US Army Corps of Engineers Considerations for Climate Preparedness and Resilience

City of Jacksonville
Special Committee on Resiliency
January 27, 2020
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US Army Corps of Engineers, Jacksonville District

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Presentation Outline

- USACE Climate Preparedness and Resilience
- Sea Level Change (SLC) through Time
- Climate Change Concerns for Florida
- Florida SLC Concerns and Examples
- Discussion

USACE Mission Areas

Navigation

Coastal Storm Damage Reduction

Flood Damage Reduction

Ecosystem Restoration

Emergency Response

Climate change has the potential to impact all USACE mission areas

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USACE Guidance and Tools Related to Climate Preparedness and Resilience

- ER 1100-2-8162, Incorporating Sea Level Changes in Civil Works Programs, 31 Dec 2013.
- ECB 2018-14, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects, 10 Sep 2018 to 10 Sep 2020.
- EP 1100-2-1, Procedures to Evaluate Sea Level Change Impacts, Responses, and Adaptation, 30 June 2019.
- ETL 1100-2-3, Detection of Nonstationarities in Annual Maximum Discharges, 28 April 2017 to 27 April 2021.
- Tool: Sea Level Change Calculator, http://corpsmapu.usace.army.mil/rccinfo/slc/slcc_calc.html
- Tool: Sea Level Tracker, http://ec2-34-205-128-255.compute-1.amazonaws.com:8080/slr_app/

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Other Information Sources related to Climate Preparedness and Resilience

- Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report web site, http://www.ipcc.ch/report/ar5/
- National Climate Assessment 4 (NCA4), vol. I: *Climate Science Special Report,* Nov 3, 2017: https://science2017.globalchange.gov
- National Climate Assessment 4 (NCA4), vol. II: *Our Changing Climate,* Nov 2018: https://science2018.globalchange.gov
- Responses to Climate Change (RCC) web site – Provides up-to-date information on USACE climate change adaptation activities, http://www.corpsclimate.us/
- NOAA Hydrometeorological Design Studies Center – Precipitation Frequency Estimates, https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

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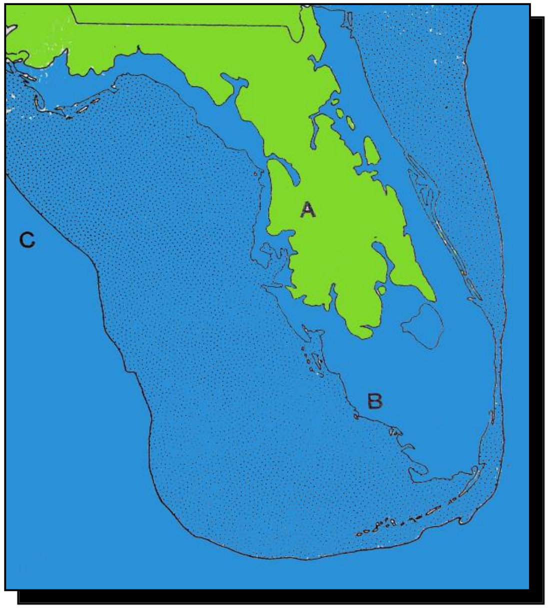
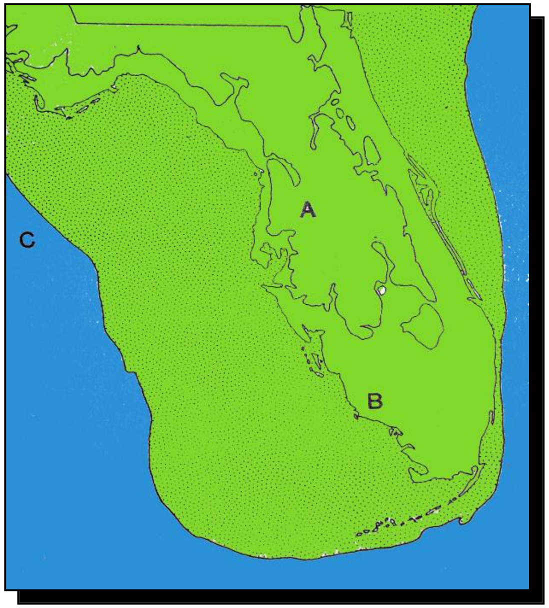
Florida Through Time – SEA LEVEL CHANGE HAPPENS

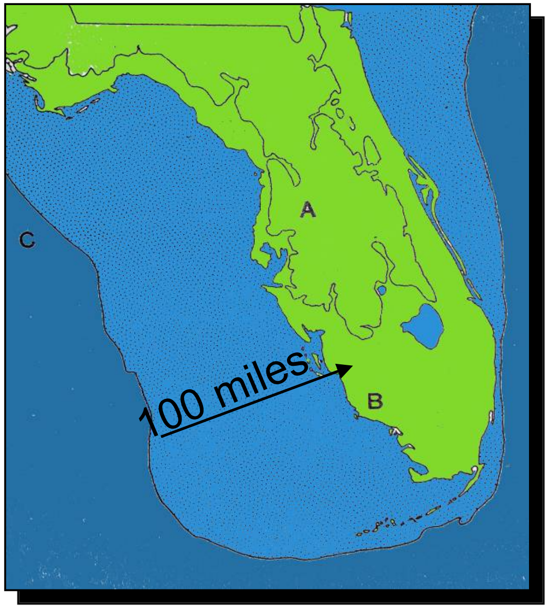


120,000 years ago
+ 6 meters (20')*

*~ ½ from Greenland
*~ ½ from Antarctica



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



Today

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

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Climate Change Concerns for Florida

- **Warmer Temperatures trigger:**
  - More extreme weather events – storms/hurricanes, droughts, fires
  - Evaporation losses up; water supply down
  - Stresses on humans, plants, animals, upland + marine ecosystems
  - Changes in water quality – lower dissolved oxygen, more acidic

- **The National Climate Assessment (NCA) 2018 states:**
  - Avg. annual US temperatures are 1.8°F higher than in 1900
  - Avg. annual US temperatures are forecast to increase about 2.5°F more in the coming decades regardless of emissions scenarios
  - By 2100, avg. annual US temps are forecast to be 3-12°F higher
  - Oceans are believed to have absorbed 93% of excess heat since the mid-20th century and more than 25% of excess carbon dioxide

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Climate Change Concerns for Florida

- **Hydrologic Pattern Changes**
  - Potential for less frequent and more intense rain events
  - Potential increased tropical storm intensity or frequency

- **NCA 2018** indicates that daily (24-hr) rainfall totals for:
  - 20-year (return interval) events are expected to increase 9-12% by around mid-century (2050) and
  - 13-21% by late 21st century

Climate Change Concerns for Florida

- **Sea Level Rise**
  - Increasing flood frequency and depth in coastal areas
  - Community Flood Insurance rates increase
  - At-Risk properties decline in value, and Property Tax revenue declines
  - Saltwater intrusion in water supply wells
  - Rising groundwater levels impact crop roots, roads and septic tanks
  - Shoreline retreat structure removal costs + natural habitat changes

- **NCA 2018** indicates that:
  - relative to year 2000, sea level is very likely to rise 1 to 4 feet by the end of the century (2100)
  - Emerging science regarding Antarctic ice sheet instability suggests that, for higher emissions scenarios, a SLR exceeding +8 feet by 2100 is physically possible, although the probability of such an extreme outcome cannot currently be assessed.

