

# BROWARD COUNTY FUTURE CONDITIONS MAP SERIES

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ENVIRONMENTAL PLANNING AND COMMUNITY RESILIENCY DIV.

SOUTH FLORIDA HYDROLOGIC SOCIETY AUGUST 22, 2018

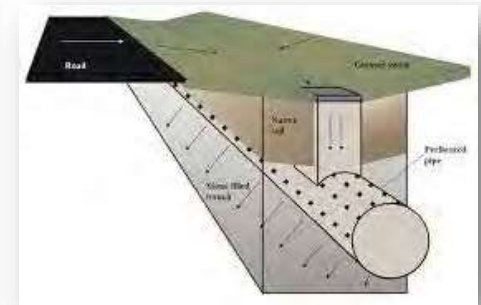
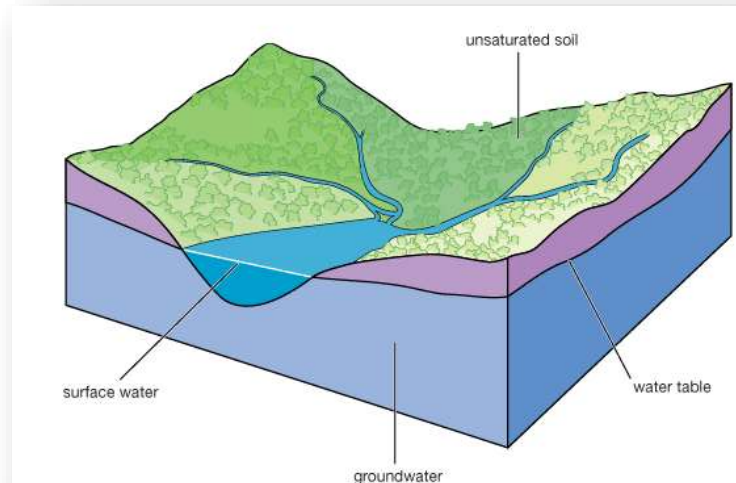
# Future Conditions Map Series

- Previously permitting criteria was based on current or historic conditions
  - Has led to some projects being quickly outdated or undersized
- February 7 2017 Broward County Commission Authorized Future Conditions Map Series
  - “To ensure the resiliency of current and future infrastructure investments, it is necessary to modernize many aspects of regional planning and licensing requirements. With the influence of climate change, and the impacts of sea level rise in particular, no longer is it prudent to rely solely upon historic and current environmental conditions as the basis for infrastructure planning, design and permitting.”
- First planned maps:
  - Future Conditions GW Elevations
  - Future Conditions 100-yr Flood



# Application

- Provides for proper design of stormwater management systems during permitting process.
- Impacts the need for correctly identifying wet or dry retention areas for proper functioning of system for on-site storage



# Current Maps

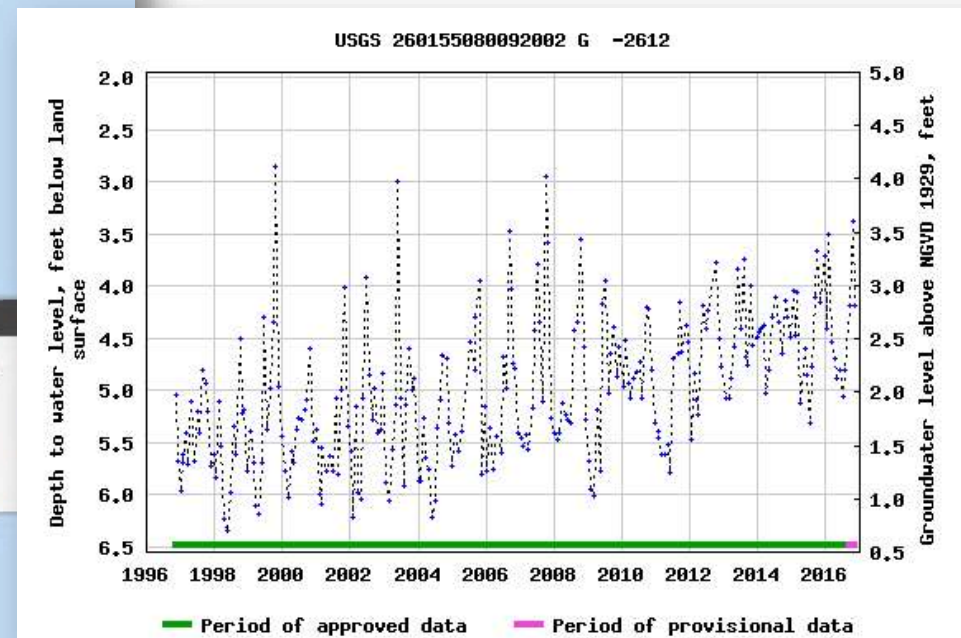
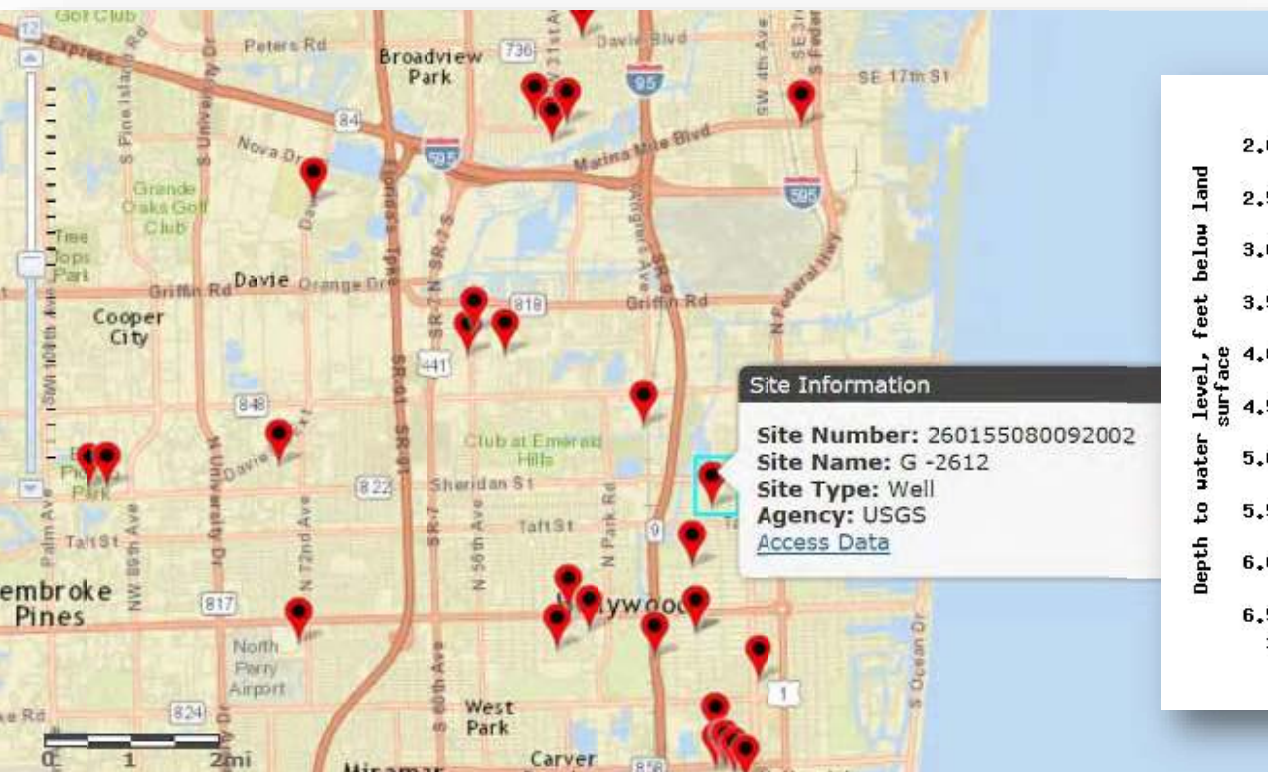
- Adopted in 2000
- Based on groundwater & surface water measurements
- Limited data (e.g., along coast line) requires use of site-specific measurements of GW
- Changes in hydrology have occurred, necessitating update

**Explanation**

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# Rising Historic Groundwater Levels

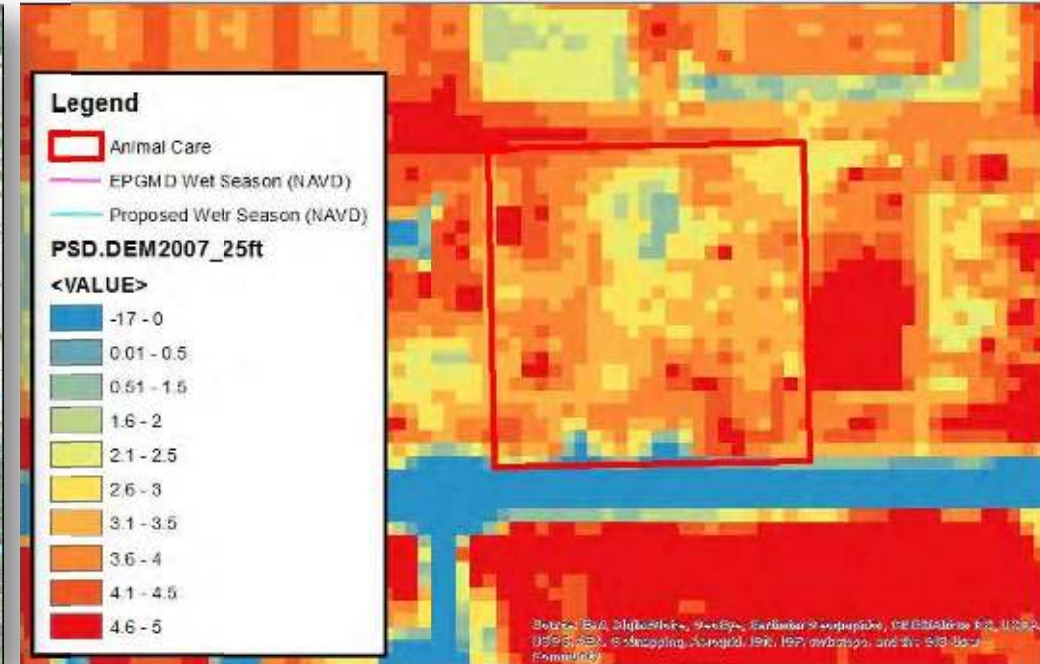
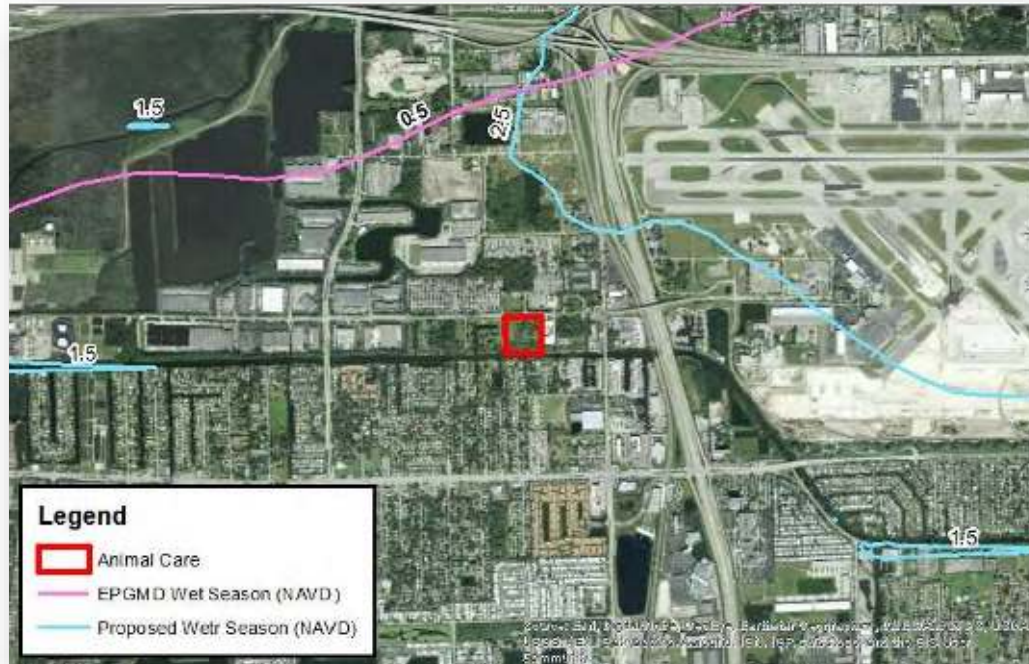


# Example- New Broward County Animal Care Facility



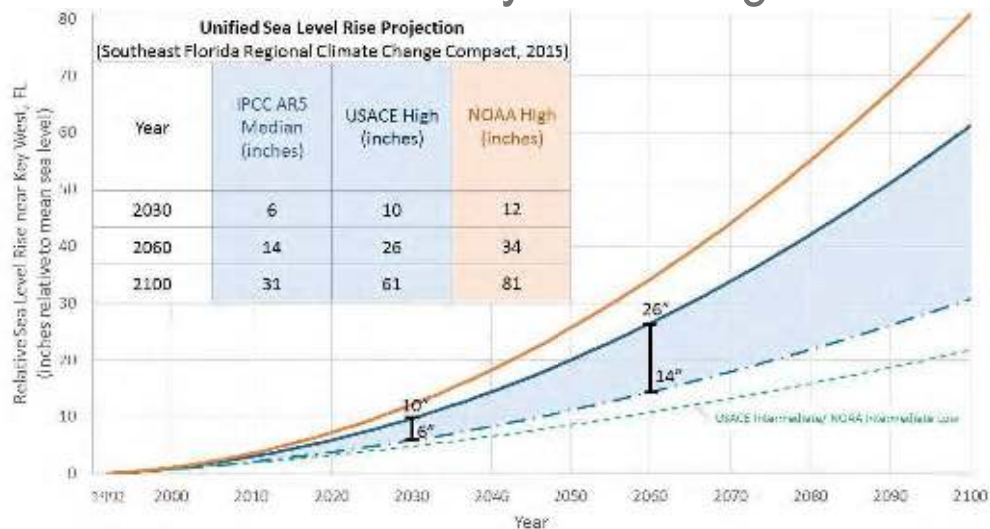


## New Vs. Old Contours & LiDAR



## New Challenge- Future Conditions

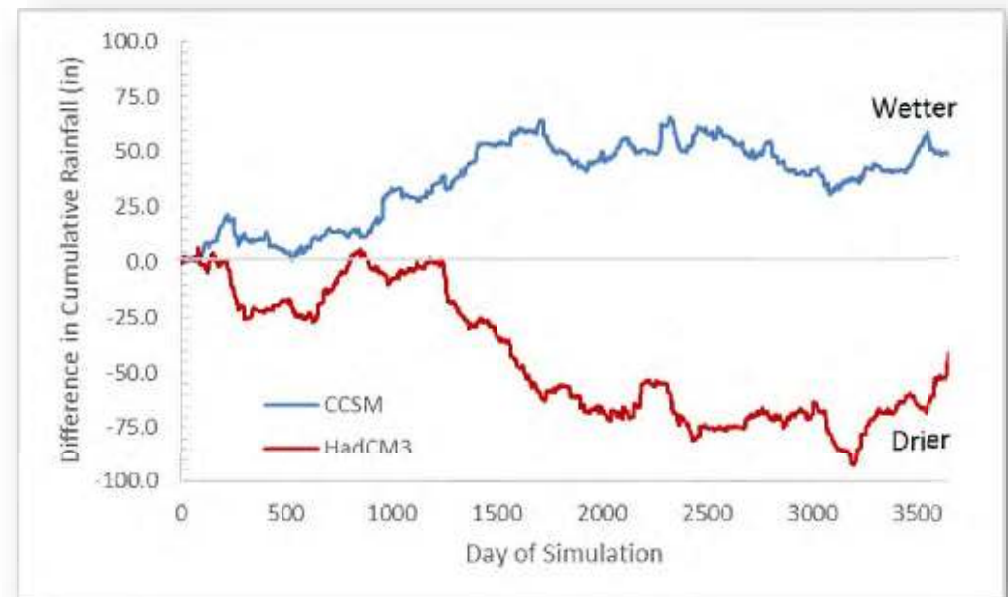
- Including:
  - Influence of sea level rise
  - Changes in precipitation
- Requires we address with modernized standards and system design





