Evaluation of Drainage Infrastructure Capacity Under Projected Sea Level and Climate Conditions, Broward County, Florida

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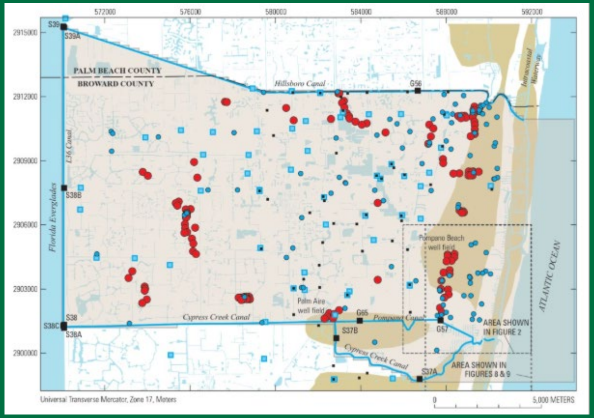
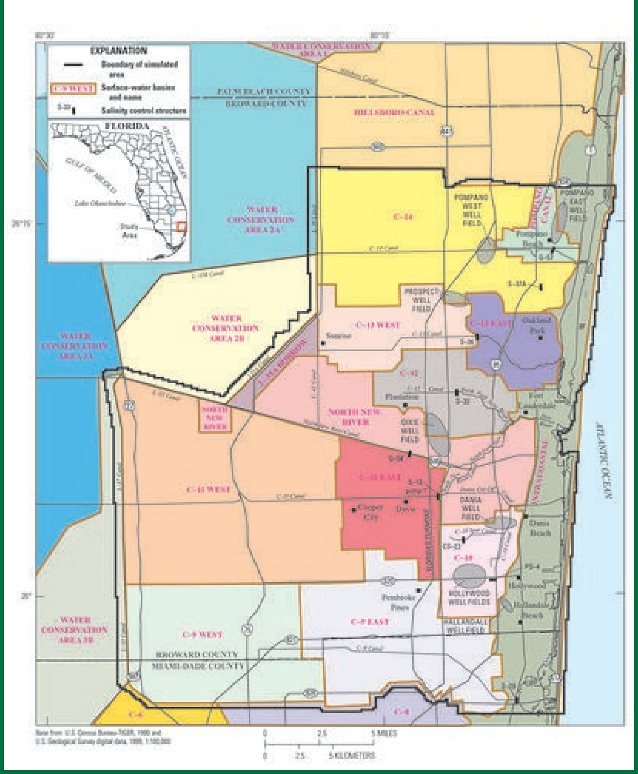
Overview

- Group of projects undertaken by the USGS with cooperation from Broward County Environmental Planning and Community Resilience Division
- Began with saltwater intrusion models
  - Primary objective of studying future sensitivities of saltwater front to pumping and sea-level rise (Northern then Central and Southern Models)
  - Used SEAWAT, historical surface water data for canals, and future sea level projections
- Fueled interest in drainage infrastructure's response to projected sea-level and potential climate change (rainfall, evaporation)
  - How might system operations and subsequent canal stages and groundwater levels change
  - 2 projects followed – first was a pilot study/proof of concept, second was a county-scale model

Northern Model (2012)



Central and Southern Model (2016)