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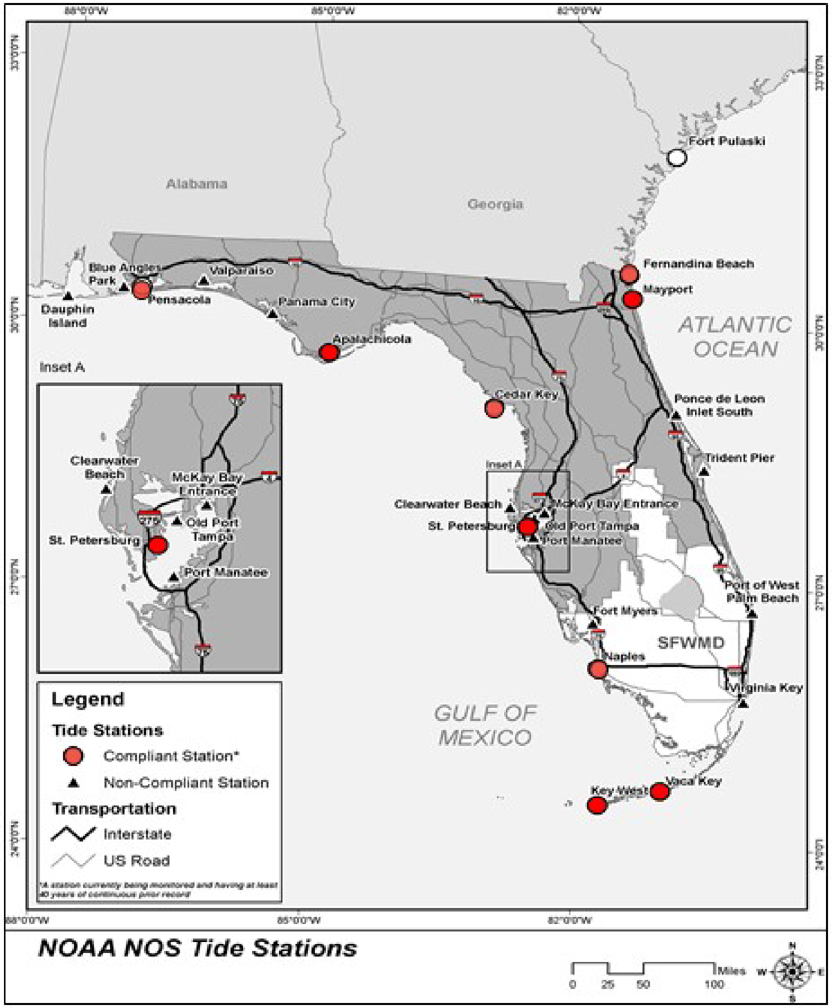
NOAA Tide Stations In Florida

Compliant Stations Have A Continuous 40-year Or Longer Data Record For Use In Calculating USACE And NOAA Sea Level Change Projections

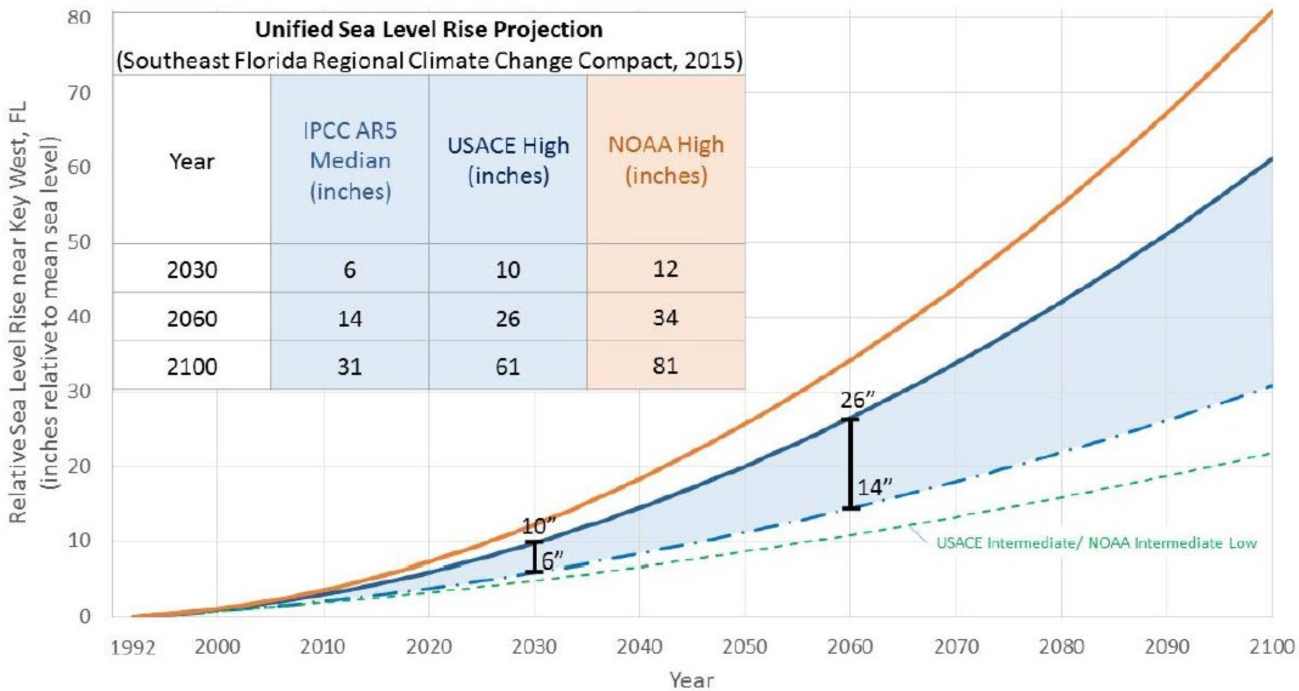


UNIFIED SEA LEVEL RISE PROJECTION

SE FL REGIONAL CLIMATE CHANGE COMPACT, 2015

SE FL COMPACT CHANGED UPPER LIMIT TO 2017 NOAA HIGH IN DEC. 2019

NEW GRAPHIC TO BE ADDED



Year	IPCC AR5 Median (inches)	USACE High (inches)	NOAA High (inches)
2030	6	10	12
2060	14	26	34
2100	31	61	81

Figure 1: Unified Sea Level Rise Projection. These projections are referenced to mean sea level at the Key West tide gauge. The projection includes three global curves adapted for regional application: the median of the IPCC AR5 RCP8.5 scenario as the lowest boundary (blue dashed curve), the USACE High curve as the upper boundary for the short term for use until 2060 (solid blue line), and the NOAA High curve as the uppermost boundary for medium and long term use (orange solid curve). The incorporated table lists the projection values at years 2030, 2060 and 2100. The USACE Intermediate or NOAA Intermediate Low curve is displayed on the figure for reference (green dashed curve). This scenario would require significant reductions in greenhouse gas emissions in order to be plausible and does not reflect current emissions trends.