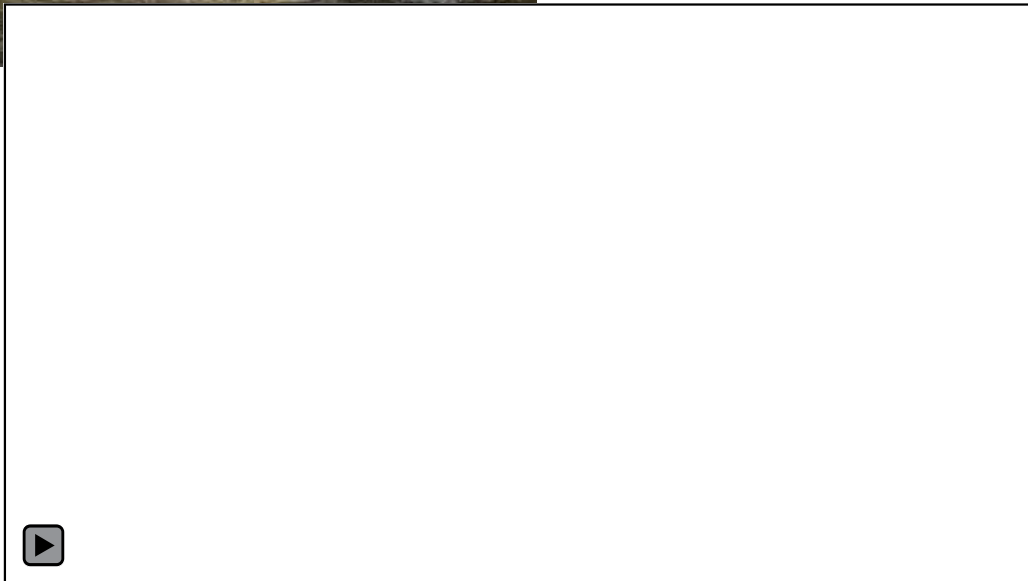
# Proposed Update Methodology

- Use of new County Wide Inundation Model
- Future period 2060-2069
- NRC 3 SLR
  - 26.6-33.9 inch increase from 1992 levels
- CCSM climate model
  - 9.1% rainfall increase
- Use of future wet season



# Current King Tides

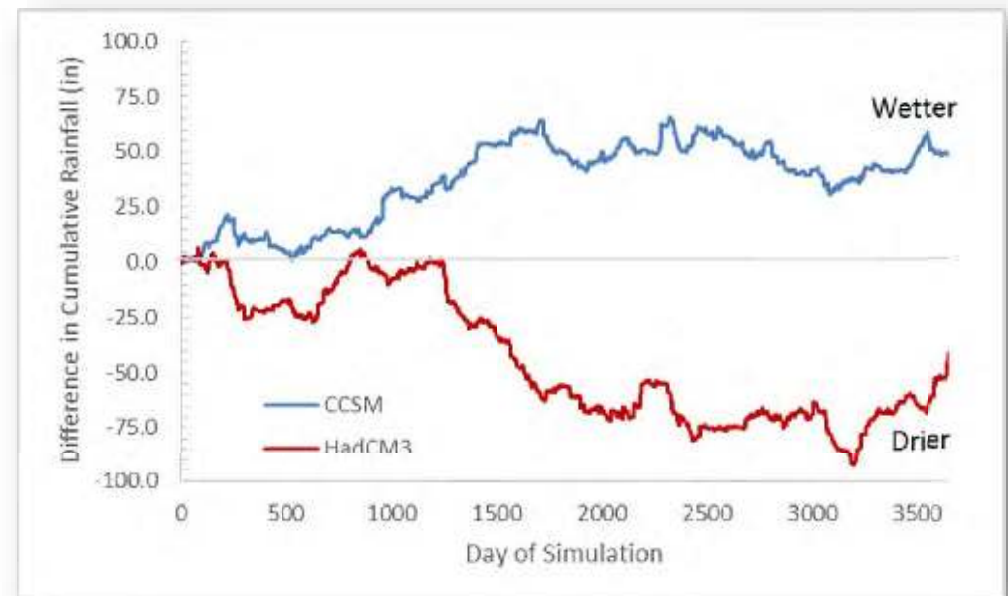
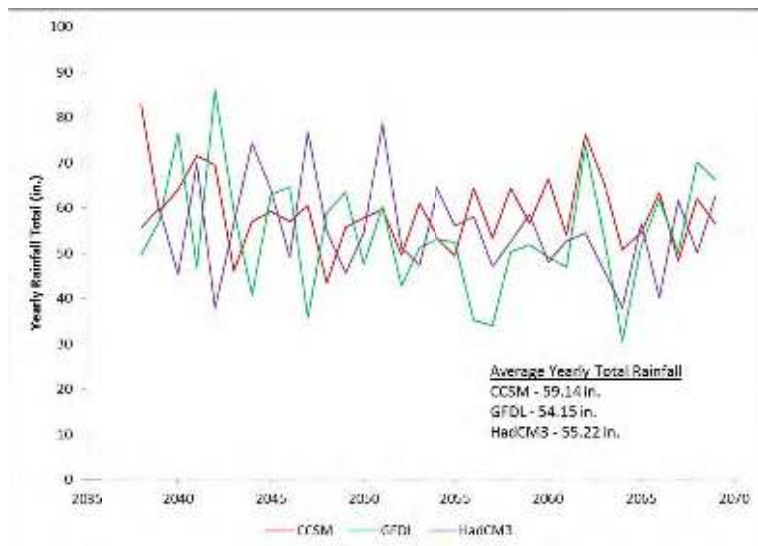




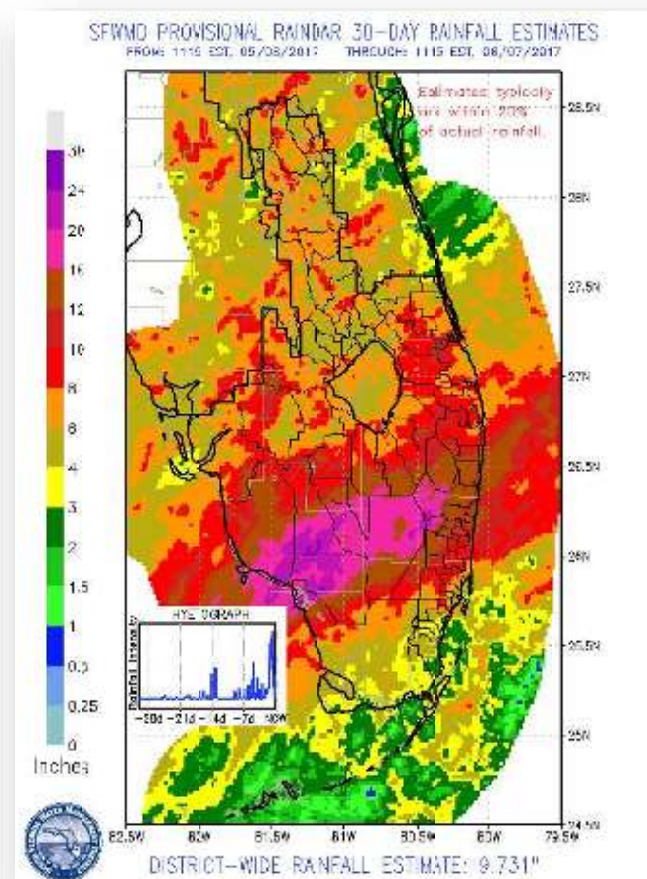
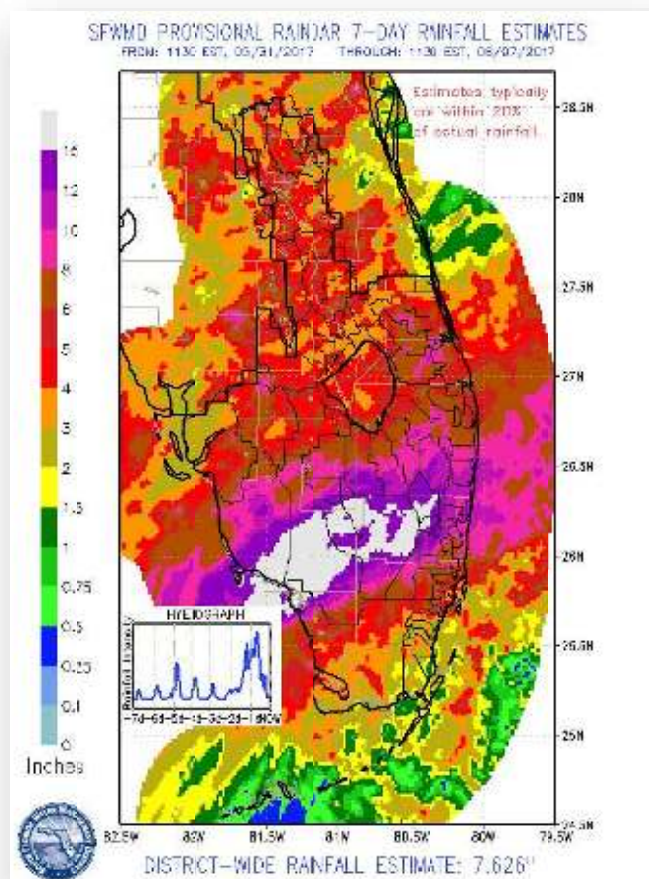
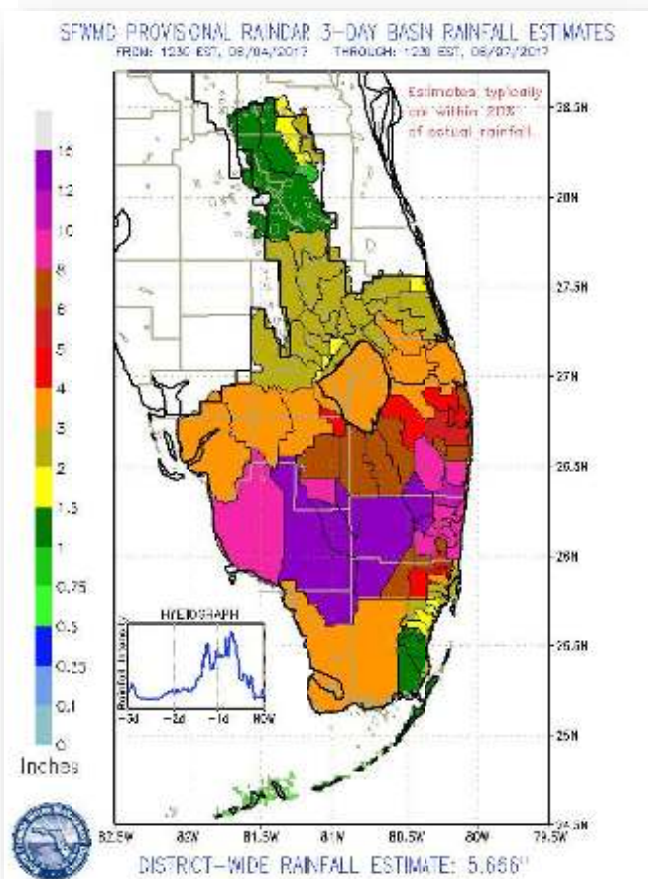


# Rainfall Patterns

- Different precipitation models
  - CCSM: 53.4 in/yr to 58.2 in/yr = +9.1%
  - HadCM3: 54.9 in/yr to 50.7 in/yr = -7.6%



# June 2017 Rain Event











Paradise Village resident using his kayak to get around in Deep



This car was left abandoned after the water overflowed in the parking lot of the Sawgrass Mills mall.

**WEATHER**

**Sawgrass Mills mall closed because of flooding**

35 MINS

The Sawgrass Mills mall in Sunrise was closed Wednesday because of flooding, police said.

**WEATHER**

**Flooding is concern for South Florida as rain continues to fall**

4 MINS

**WEATHER**

**Davie residents find fish in yards after days of heavy rain**

11 IR

**SOUTH FLORIDA WATER MANAGEMENT DISTRICT**

WHO WE ARE OUR WORK DOING BUSINESS WITH US COMMUNITY RESIDENTS

## Storm Like Volumes of Rain, Flood Control System Working Properly

The South Florida Water Management District (SFWMD) system received tropical storm like volumes of rainfall over the last three days with the majority occurring yesterday (Tuesday June 6, 2017). Accumulated rainfall ranges are between 4 and 14 inches in a wide band stretching from Collier County across the state to Palm Beach and Broward Counties.

SFWMD was prepared for this rain event, as water managers lowered canals in the preceding days. The SFWMD system is working properly to handle these high volumes of water, however, if you are experiencing flooding in your area the most likely cause is either a secondary canal system controlled by your local water drainage district or one operated by your Home Owners Association.

*Use the interactive map below to find your local water drainage district's contact information. Click anywhere in the shaded portion for more contact details or enter your address in the search box located at the top right of the map.*

Earthstar Geographics | SFWMD, Engineering and Construction

esri

<https://www.local10.com/slideshow/south-florida-flooding-in-pictures>



The floodwater rose as nearly as high as this swimming pool in Plantation.

Hide Caption



The campus of American Heritage School in Plantation is practically underwater because of the flooding.

Hide Caption



If flooding or not, school must go on.

Hide Caption



The parking lot of the Cleveland Clinic in Weston was flooded.

Hide Caption





Two dogs take a stroll on a kayak, in the Dania Beach floodwater.

Hide Caption



William Potash 10, paddles with his friends in the Vista Hiale neighborhood in western Davie, using a canoe to navigate the streets after several days of rain flooded the development, June 7, 2017. The kids also provided residents a ride in the canoe to get to their homes, while other residents wandered the flooded streets to try and figure out what the city plans to do to help. **CHARLES TRAINOR JR** - [ctrainor@miamiherald.com](mailto:ctrainor@miamiherald.com)



A car appeared to be stuck in the floodwater on Dykes Road in Davie.

Hide Caption



This Southwest Ranches home looks more like a boat house.

Hide Caption

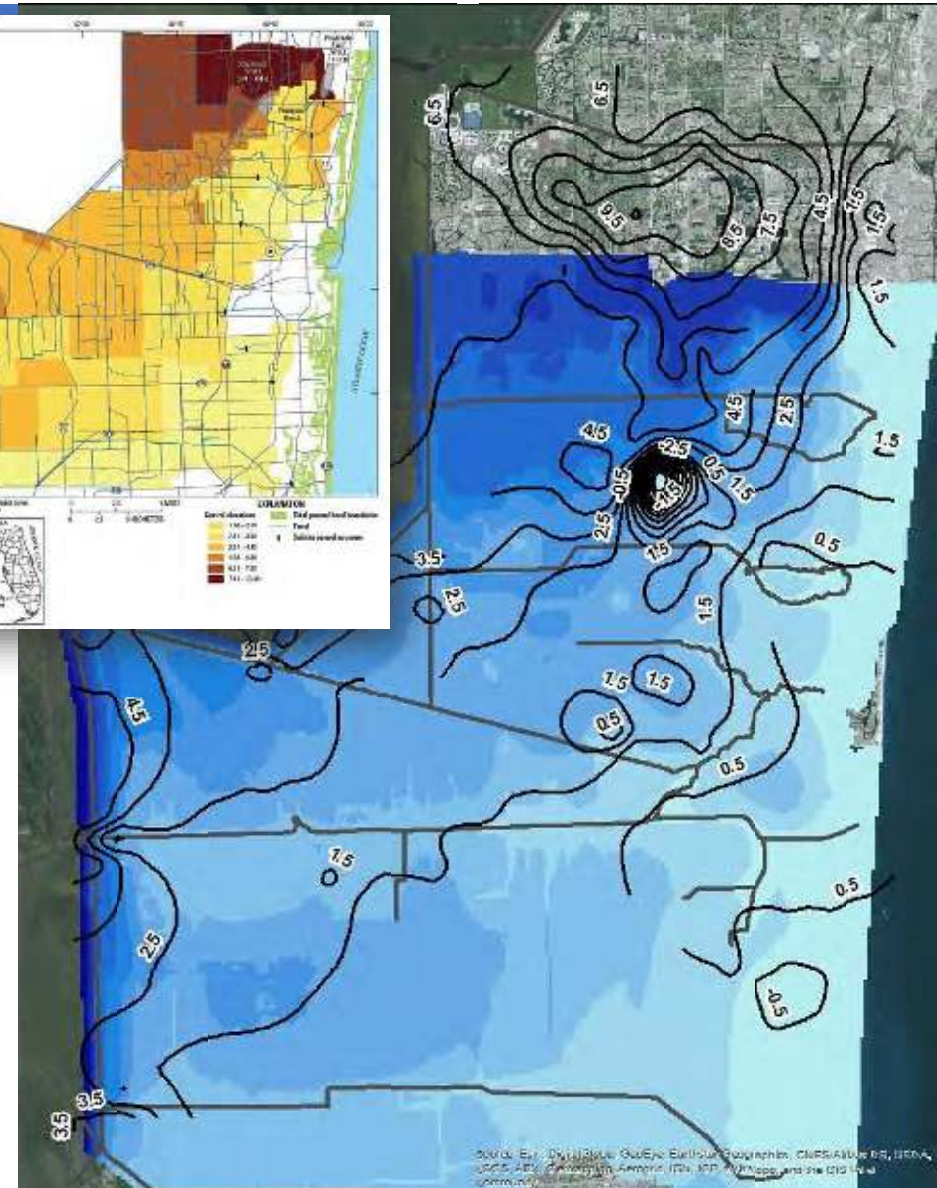
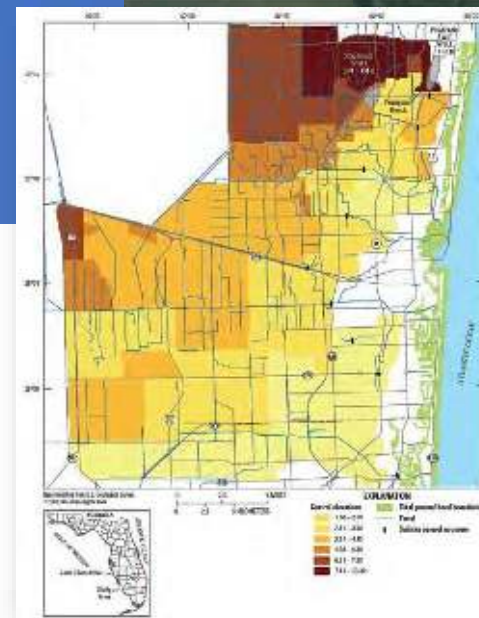