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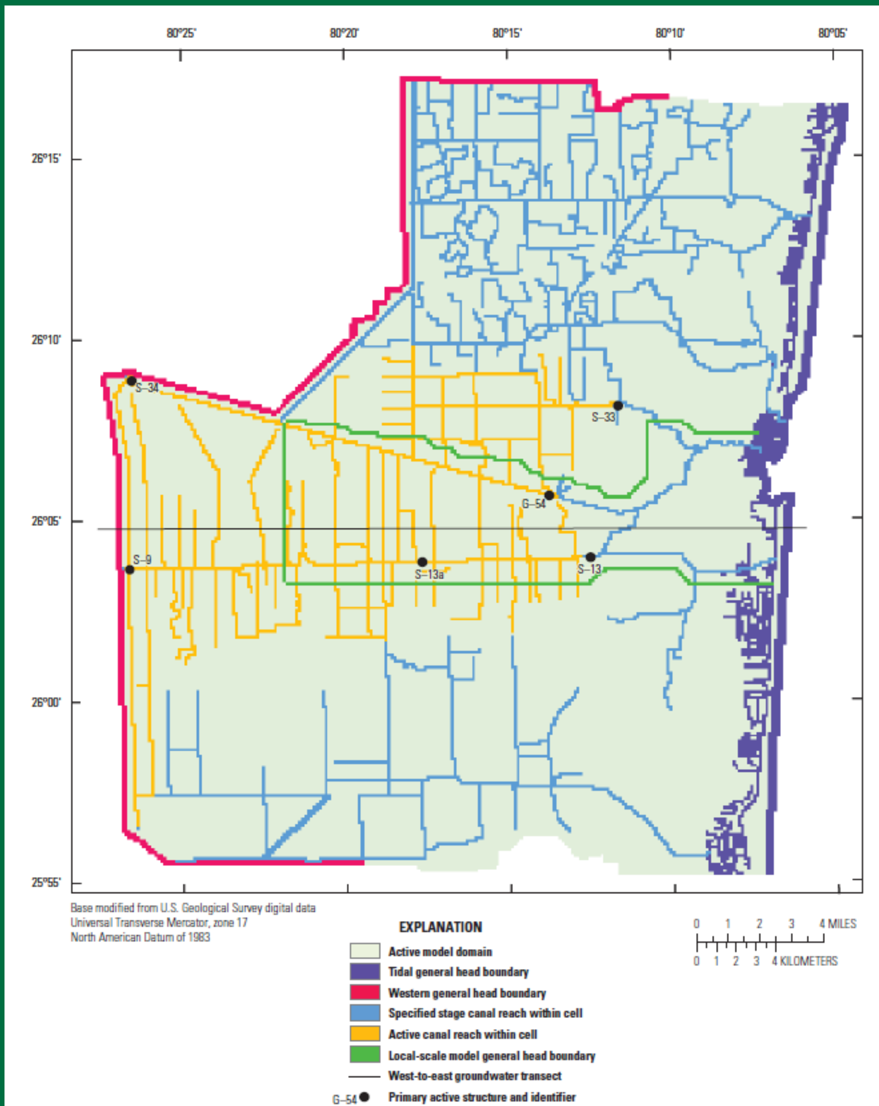
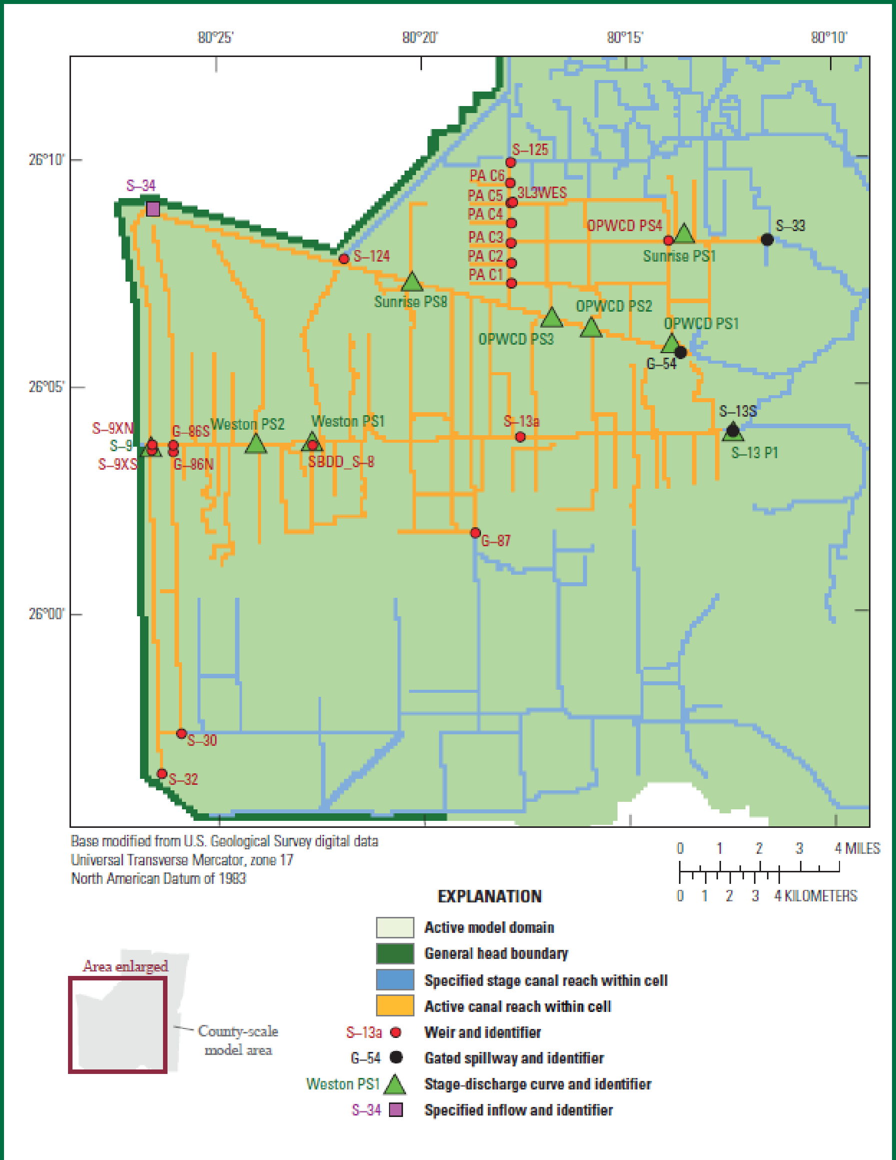
Inundation Model (Phase I)

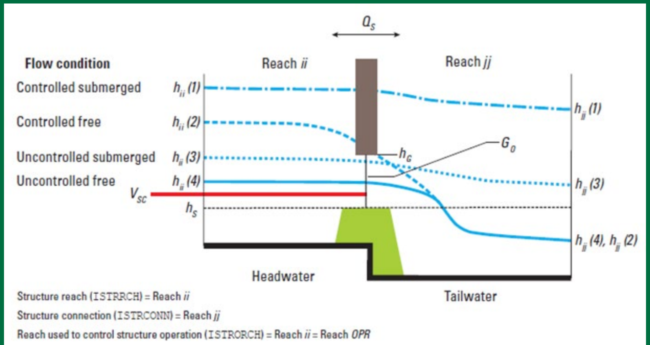


- Look into increased risk of inundation under future conditions (Published 2018)
- Same model boundaries as southern and central Broward saltwater intrusion model
- Modified saltwater intrusion model – removed solute transport, vertically simplified aquifer layering, modified temporal resolution, simulated portions of canal system dynamically (yellow portions in figure)
- Created sub-model with increased resolution
  - Test sensitivity to spatial resolution
- Simulated groundwater levels and structure operations under projected climate and sea level conditions
- Model information
  - 500 ft grid resolution, 167 ft in sub-model
  - Historical simulation period: 1990-1999
  - Future simulation period: 2060-2069
  - Surface-Water Routing process (SWR1) used to simulate canal/drainage network

Inundation Model (Phase I)

