Broward/USGS Modeling Efforts: Climate Change Planning

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Presented to the
Florida Water and Climate Alliance (Florida WCA)
Workshop #10
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Florida Water and Climate Alliance

- Increasing the relevance and usability of climate change and variability data and tools
- Understanding the context/situation
- Assessing tools
- Evaluating practical applicability
- **Using the quantitative climate information for planning and decision making processes**

Presentation Outline

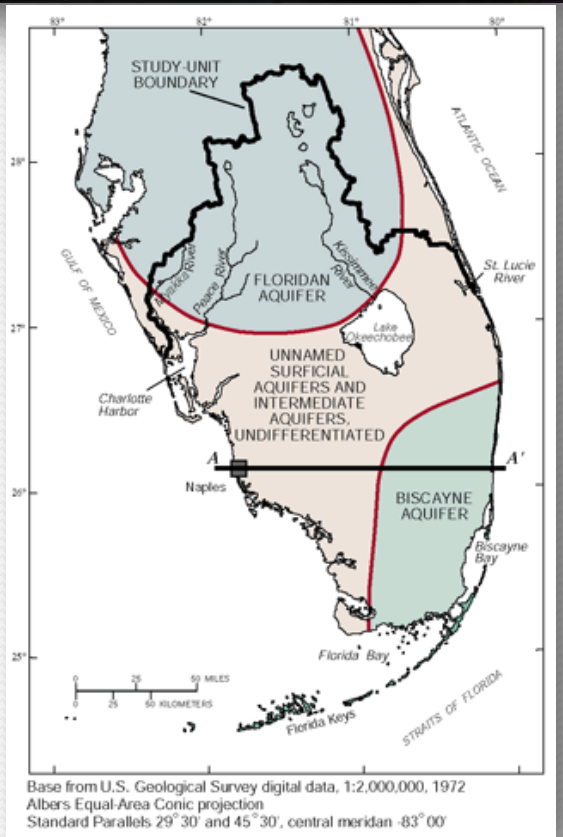
- Broward County Models
  - Saltwater Intrusion
  - Climate/Inundation
- Model Development Update
- Model Applicability & Limitations
- Climate Change Variables
- Focal Area Discussion
  - Areas of Concern
  - Adaptive Strategies

Background

- Coastal Aquifer

- Anthropogenic Stresses:
  - Everglades drainage
  - Well field pumping
  - Canal water level management
  - Agricultural/Urban development

- Natural Stresses:
  - Sea level rise
  - Rainfall variations



Broward Modeling Development

WHY?

To address saltwater intrusion, climate variability and Sea Level Rise—needed integration of density-dependent model components.

Collaboration with USGS/Local Gov't developed fully-integrated surface-water and groundwater model using MODFLOW based tools combined with:

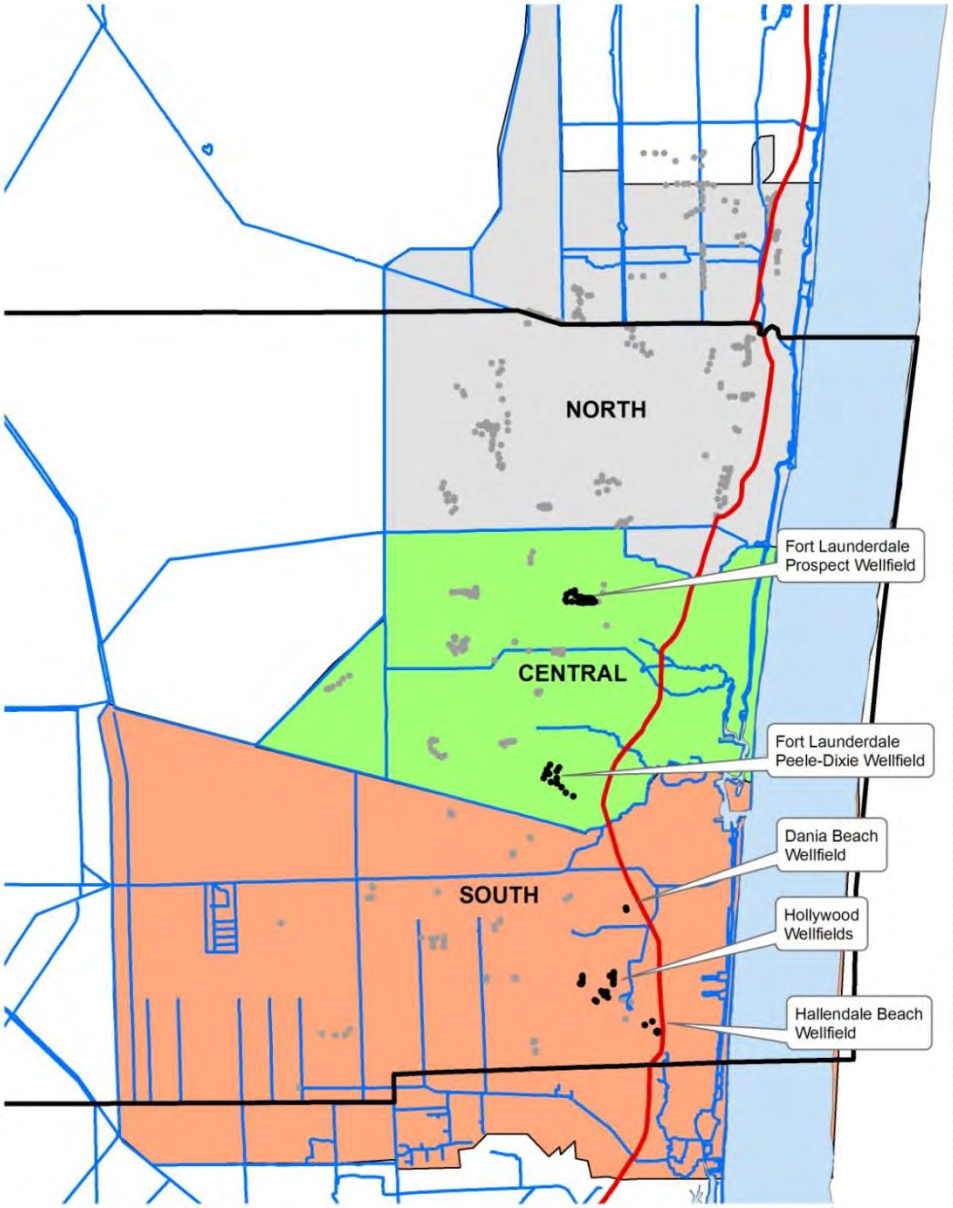
- Unique surface-water process
- Density dependent flow

- Outputs include the impacts of SLR on GW elevations, flood management operations and water quality in support of water supply operations

Variable Density Model

- Use the **historical data record to calibrate aquifer flow and transport parameters**
- **Conduct a sensitivity analysis** to determine
  - Data most useful for calibrating
  - **Model parameters of most influence**
- Quantify the relative importance of various hydrologic mechanisms
- **Perform predictive scenarios**

Model Extents



Variable Density Models-STATUS

Completed

- Hydrostratigraphic Framework
- Data collection (Water level & Chloride)

