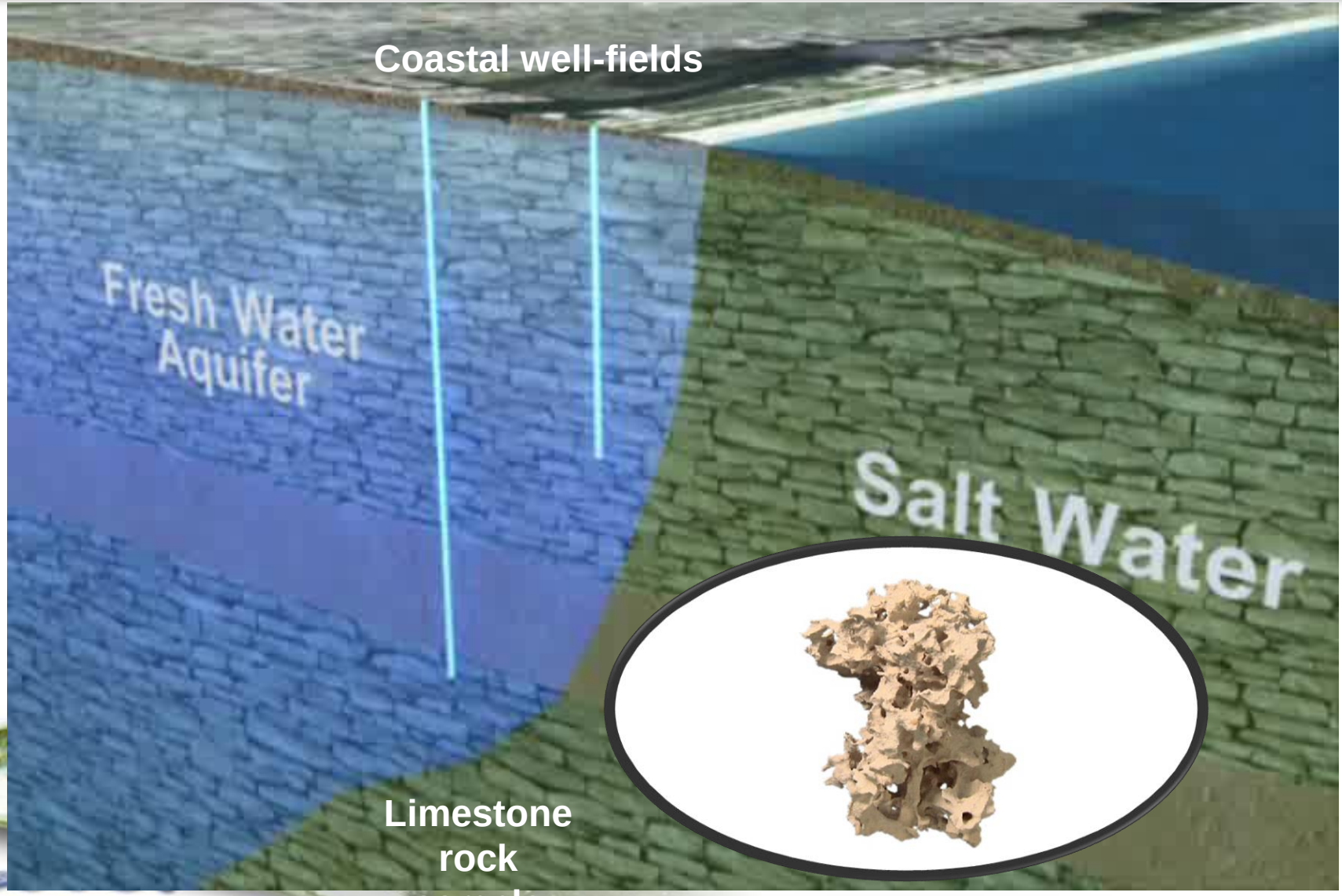
- Preliminary screening based on original designs.
- 28 gravity structures on the East Coast
- Most vulnerable structures are in Miami-Dade and Broward counties