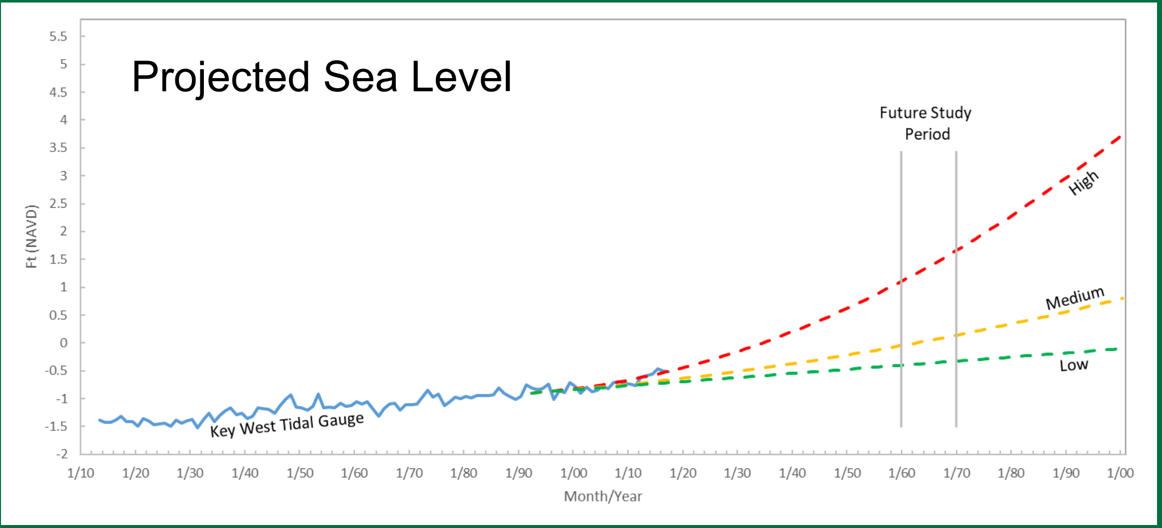


- Dynamically simulated canal system:
  - 19 weirs
  - 1 specified inflow (from adjacent water conservation area)
  - 3 gated spillways
  - 9 pumps
- Weirs – flow from drainage area occurs once upstream stage reaches invert elevation (governed by fixed crest weir equation)
- Pumps – flow begins once a control elevation is reached upstream and increases linearly to a maximum rate at a second higher elevation
- Gates – gate begins to open once a higher control elevation is reached and remains open until a lower control elevation is reached

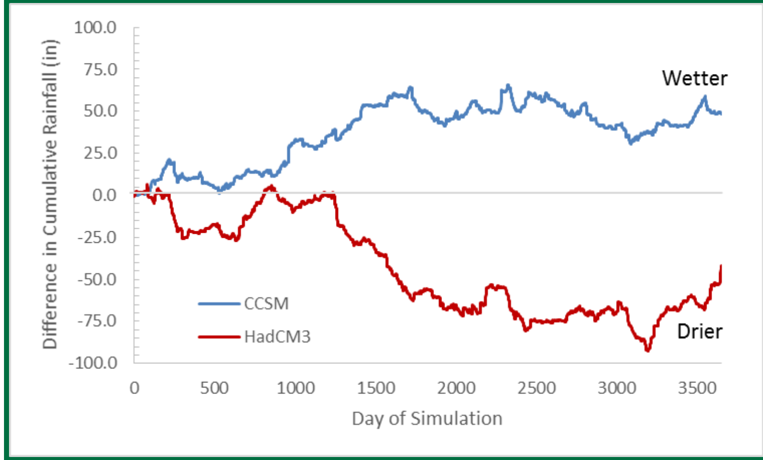


Inundation Model (Phase I)

- Simulated historical period (1990-1999) and future period (2060-2069)
- Southeast Florida Regional Climate Change Compact adopted sea-level rise curves (2011)
  - Low projection - historical linear sea-level rise trend (approx. 6” increase for 2065)
  - Medium projection – modified NRC Curve I (approx. 11” increase for 2065)
  - High projection – modified NRC Curve III (approx. 27” increase for 2065)
- Future precipitation and potential evapotranspiration (PET) from Center for Ocean-Atmospheric Prediction Studies (COAPS)
  - Dynamically downscaled regional climate model (10 km resolution) results using general circulation model output as boundary conditions
  - Daily bias-corrected rainfall with estimates of PET from HadCM3 and CCSM
  - HadCM3 (approx. 8% decrease in rainfall)
  - CCSM (approx. 9% increase in rainfall)



Difference in Rainfall From Historical Period



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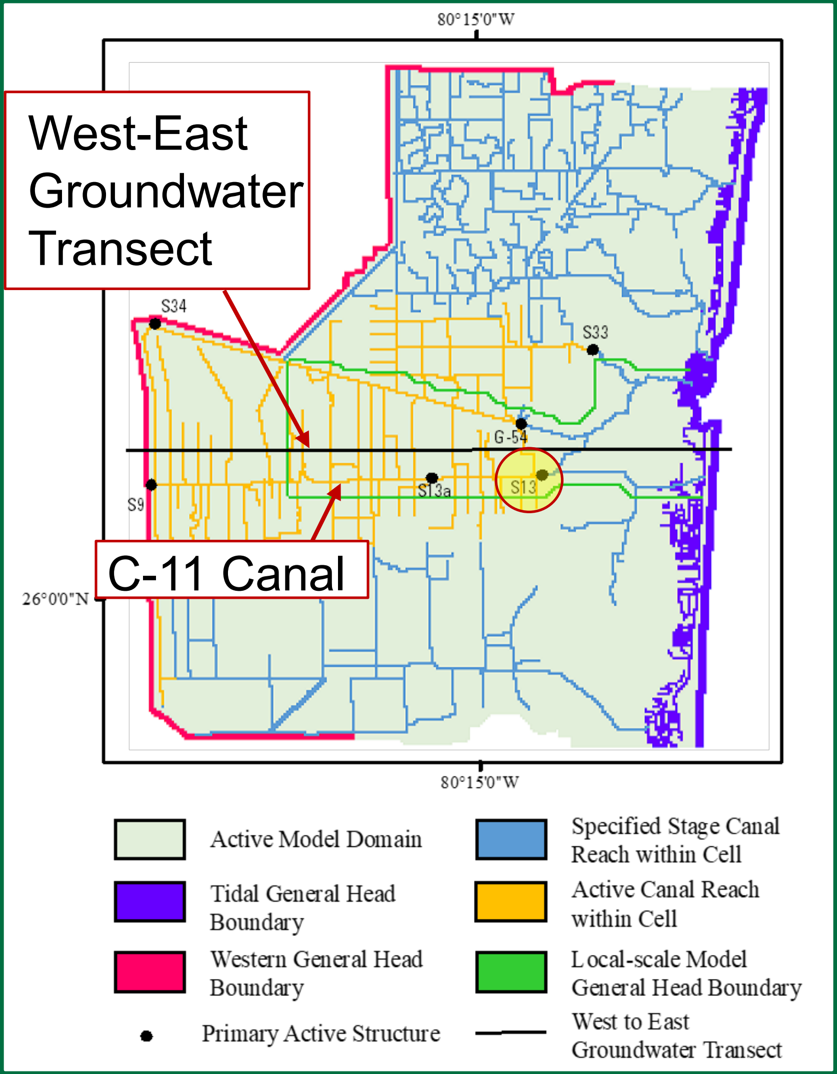