# Sawgrass Mills



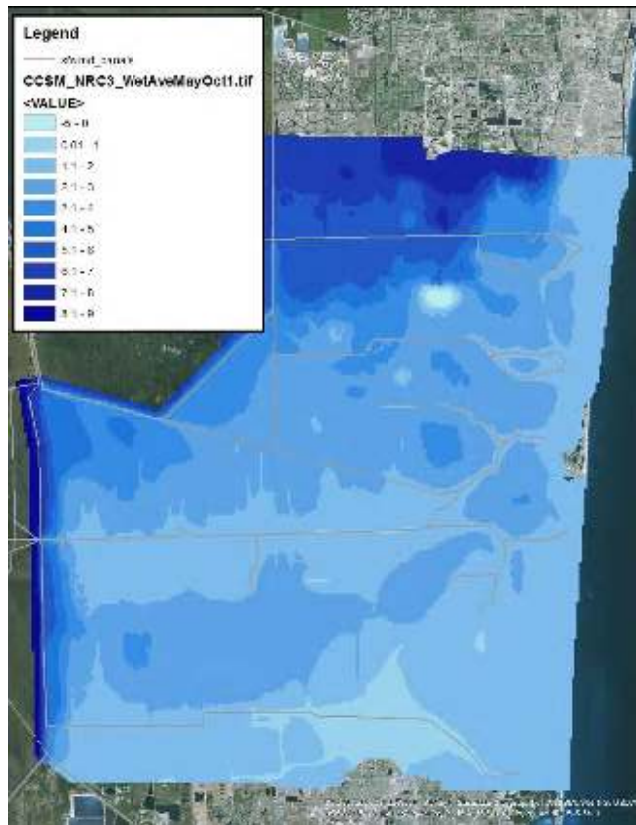
# Current Map to Modeled 1990-1999

- Match the overall break points for most contours
- Better define influence of wellfields
- Agreement with design elevations

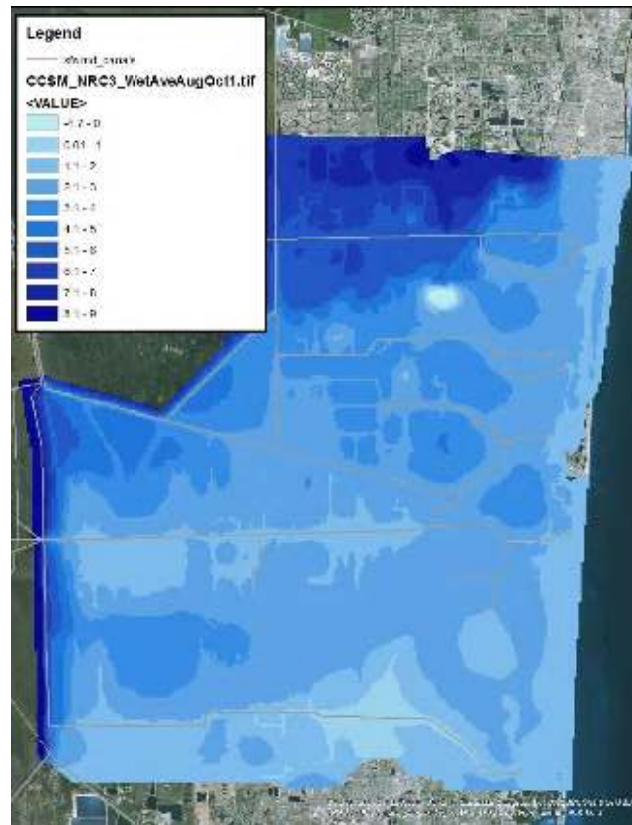




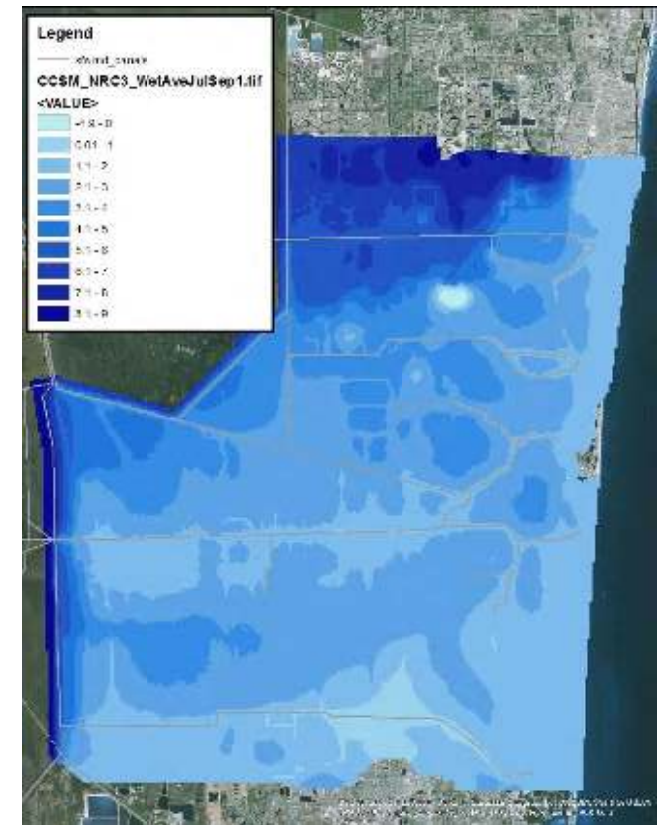
# CCSM Results- Future Wet Season Averages



May-Oct



Aug-Oct

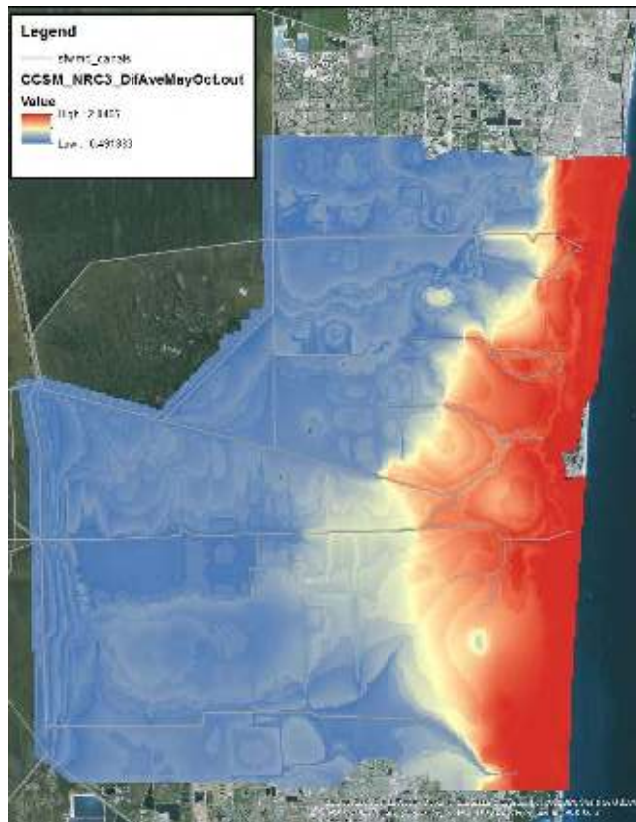


Jul-Sep

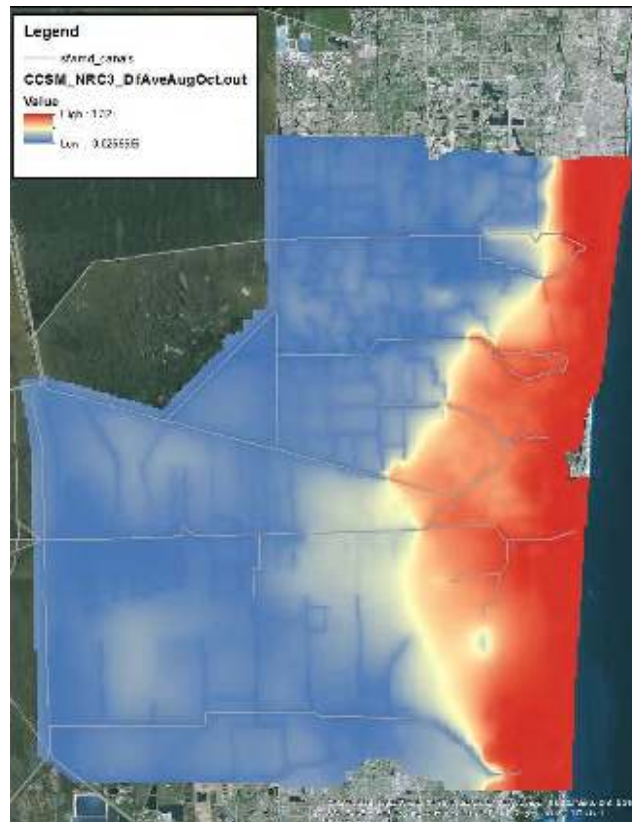


# CCSM Results- Difference Against Base

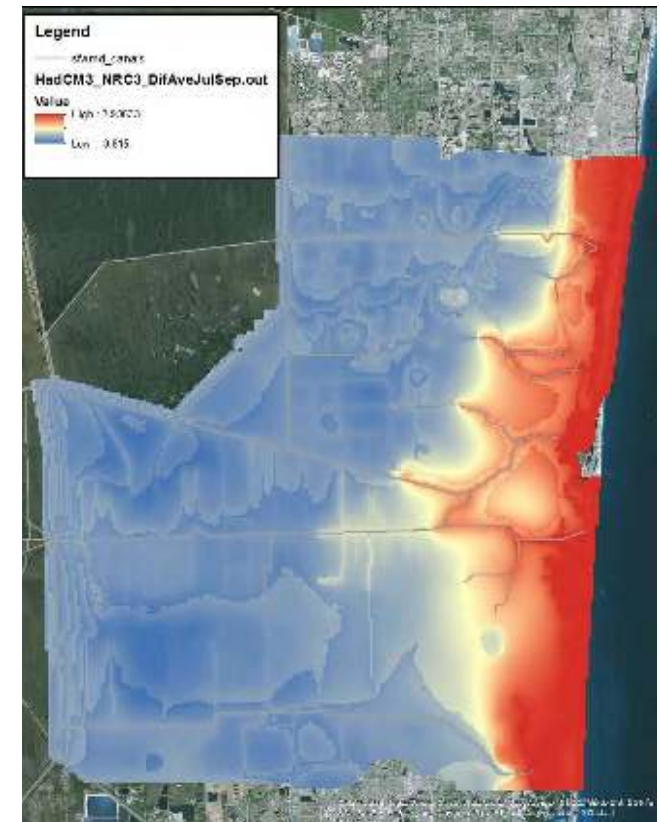
May-Oct



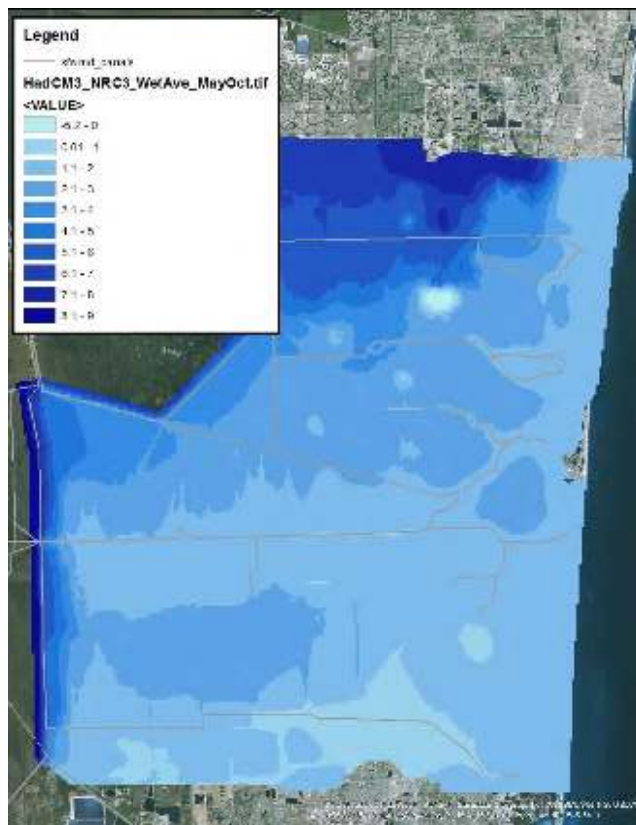
Aug-Oct



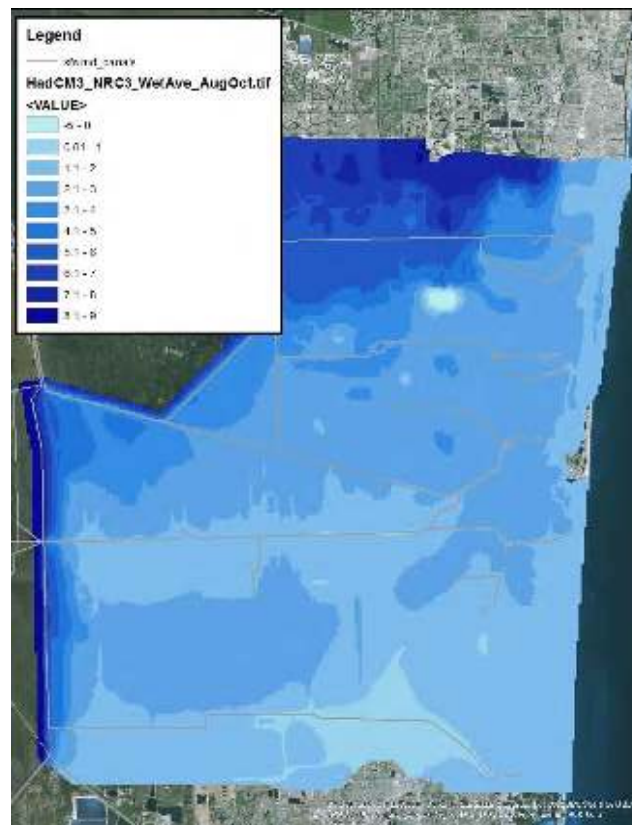
Jul-Sep



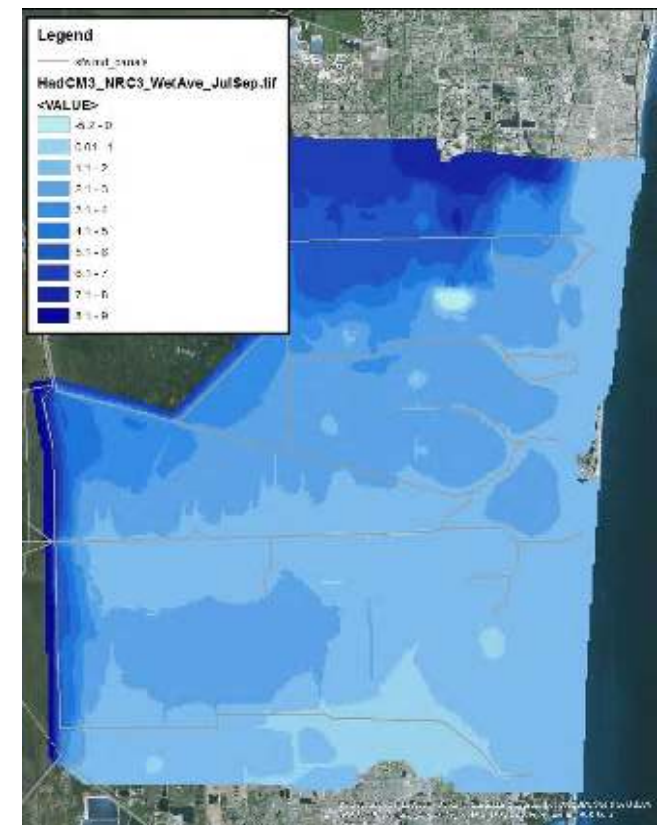
# HadCM3 Results- Future Wet Season Averages