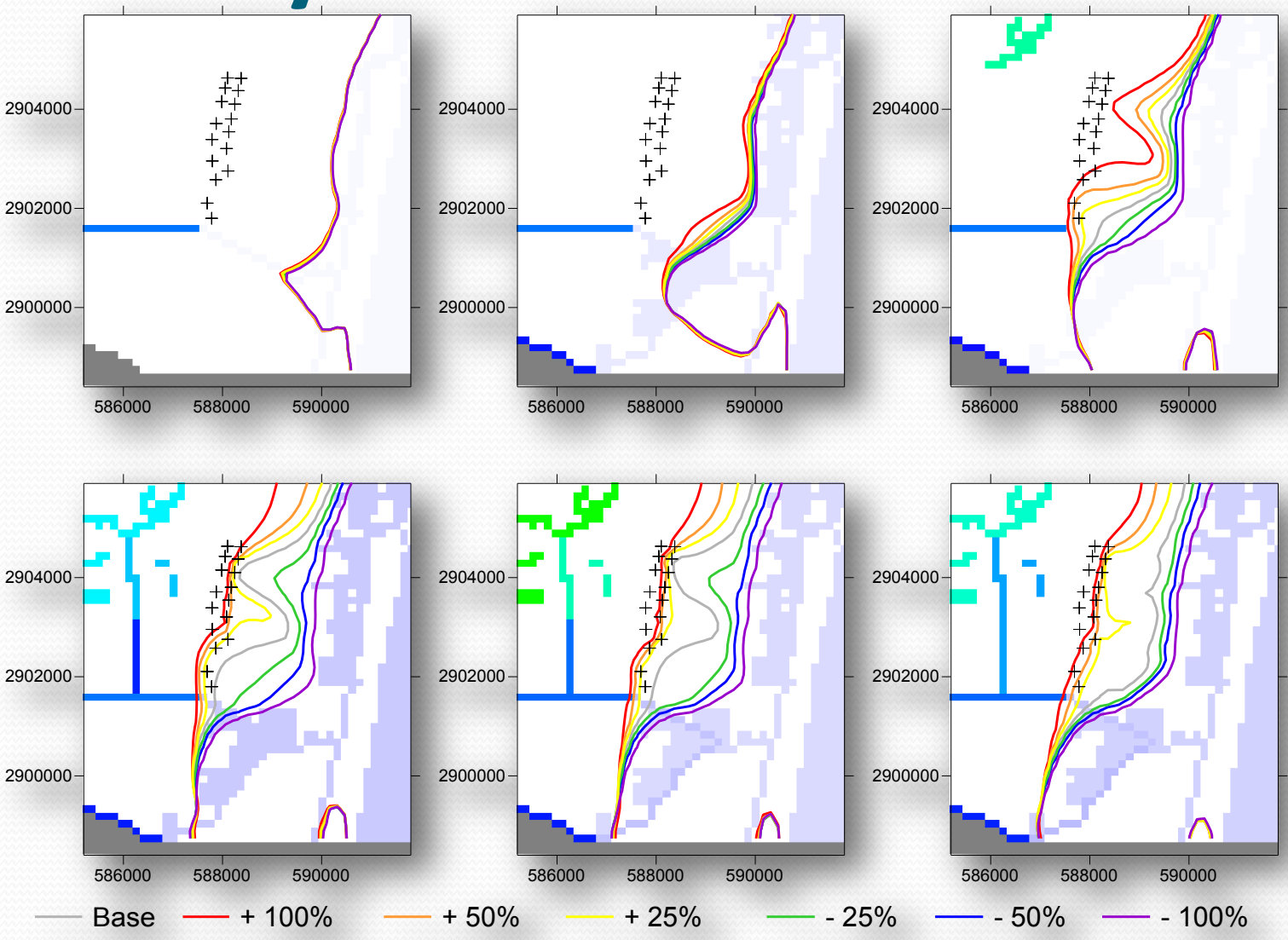
In Progress

- Establishing historical land use from aerial photos
- Filling in data gaps
- Thiessen polygons for rain data
- Canal system with structural operations

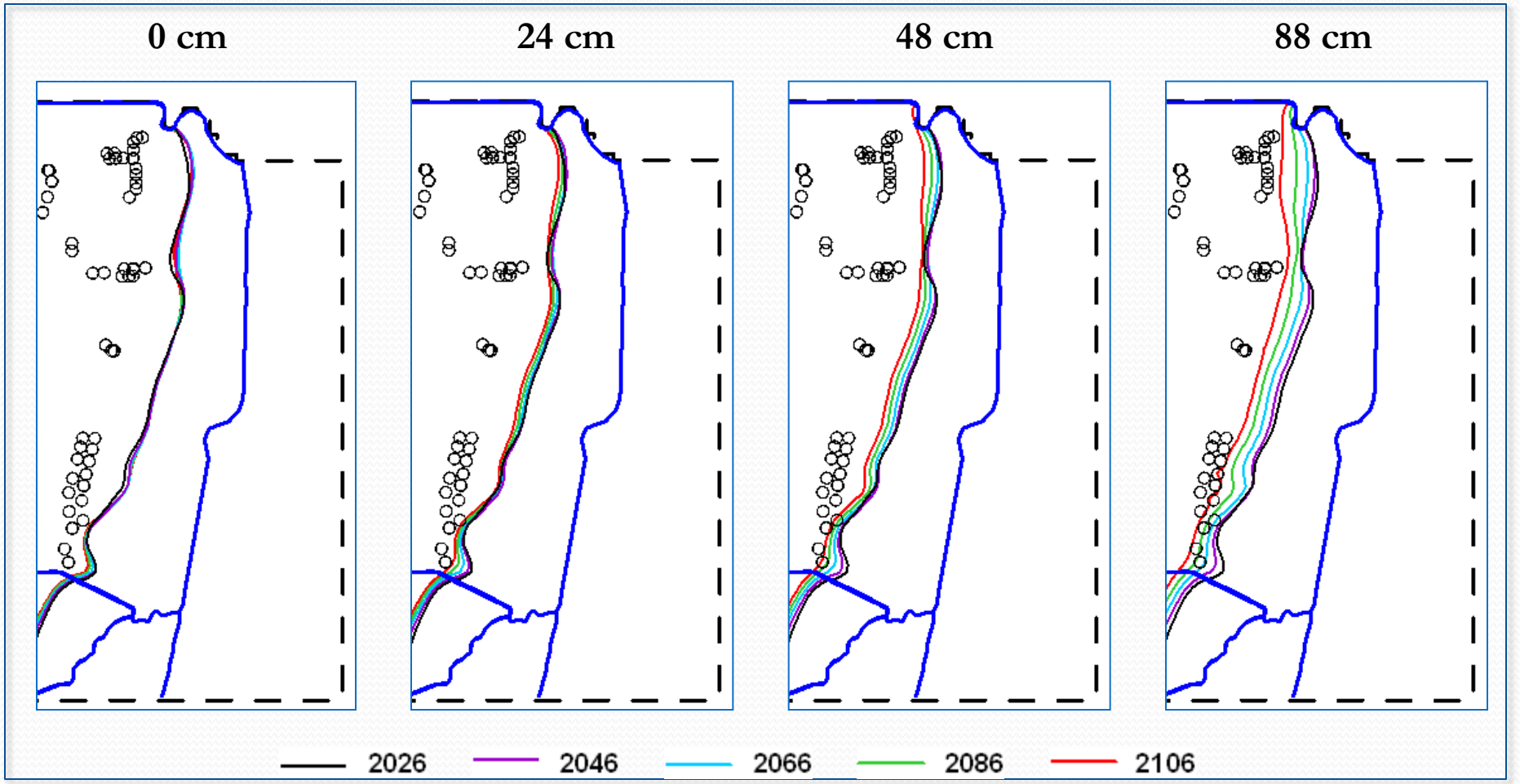
Future Tasks

- Calibration and sensitivity analysis
- Quantification of hydrologic mechanisms
- Predictive scenario testing

Sensitivity- Well Field Withdrawals



Movement of 250 mg/L Salt Front with Varying Sea Level Rise Estimates



Climate/Inundation Model

- 3 year project that implements recommendations of Broward County CCTF
- Use of numerical models to assess the potential effects of climate and sea-level change on current surface water management and drainage systems
- Development of integrated surface water/groundwater flow and transport models of 2 representative areas of Broward County
- Provide for better understanding of how climate change and sea level rise:
  - May affect current surface water management practices
  - how adverse effects can be mitigated

Tidal Flooding 9/18/09 – Las Olas

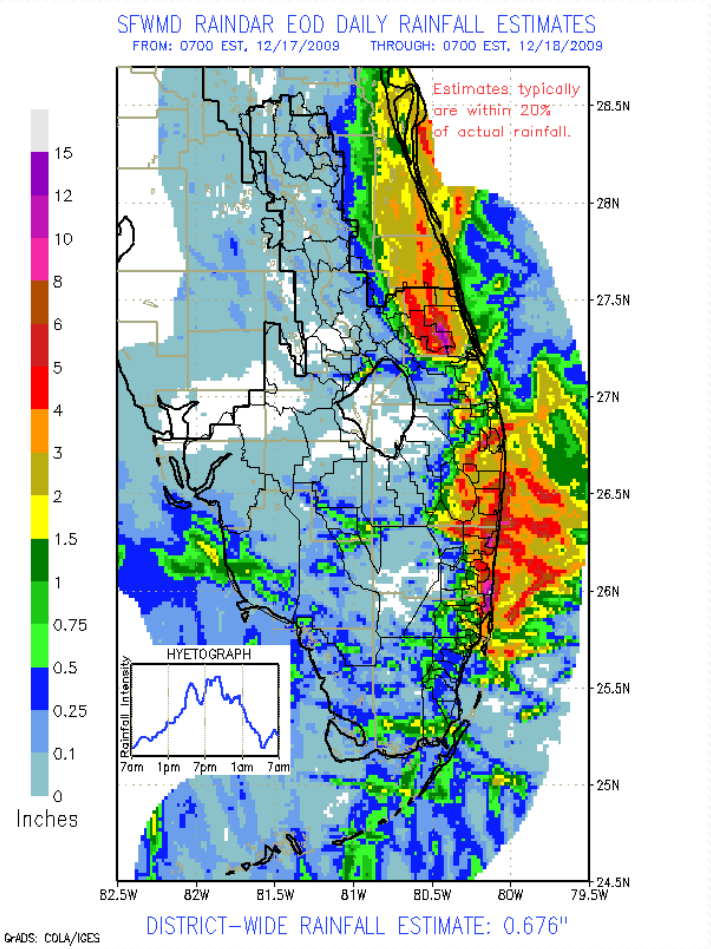
•Isle of Capri Drive

(8 inches above average high tide)

