NEW CLIMATE CHANGE INFORMATION FOR ENHANCING EVERGLADES RESTORATION CLIMATE PREPAREDNESS AND RESILIENCE

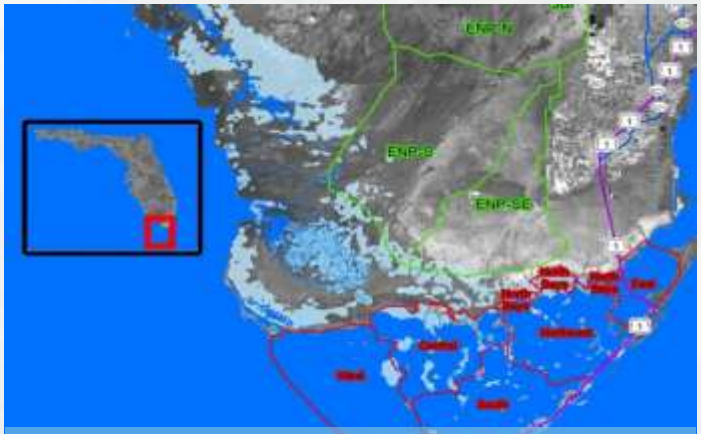
Glenn B. Landers, P.E.
USACE Jacksonville District
GEER Conference, Coral Springs, FL
April 19, 2017

PRESENTATION OUTLINE

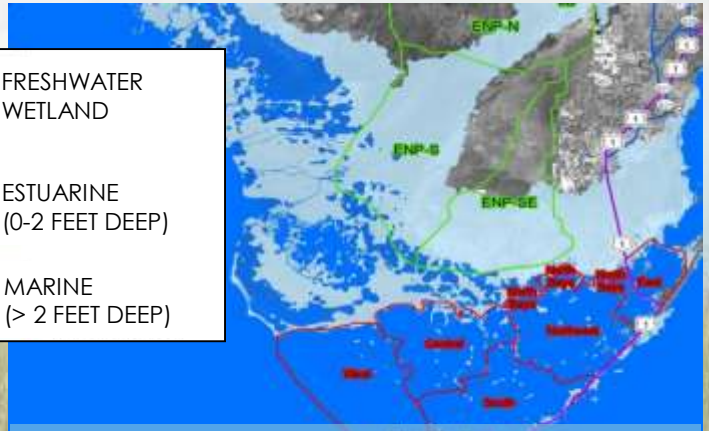
- CISRERP 2014 and 2016 Findings on Climate Change
- The RECOVER 5-Year Plan and Climate Change
- USACE Climate Preparedness and Resilience Guidance
- Climate Change and SLR Scenarios for CERP Planning

CISRERP 2014 REPORT FINDINGS ON CLIMATE CHANGE AND SLR

- Potential significant changes in precipitation and temperatures coupled with increasing sea level have important implications for the CERP (under some future scenarios there is "…insufficient freshwater to sustain the natural and built systems.")
- Climate change is not adequately considered in the CERP planning process and should be integrated into future ongoing analysis and monitoring
- CERP planners should consider implications of sea-level rise and potential hydrologic change in systemwide planning and project prioritization
- High priority research needs related to climate change and Everglades restoration



EVERGLADES NATIONAL PARK
EXISTING CONDITIONS



EVERGLADES NATIONAL PARK
+2 FEET SLC CONDITIONS with PEAT LOSS IN SRS

CISRERP 2016 REPORT FINDINGS ON CLIMATE CHANGE AND SLR

- Major advances in knowledge since the CERP was developed in the 1990s:
  - Predrainage hydrology
  - Climate change and sea level rise
  - Feasibility of storage alternatives
- A reexamination of CERP restoration goals is in order – should consider the need for benefits that are robust in the face of climate change or mitigate its effects
- Uncertainties of future storage and climate should be incorporated into CERP planning
- A systemwide analysis of the potential future state of the Everglades ecosystem needs to be conducted to inform decision making – Should include scenario analyses of storage and climate change