May-Oct



Aug-Oct

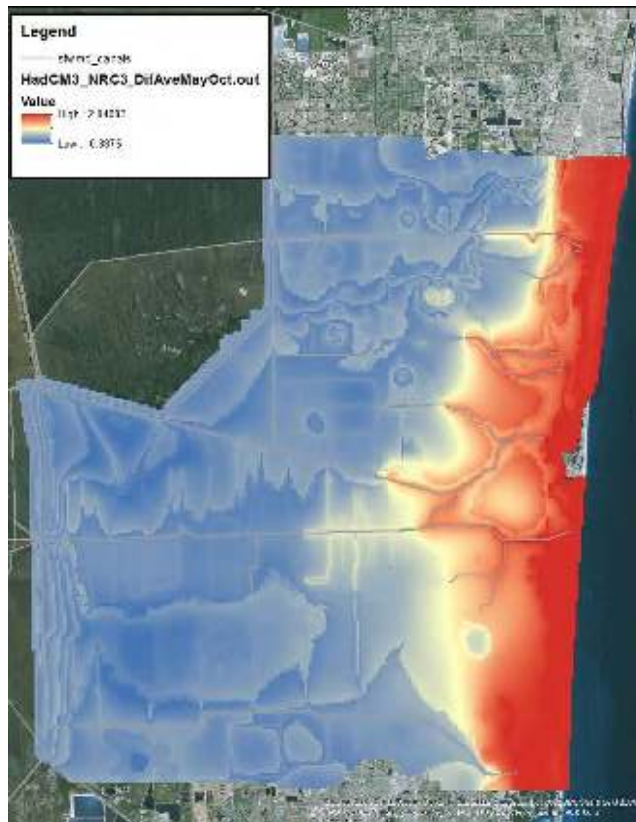


Jul-Sep



# HadCM3 Results- Difference Against Base

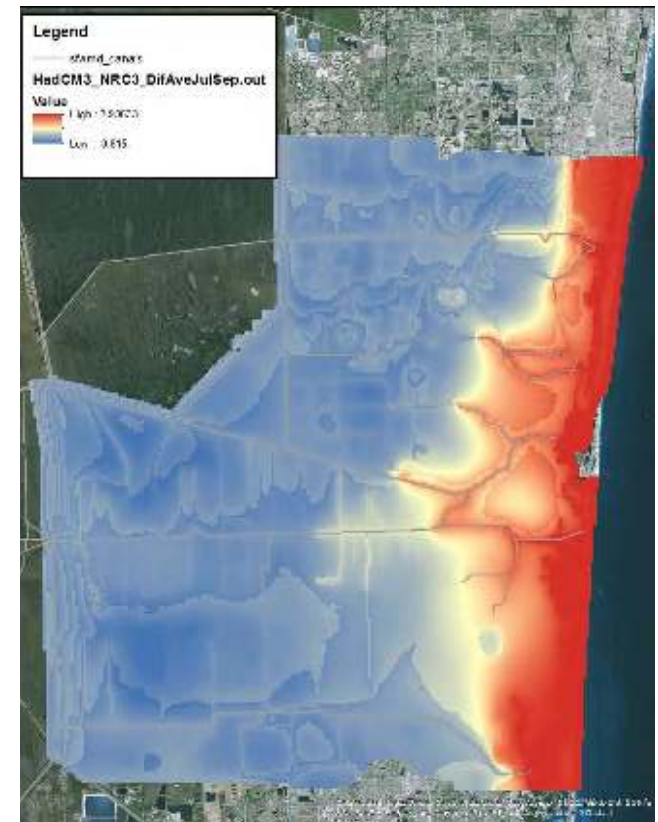
May-Oct



Aug-Oct



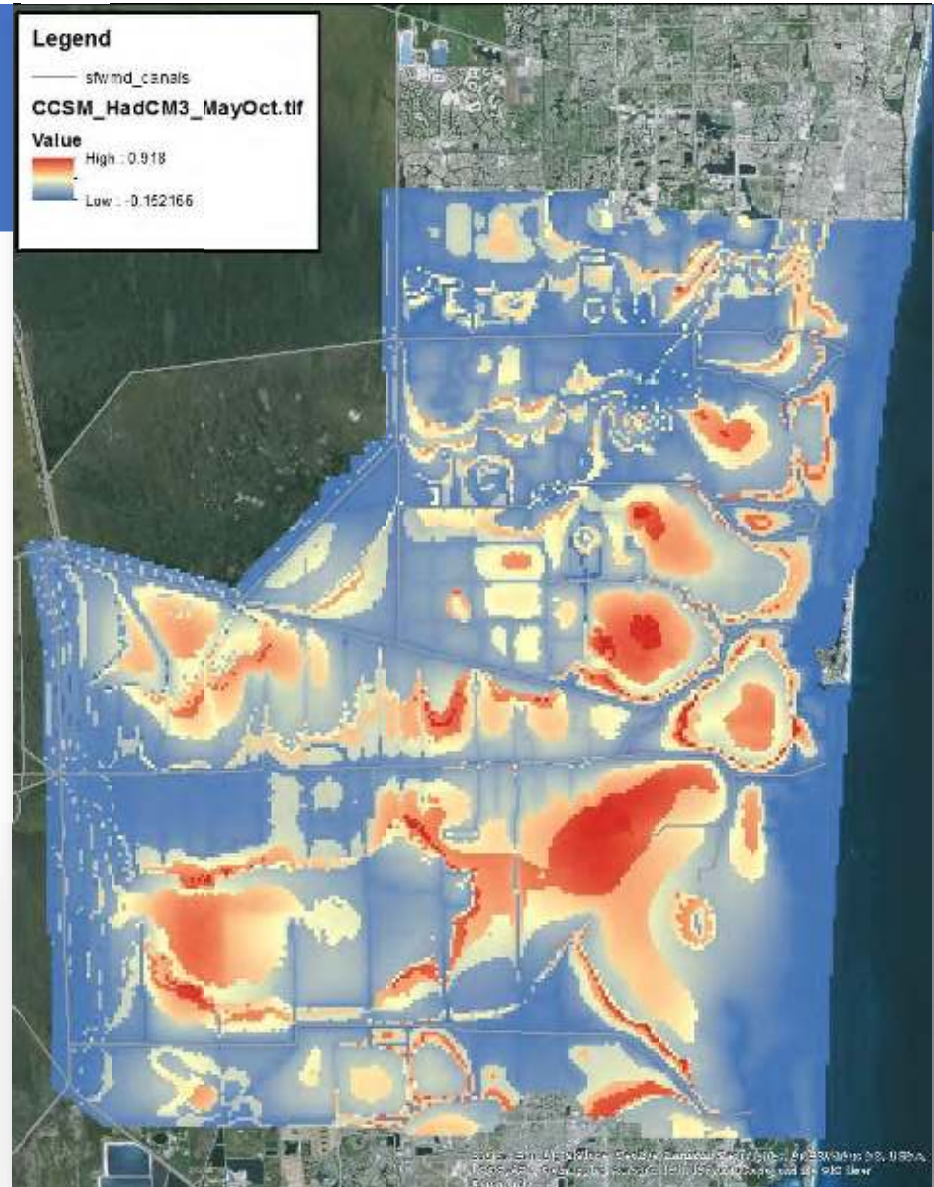
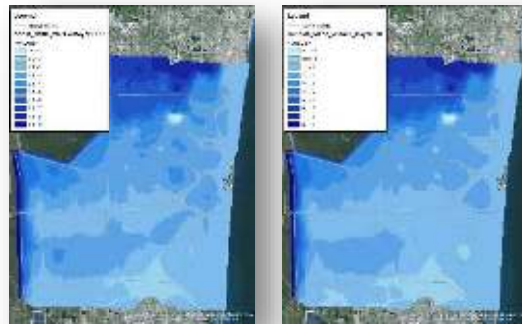
Jul-Sep



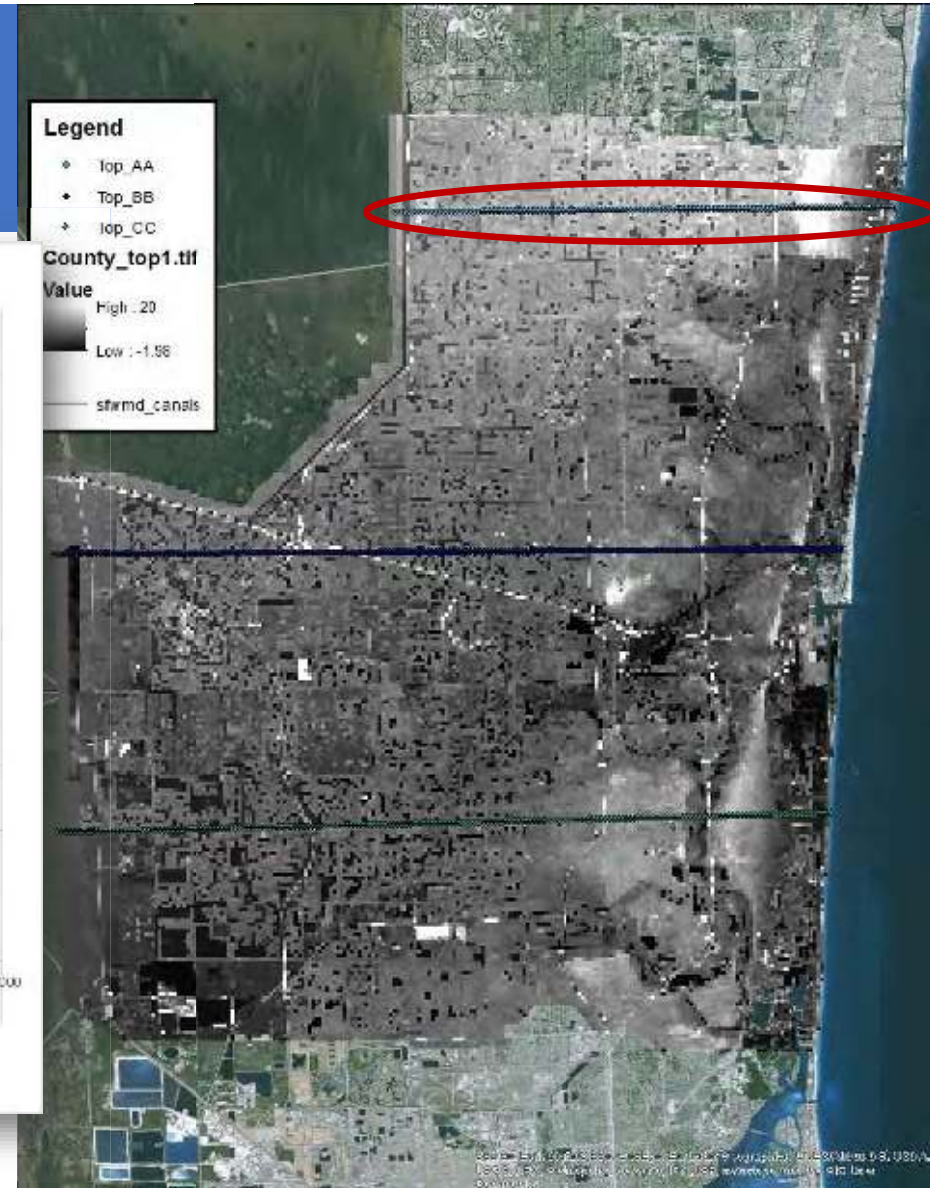
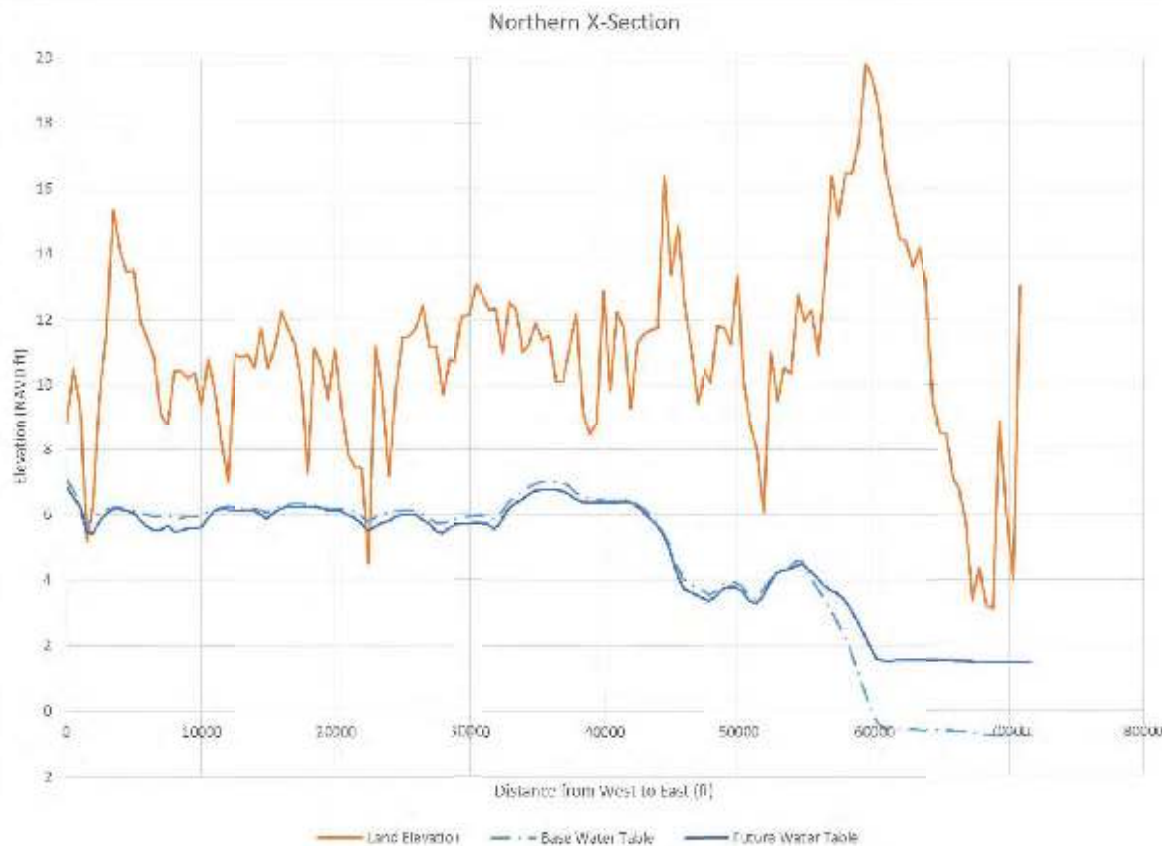


# CCSM Vs. HadCM3

- Same NRC 3 Sea level increases
- Different precipitation models
  - CCSM: 53.4 in/yr to 58.2 in/yr = +9.1%
  - HadCM3: 54.9 in/yr to 50.7 in/yr = - 7.6%
- Max difference of 0.918 ft in certain areas