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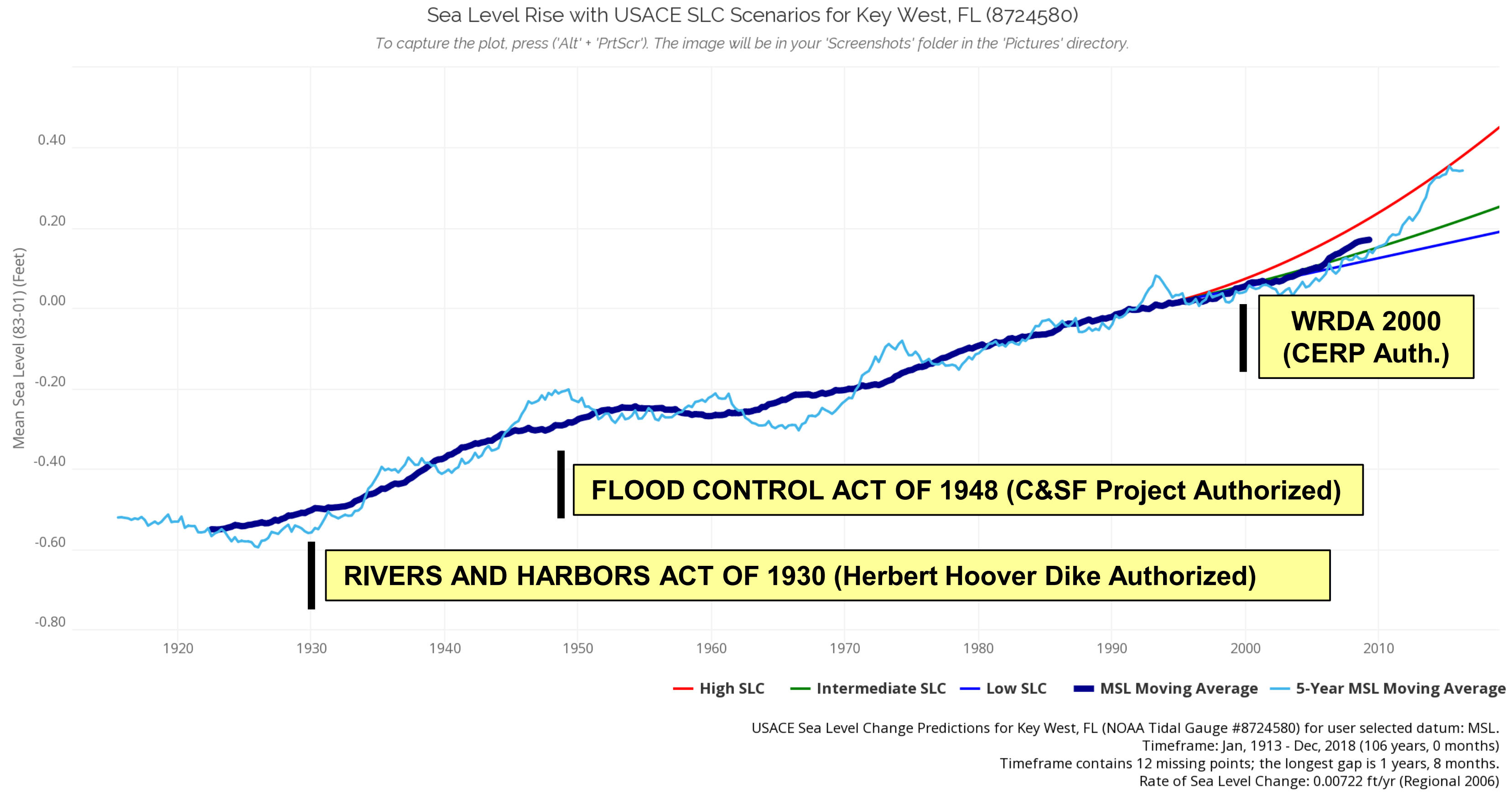
ACCELERATING SEA LEVEL CHANGE IN FLORIDA 105-YEARS JAN 1913 TO DEC 2018, KEY WEST, FL



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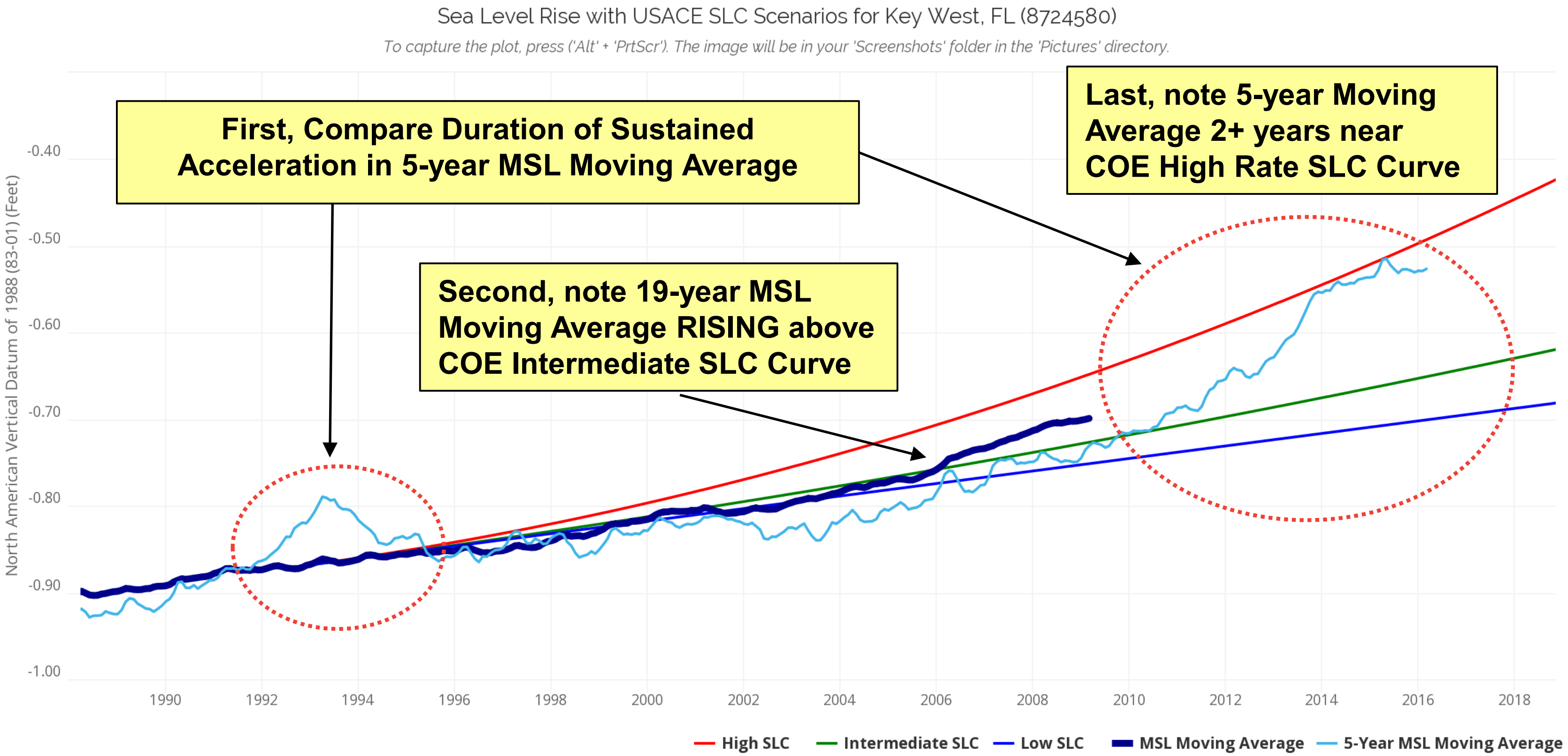
ACCELERATING SEA LEVEL CHANGE IN FLORIDA 30-YEARS 1988 TO 2018, KEY WEST, FL