INCORPORATING CLIMATE CHANGE IN THE RECOVER: 5-YEAR PLAN

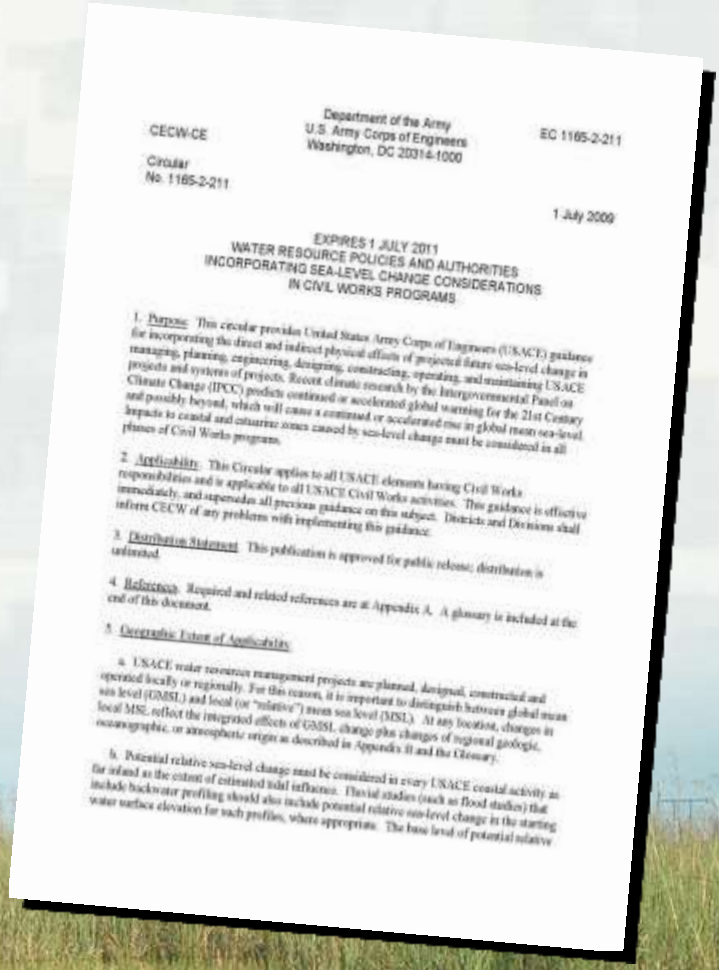
1. **Science Review and Integration**
   - **Consider new (or updated) drivers related to climate change**
2. **RECOVER's role in CERP implementation**
3. **Recommendations for refinements of CERP Interim Goals (IG)**
4. **Recommendations for refinements of CERP Interim Targets (IT)**
5. **Opportunities for Adaptive Management**
6. **Communication of RECOVER Science**

SCIENCE INTEGRATION

Science Review and Integration Tasks	FY2017	FY2018	FY2019	FY2020	FY2021
Task 1 – Update Conceptual Ecological Models (CEMs) and Hypotheses Clusters					
Task 2: Vulnerability Analysis					
Task 3: Update Performance Measures					
Task 4: Review 2009 MAP					
Task 5: Update MAP components					

USACE CLIMATE PREPAREDNESS AND RESILIENCE GUIDANCE

- **ER 1100-2-8162: Incorporating Sea Level Change in Civil Works Programs,** 31 Dec. 2013
  - Permanent Design Requirement for all phases of Corps Civil Works subject to tidal influence
  - Consider three future scenarios per National Research Council guidance
- **ETL 1100-2-1: *Procedures To Evaluate Sea Level Change: Impacts, Responses and Adaptation,*** 30 June 2014 to 31 March 2019
  - Planning Horizon extended to 100 years
- **ECB 2016-25: Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects**, 16 Sep 2016 to 16 Sep 2018



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

CECW-CE

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 climatic 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

HYDROLOGIC + TEMPERATURE CHANGES

TEMPERATURE/RAINFALL

- +5 to +9 F by 2100
- ET: +15-20 %
- Rainfall: + / - 20%
- More Intense Rainfall Events, But More Severe Droughts