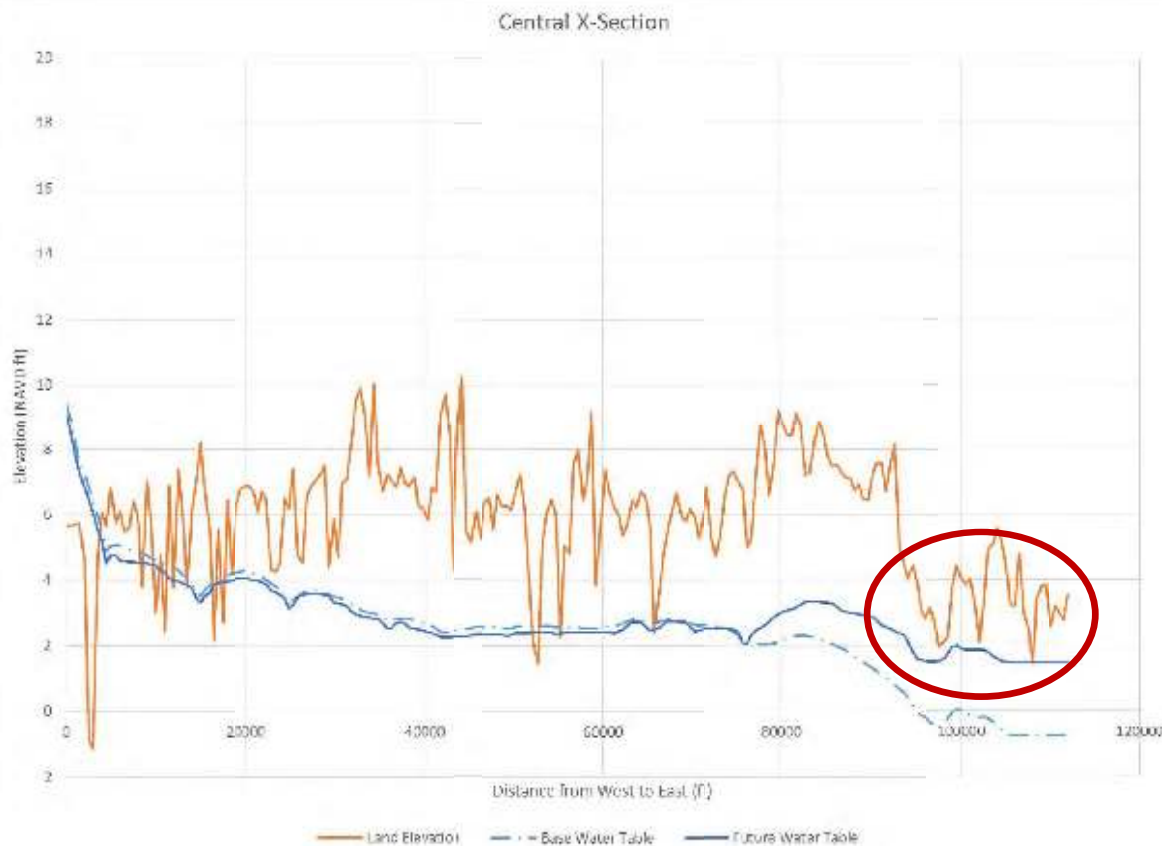


# Northern Cross-Sectional Interpretation

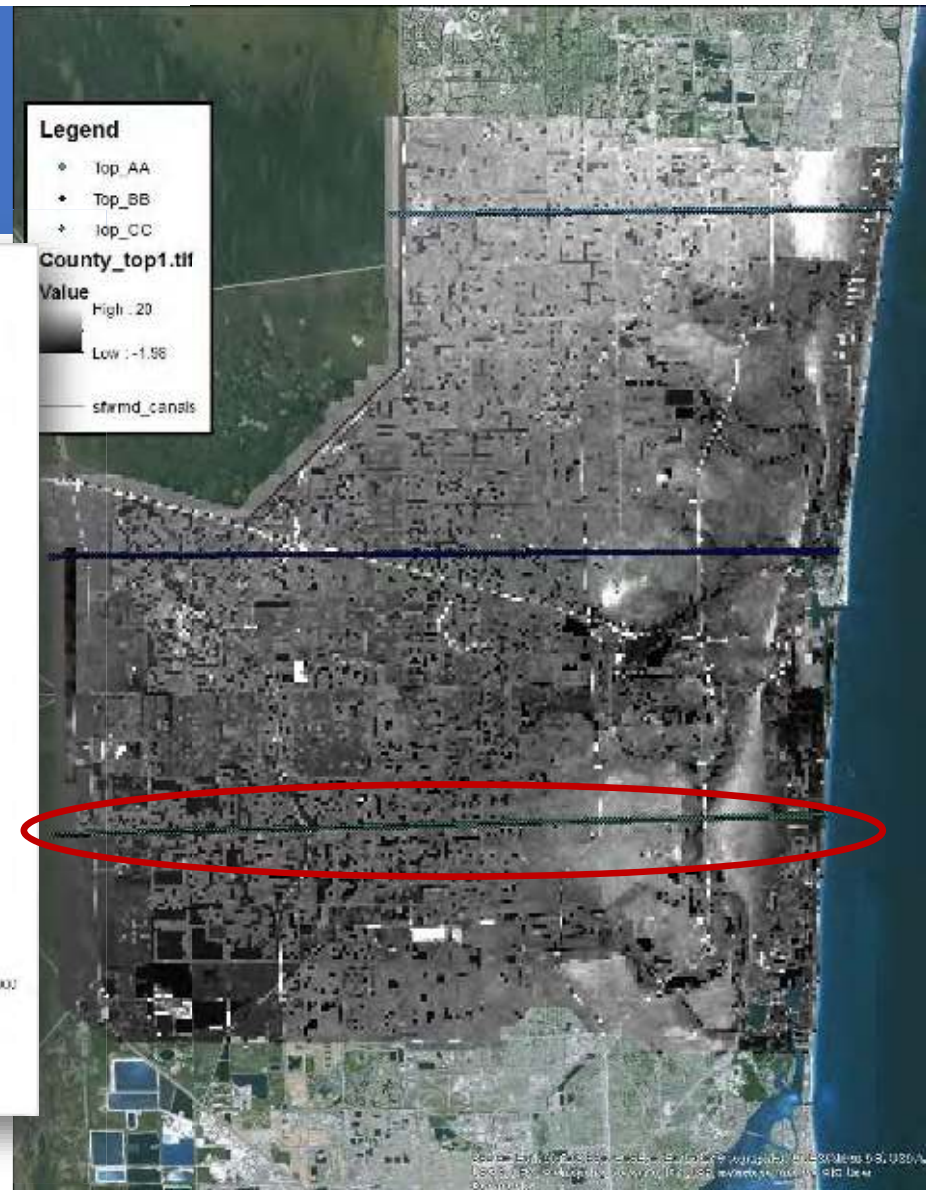
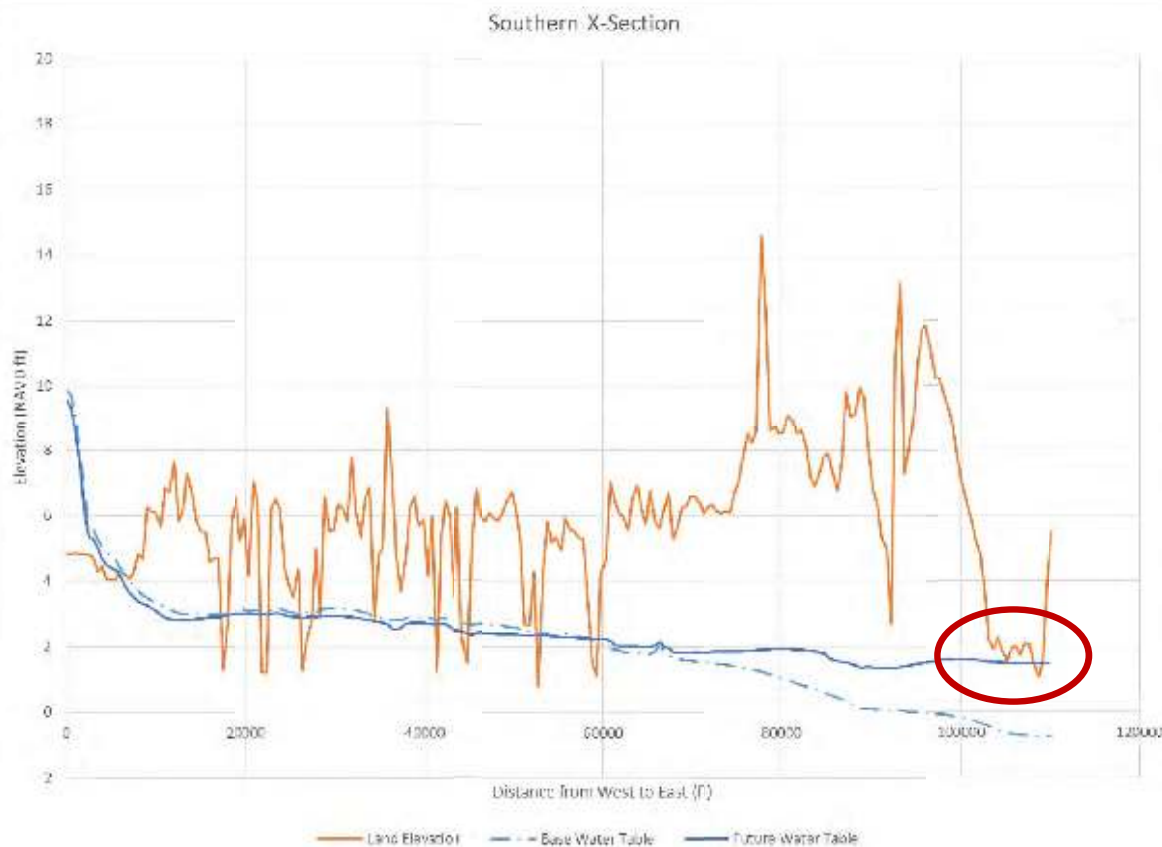




# Central Cross-Sectional Interpretation



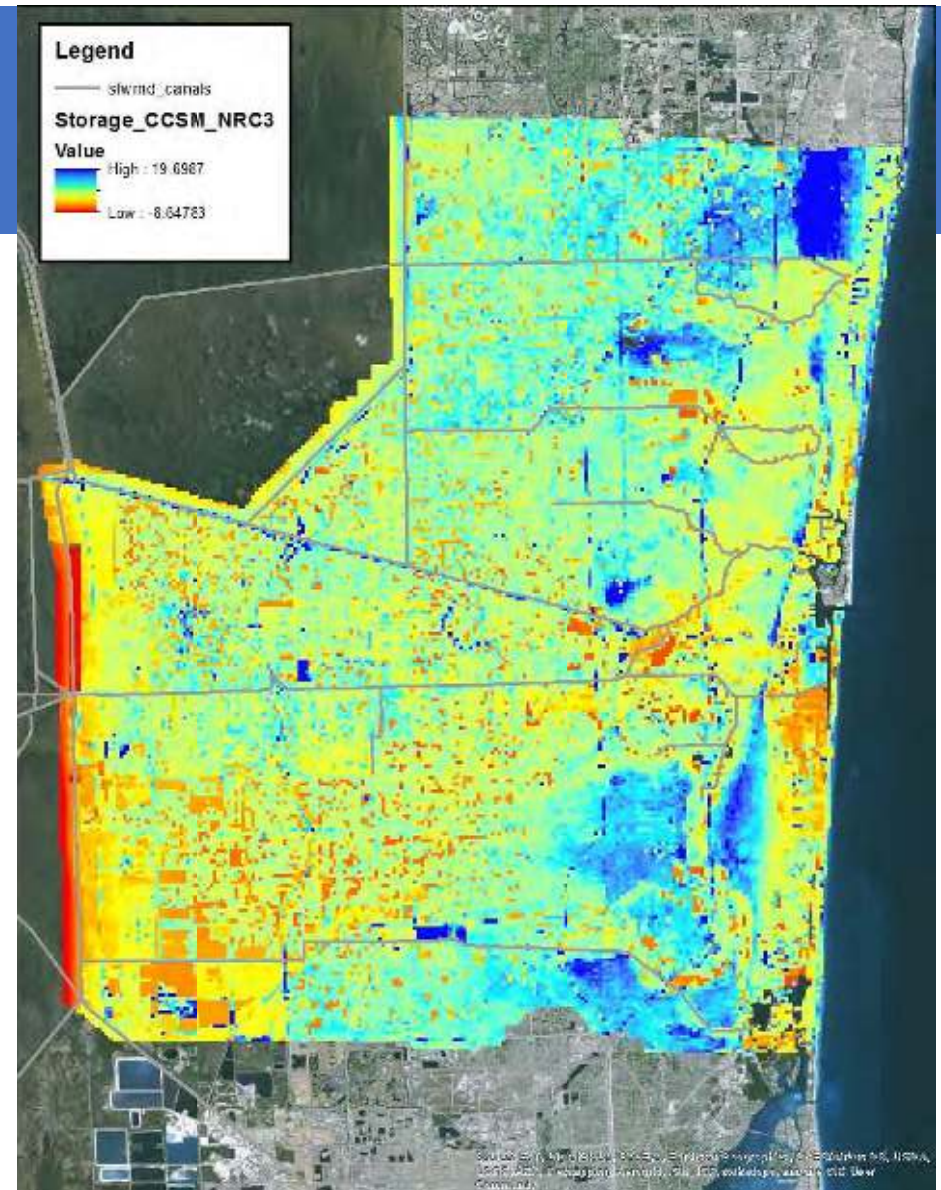
# Southern Cross-Sectional Interpretation





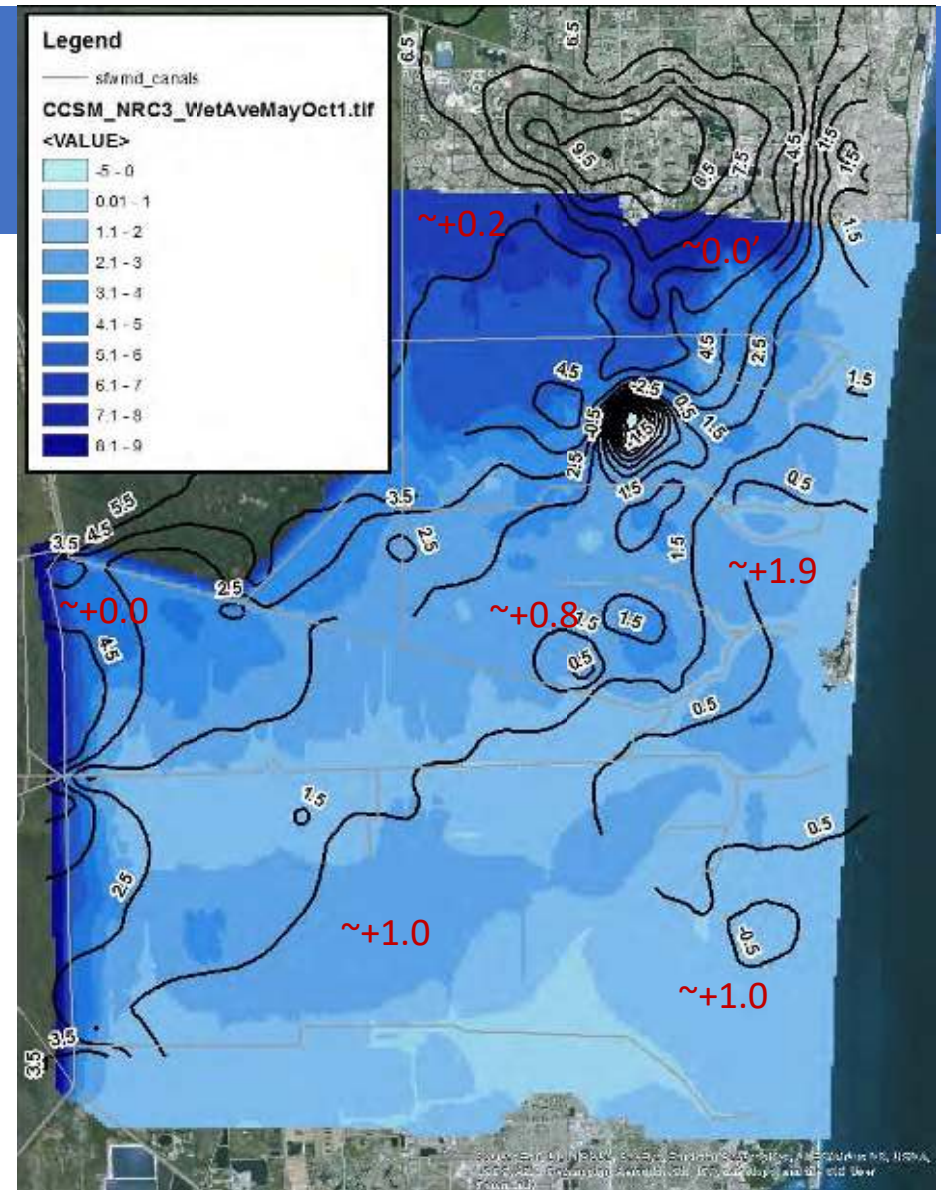
# Storage

- Red shows water or no storage
- Blue indicates most storage potential



# Proposed Map Vs. Current Map

- Similar to Modeled Base case
  - Minor changes in Western Broward
  - More significant increases in tidally influenced Eastern Broward