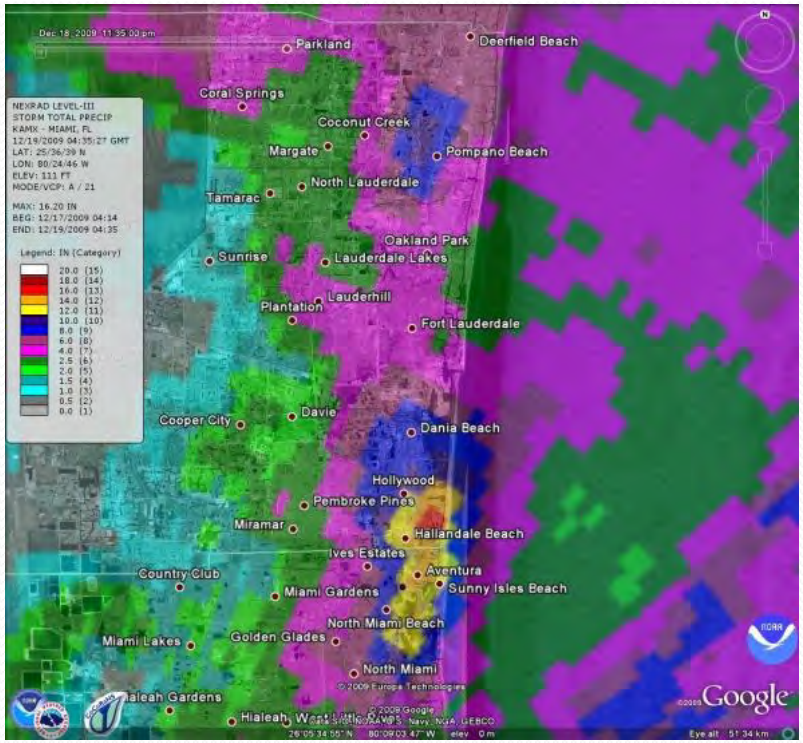
•Las Olas Isles

•Riverwalk

Storm Events



9.5" in Northern Broward County

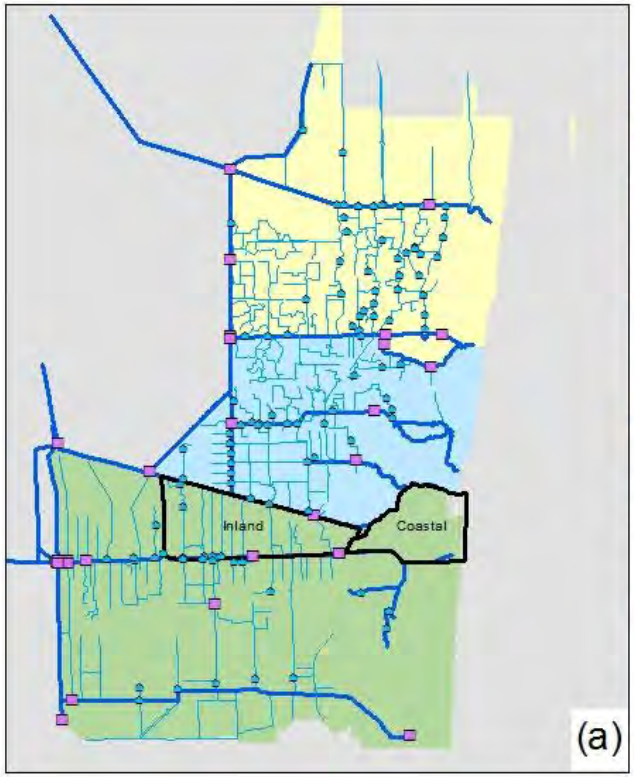


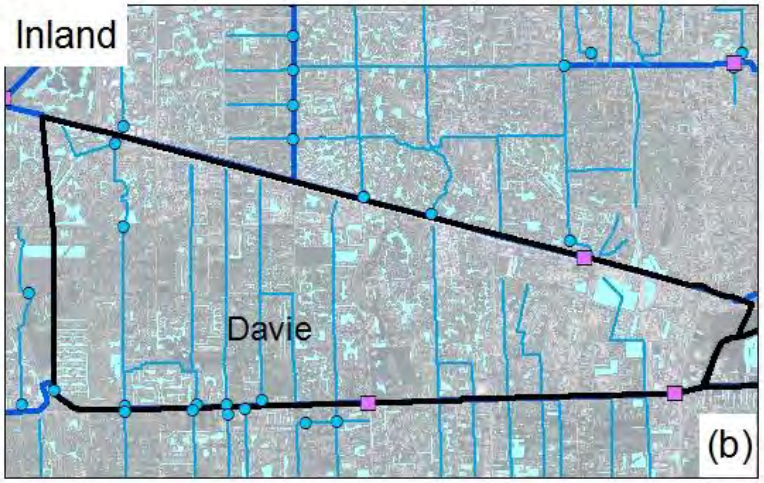
16.2" in Southern Broward County

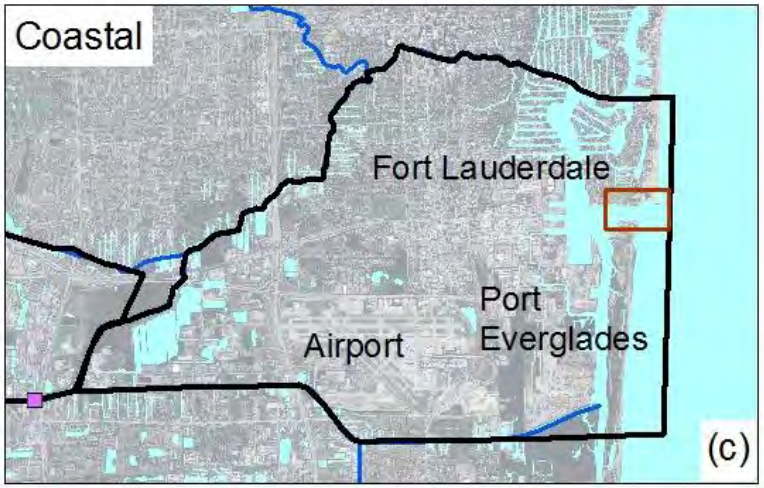
Storm Events

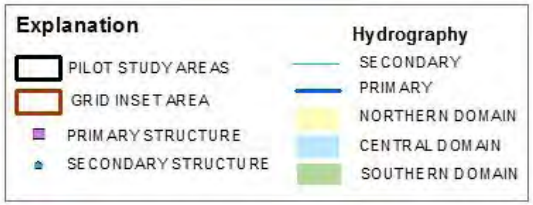
Development Updates

Domains & Structures

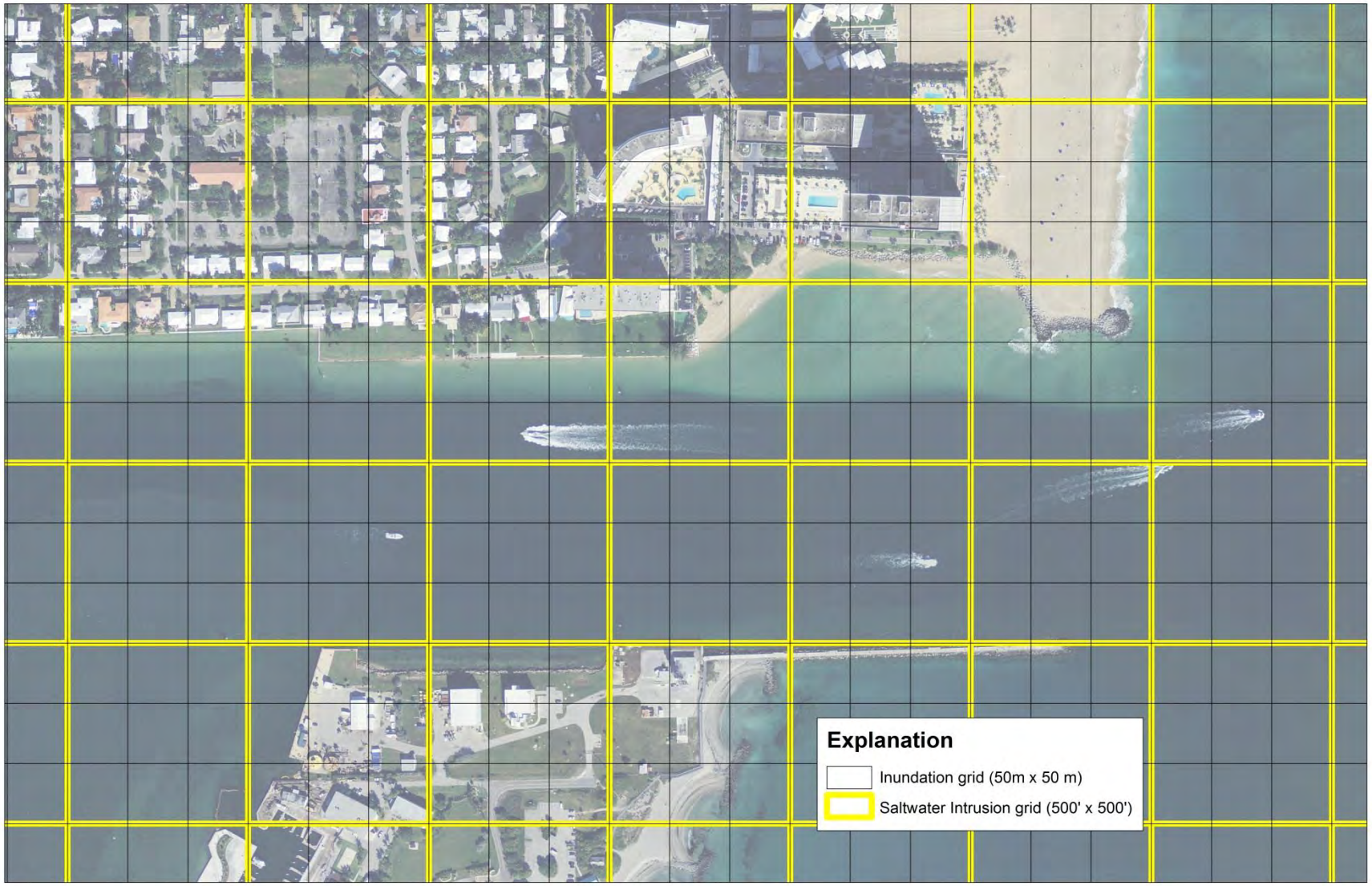






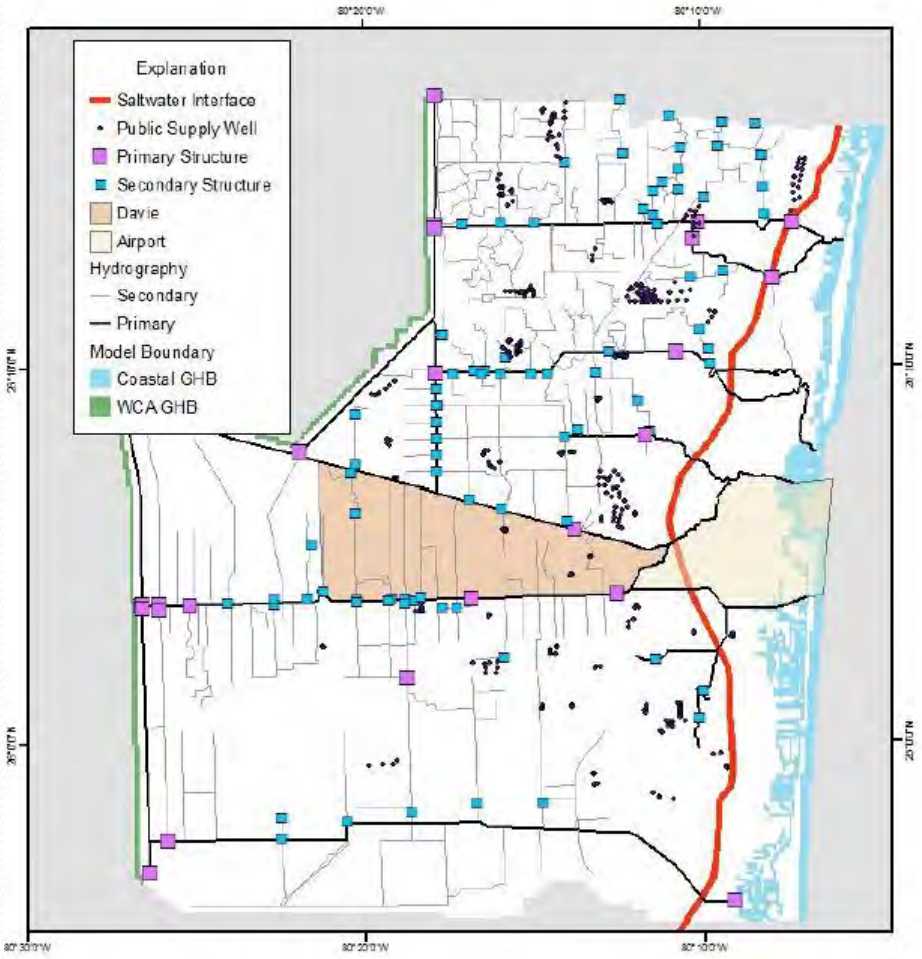


Grids


Explanation
Inundation grid (50m x 50 m)