HURRICANES

- Warmer ocean temperatures create potential for stronger hurricanes (e.g., Andrew, Katrina)
- Effect of Climate Change on natural cycle of hurricanes is uncertain

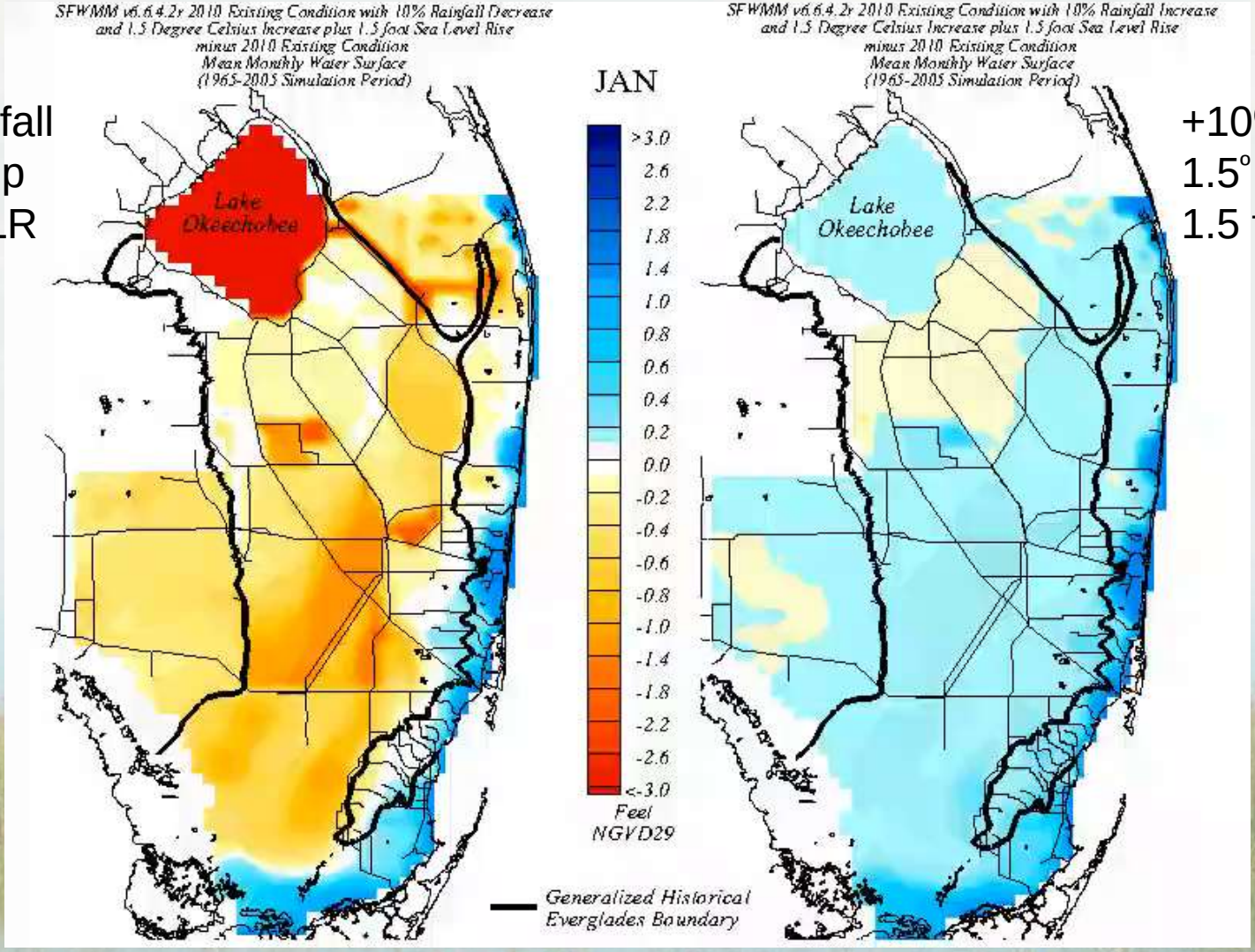
LAKE OKEECHOBEE DROUGHT

- All time low stages in 2007 and 2008

8

Climate and Sea Level Rise Scenarios

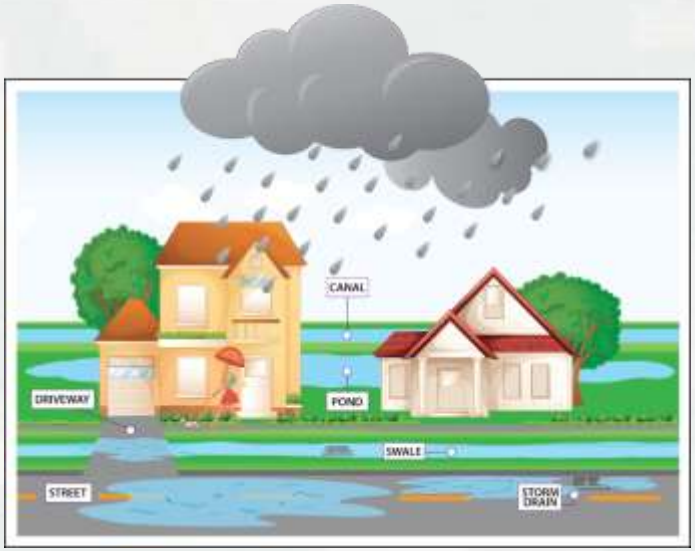
-10% Rainfall
1.5° C Temp
1.5 feet SLR



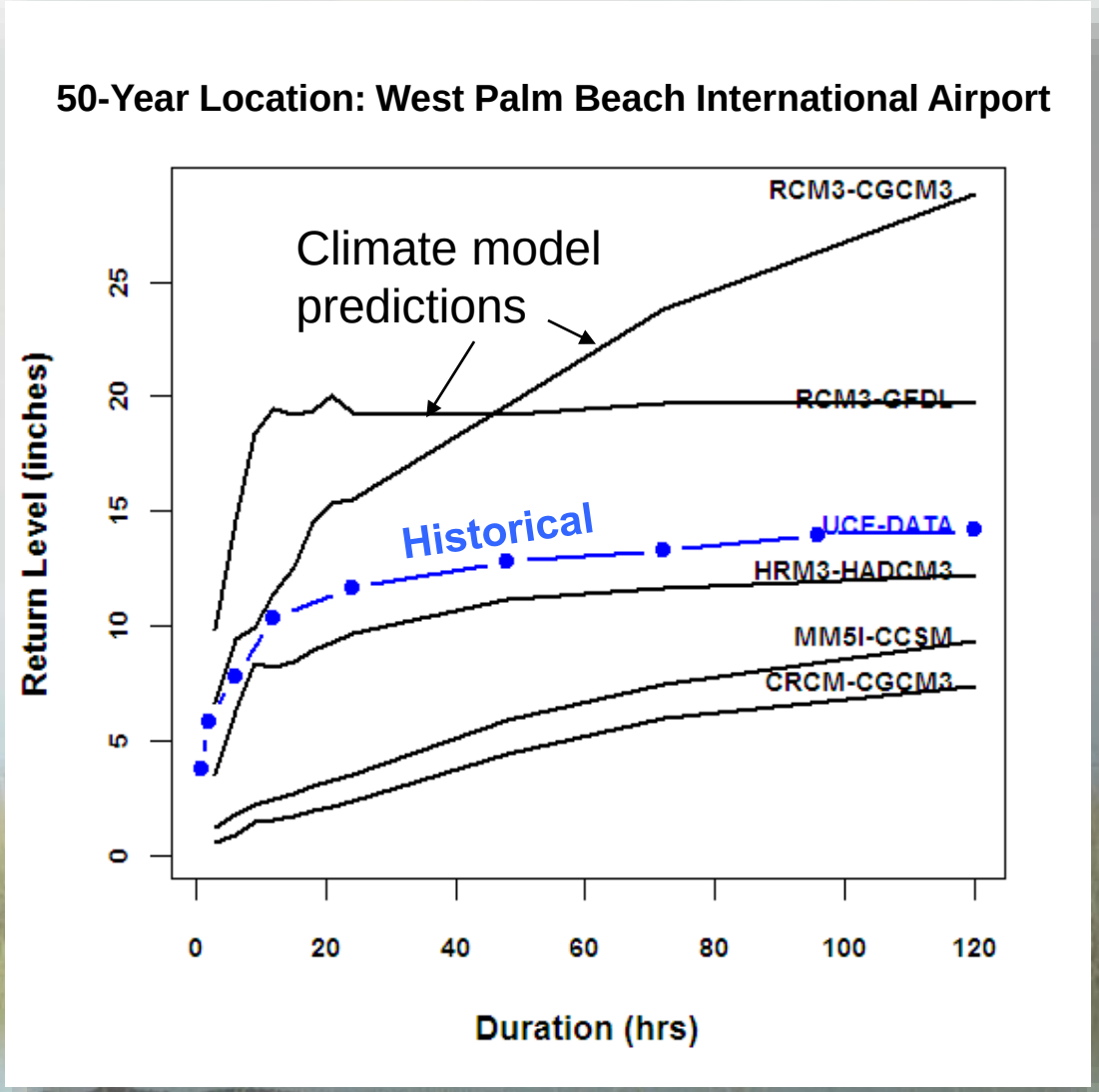
+10% Rainfall
1.5° C Temp
1.5 feet SLR

Historic Palm Beach Flooding January 9-10 2014

Potential changes in Rainfall Extremes : Do we have “actionable science”?