# Adoption Process

- Approval by Broward County Water Advisory Board and TAC
- Broader stakeholder outreach
- Motion to Direct County Attorney to draft item
- Final revision of Map
- Public Meeting/Stakeholder Meetings
- LUPA/Planning Council Review
- Motion to Set Public Hearing
- Public Hearing/Commission Approval

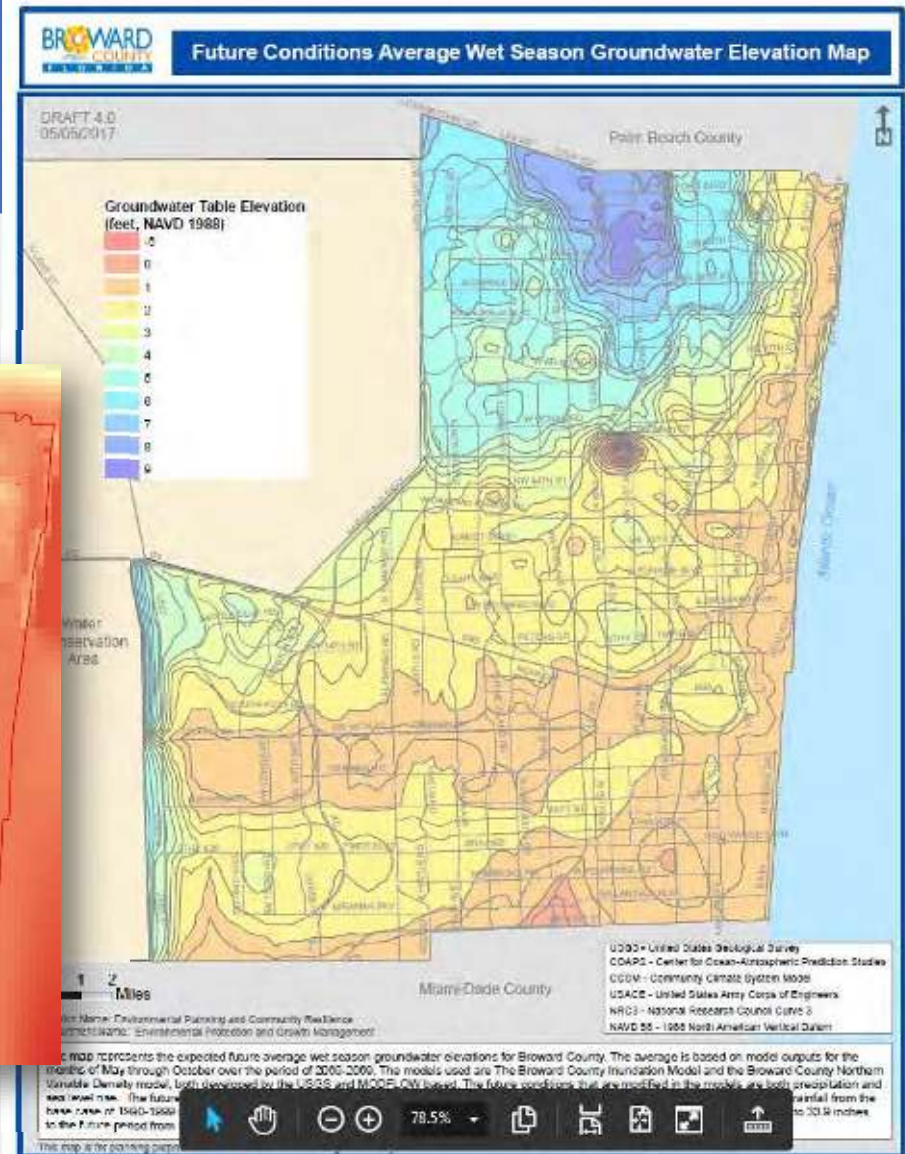
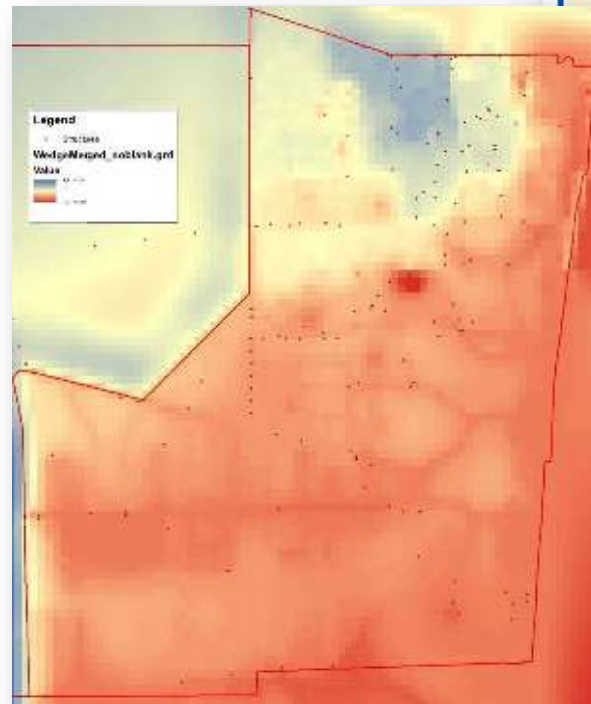
\*At each step comments may be made and updates would have to occur to lead to final product that would be more likely adopted by Commission



- Addition of future condition map series
- Current plate used is WM 2.1 (average wet season water levels) as noted in the antecedent conditions criteria
- EPGMD Regulations adopted by Ord.

# Final Map

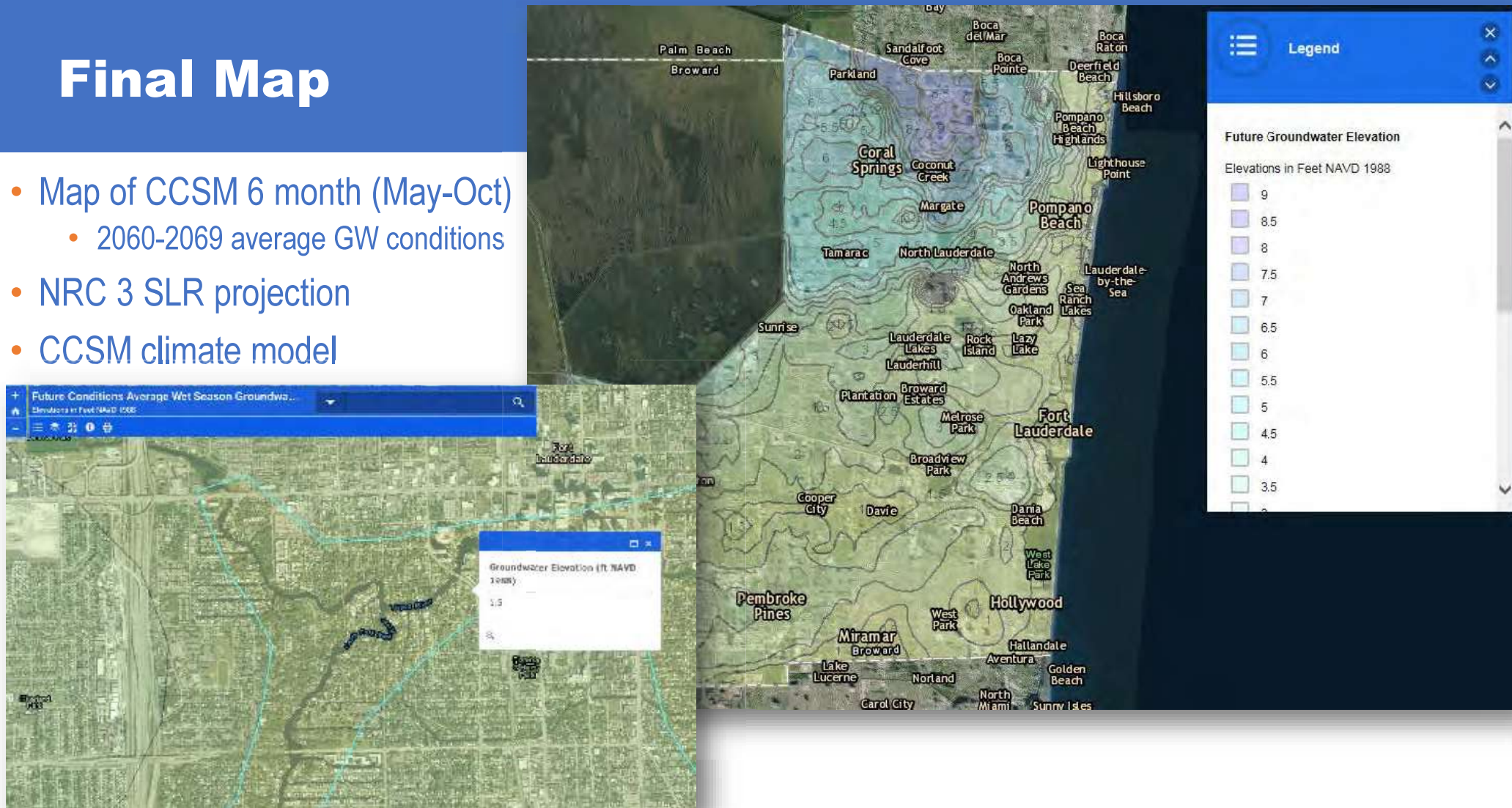
- Map of CCSM 6 month (May-Oct)
    - 2060-2069 average GW conditions
  - NRC 3 SLR projection
  - CCSM climate model
- 
- The map shows the projected average groundwater conditions for the period 2060-2069 under CCSM climate model. It includes a legend with a color scale ranging from 0 to 276.25440.





# Final Map

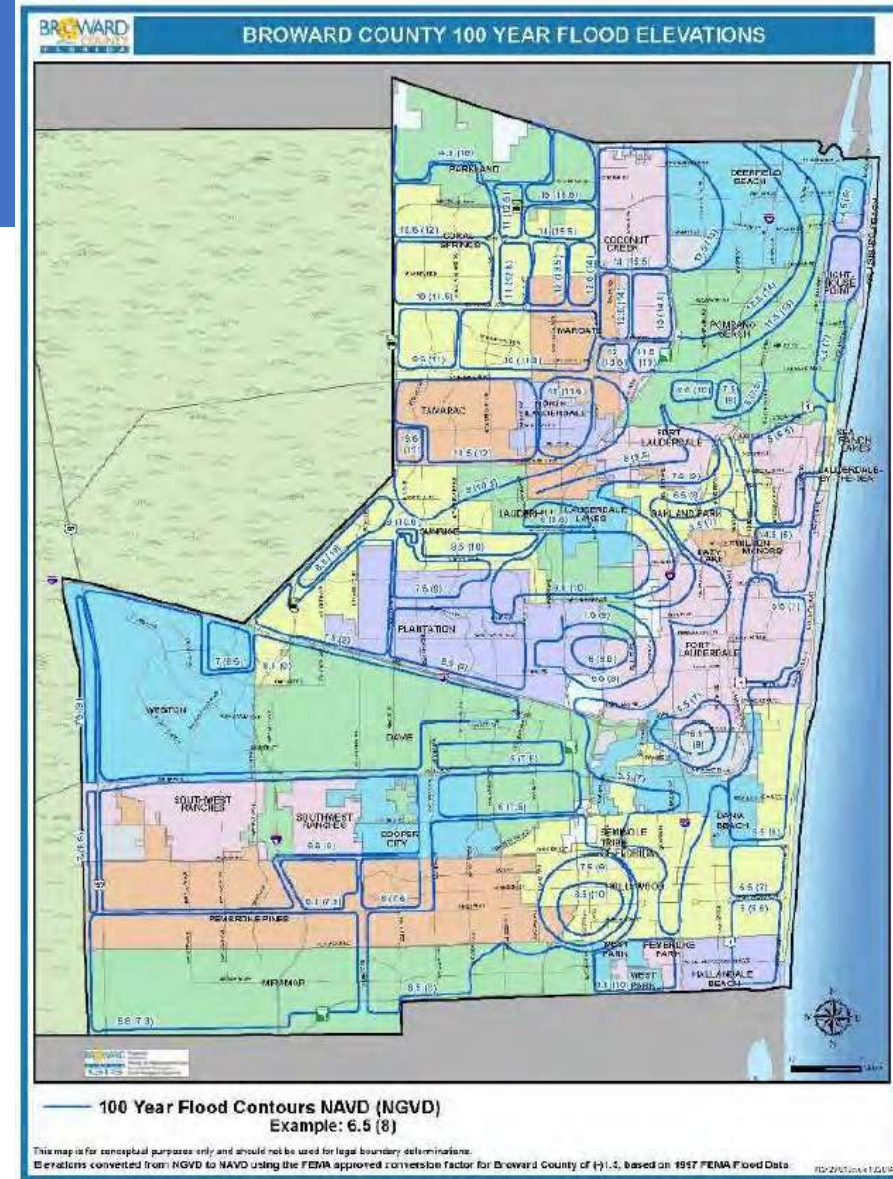
- Map of CCSM 6 month (May-Oct)
  - 2060-2069 average GW conditions
- NRC 3 SLR projection
- CCSM climate model



# History and permitting options

Must highest elevations from:

1. Current 100-yr flood map developed in 1977
  - Used to determine finished floor elevations
  - not used for insurance as FEMA FIRM Map
  - Used historic rainfall, groundwater levels, sea level, USGS Quad maps, elementary runoff computations, and assumption of land use build out
2. FEMA maps reflect existing conditions and determine insurance premiums
  - Versions updated in 70's, 80's, 90's, and 2014
  - Next update anticipated in 2019 to reflect Coastal Restudy (include new Coastal A Zone)
3. Site specific 100-year calculation
  - Based on proposed land use, 100-year rainfall, antecedent GW levels
4. 18 inches above crown of road





# Future Conditions 100-yr Flood Map

- RFP R2114367P1 issued June 2017
- 5 firms submitted proposals
- Geosyntec was selected as winning bid and negotiations held December 2017-February 2018
- Approved by Commission May 2018

Broward County Board of  
County Commissioners

Bid R2114367P1

## Bid R2114367P1 100-Year Flood Elevation Map and Associated Modeling

Bid Number R2114367P1  
Bid Title 100-Year Flood Elevation Map and Associated Modeling

Bid Start Date May 26, 2017 2:30:01 PM EDT  
Bid End Date Jun 28, 2017 5:00:00 PM EDT  
Question & Answer End Date Jun 14, 2017 5:00:00 PM EDT

Bid Contact Danea Cohen-Lbanks  
Purchasing  
954-357-6317  
dcohen@broward.org

Contract Duration 2 years  
Contract Renewal 1 annual renewal  
Prices Good for Not Applicable  
Pre-Bid Conference Jun 7, 2017 3:00:00 PM EDT

Attendance is optional  
Location: Attendance at the pre-submittal conference is optional. This information session presents an opportunity for vendors to clarify any concerns regarding the solicitation requirements.  
If you require any auxiliary aids for communication, please call 357-6066 so that arrangements can be made in advance.  
Governmental Center Building  
115 South Andrews Avenue  
Room 302  
Fort Lauderdale, FL 33301

Bid Comments Scope of Work: Broward County Environmental Planning and Community Resilience Division is seeking a qualified firm to provide a 100-Year Flood Elevation Map and Associated Modeling as outlined in the attached detailed Scope of Work. The program consists of the updating the Broward County 100-year Flood Elevation Map with consideration of future climatic conditions, including sea level rise, through the refinement and application of the latest countywide integrated MIKE SHE/MIKE 11 hydrologic-hydraulic model and in accordance with the outcomes of community stakeholder meetings.

Goal Participation: This solicitation includes Broward County certified County Business Enterprises (CBE) goal of 13%. Refer to Special Instructions and the Office of Economic and Small Business Development Requirements section for additional information.

Questions and Answers: The County provides a specified time for Vendors to ask questions and seek clarification regarding the requirements of the solicitation. All questions or clarification inquiries must be submitted through BidSync by the date and time referenced in the solicitation document (including any addenda). The County will respond to all questions via Bid Sync.

Vendor MUST submit its solicitation response electronically and MUST confirm its submittal in order for the County to receive a valid response through BidSync. Refer to the Purchasing Division website or contact BidSync for submittal instructions. It is the Vendor's sole responsibility to assure its response is submitted and received through BidSync by the date and time specified in the solicitation. The County will not consider solicitation responses received by other means. Vendors are encouraged to submit their responses in advance of the due date and time specified in the solicitation document. In the event that the Vendor is having difficulty submitting the solicitation document through Bid Sync, immediately notify the Purchasing Agent and then contact BidSync for technical assistance.