Adaptation to Rising Seas as Feasible
Forward Pumping at S-26 Structure

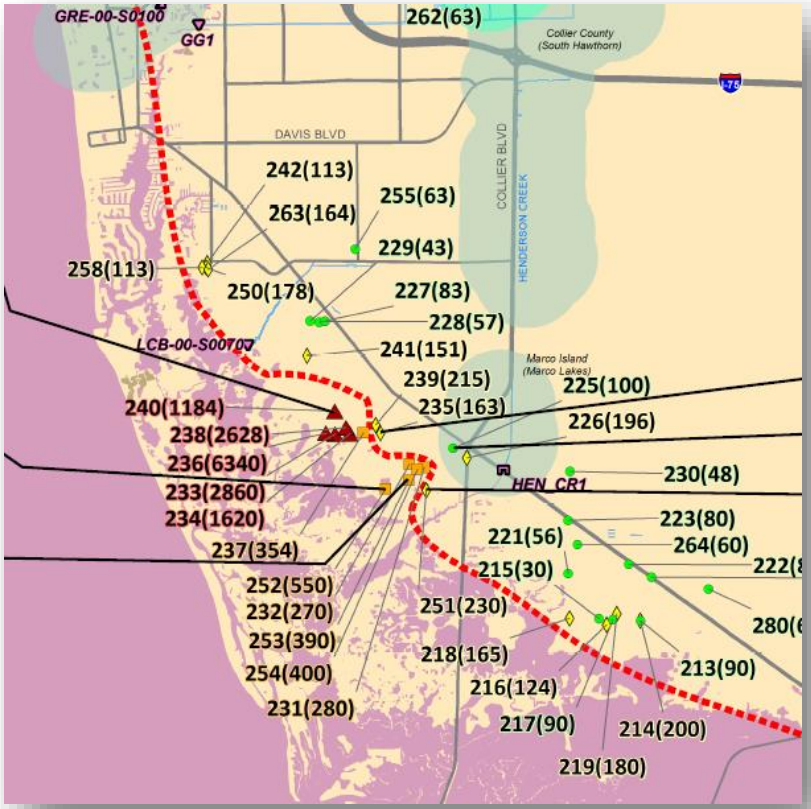


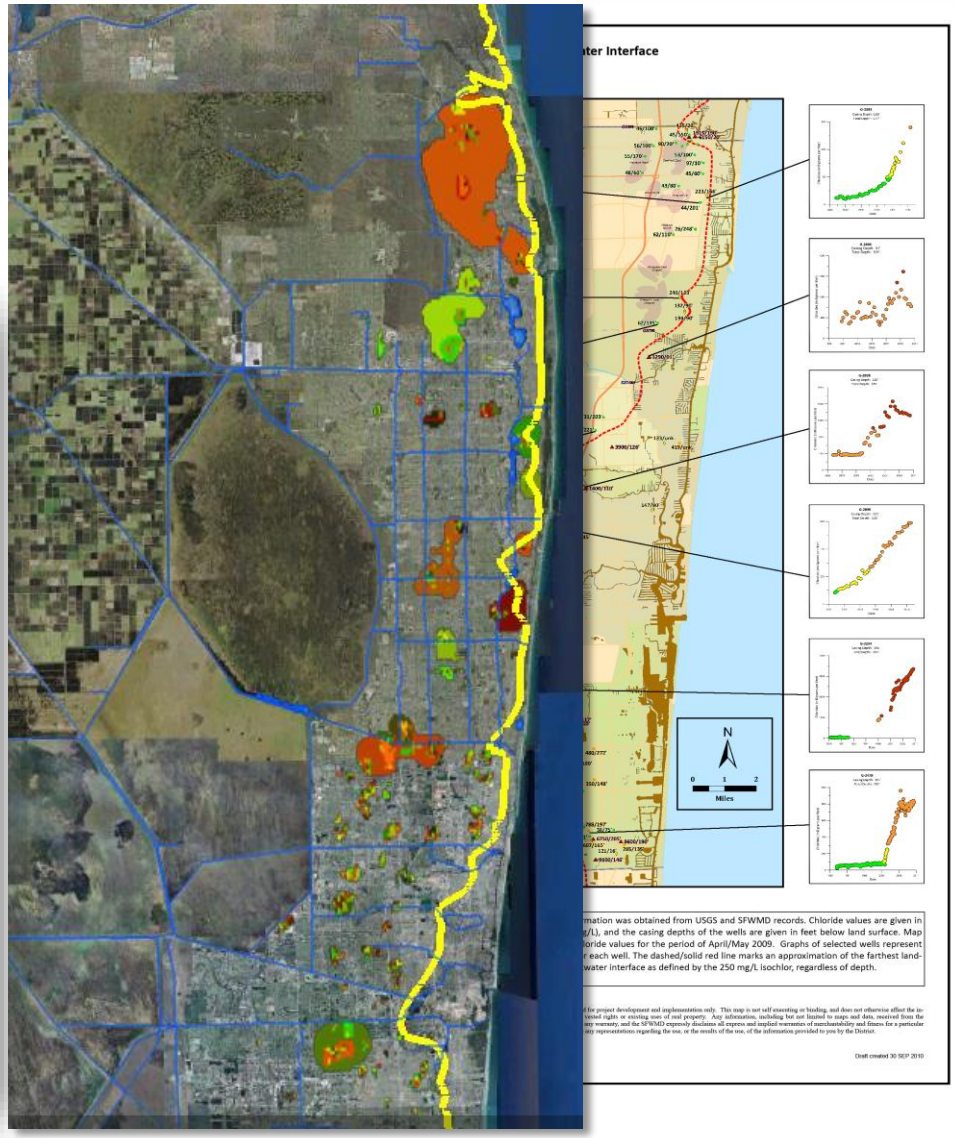
Exposure: Saltwater Intrusion