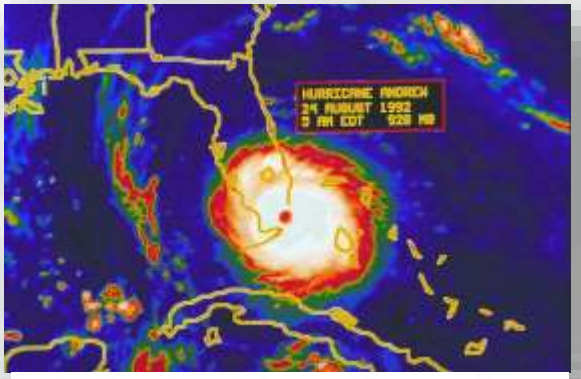


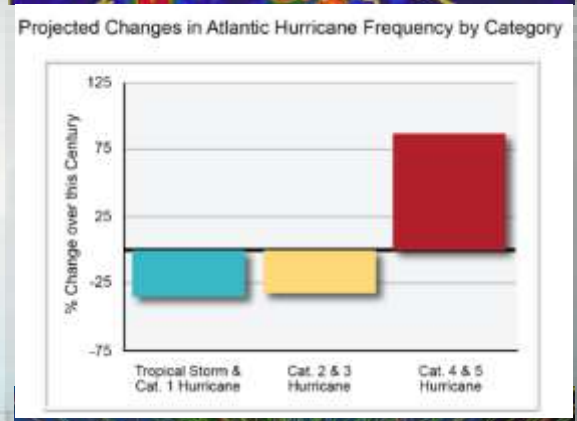
Uncertainty due to significant model spread (General Circulation Model & Regional Climate Model Combinations)



Tropical Storms & Climate Change

- **Tropical cyclones to shift towards strong storms (2-11% intensity increase by 2100)**
- **Decrease in global frequency of tropical cyclones (6-34%)-recent paper says this will increase!**
- **Increase in the frequency of the most intense cyclones**
- **Increase in rainfall rate, 20% within 100 km of storm center**





CERP SLR SCENARIOS

- Reference C&SF Restudy Report, Apr 99, Appendix B, pp. B-262 to B-269.
- EPA was designated as the lead federal agency for guiding coastal communities in preparing for SLR.
- CERP SLR Scenarios were modeled with SLR in 2050 +6 inches above 1995 levels per EPA guidance
- Modeling indicated that some coastal canal stages might need to be raised +6 inches to mitigate potential saltwater intrusion, and that additional water use restriction days might be needed

RELATIVE SEA LEVEL CHANGE SCENARIOS FOR KEY WEST, FL (FEET) (USACE, 1989-2014)