# Scope



1. Project Kick Off and Schedule Development
2. Initial Data Collection and Review
3. Community Stakeholder Meeting Support
4. Supplemental Data Collection Based on Stakeholder Meetings
5. Development of ArcGIS Tool- MODFLOW to MIKE SHE/MIKE 11
6. Update Current Conditions MIKE SHE/MIKE 11
7. Develop Future Conditions MIKE SHE/MIKE 11 Inputs
8. Future Model Execution and Results Processing
9. Develop ArcGIS Tool- Coastal A Zone Integration
10. Develop ArcGIS Tool- Generate 100-yr Contour Map
11. CRS Evaluation and Recommendations
12. Presentations of Results to County and Stakeholders
13. Prepare and Submit Draft Summary Report
14. Prepare and Submit Final Summary Report
15. Project Management



### 3) Community Stakeholder Meeting Support

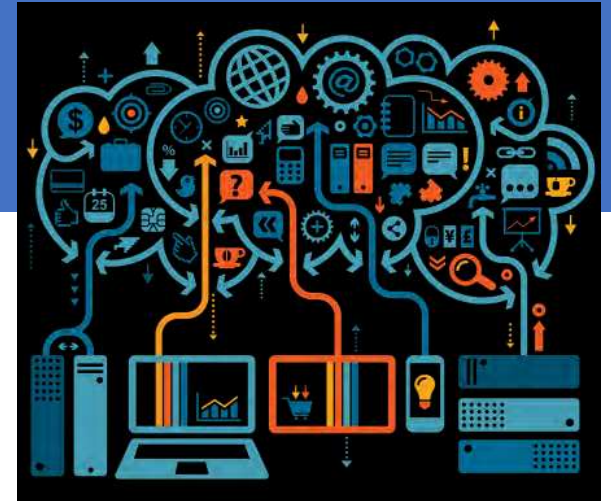
- Similar to FEMA process
- Engage community before modeling is started to gain input
  - Proposed map development
  - Community specific considerations
- Obtain relevant data from stakeholders
- Give opportunity to revise methodology and gather other valuable information/data for inclusion
- In the end, community buy in needed for formal adoption of new map



## 2 & 4) Data Collection

- LiDAR data
- Jurisdictional Data
- Soils / Hydrogeology / Aquifer Characteristics
- Current Land Use / Future Land Use
- FEMA Coastal Modeling
- Gauge and Tidal Data
- Rainfall and Calibration Storm
- Reference Climate Documentation
- Sedimentation Data

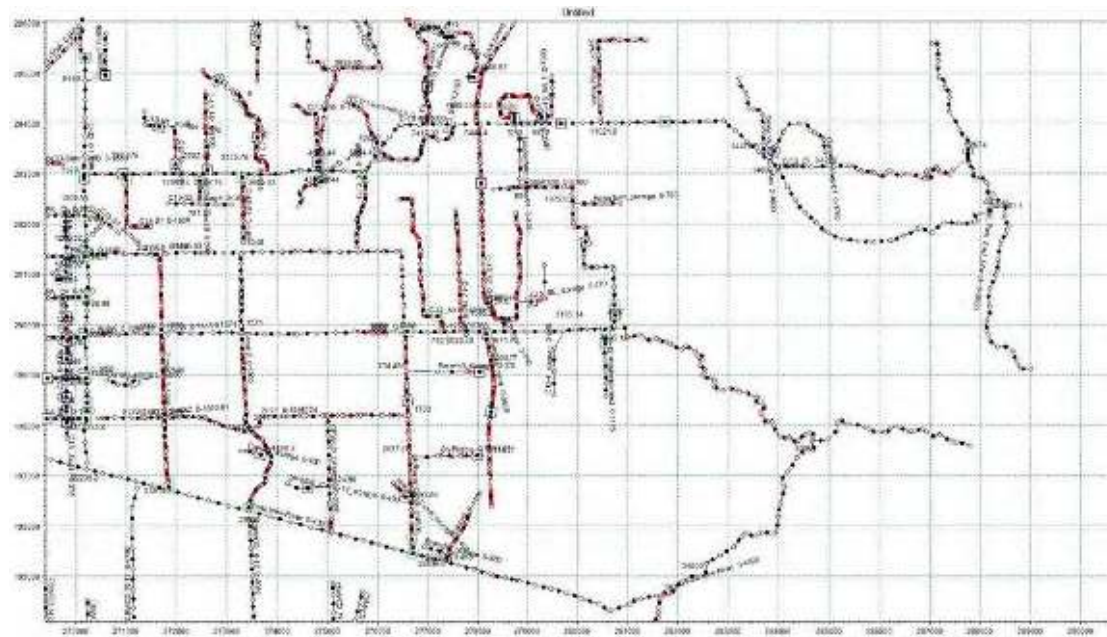
- Municipality Stormwater Plan and Model Acquisition
- Planned Major Infrastructure Projects
- SFWMD ERPs, As-built plans, etc.
- SFWMD Future Water Control Projects
- Field Reconnaissance
- Field Survey - Structures, Cross-sections, Sediments





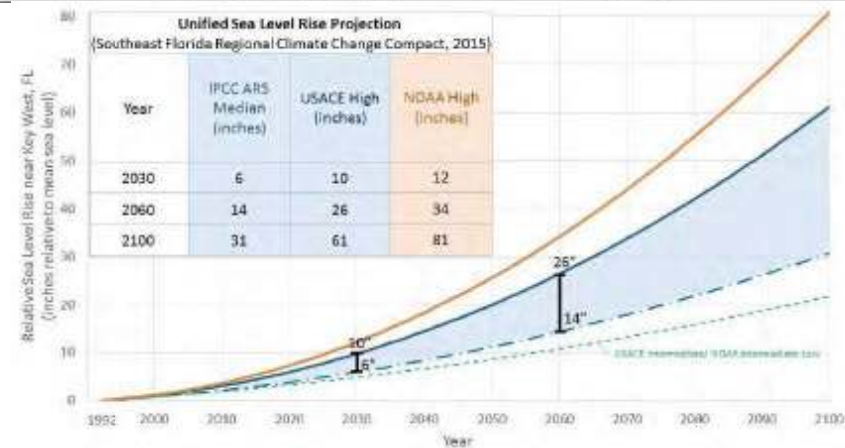
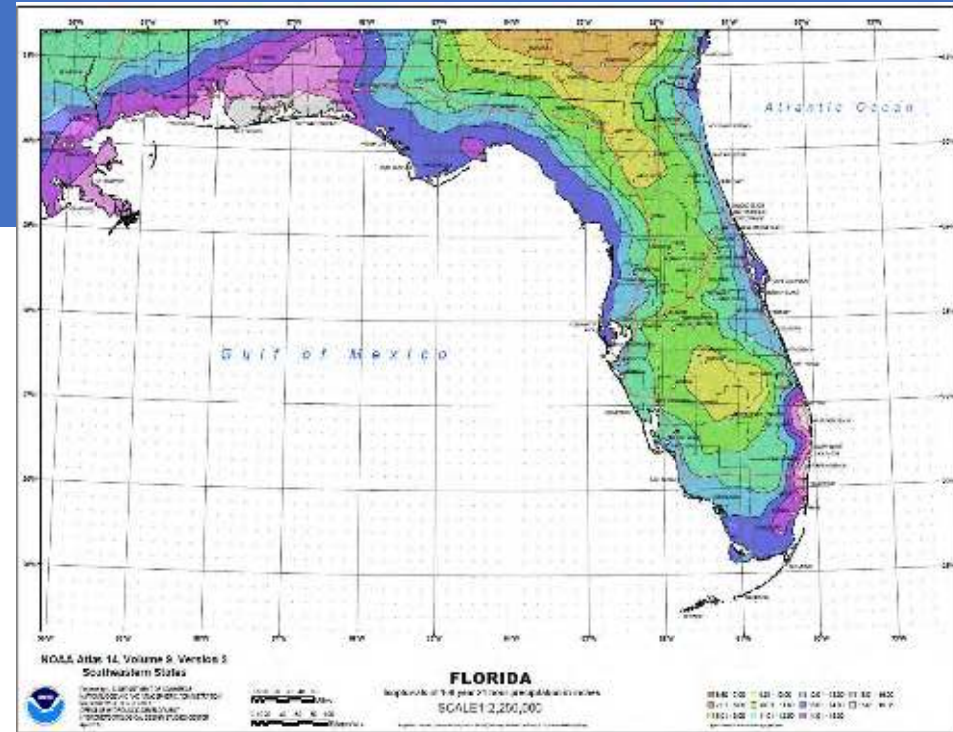
## 6) Update current conditions

- Update with new information gather as part of:
  - Task 2 initial data collection
  - Task 3 community stakeholder meetings
  - Task 4 supplemental data collection and field survey
- May include updates to drainage system, control structures, cross section updates, and validation to recent storms
- Reduce grid size from 500'
- Land use refinement
- Storage representation/ponded drainage
- Hydrologic parameters update
- Possible conversion of MIKE 11 to MIKE Hydro



## 7) Future Conditions

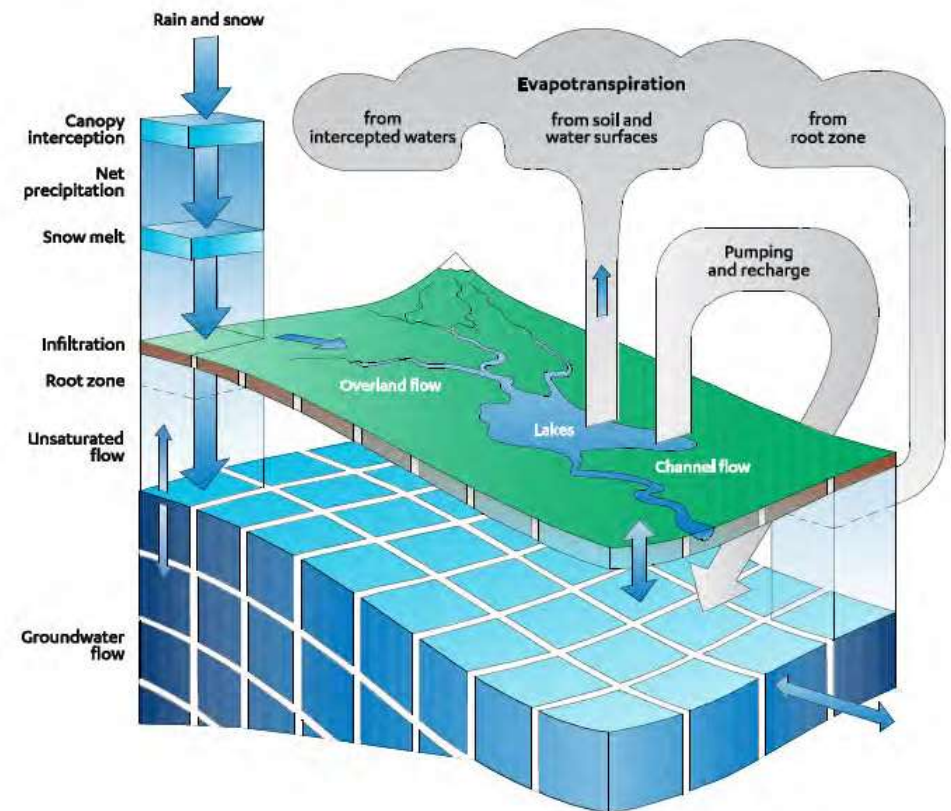
- Develop Rainfall Data Set (options to be evaluated)
  - Use NOAA Atlas 14 data
  - Use statistically downscaled localized constructed analogs (LOCA)
  - Dynamically downscaled data from COAPS
  - Dynamically downscaled data from CORDEX
  - Probabilistic approach
- Use two future SLR data sets based on Compact recommendations
  - 2060-2069 for Map
  - Year 2100 for CRS credits
- Future average GW levels from BC MODFLOW models
- Other considerations
  - Future Land Use
  - Future Structure Operations
  - Planned Infrastructure Improvements





## 8) Future Model Execution and Results Processing

- Storm events for 10, 25, 50, 100, and 500 year storms events
- Future Conditions Simulation for 2060-2069
- Future Condition Simulation for 2100
- Contour maps of:
  - **Max depth of overland flow**



## 5, 9, & 10) Tools Development- Future Updates

Tools will be developed to help streamline updates to future iterations of 100-yr Flood Map

1. Update MIKE SHE model with new antecedent GW levels from MODFLOW
2. Update MIKE SHE with updates from FEMA Coastal Restudy
3. Automate process of contour line generation of final outputs





## 11) CRS Evaluation and Recommendations

- Evaluate current CRS credits for Broward County and applicable municipalities
- Evaluate credit opportunities
- Prepare potential CRS credit recommendations



*National Flood Insurance Program*

### Community Rating System

*A Local Official's Guide to*

*Saving Lives*

*Preventing Property Damage*

*Reducing the Cost of Flood Insurance*

*FEMA B-573 / May 2015*



## 13 & 14 ) Final Presentation and Report

- Presentations for stakeholders and County
- Prepare draft for review
- Publish final report
  - Details of project
  - QA/QC element





# Adoption Process

- Review by Broward County Water Advisory Board and its Technical Advisory Committee
- Public Meetings/ Broad Stakeholder Outreach
- Digital Map available online for Public (
- LPA/Planning Council Review
- Motion to Set Public Hearing
- Public Hearing/Commission Approval



**Questions?**



# What can we do today?

## FLUX ZONE CONCEPT

### What do we have to include to meet today's criteria?

Today's Calculations - water quality (exfiltration trench) and quantity (drainage wells)

### What is the life expectancy of the project?

Assumptions for probable conditions over the life cycle of the project

- Pragmatic – direct application of SLR projections (i.e. assume water table rises 2 feet)
- Precise – use tools currently under development (SLR future conditions surface and ground water modeling)

### What do we have to change to meet expected conditions over the life of the project?

Tomorrow's Calculations - water quality (exfiltration trench) and quantity (drainage wells)

- Pragmatic – designed for maximum practical time period; or
- Resilient – designed for probable conditions at predetermined end of project life.