Saltwater Intrusion Mapping (2009) and Monitoring Network Evaluation

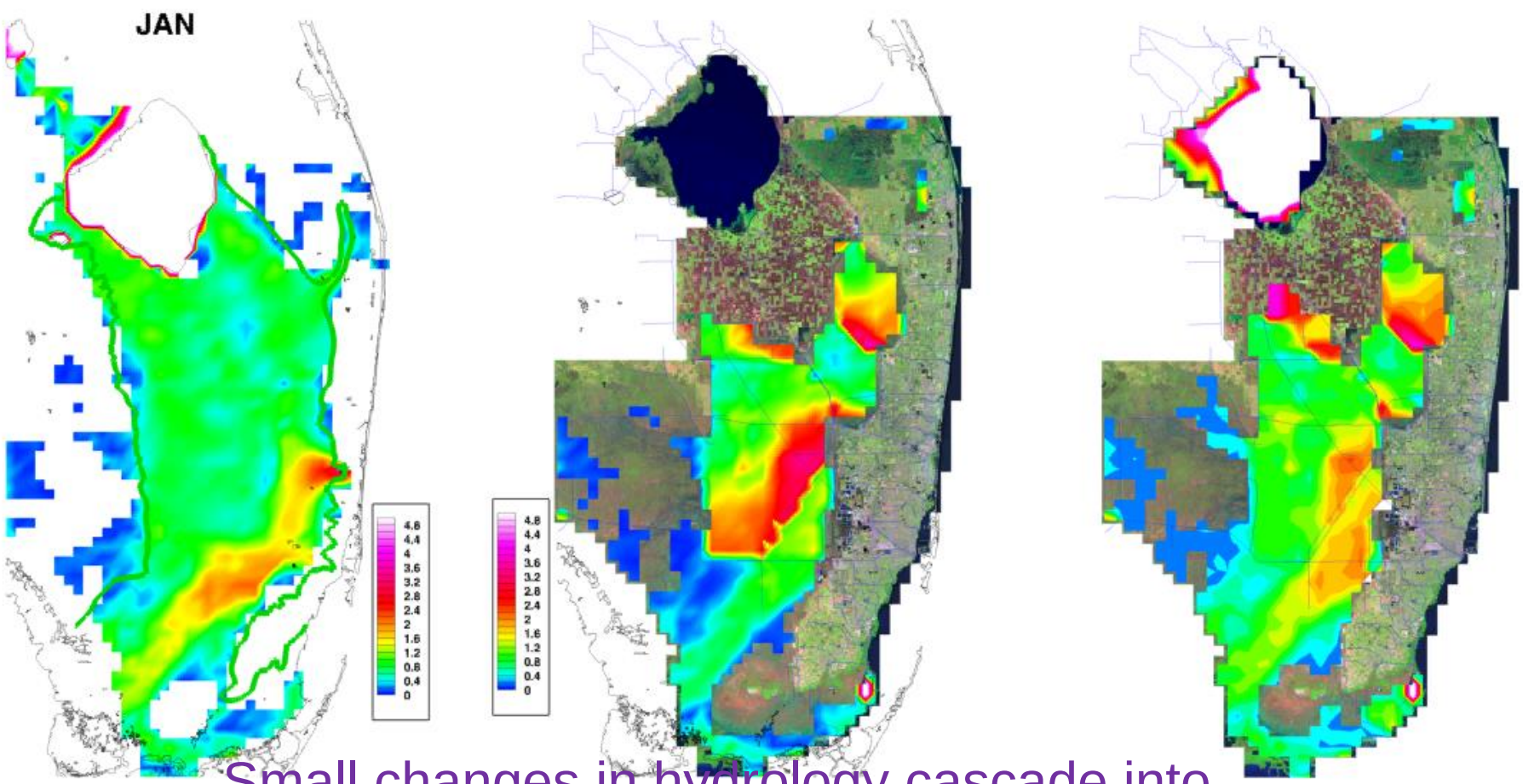
- Developed saltwater intrusion maps for vulnerable coastal areas