Year	USACE Low	USACE Int. (Mod. NRC Curve I)	USACE High (Mod. NRC Curve III)
Scenario >	Continue Historic Relative SLC	Global SLC +0.5m by 2100	Global SLC +1.5m by 2100
1992	0.0	0.0	0.0
2010	0.1	0.2	0.3
2060	0.5	0.9	2.2
2100	0.8	1.8	5.1
2110	0.9	2.1	6.0
2120	0.9	2.4	7.0

Notes: USACE projections are for historic, modified NRC Curve I and modified NRC Curve III rates of sea level change developed for Key West, Florida per USACE Engineering Circular (EC) 1105-2-186 (1989), 1165-2-211 (2009) and Engineering Regulation (ER) 1100-2-8162 (2013). These documents were based on guidance in the National Research Council (NRC) report, *Responding to Changes in Sea Level; Engineering Implications* dated September, 1987. The projections are developed using the local historic rate of sea level rise at Key West as reported by NOAA (2.20 mm/yr). The USACE and NRC guidance documents do not address dates beyond 2100. All projections start from 1992 control for the national survey datum.

RELATIVE SEA LEVEL CHANGE SCENARIOS FOR KEY WEST, FL (FEET) (NOAA 2012, USACE 2013)

Year	USACE Low NOAA Low	USACE Int. NOAA Int-Low (Mod. NRC Curve I)	NOAA Int-High	USACE High (Mod. NRC Curve III)	NOAA High
Scenario >	Continue Historic Relative SLC	Global SLC +0.5m by 2100	Global SLC +1.2m by 2100	Global SLC +1.5m by 2100	Global SLC +2.0m by 2100
1992	0.0	0.0	0.0	0.0	0.0
2010	0.1	0.2	0.2	0.3	0.3
2060	0.5	0.9	1.8	2.2	2.9
2100	0.8	1.8	4.1	5.1	6.7
2110	0.9	2.1	4.8	6.0	8.0
2120	0.9	2.4	5.6	7.0	9.3