Saltwater Intrusion grid (500' x 500')

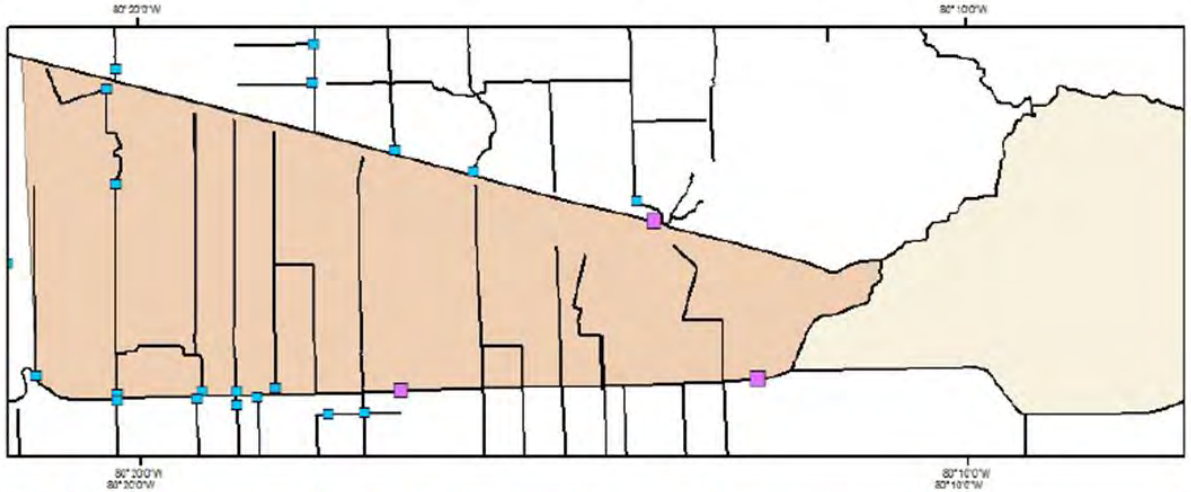
Additional Inundation Detail

- More robust representation of structures



Additional Inundation Detail

- More hydrology

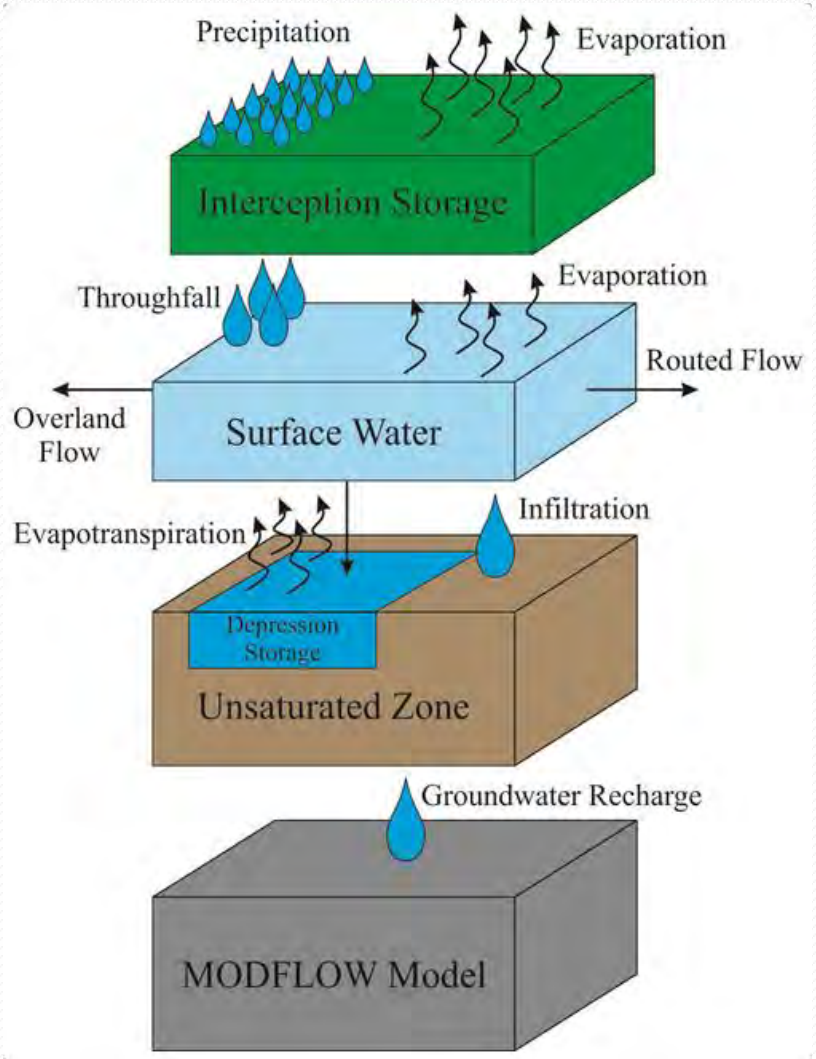


Primary & Secondary Canals In Saltwater Intrusion Models

Tertiary Canals That May Be Added for Inundation Models

Additional Inundation Detail

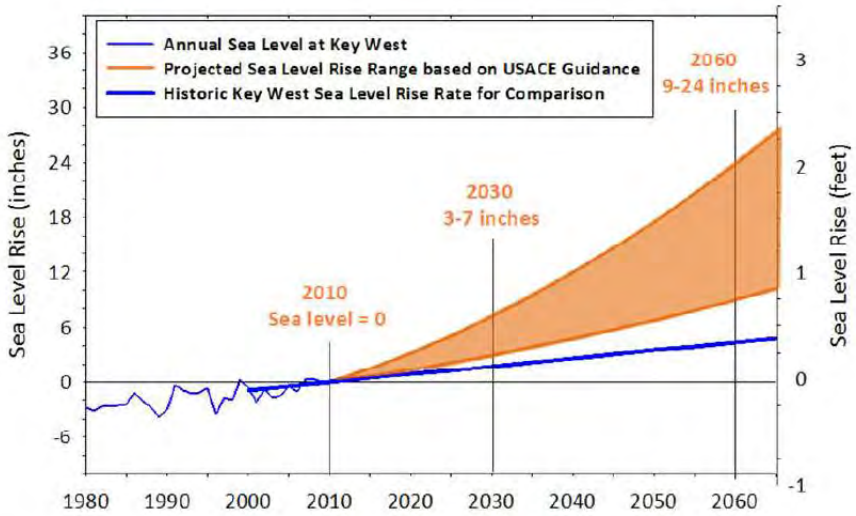
- More hydrologic processes
  - Urban Runoff (URO) Processes