Average Wet Season Groundwater Levels

- West (Water Conservation Area) to East (Tide) groundwater transects for future conditions simulations (2060-2069)
- Show east/west divide of C-11 canal at S-13a structure
- Show increases in groundwater levels in eastern C-11 canal and reduction in groundwater gradient (west to east)

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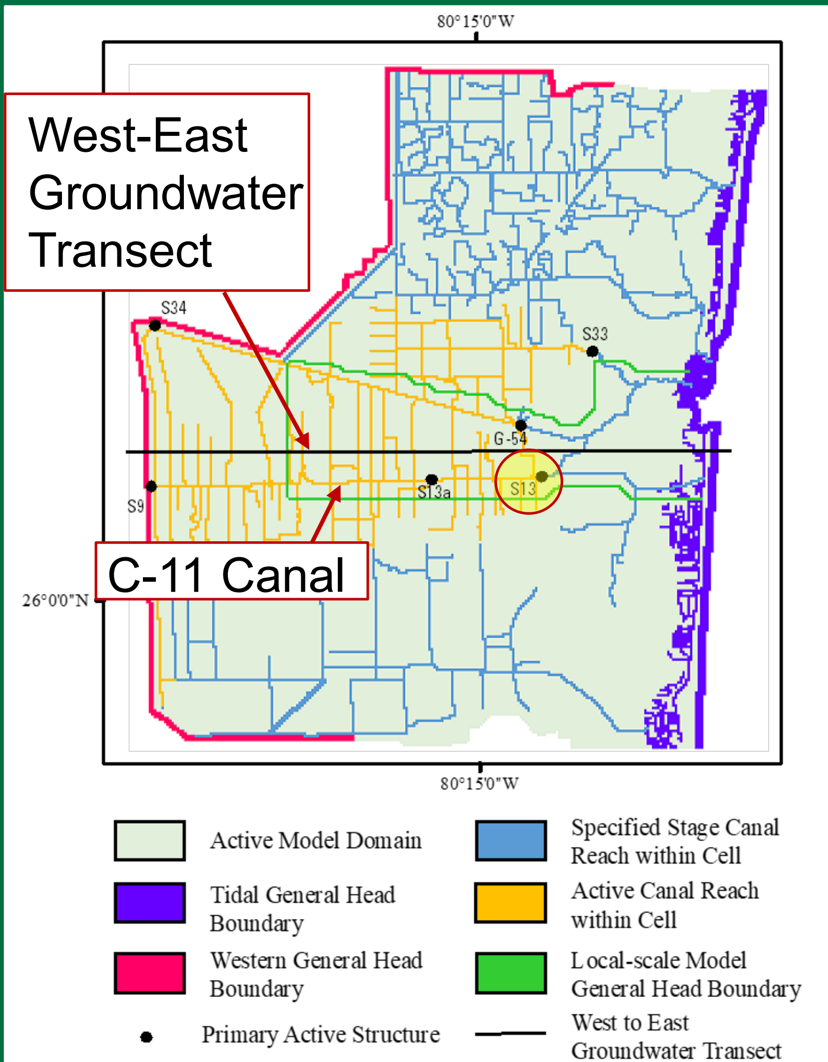
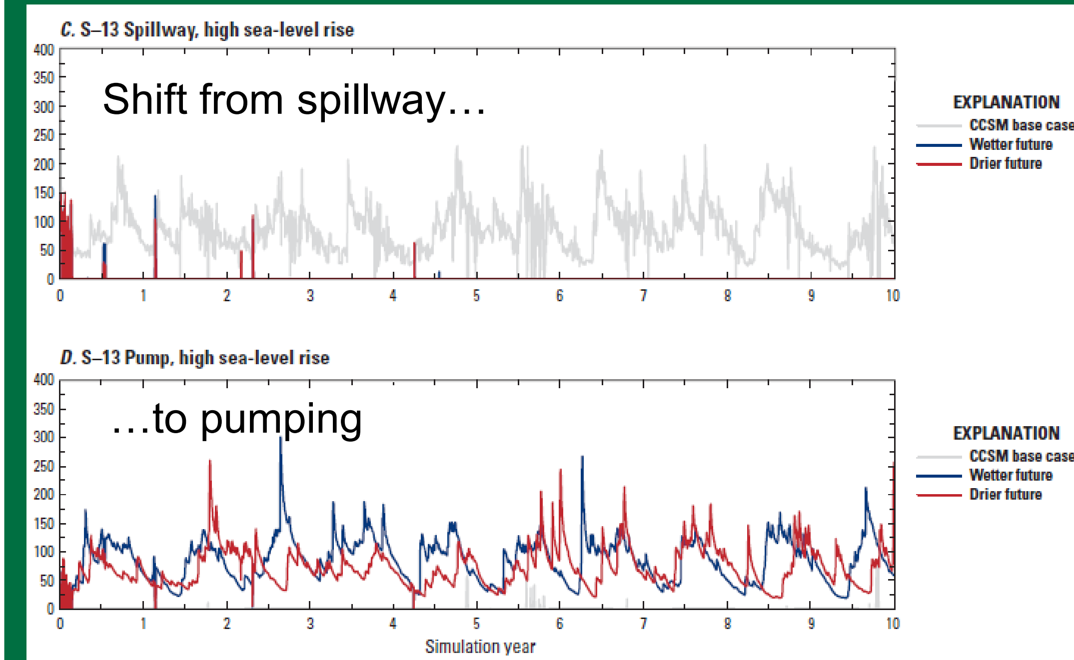


S-13 Spillway and Pump Flow (CFS)



- S-13 has a gated spillway and a pump used for flood control
- The target control elevation for the spillway operation is 0.1 ft NAVD
- Average sea level is projected to top this for the "high" scenario
- Shift to flood control pump operations raises canal levels (could lower pumping curve)