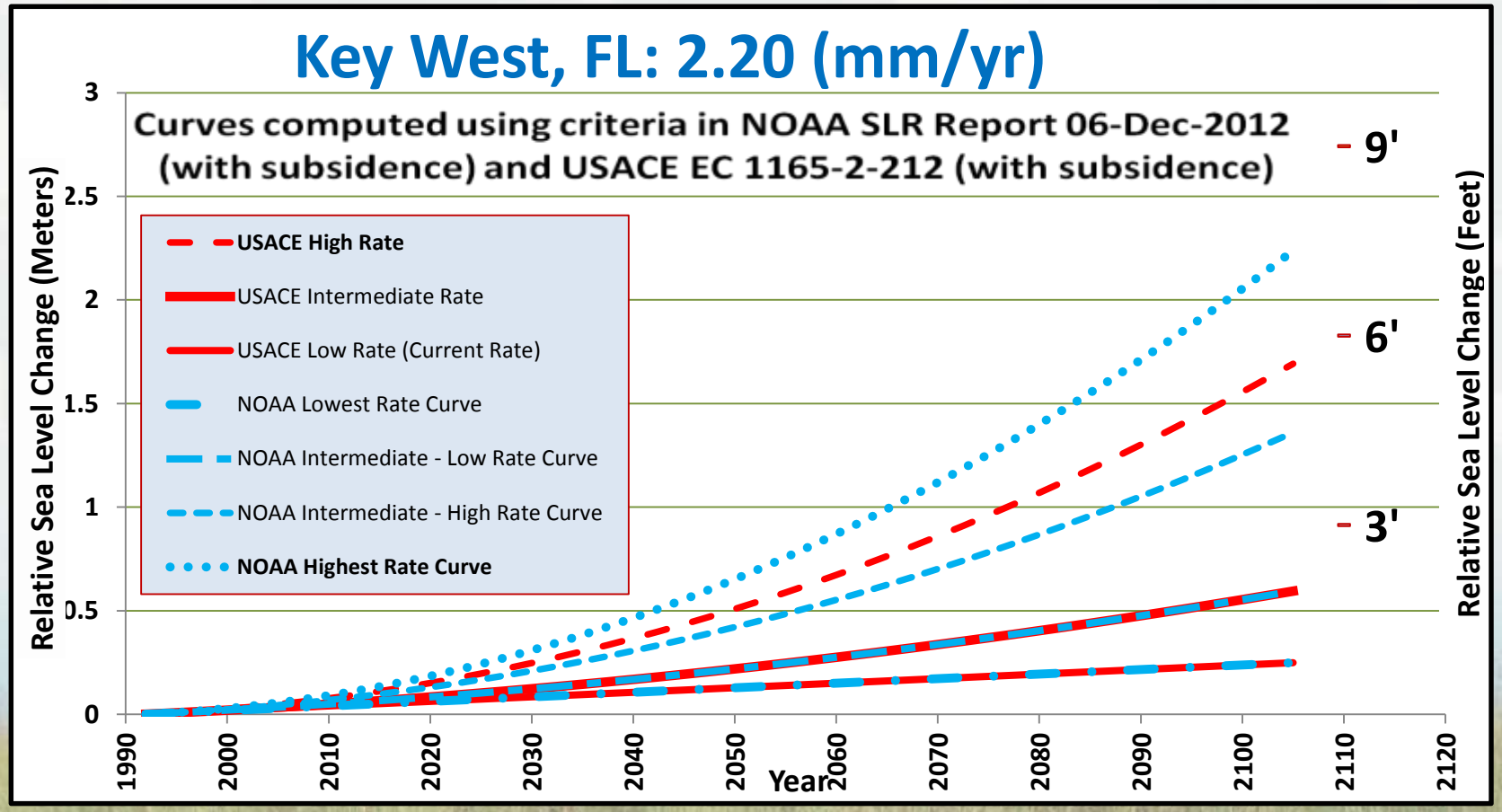
Notes: USACE projections are for historic, modified NRC Curve I and modified NRC Curve III rates of sea level change developed for Key West, Florida per USACE Engineer Regulation (ER) 1100-2-8162 (2013). This ER is based on guidance in the National Research Council (NRC) report, *Responding to Changes in Sea Level; Engineering Implications* dated September, 1987. The projections are developed using the local historic rate of sea level rise at Key West as reported by NOAA (2.20 mm/yr). NOAA projections use the same EC equations modified for different global SLR scenarios. The USACE and NOAA guidance documents do not address dates beyond 2100. All projections start from 1992 control for the national survey datum.

RELATIVE SEA LEVEL CHANGE SCENARIOS FOR KEY WEST, FL (FEET) (USACE 2014 + NOAA 2017)

Year	USACE Low NOAA Low	USACE Int. NOAA Int-Low (Mod. NRC Curve I)	NOAA Int-High	USACE High (Mod. NRC Curve III)	NOAA High
Scenario >	Continue Historic Relative SLC	Global SLC +0.5m by 2100	Global SLC +1.2m by 2100	Global SLC +1.5m by 2100	Global SLC +2.5m by 2100
1992	0.0	0.0	0.0	0.0	0.0
2010	0.1	0.2	0.2	0.3	
2060	0.5	0.9	1.8	2.2	
2100	0.8	1.8	4.1	5.1	8.5
2110	0.9	2.1	4.8	6.0	
2120	0.9	2.4	5.6	7.0	