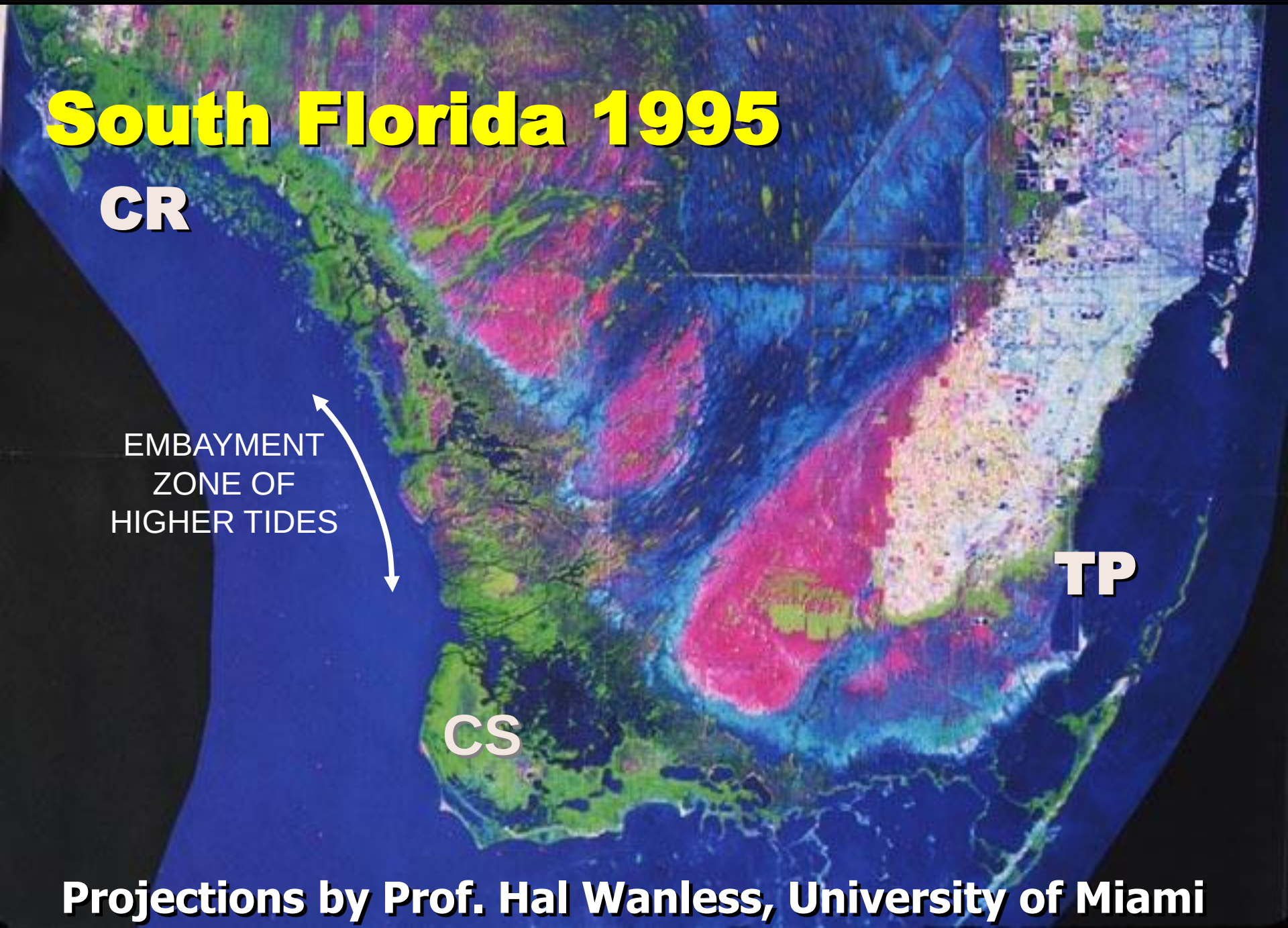


Exposure: Climate Change and Sea Level Rise Impact Everglades Restoration