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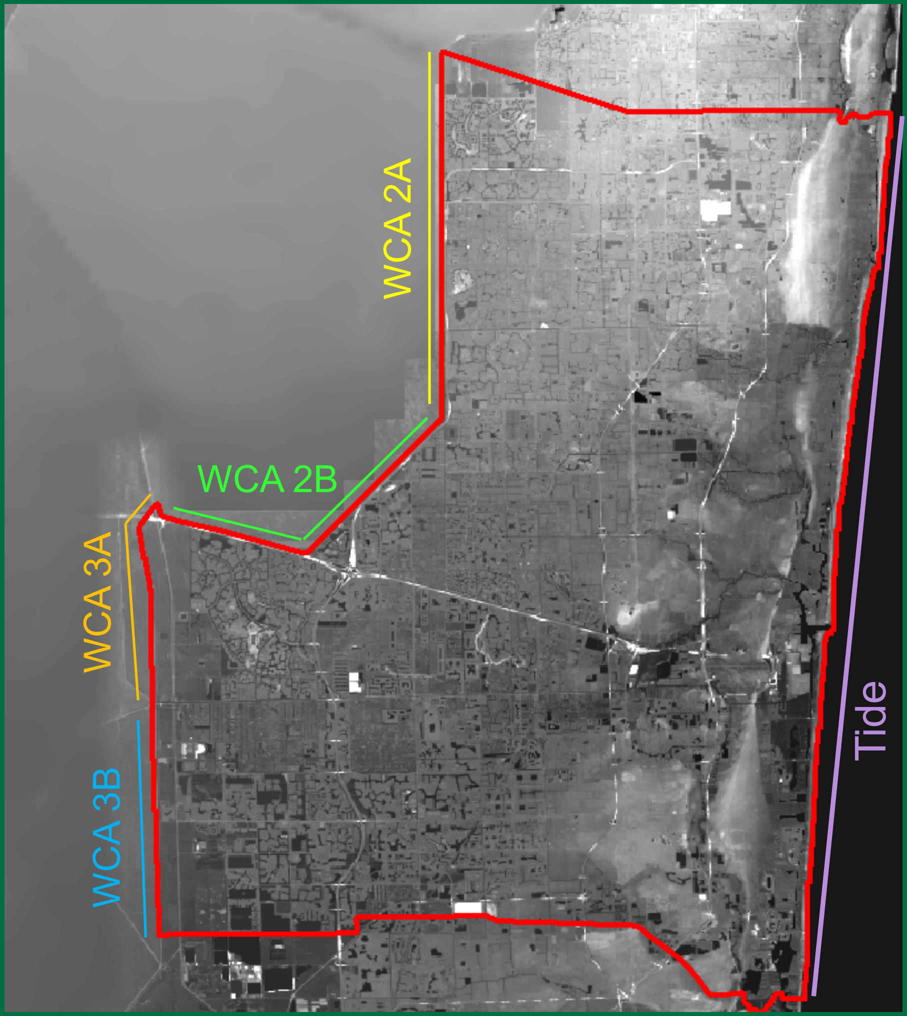
Inundation Model (Phase II)

- Results of first study identified several needs:
  - Dynamically modeled canals and structures throughout the county
  - Increased drainage feature density
  - Inclusion of northern portion of the county into the study area (from northern saltwater intrusion model)
  - Reduced spatial resolution without the need for a sub-model (more difficult and time consuming)
- Led to Phase II of the Inundation Model Project (June 2018 - June 2021)
  - Northern and central/southern saltwater model boundaries
  - 250 ft grid resolution
  - Dynamically simulated canal/drainage network

Land surface elevation at 250 ft grid resolution



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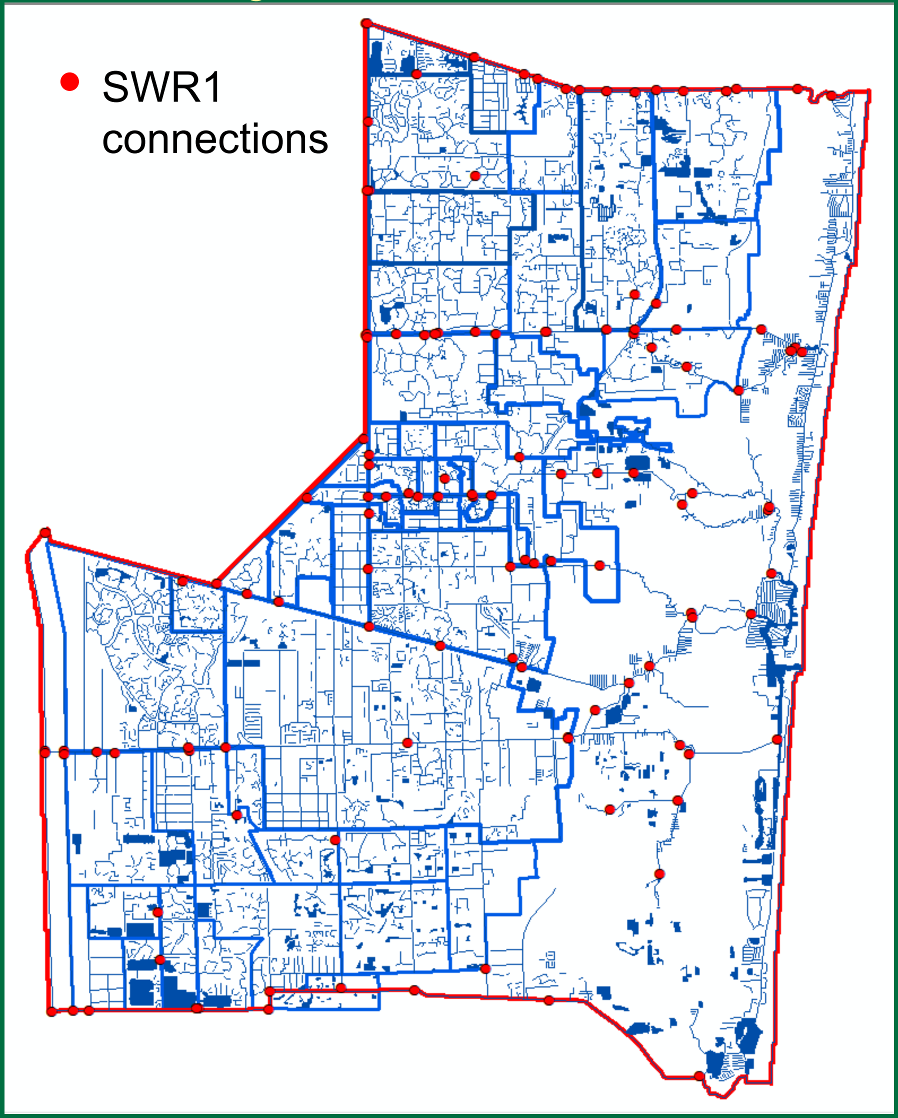
Inundation Model (Phase II)