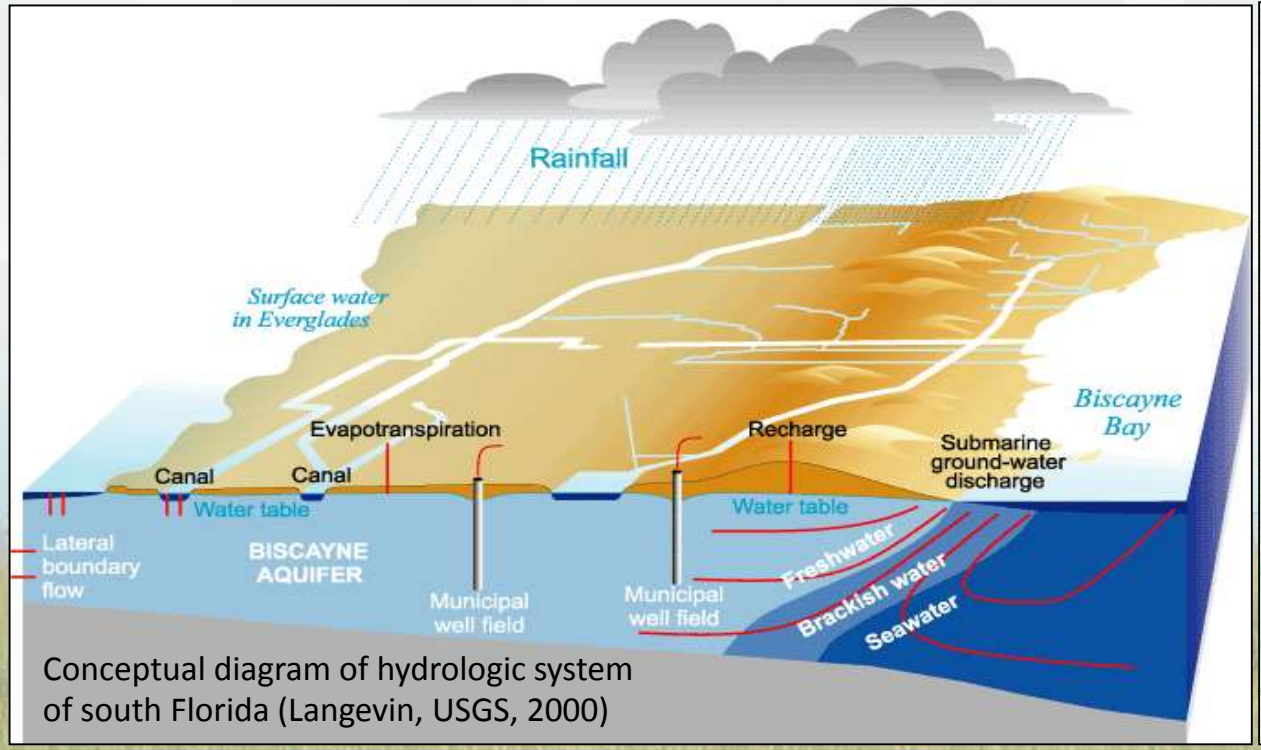
Notes: USACE projections are for historic, modified NRC Curve I and modified NRC Curve III rates of sea level change developed for Key West, Florida per USACE Engineering Technical Letter (ETL) 1100-2-1 (2014). This ETL is based on guidance in the National Research Council (NRC) report, *Responding to Changes in Sea Level; Engineering Implications* dated September, 1987. The projections are developed using the local historic rate of sea level rise at Key West as reported by NOAA (2.20 mm/yr). NOAA projections use the same EC equations modified for different global SLR scenarios. The USACE and NOAA guidance documents do not address dates beyond 2100. All projections start from 1992 control for the national survey datum.

SEA LEVEL CHANGE SCENARIOS



FLOOD RISK VS. WATER SUPPLY

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



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


Hollywood, Florida – 2007


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

18

CLIMATE CHANGE CONCERNS FOR EVERGLADES RESTORATION

- **Hydrologic Pattern Changes**
  - Potential for less frequent and more intense rain events
  - Potential increased tropical storm intensity or frequency
- **Warmer Temperatures**
  - Evaporation losses up; water supply down
  - Stresses on plant, animal, and marine ecosystems
  - Changes in growing season and migratory bird patterns
  - Changes in water quality (higher temp, lower oxygen, more acidic?)
- **Sea Level Rise**
  - Salinity changes in coastal bays, plus tidal creeks and rivers
  - Accelerating shoreline retreat due to loss of freshwater peat soils
  - Higher water levels in SRS = increasing flood risks (Sparrows, 8.5 SMA)
  - Saltwater moving up SRS will eventually threaten water supply wells


RECOVER
assessment
integration
evaluation
science