USACE Sea Level Change Predictions for Key West, FL (NOAA Tidal Gauge #8724580) for user selected datum: NAVD.
Timeframe: Jan, 1913 - Nov, 2018 (106 years, 11 months)
Timeframe contains 12 missing points; the longest gap is 1 years, 8 months.
Rate of Sea Level Change: 0.00722 ft/yr (Regional 2006)

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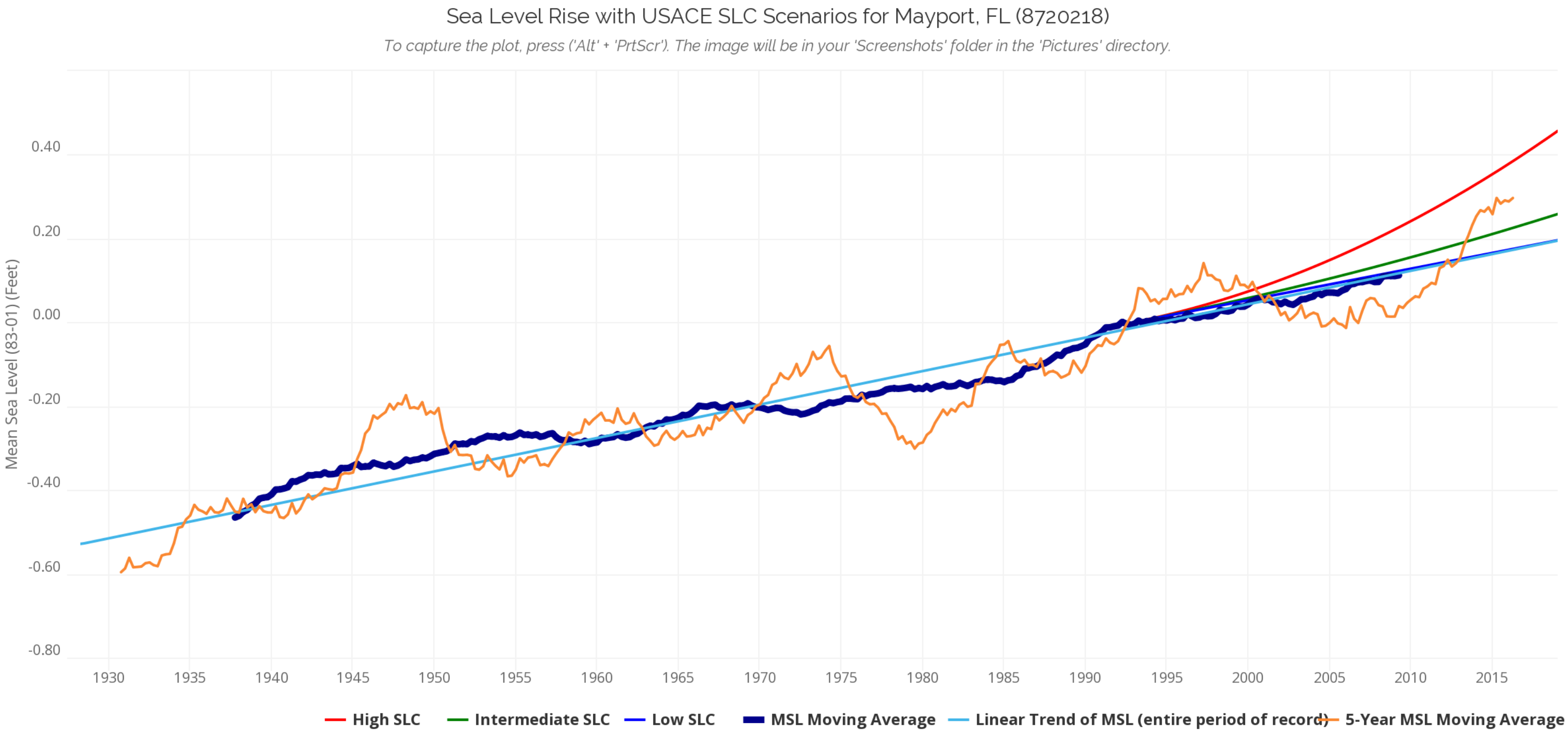
Accelerating Sea Level Change in Florida APR 1928 to DEC 2018, Mayport, FL



USACE Sea Level Change Predictions for Mayport, FL (NOAA Tidal Gauge #8720218) for user selected datum: MSL.
Timeframe: Apr, 1928 - Dec, 2018 (91 years, 9 months)
Timeframe contains 4 missing points; the longest gap is 0 years, 1 months.
Rate of Sea Level Change: 0.00751 ft/yr (Regional 2006)

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Relative Sea Level Change Scenarios for Mayport, FL (FT)

Year	USACE and NOAA 2012 Low	USACE Intermediate NOAA 2012 Int-Low (Mod. NRC Curve I)	NOAA 2012 Int-High	USACE High (Mod. NRC Curve III)	NOAA 2012 High	NOAA 2017 Extreme 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	Global SLC +2.5m by 2100
1992	0.00	0.00	0.00	0.00	0.00	0.00
2020	0.22	0.29	0.45	0.51	0.62	0.79
2060	0.54	0.95	1.86	2.25	2.90	4.13
2100	0.85	1.89	4.18	5.18	6.81	10.50
2110	0.93	2.17	4.91	6.09	8.04	
2120	1.01	2.47	5.69	7.08	9.38	14.47

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 Regulation (ER) 1100-2-8162, dated 31 Dec 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 2012 projections use the same ER equations modified for different global SLR scenarios. USACE guidance documents do not address SLR dates beyond 2100. All projections start from 1992 control for the national survey datum. NOAA Technical Report in Jan. 2017 recommended more scenarios, all starting in year 2000, and a global sea level change extreme scenario of +2.5m by 2100.