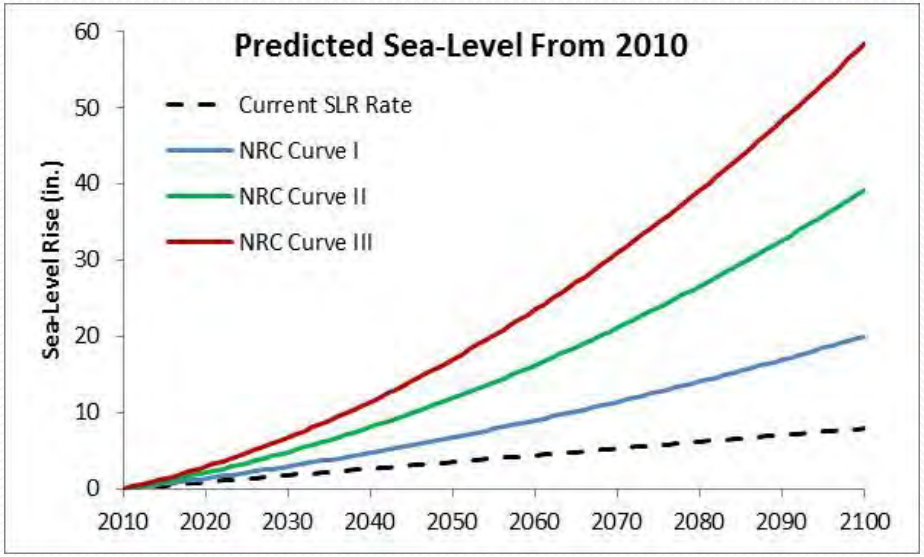


Climate Change Variables

Sea Level Rise

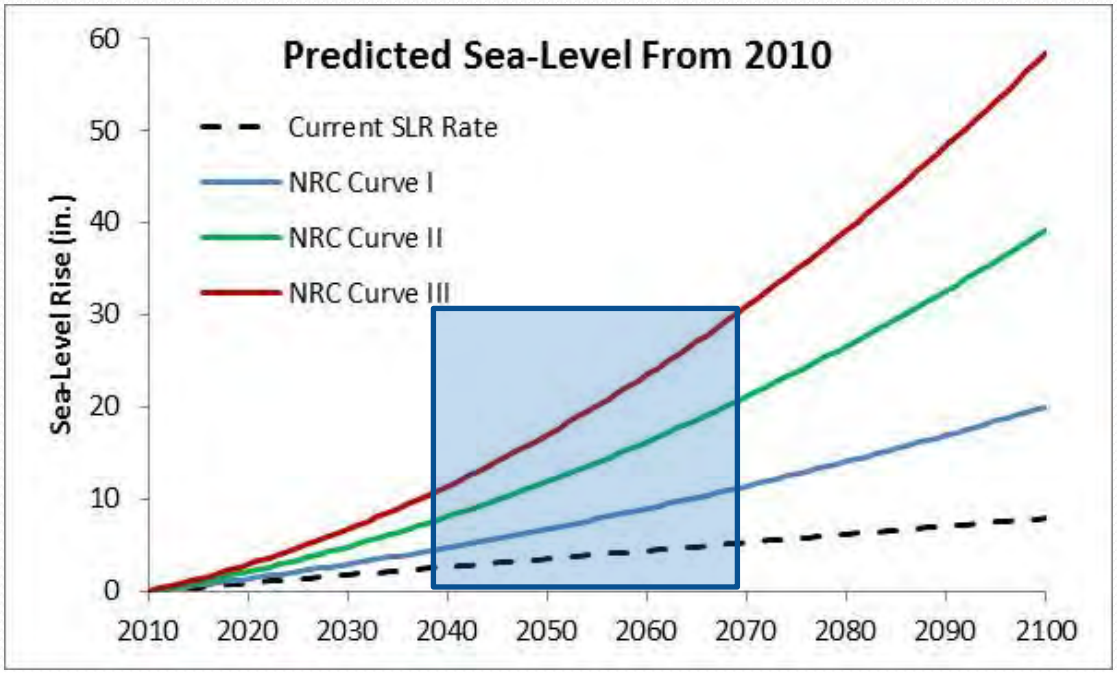
- Future scenarios will also incorporate various predictions of sea level rise (SLR)
- Predicted SLR in 2100 ranges from 8 to 60 inches
- SLR can lead to reduced capacity of coastal structures and ability to drain water to the coast
- Additional complications from SLR arise from storm events and high-high tide events
- SLR estimates produced using U.S. Army Corps of Engineers guidelines as used in Climate Change Compact documentation.





From "A Unified Sea Level Rise Projection for Southeast Florida" by Southeast Florida Regional Climate Change Compact Counties

Sea Level Rise

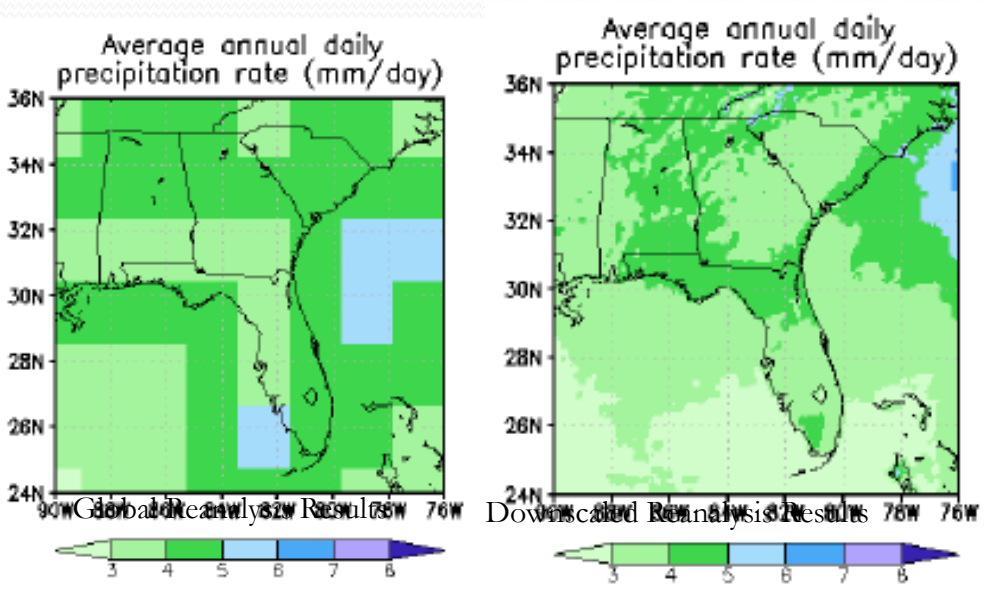


Sea-Level Rise Prediction (USACE method)

Year	Current Rate	NRC Curve 1	NRC Curve 2	NRC Curve 3
2010	0.000	0.000	0.000	0.000
2020	0.882	1.373	2.150	2.928
2030	1.764	2.959	4.850	6.746
2040	2.646	4.758	8.102	11.454
2050	3.528	6.771	11.906	17.052
2060	4.409	8.997	16.260	23.539
2070	5.291	11.437	21.165	30.917
2080	6.173	14.090	26.622	39.183
2090	7.055	16.956	32.630	48.340
2100	7.937	20.036	39.189	58.387

Downscaled GCM Results

- Global Climate Model (GCM) Results
- Large spatial discretization
- Many have poor representation of FL, mixed land and water cells
- Significant errors at finer temporal and spatial resolutions



Global Reanalysis Results

Downscaled Reanalysis Results

Source: Stefanova et al., 2011

- Dynamically Downscaled GCM Results
- Center for Ocean-Atmospheric Studies (COAPS)
- Regional Climate Model (RCM) coupled to GCM
- 10 km grid resolution
- Uses FSU-FCI Regional Spectral Model
- Output has be utilized as hydrologic model inputs in other USGS studies
- May not fully represent localized climate accurately even at 10 km scale

Development of Future Scenarios

Proposed Base & Future Scenarios for Inundation Project

A. Community Climate Systems Model (CCSM)

- Baseline - 20th Century CCSM Precipitation, No SLR
- Low SLR Prediction – 21st Century CCSM Precipitation, Low SLR Estimate
- High SLR Prediction - 21st Century CCSM Precipitation, High SLR Estimate