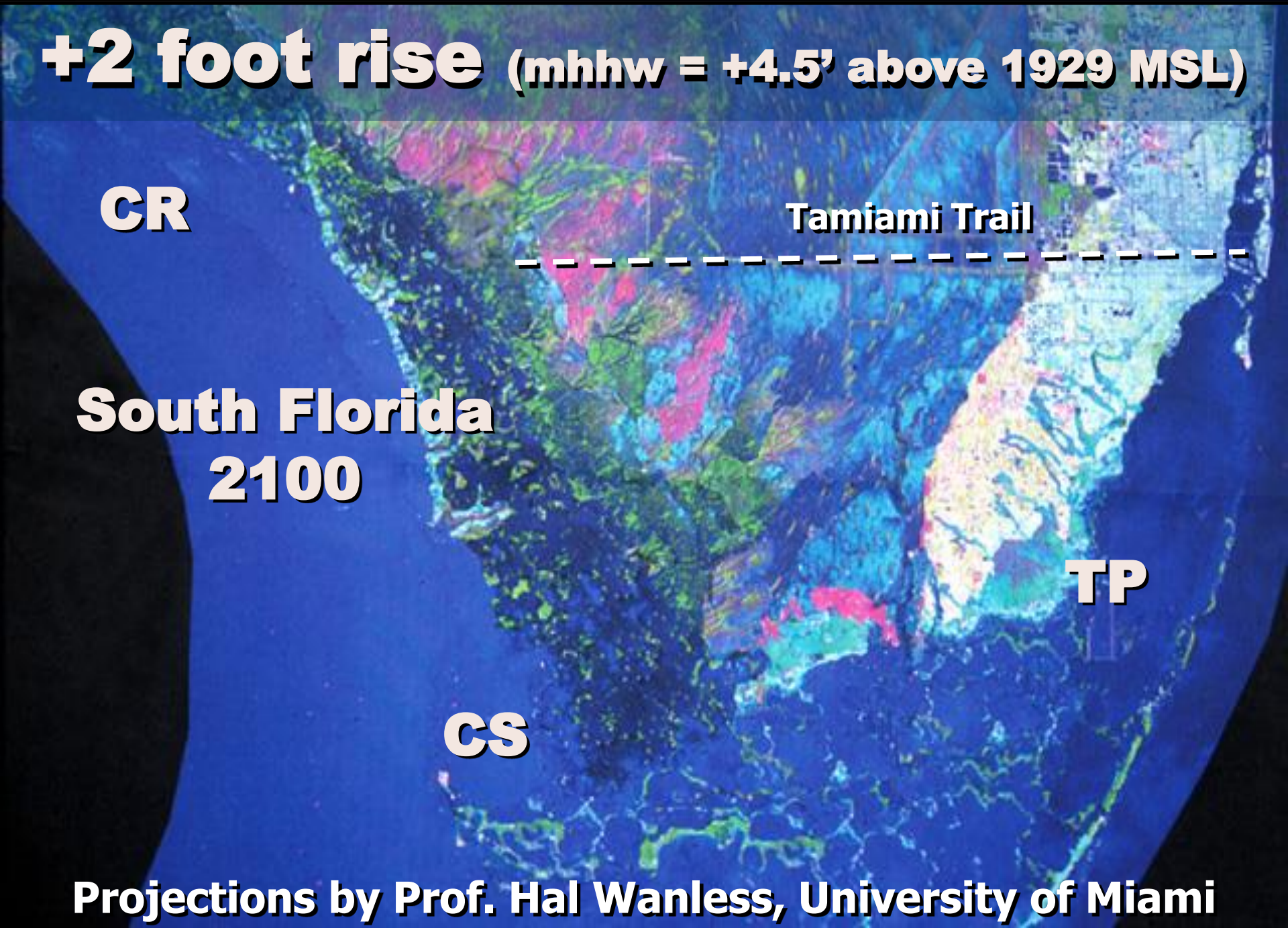
Natural System | **Managed System** | **CERP**