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Sea Level Rise Concerns in Northeast Florida

- Direct Impacts (SLR + coastal storms on communities, businesses and Mayport NAS)
- Flood Frequency and Drainage (increased flooding, particularly in low elevation areas and historic 500-year old St. Augustine)
- Water Supply and Storage (saltwater intrusion in coastal areas, St. Johns River and some groundwater)
- Natural System (coastal ecosystems and St. Johns River basin)

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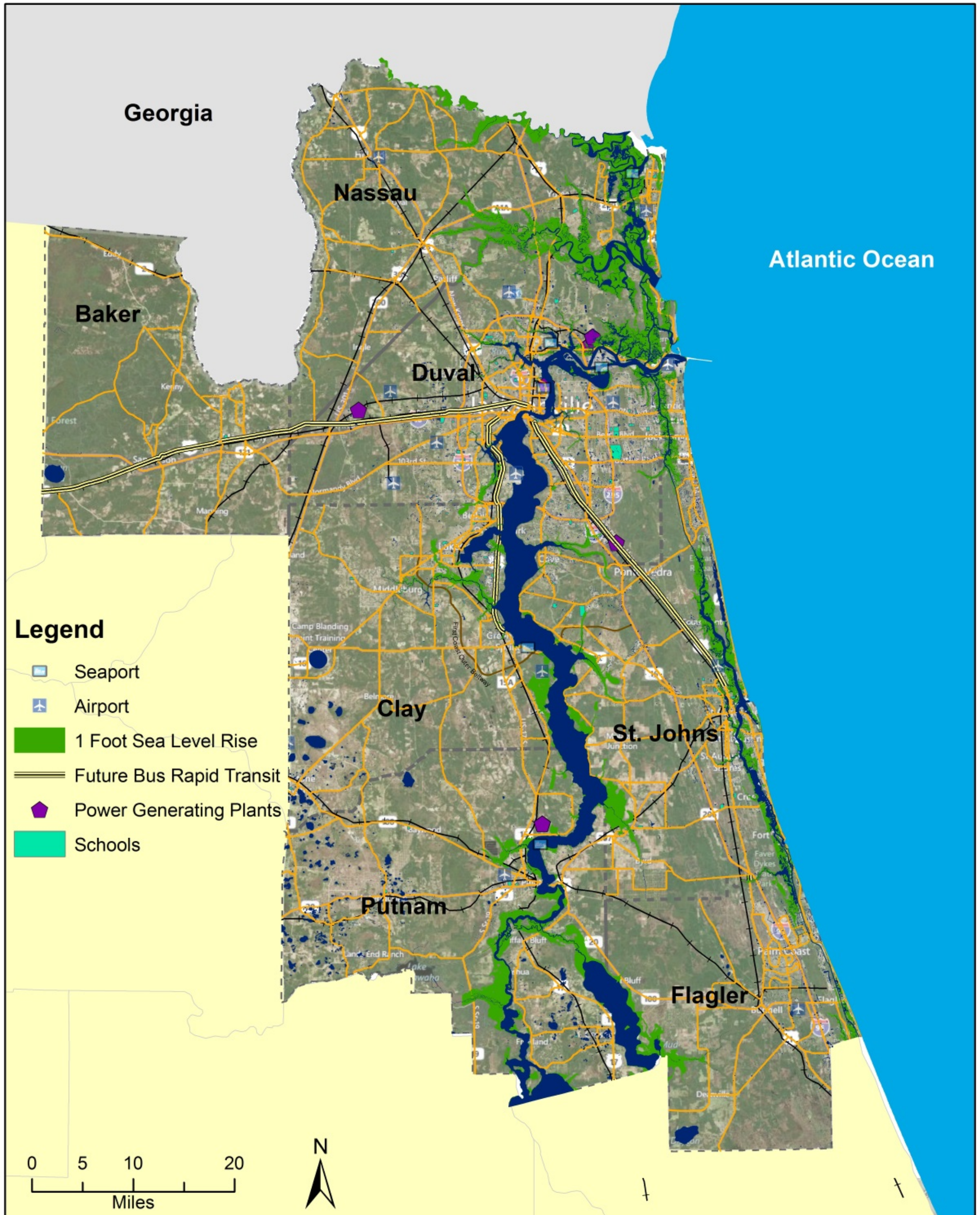

Northeast Florida Sea Level Rise - 1 Foot Rise

Credit: Northeast Florida Regional Council

Sea Level Rise Impacts in Northeast Florida

- Flood risks increase
- Salinity impacts on Coastal and River ecosystems, adjacent areas and groundwater
- Decreases surface storage of freshwater
- **+ 1 Foot**

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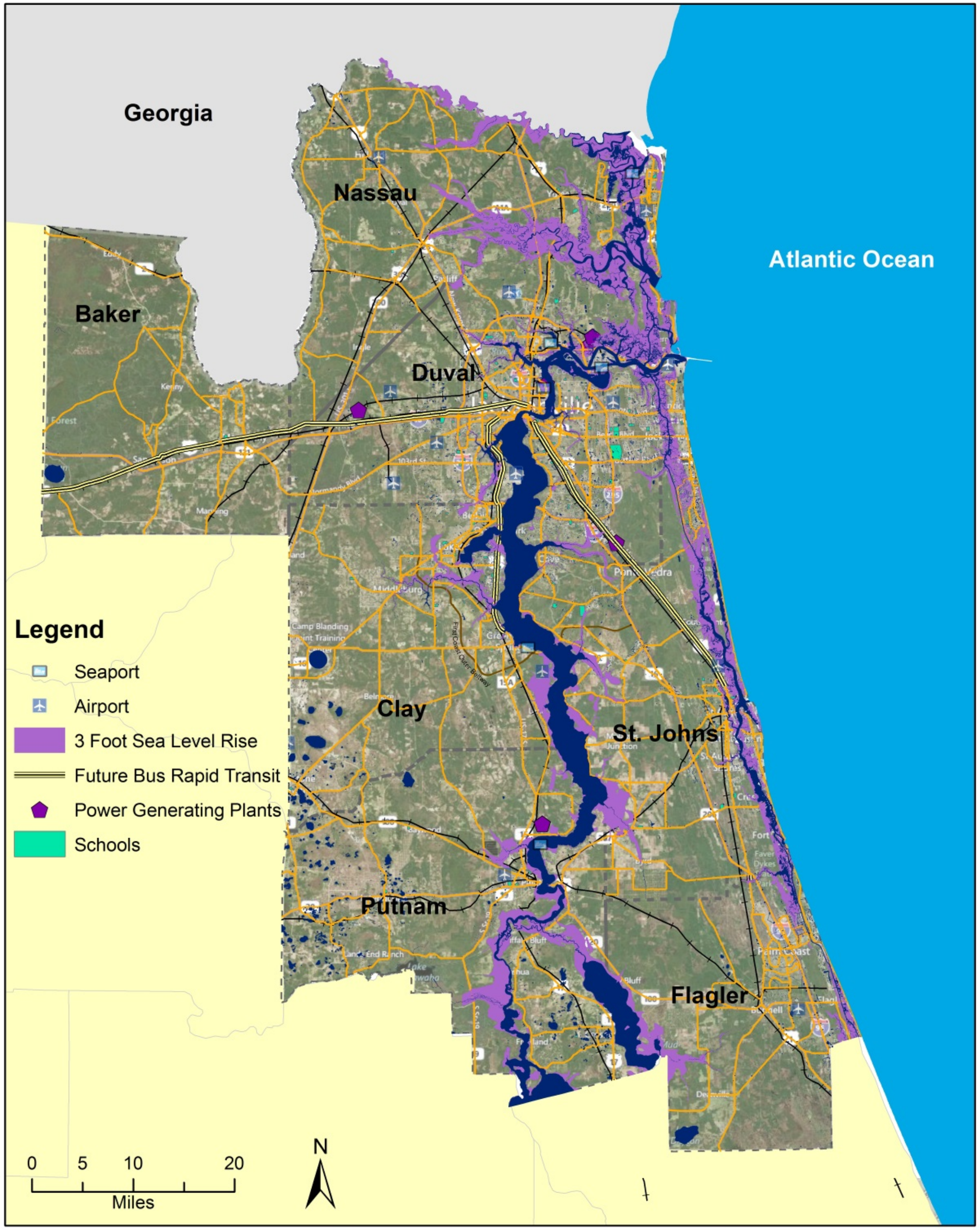