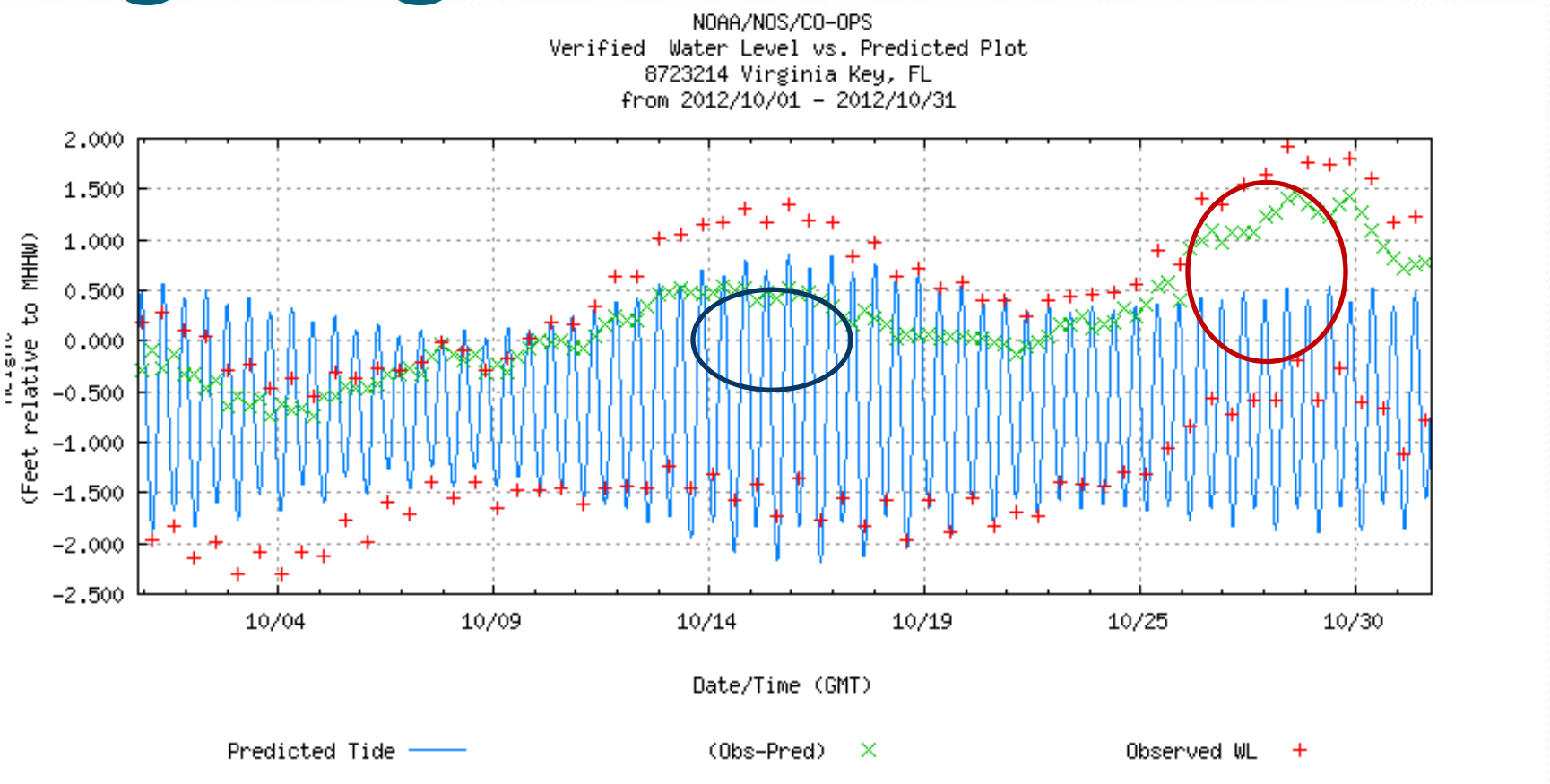
B. Hadley Centre Coupled Model v3 (HadCM3)

- Baseline – 20th Century HadCM3 Precipitation, No SLR
- Low SLR Prediction – 21st Century HadCM3 Precipitation, Low SLR Estimate
- High SLR Prediction – 21st Century HadCM3 Precipitation, High SLR Estimate

C. Geophysical Fluid Dynamics Laboratory (GFDL)

- Baseline – 20th Century GFDL Precipitation, No SLR
- Low SLR Prediction – 21st Century GFDL Precipitation, Low SLR Estimate
- High SLR Prediction – 21st Century GFDL Precipitation, High SLR Estimate

High High Tide Events



Average of lunar high tide events over high tides for 2011 = 8-10 inches

Storms & weather patterns may push high tides > 24 inches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Design Storms

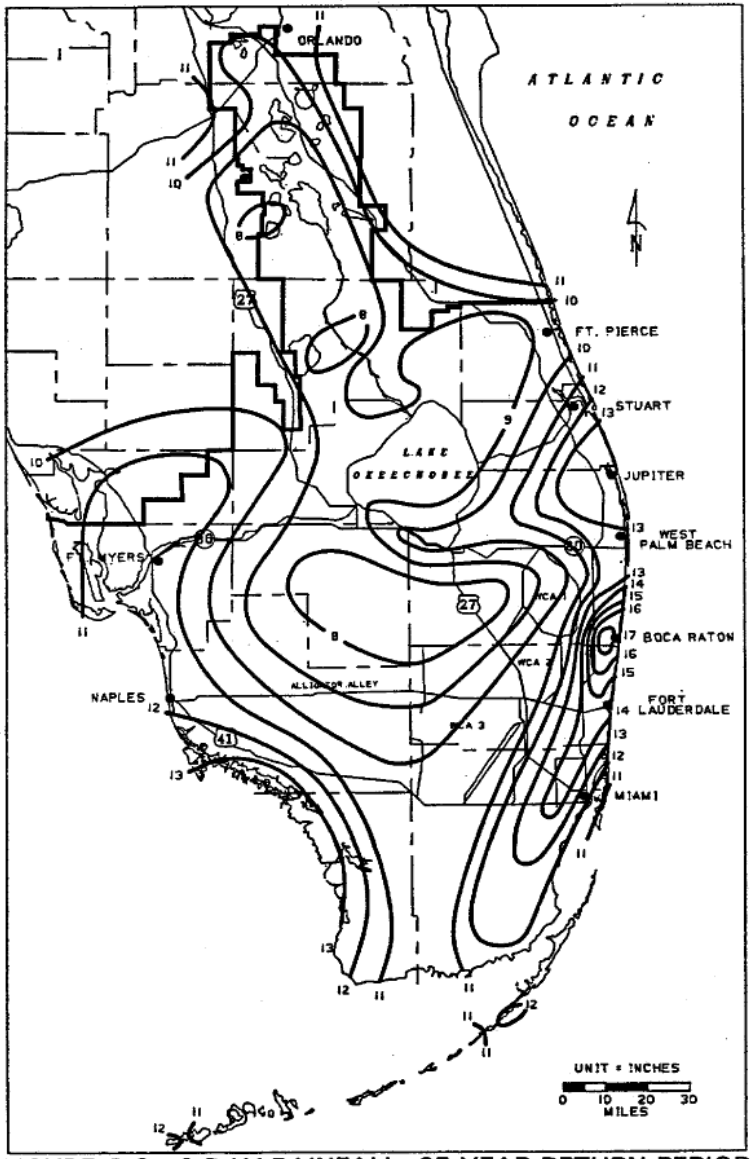
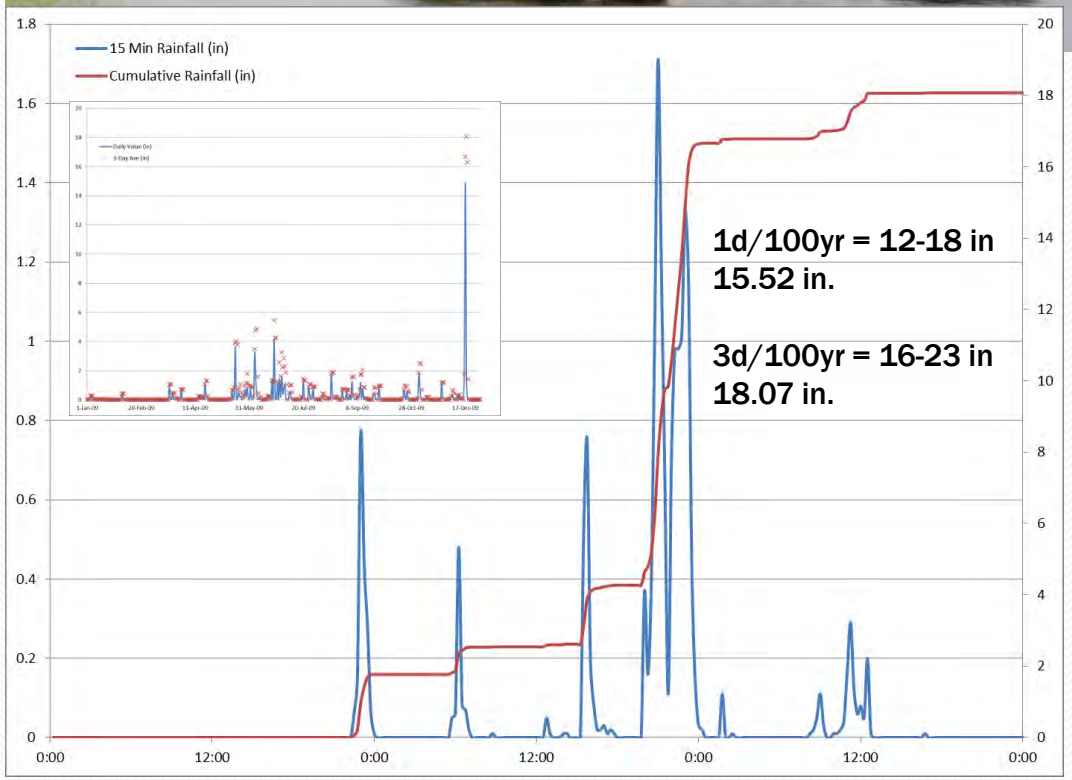
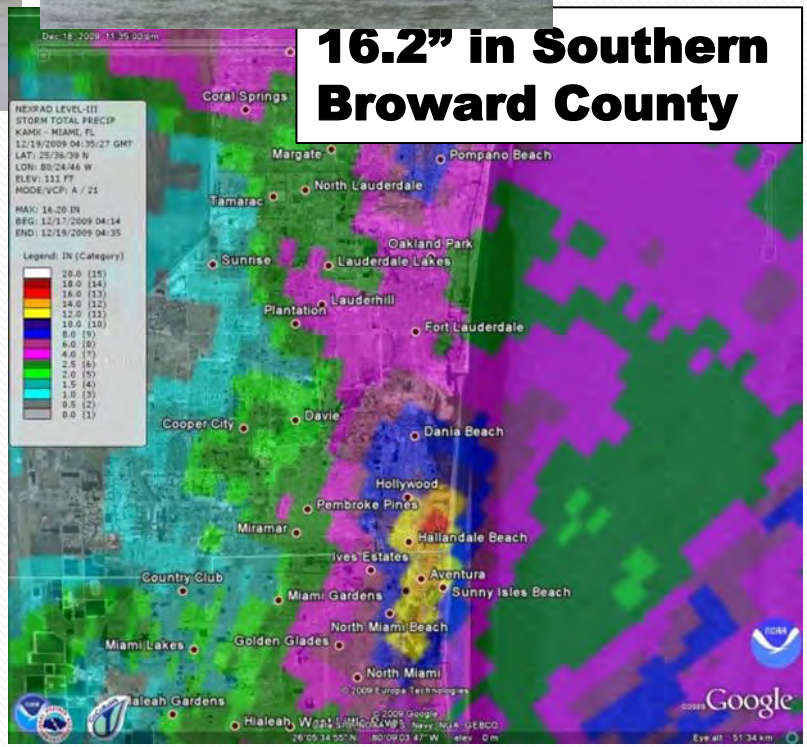