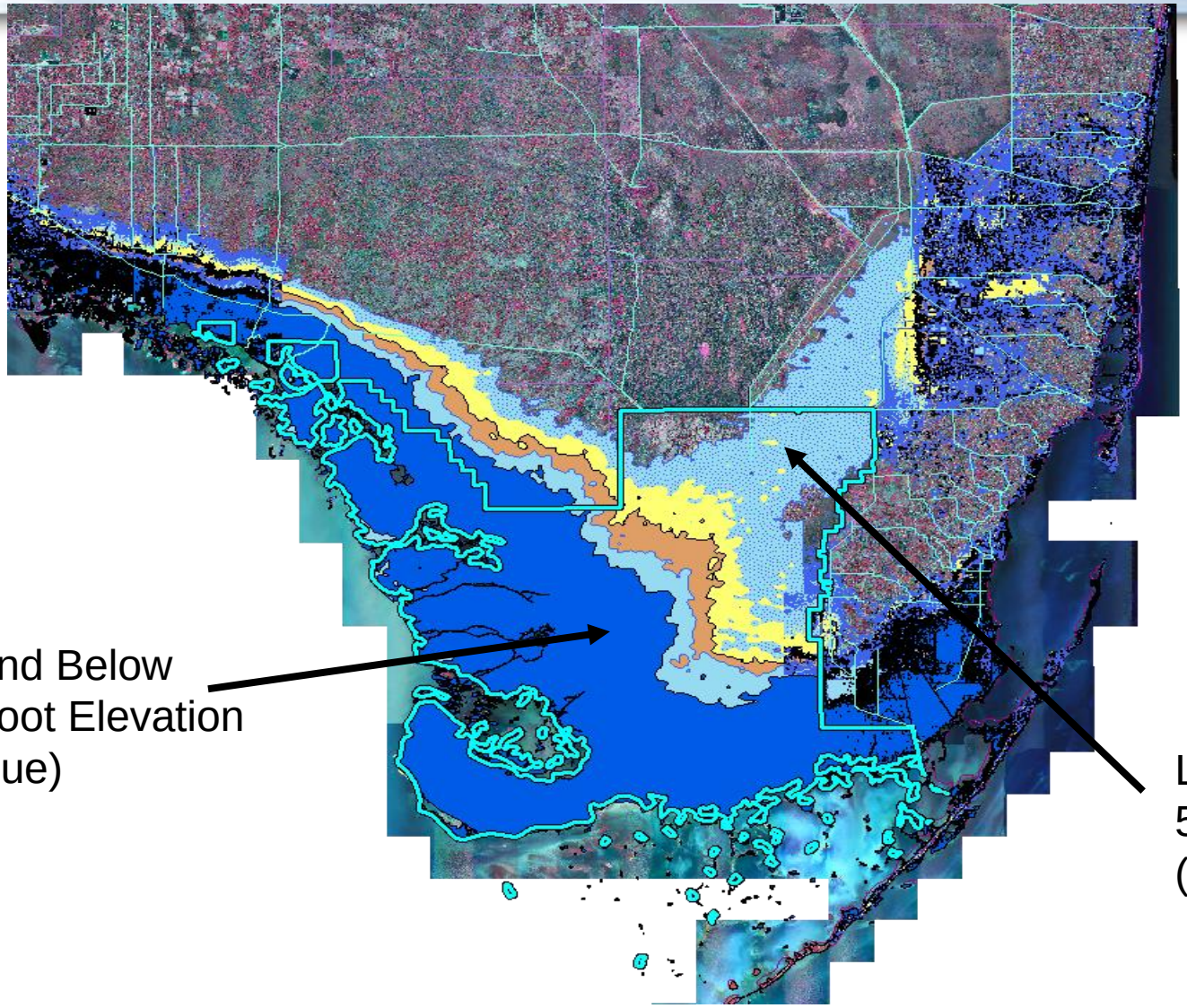
Small changes in hydrology cascade into large changes in regional water balance