Northeast Florida Sea Level Rise - 3 Foot

Credit: Northeast Florida Regional Council

Sea Level Rise Impacts in Northeast Florida

+3 FEET

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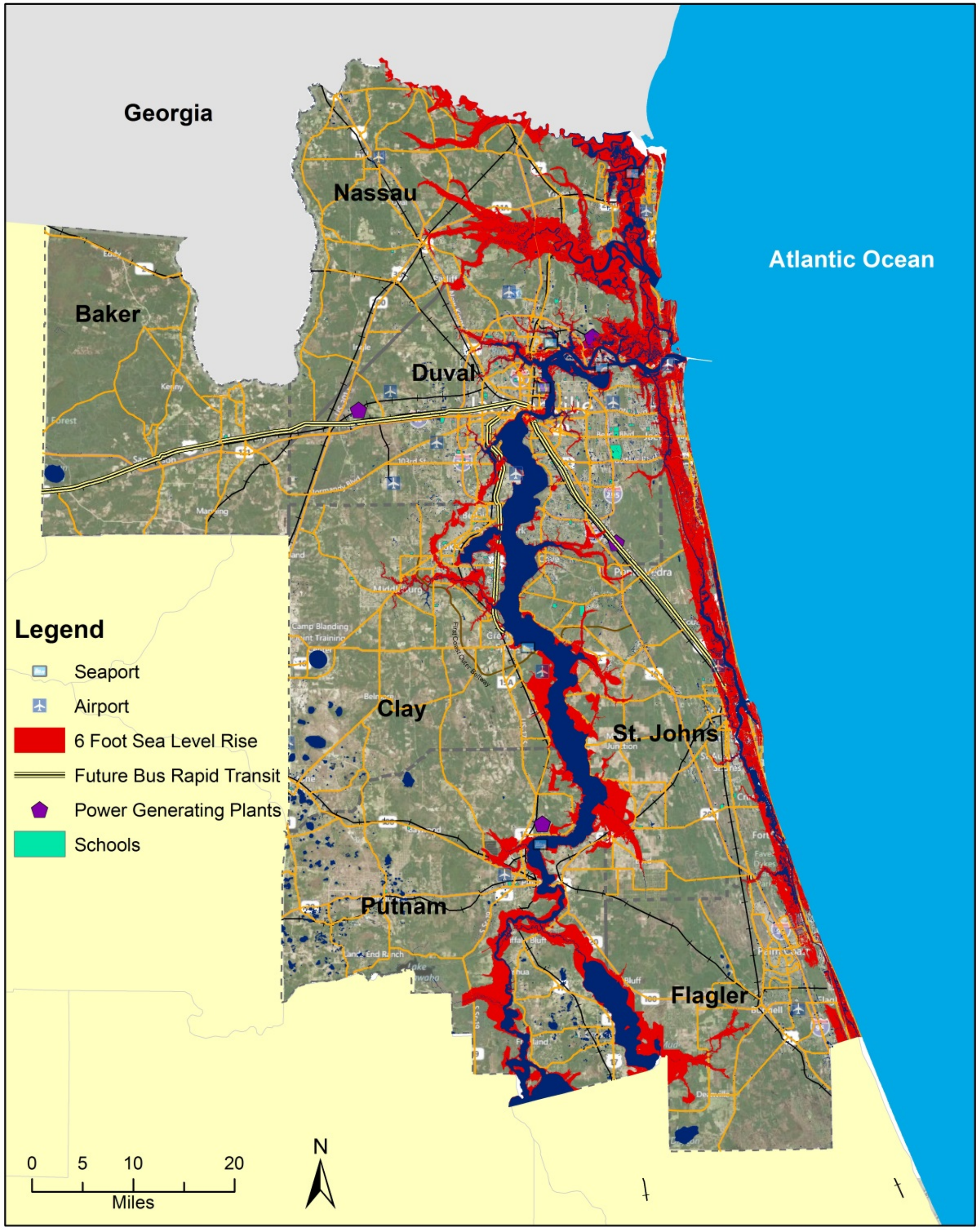
Sea Level Rise Impacts in Northeast Florida

+6 FEET



Northeast Florida Sea Level Rise - 6 Foot Rise

Credit: Northeast Florida Regional Council

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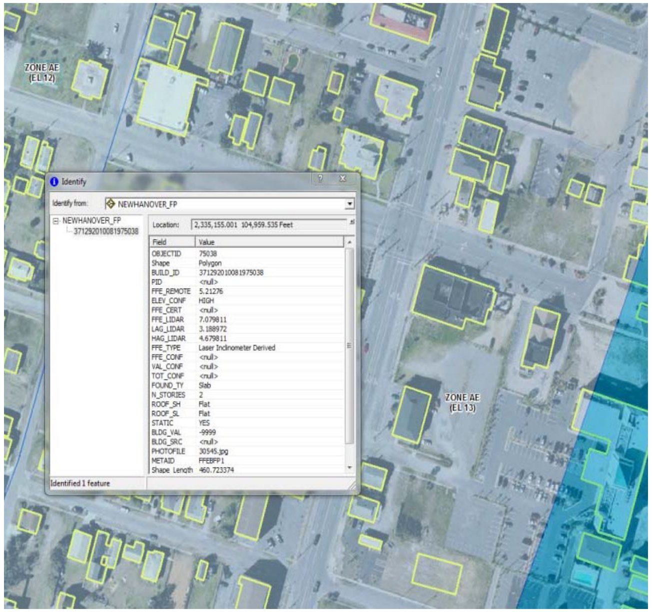
RISK ASSESSMENT
Mobile LIDAR Technology For Street And Structure Elevation Data



Credit: North Carolina Flood Risk Info System and FL Dept. of Emergency Management

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United Kingdom Climate Adaptation Approaches: Precautionary Versus Managed Adaptive