- Surface-water model construction:
  - Level-pool routing approach
  - 20 primary drainage areas
  - 55 level pool areas within primary drainage areas
  - 13 gates
  - 32 pumps
  - 41 weirs
  - 3 inflows from WCAs (S39, S38, S34)
  - Leakance coefficients estimated using steady-state wet season average conditions simulation
- Historical simulation period (2013-2017), currently running
- Future period (2065-2070 proposed), next steps

Canal/drainage network



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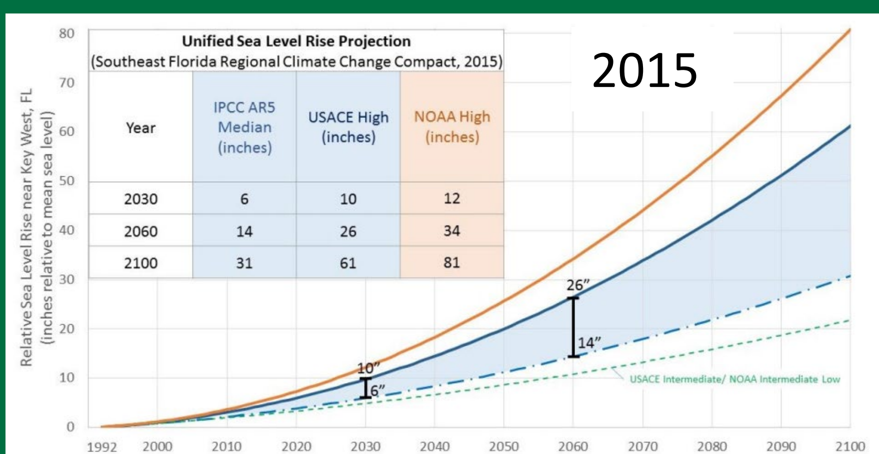
Inundation Model (Phase II)

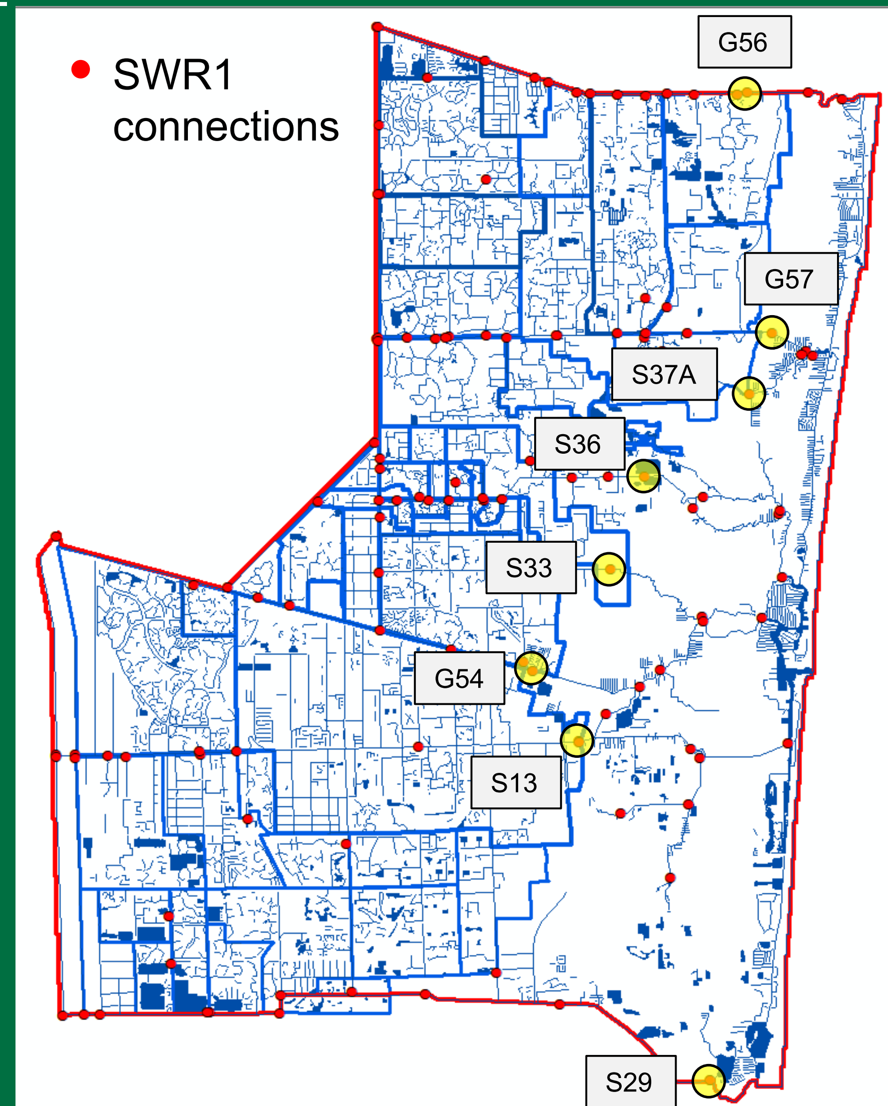
- Coastal structure operations
  - Gates with pumping ability available at S-13 structure

Coastal Structures		
Name	Canal	Control Elevation ft (NAVD)
G56	Hillsborough Canal	5.5 - 6.5
G57	Pompano Canal	3.0
S37A	C-14	2.0
S36	C-13	3.0
S33	C-12	2.0
G54	North New River Canal	2.0 - 3.0
S13	C-11	0.1
S29	C-9	0.5

- New sea-level rise curves adopted in 2015 (increased), then in 2019 (increased)