FIGURE C-8. 3-DAY RAINFALL: 25-YEAR RETURN PERIOD

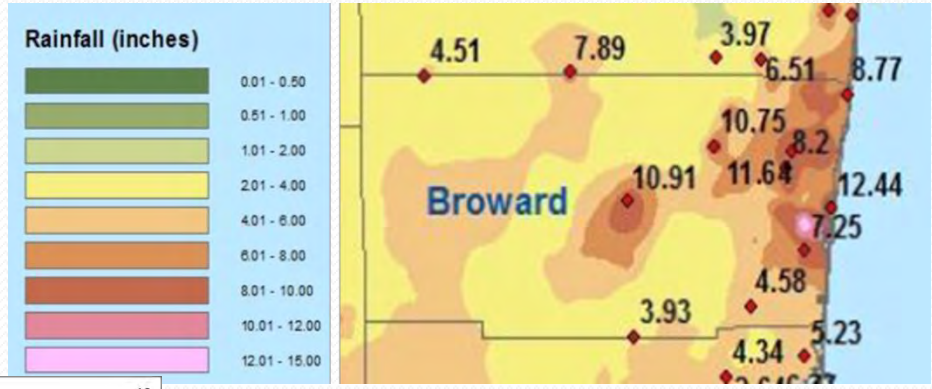
Duration	Return Period (yr)	Broward Rainfall (in)
1 hr	5	3.2
1 day	3	6-6.5
1 day	5	6-8
1 day	10	7-11
1 day	25	9-13
1 day	100	12-18
3 day	10	10-14
3 day	25	12-17
3 day	100	16-23

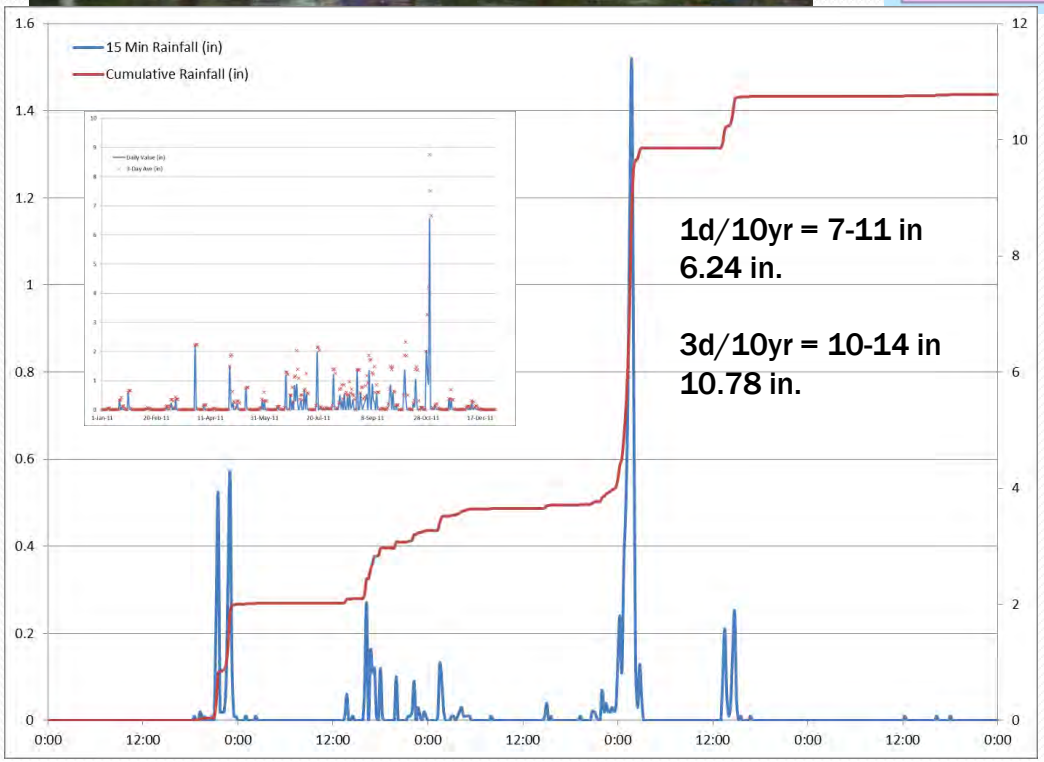
100 Year Storm- December 17-19, 2009





10 Year Storm- October 29-31, 2011



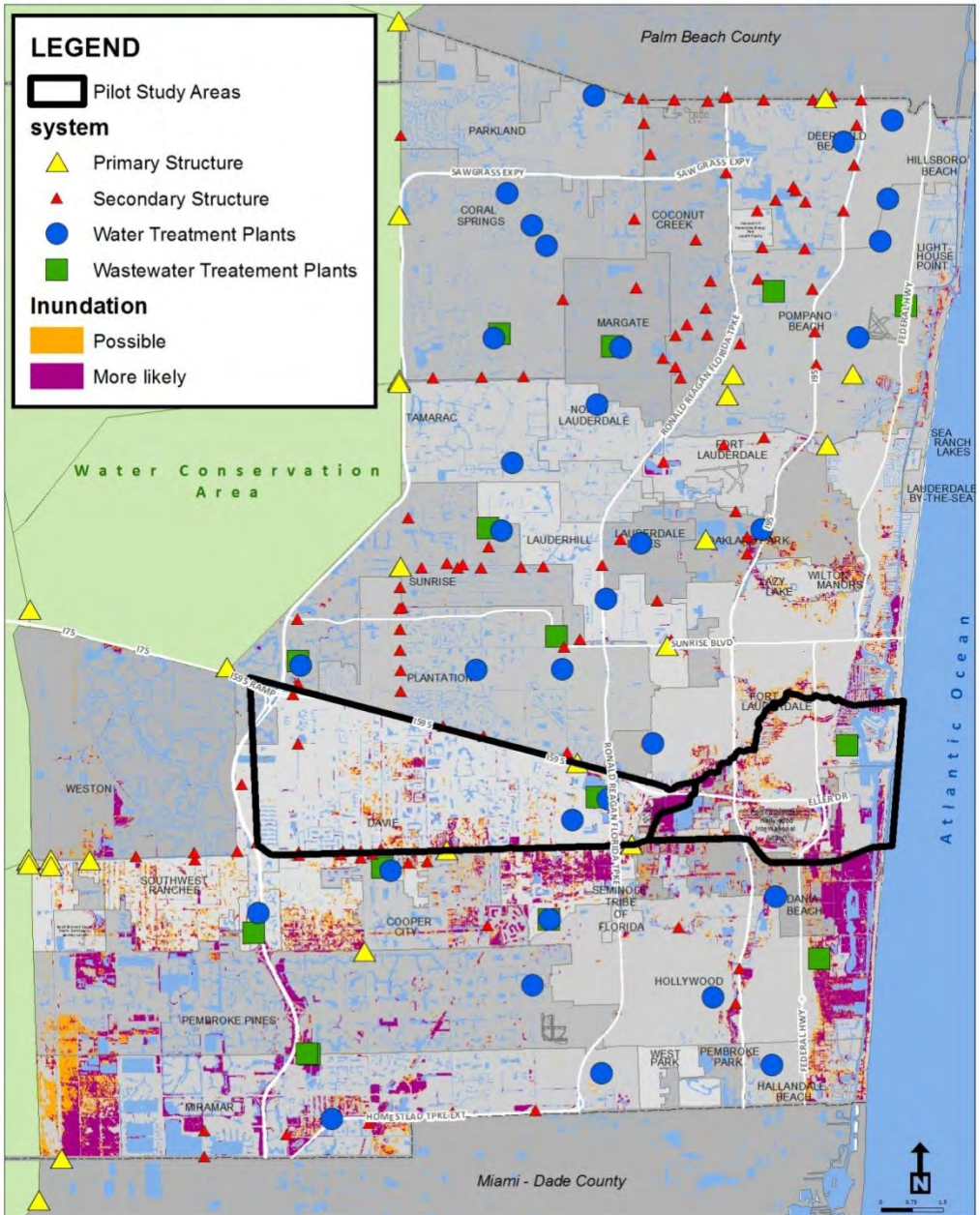


Outputs

- Hydrographs
- Chlorides
- Maps of flooding extents:
  - Depth -> 6 inches
  - Duration -> 72 hours