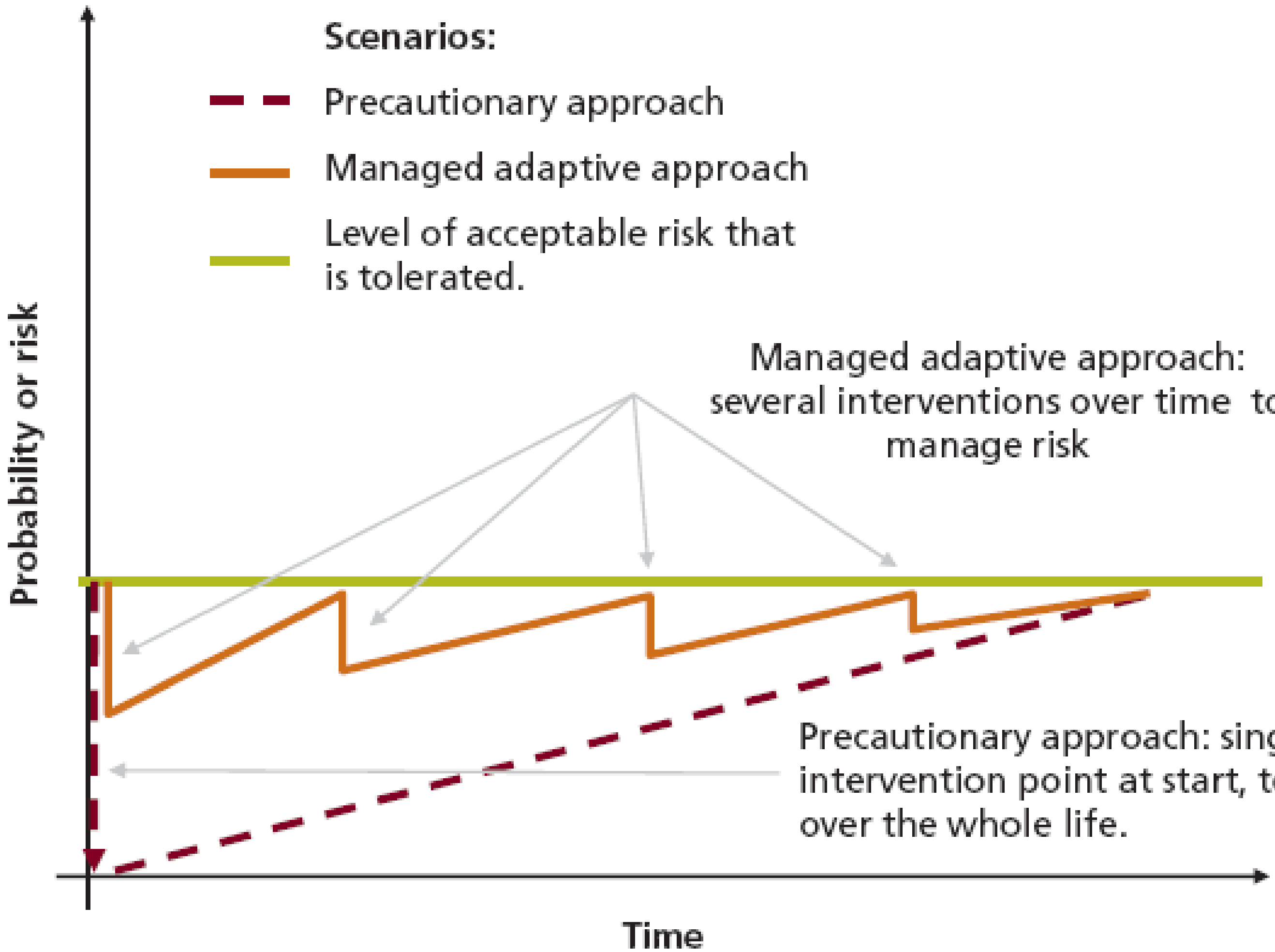

Figure courtesy of Jonathan Simm, HR Wallingford, UK

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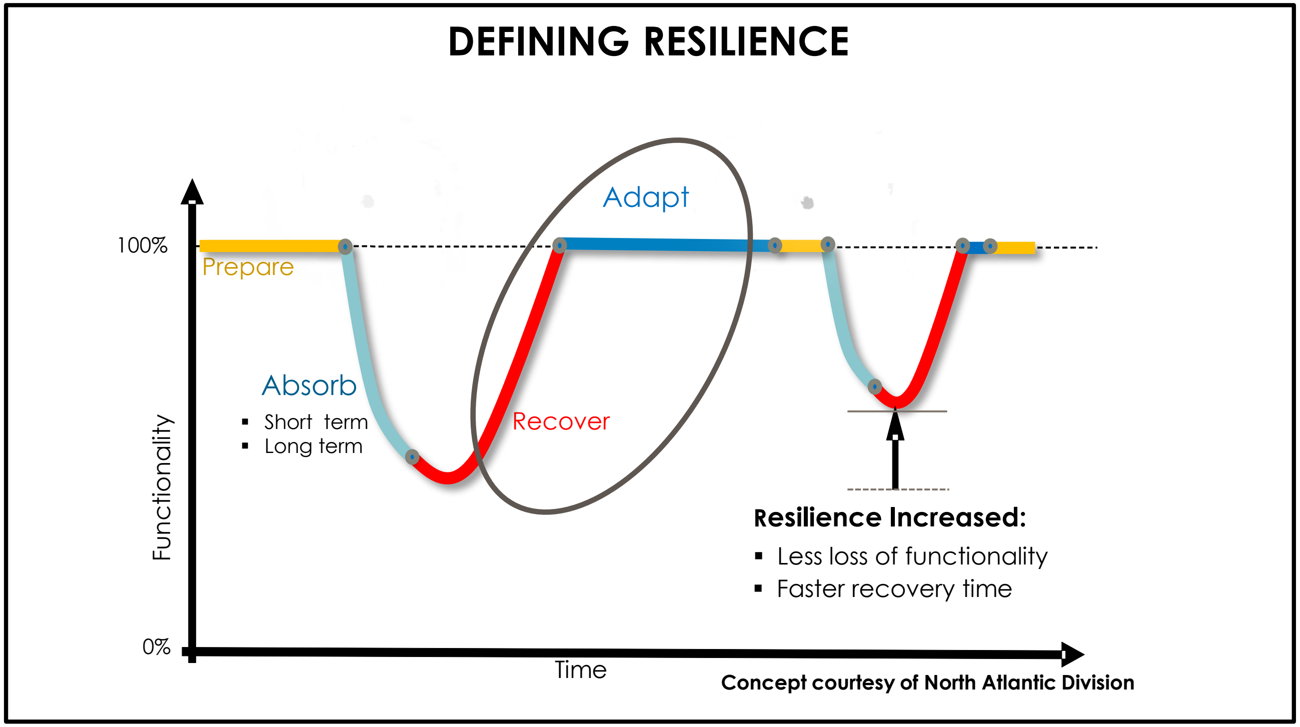
A Focus Toward Resiliency



Resiliency means building the ability of a community to "bounce back" after hazardous events such as hurricanes, coastal storms and flooding – rather than simply reacting to impacts. National Ocean Service, NOAA