Canal/drainage network and Coastal Structures



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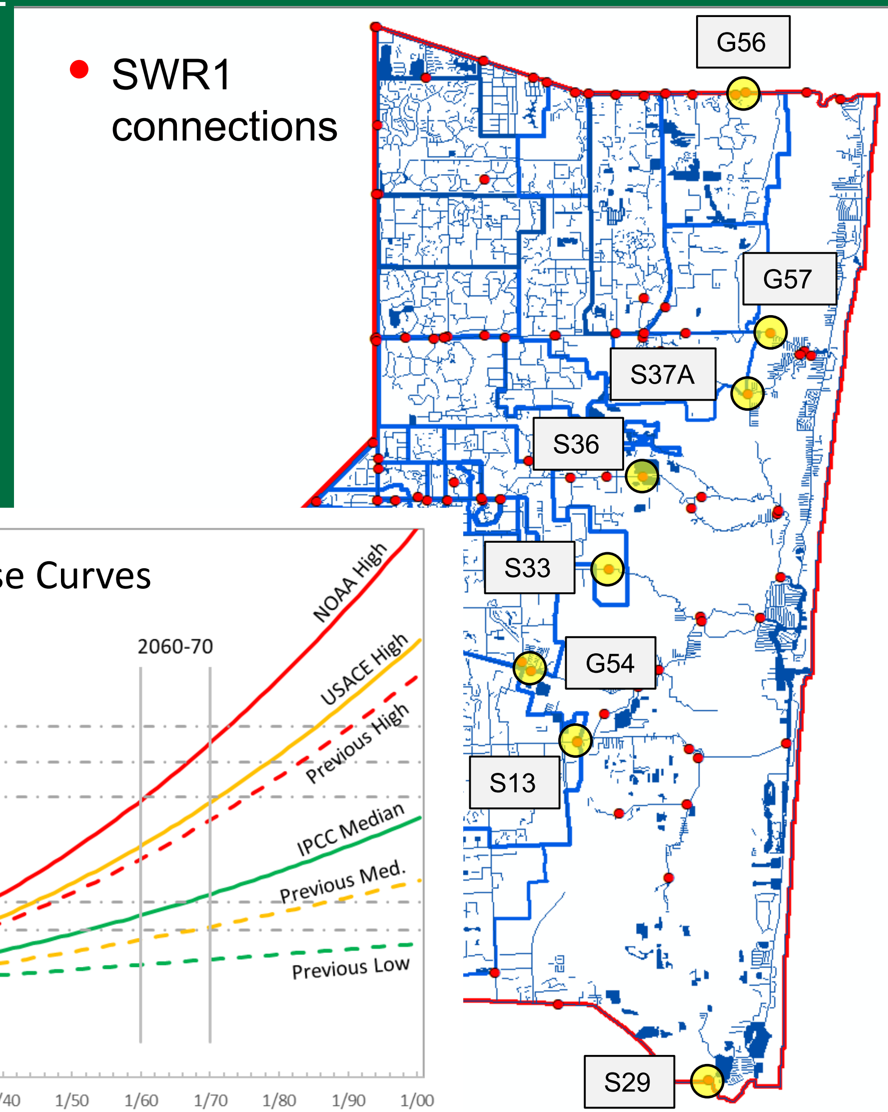

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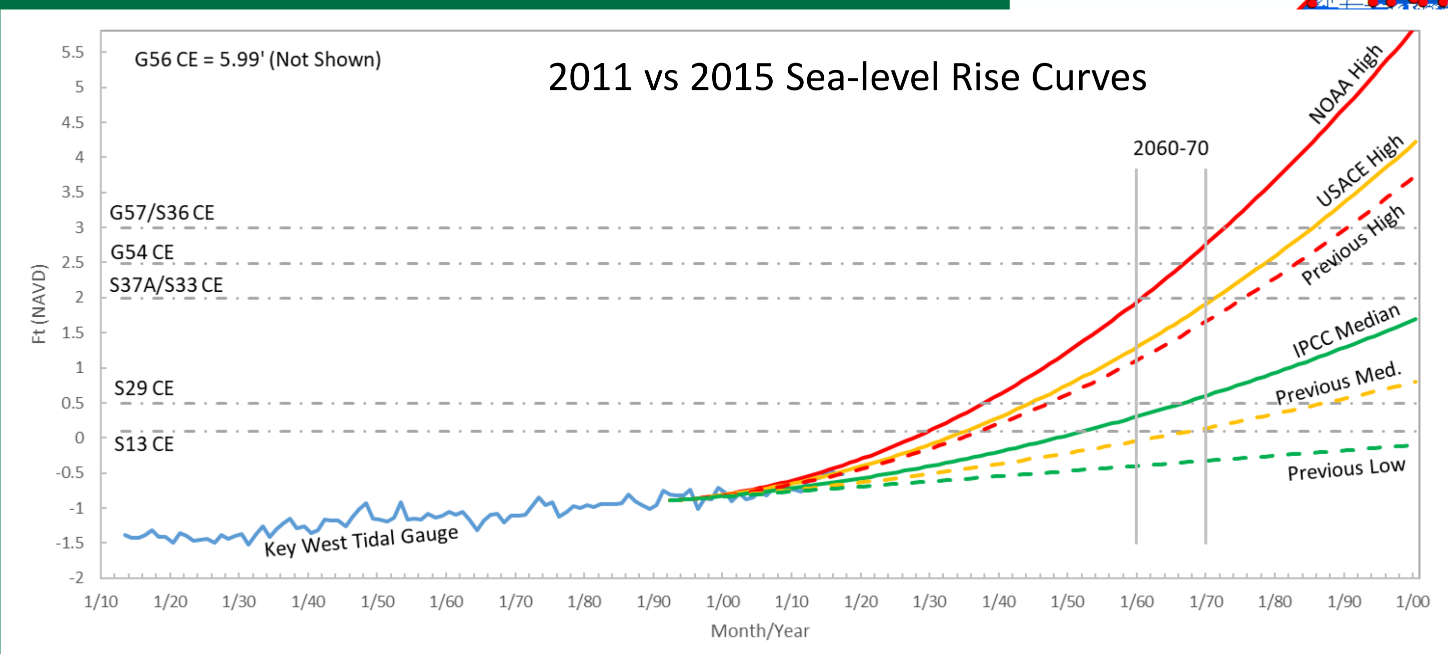