Projections by Prof. Hal Wanless, University of Miami


+2 foot rise (mhhw = +4.5' above 1929 MSL)
CR
Tamiami Trail
South Florida
2100
TP
CS
Projections by Prof. Hal Wanless, University of Miami

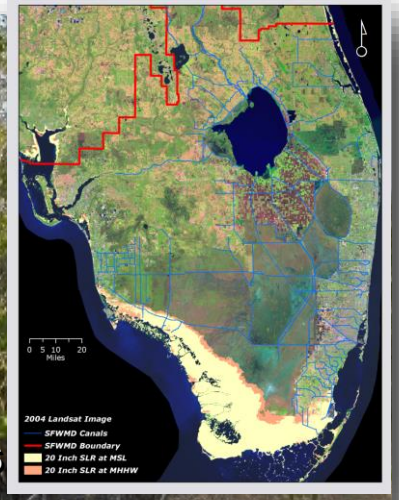
Sea Level Rise Impact on Southern Everglades



Land Below
1 foot Elevation
(Blue)

Land Below
5 foot Elevation
(All colors)

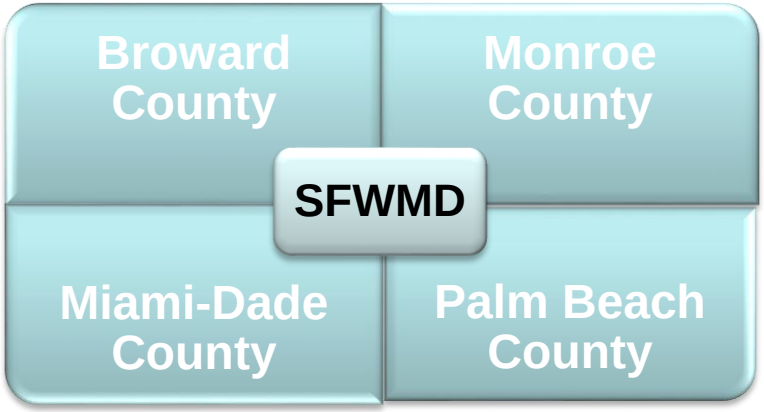
Exposure: Inundation & Collapse of Freshwater Wetlands in the Southern Coasts

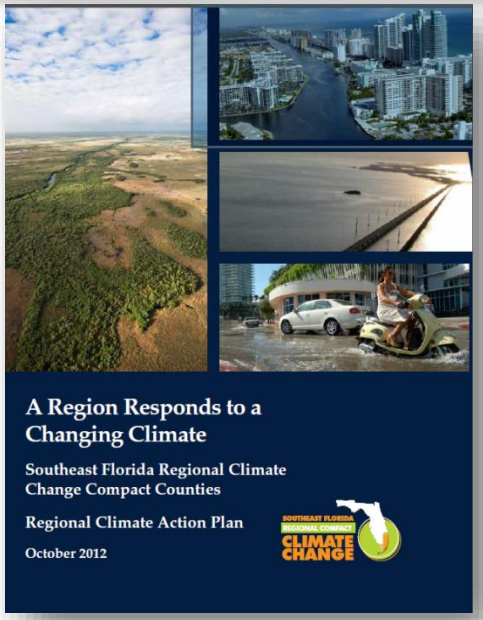


Credit:
Prof. Hal Wanless

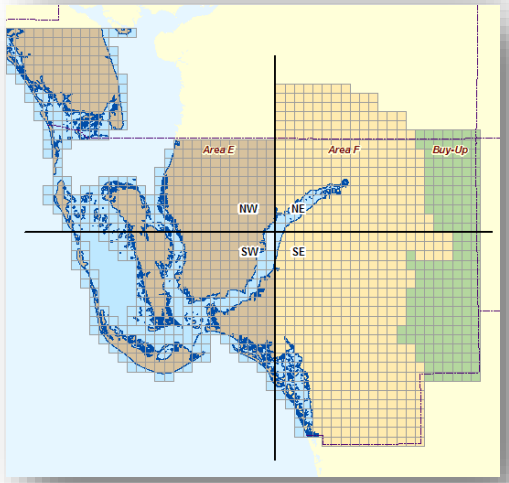
Regional Coordination

- **Southeast Florida Regional Climate Change Compact (Palm Beach, Broward, Miami-Dade, and Monroe)**





- **SFWMD Participation**
  - **Steering committee member (non-voting)**
  - **Technical assistance**



Questions