Focal Area Discussion

BROWARD COUNTY SEA LEVEL RISE MAPPING: THREE-FOOT



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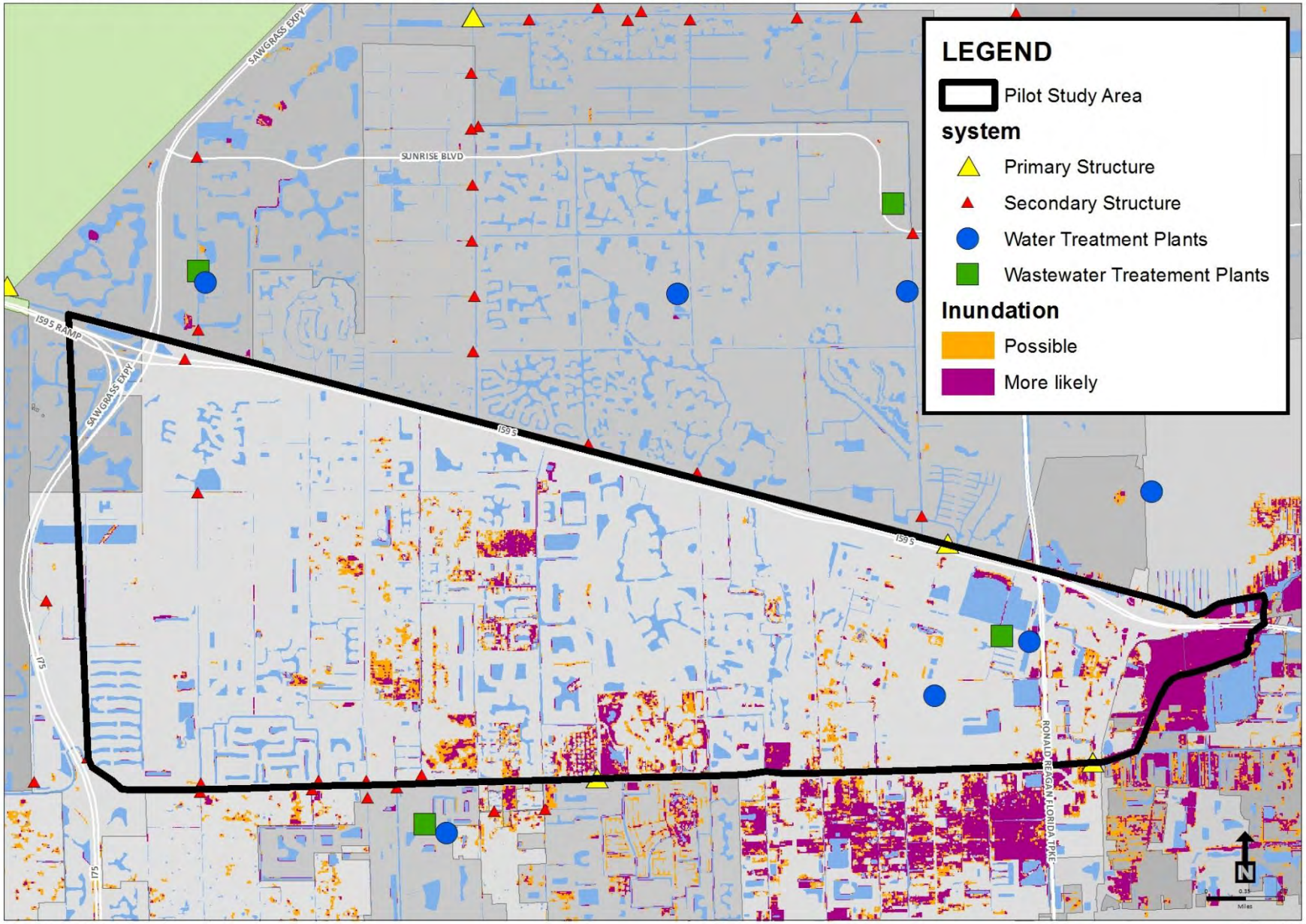

BROWARD COUNTY FLORIDA

emusgrave/vmorrow #12104

Prepared By:
Broward County GIS
Planning and Redevelopment Division
Environmental Protection and Growth Management Dept

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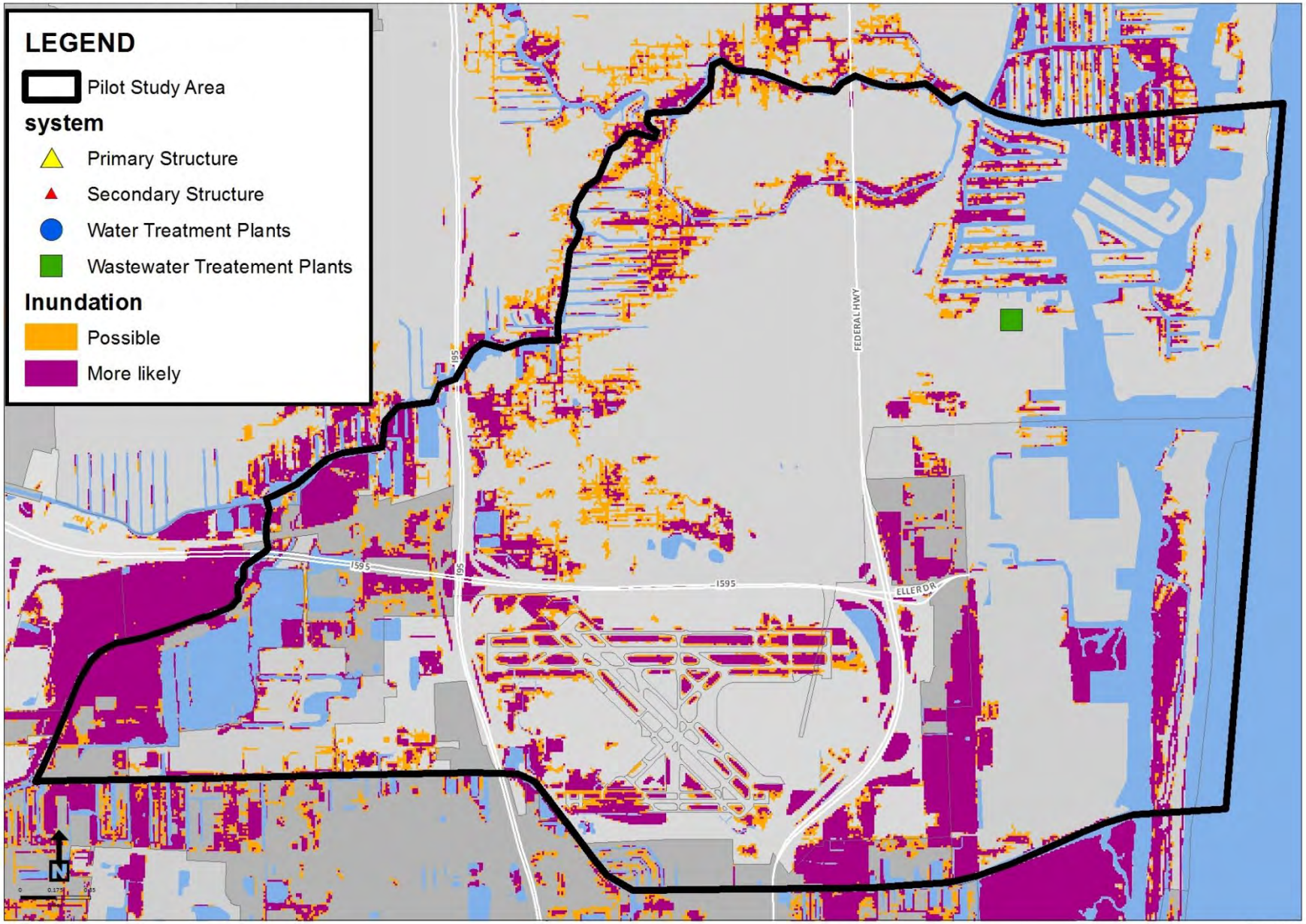

BROWARD COUNTY FLORIDA

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Scenario Development- Saltwater Intrusion

General Assessments

- Sea level rise scenarios with seasonal changes in precipitation
- Impacts on wet season/dry season groundwater levels
- Changes in groundwater chlorides
- Develop and test adaptive scenarios

Potential Adaptive Scenarios

- Using current pumping rates with projected sea level rise to determine future viability of coastal well fields
- Drainage Wells for mitigating/managing coastal saltwater intrusion interface
- Movement of G-54 Structure eastward
- Deepening or construction of new canals west of wellfields to increase recharge
- Exploring relationship of rainfall and saltwater front movement
- Data worth analysis for optimizing saltwater monitoring network

Scenario Development- Climate/Inundation

General Assessments

- Degree of inundation in response to various SLR rates
- Design Storm Events
- High Tide Events
- Combinations of SLR, storms events, and high tide
- Assess impacts on inland and coastal groundwater and surface water levels
- Develop and test adaptation strategies

Potential Adaptive Scenarios

- Replacement of gravity drainage infrastructure with pumps
- Movement of control structures
- Retrofitting current control structures (adding or increasing pump capacity)
- Increasing coastal sea wall heights

Summary

- Regional water resource planning needed to coordinate:
  - Future water supply demands
  - Restricted use of Biscayne Aquifer
  - Reuse Requirements
  - Influences of climate change
- Various tools have been developed to help guide management decisions and water management strategies for:
  - Protection of current resources
  - Development of alternative water resources
  - Conservation to reduce demands
- This wide variety of integrated water resources projects will help decide prudent investments and long term sustainability

NEXT STEPS

- Building communication tools to translate complex modeling to decision makers
- Creating visual graphics and animations that capture modeling outputs at the streetview
- Incorporating economic analysis of impacted areas to provide for cost/benefits
- Guide the adaptation stratagies needed for long-term planning and sustainability

Questions

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