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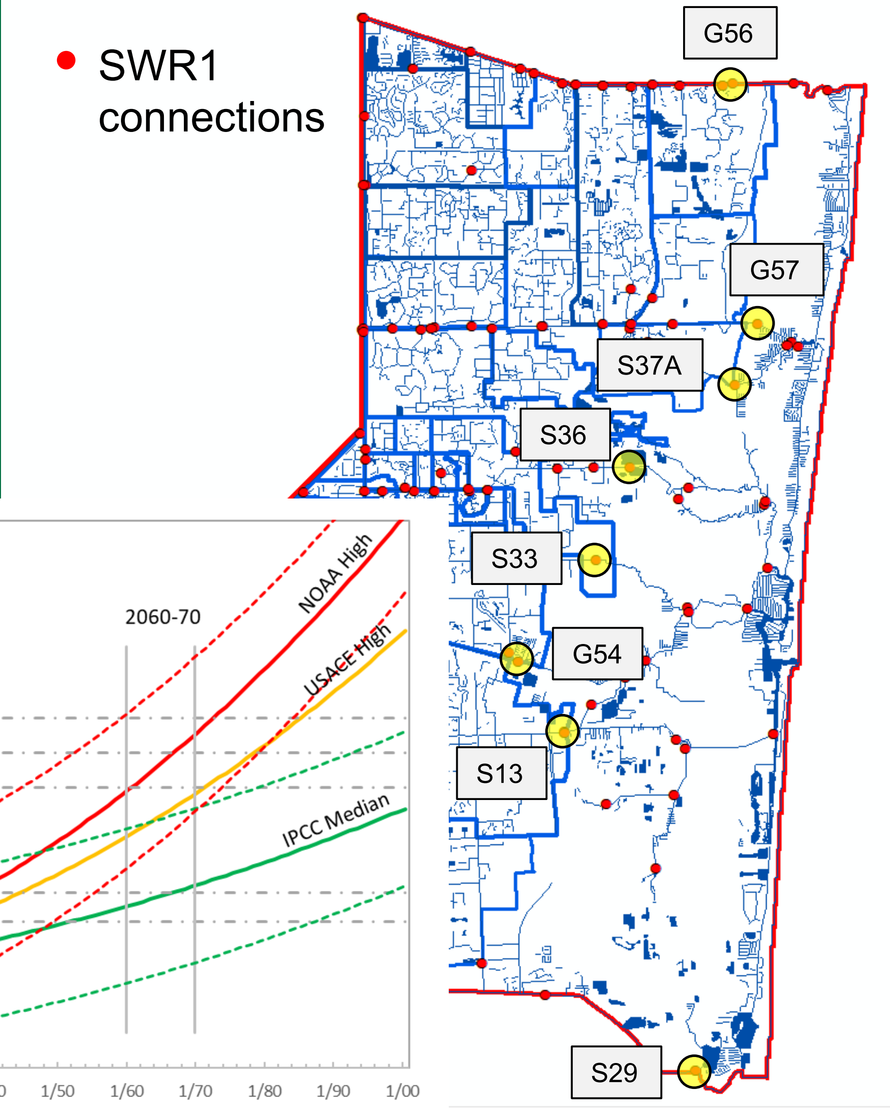

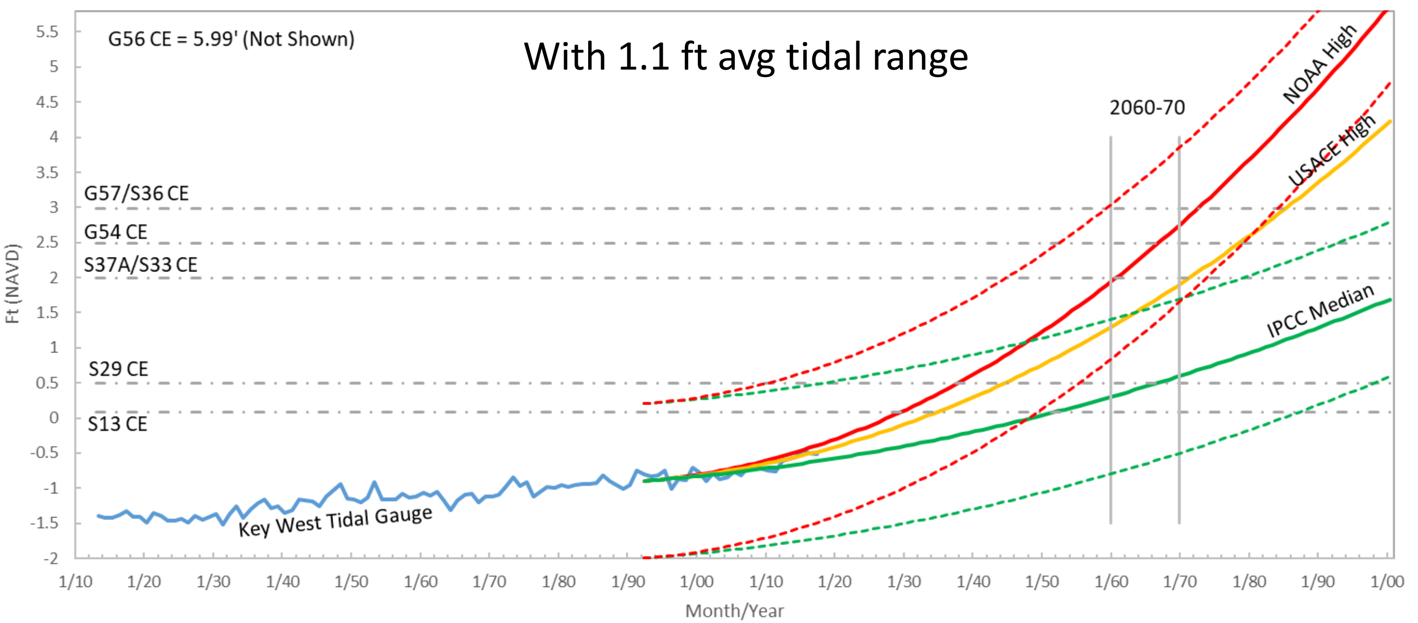

Inundation Model (Phase II)

- Future scenario development includes changes to rainfall and potential evapotranspiration (PET) as well as sea level
  - Phase I study suggested primary driver of increases in the likelihood for inundation was due to increased sea level and can be worsened by rainfall events
- Possible changes in yearly totals, seasonality, and intensity of events
- Previous study used dynamically downscaled regional climate model projections which is highly uncertain
- Other approaches use existing rainfall records and projected changes to synthesize future climate
- Can introduce “design storms” of different return intervals for testing purposes

Example Rainfall Events

One Day Rainfall		Total 72 hr
Return Period	Range	Rainfall
5 Year	5-8 in	9.5
10 Year	6-9 in	10.9
25 Year	8-12 in	12.2