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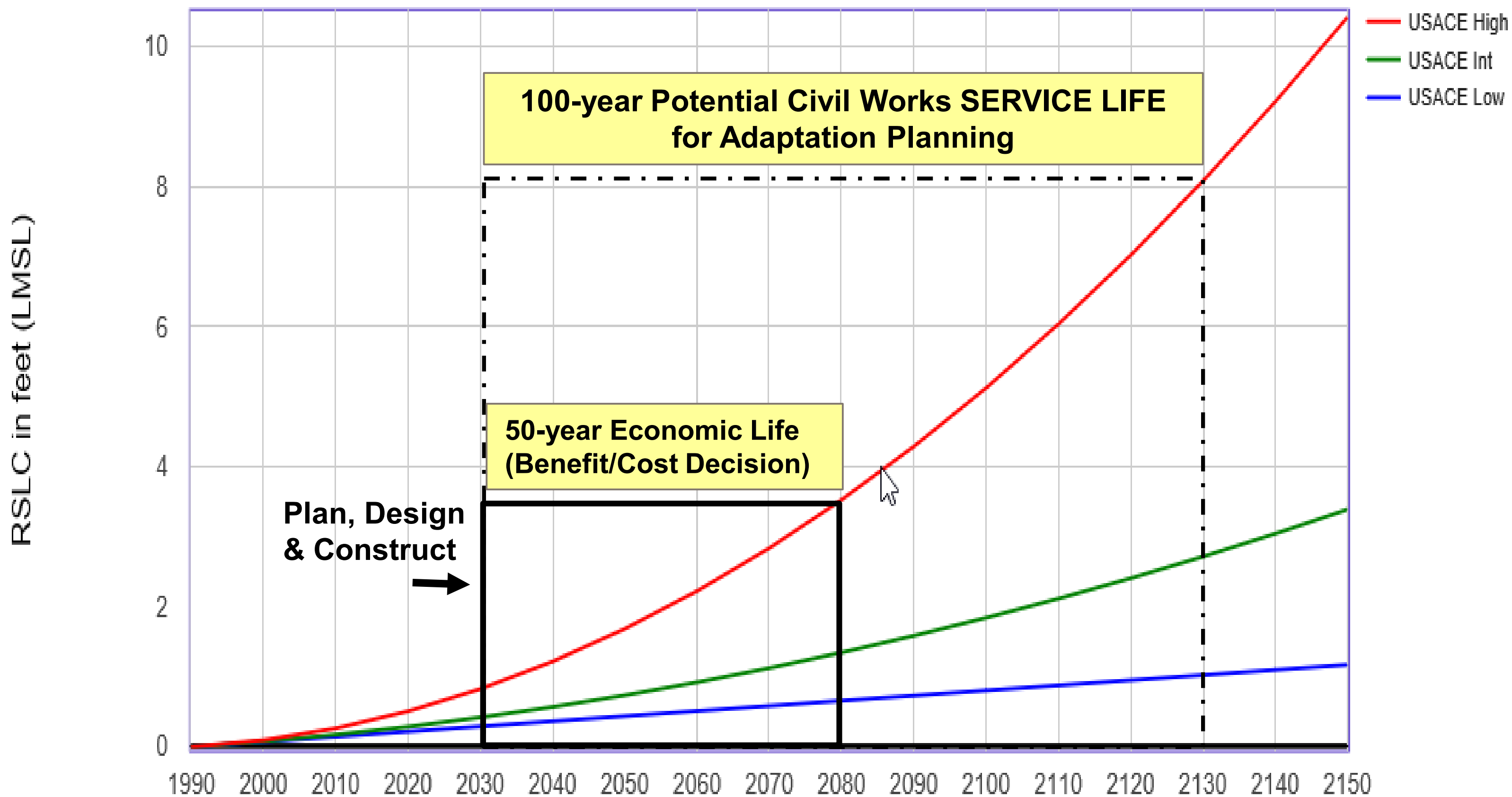
Sea Level Change
Planning and Design Considerations



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Conclusions and Discussion Ideas

- **The Trend is Clear:**
  - Sea level rise PERMANENTLY increases coastal flood risks
  - Anticipate SLR accelerating and likely continuing far beyond 2100
  - Without action, buildings AND lands subject to SLR will depreciate as risks increase

- **Taking Action:**
  - Begin planning and developing measures (structural, non-structural, natural and nature-based) to address risk
  - "Every dollar spent before an event saves four to five dollars in reconstruction costs after." (National Research Council 2014)
  - Consider Septic Tank Systems as a risk and prioritize, as appropriate
  - When and where applicable, start the dialogue to plan for managed retreat and timely voluntary actions

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Closing Thoughts

Actions Pay Dividends:

- Others are Stepping Up: Resiliency is the new Sustainability
- State of Florida, Miami Dade, Broward, St. Augustine all have Offices of Resiliency actively developing actions to protect communities
- A Resilient Community withstands the economic impacts that come with Climate Change
- Grants are available to help communities improve Invest in long-term risk reduction and improve Resiliency

A Resilient Community Requires Community Engagement and Actions to Reduce Risks

Resiliency is supported federally, managed regionally and implemented locally.

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Thank you!

For additional information, contact:

Glenn.B.Landers@usace.army.mil

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RELATIVE SEA LEVEL CHANGE SCENARIOS FOR KEY WEST, FL (FEET)

PER USACE 2013 AND NOAA 2012 GUIDANCE

Year	USACE Low	USACE Int		USACE High	
	NOAA Low	NOAA Int. Low	NOAA Int. High		NOAA 2012 High
1992	0.00	0.00	0.00	0.00	0.00
2000	0.06	0.06	0.08	0.08	0.09
2010	0.13	0.16	0.23	0.25	0.3
2020	0.21	0.28	0.43	0.5	0.61
2030	0.28	0.41	0.69	0.82	1.02
2040	0.35	0.56	1.01	1.21	1.53
2050	0.43	0.73	1.39	1.67	2.15
2060	0.5	0.91	1.82	2.21	2.86
2070	0.57	1.11	2.31	2.83	3.68
2080	0.65	1.34	2.86	3.52	4.6
2090	0.72	1.57	3.47	4.28	5.63
2100	0.79	1.83	4.13	5.12	6.75
2110	0.87	2.11	4.85	6.03	7.98
2120	0.94	2.4	5.62	7.02	9.31
2130	1.01	2.71	6.46	8.07	10.74
2140	1.09	3.04	7.35	9.21	12.28
2150	1.16	3.38	8.3	10.42	13.91
2160	1.24	3.74	9.3	11.7	15.65
2170	1.31	4.13	10.36	13.05	17.49
2180	1.38	4.52	11.48	14.49	19.44
2190	1.46	4.94	12.66	15.99	21.48
2200	1.53	5.38	13.89	17.57	23.63

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RELATIVE SEA LEVEL CHANGE SCENARIOS FOR KEY WEST, FL (FEET)

Per NOAA 2017 Guidance

	NOAA2017	NOAA2017	NOAA2017	NOAA2017	NOAA2017	NOAA2017	NOAA2017
Year	VLM	Low	Int-Low	Intermediate	Int-High	High	Extreme
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.02	0.13	0.16	0.23	0.30	0.33	0.36
2020	0.04	0.26	0.33	0.46	0.56	0.69	0.72
2030	0.05	0.43	0.52	0.75	0.98	1.18	1.35
2040	0.07	0.56	0.69	1.02	1.38	1.74	1.97
2050	0.09	0.72	0.92	1.38	1.94	2.46	2.92
2060	0.11	0.85	1.08	1.77	2.56	3.38	4.04
2070	0.12	1.02	1.28	2.23	3.31	4.49	5.35
2080	0.14	1.12	1.44	2.72	4.17	5.74	6.86
2090	0.16	1.25	1.64	3.28	5.12	7.09	8.56
2100	0.18	1.31	1.77	3.84	6.14	8.56	10.43
2120	0.21	1.51	2.10	4.69	7.64	11.32	14.60
2150	0.27	1.74	2.59	6.46	11.19	16.99	22.41
2200	0.35	2.07	3.38	9.78	18.47	29.27	37.70

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RISK MANAGEMENT DECISION

- Sustainable
- Robust: performs well under a 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, minimize worst-case outcome**

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