# Exfiltration Trench

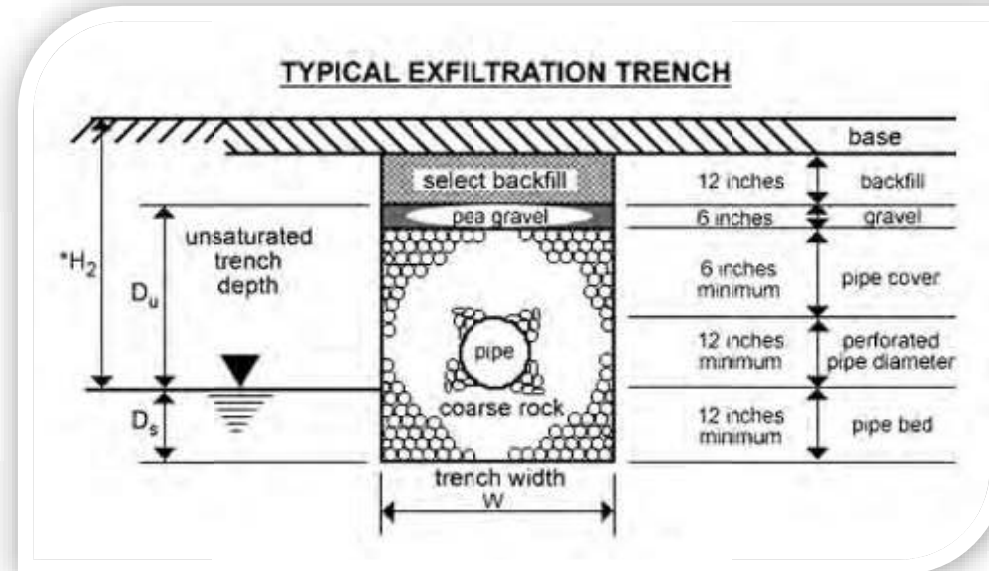
## Regular Formula

$$L = \frac{FS[(\%WQ)(V_{wq}) + V_{add}]}{K(H_2W + 2H_2D_u - D_u^2 + 2H_2D_s) + (1.39 \times 10^{-4})WD_u}$$

## Conservative Formula

(Required when  $D_s > D_u$ , a likely condition in a SLR scenario)

$$L = \frac{FS[(\%WQ)(V_{wq}) + V_{add}]}{K(2H_2D_u - D_u^2 + 2H_2D_s) + (1.39 \times 10^{-4})WD_u}$$



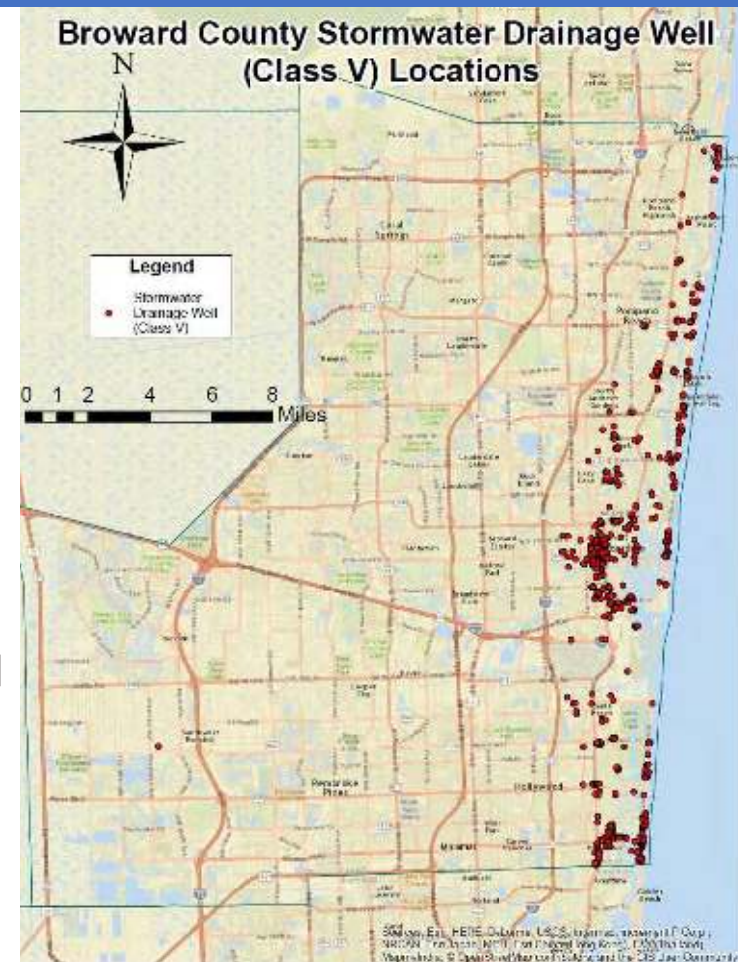
# Drainage Wells

## Underground Injection Control (UIC)

- Protects Florida's underground sources of drinking water (USDW)
- USDW = aquifer with a total dissolved solids concentration of less than 10,000 milligrams per liter.

## >13,000 Class V wells in Florida

- Class V Group 6 = drainage wells
  - $\approx 680$  in Broward
  - Typically allowed east of US1 (exceeds 10,000 mg/L TDS)
  - Discharge capacity ranges from <100 up to 1000 GPM/ft-head
  - Typical conservative estimate: 250 GPM/ft-head





# **Surface Water Management**

## Design Example 1

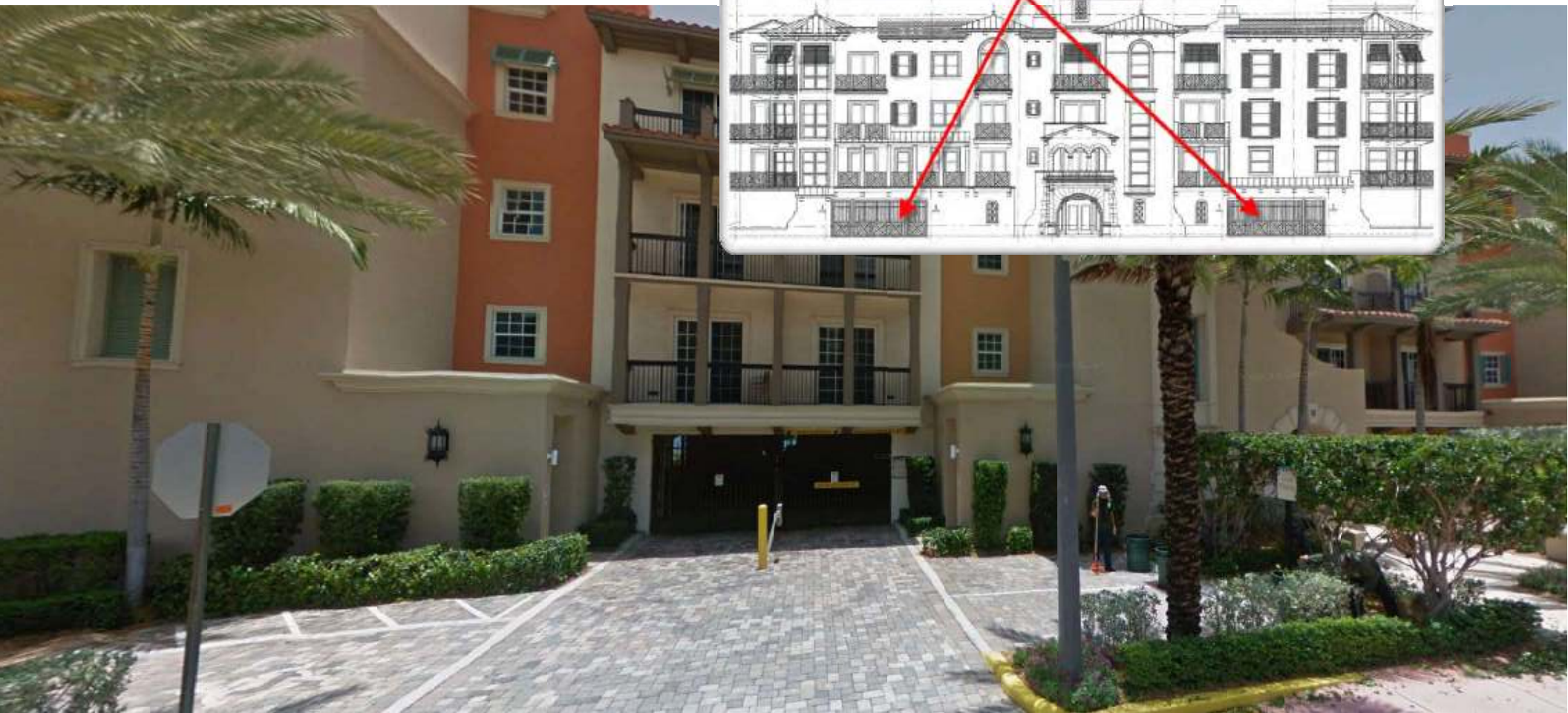
# Surface Water Management Design Example 1





# Surface Water Management

## Design Example 1





# Surface Water Management

## Design Example 1

### Permitted Conditions

WSWT: **1.5' NAVD**

WATER QUALITY VOLUME

Required: 0.08 acre-feet

Provided

0.08 acre-feet

By 70 LF exfiltration trench

100-YR, 3-DAY PRE-POST MAX

Required: 9.38' NAVD

Provided

9.38' NAVD

By 1 gravity drainage well

### SLR Scenario

WSWT: **3.5' NAVD**

WATER QUALITY VOLUME

Required: 0.08 acre-feet

Provided

**0.05 acre-feet**

By 70 LF exfiltration trench

100-YR, 3-DAY PRE-POST MAX

Required: 9.38' NAVD

Provided

**9.65' NAVD**

By 1 gravity drainage well

# Surface Water Management

## Design Example 1

### SLR impacts to drainage system

Exfiltration trench lost 37.5% of capacity

- reduced pressure head
- reduced unsaturated depth
- reduced void space
- changes required use of conservative formula

Drainage well lost 34% of discharge capacity

- reduced pressure head on well
- at 342 GPM/foot head
  - Peak discharge reduced from 2011 GPM (4.48 CFS) to 1327 GPM (1.52 CFS)

# Surface Water Management

## Design Example 1

### SLR Scenario

WSWT: **3.5' NAVD**

WATER QUALITY VOLUME

Required: 0.08 acre-feet

Provided

0.05 acre-feet

**By 70 LF exfiltration trench**

100-YR, 3-DAY PRE-POST MAX

Required: 9.38' NAVD

Provided

9.65' NAVD

**By 1 gravity drainage well**

### SLR Adjusted Design

WSWT: **3.5' NAVD**

WATER QUALITY VOLUME

Required: 0.08 acre-feet

Provided

0.08 acre-feet

**By 110 LF exfiltration trench**

40 LF additional exfiltration trench

100-YR, 3-DAY PRE-POST MAX

Required: 9.38' NAVD

Provided

9.38' NAVD

**By 1 pumped drainage well**

Added pump to drainage well

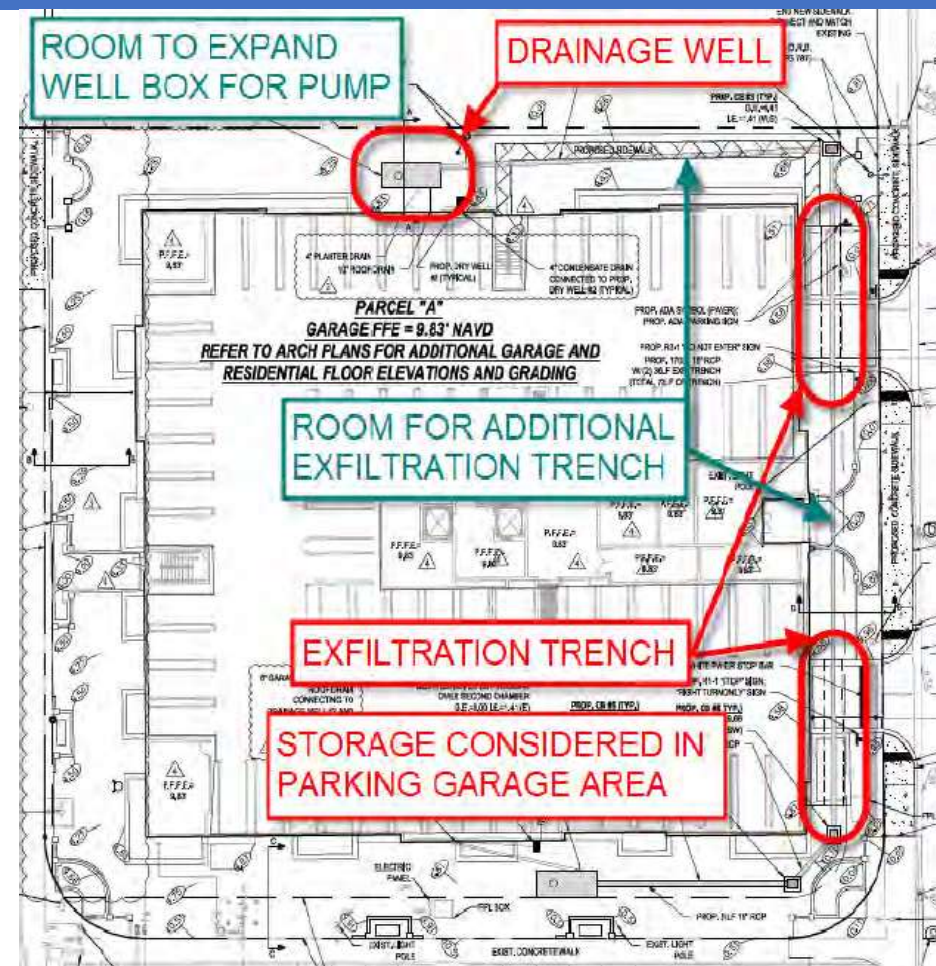


# Surface Water Management

## Design Example 1

## Changes

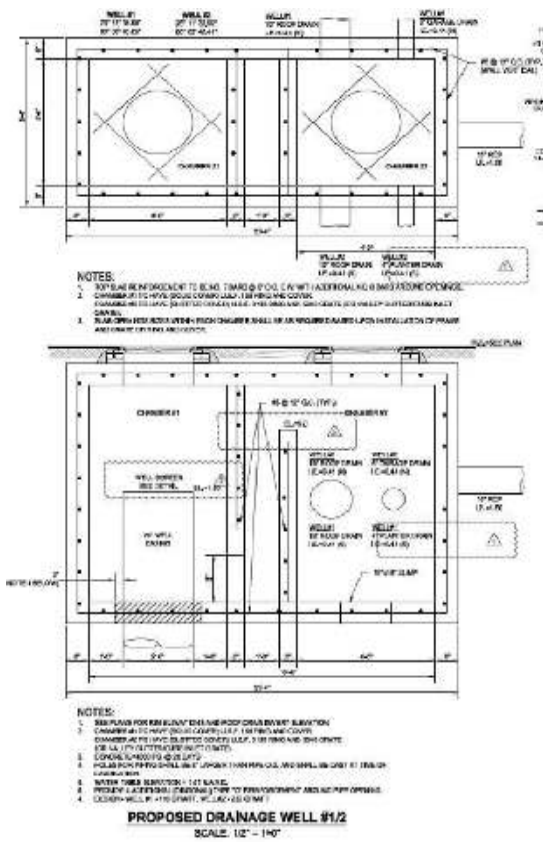
1. 40 LF additional exfiltration trench
  - Add now or retrofit
2. Pump on drainage well
  - Add now or retrofit



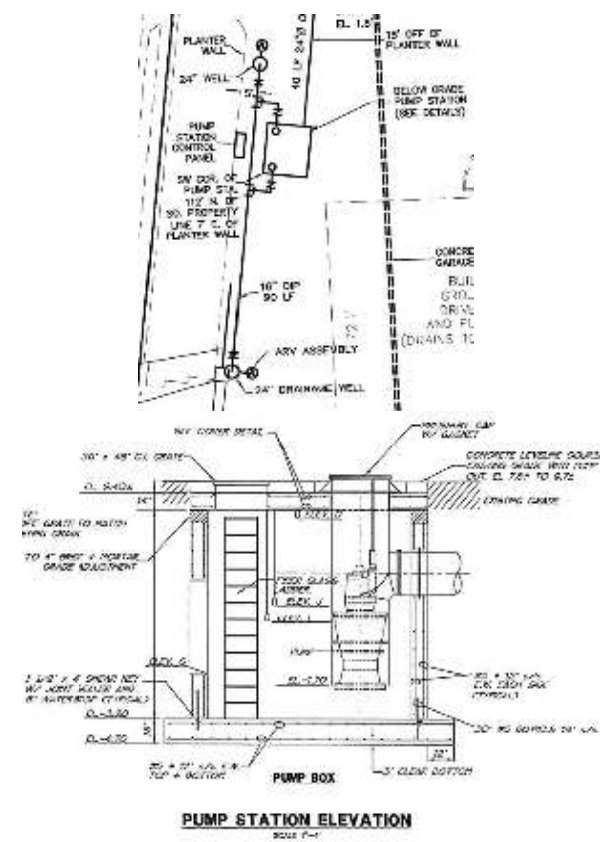
# Surface Water Management

## Design Example 1

Permitted Condition: Gravity Well



SLR Scenario: Change to Pumped Well



# **Surface Water Management**

## Design Example 2



# Surface Water Management

## Design Example 2

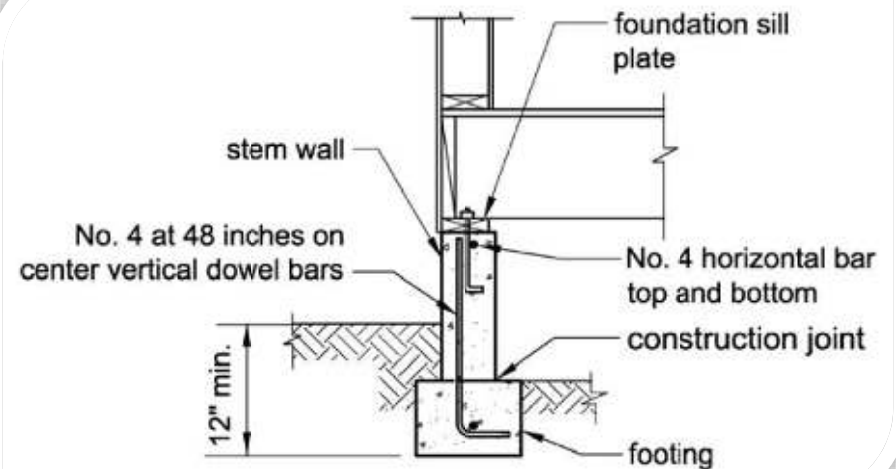


# Surface Water Management

## Design Example 2



Stem Wall Example



# Surface Water Management

## Design Example 2

### Permitted Conditions

WSWT: **0.5' NAVD**

WATER QUALITY VOLUME

Required: 0.05 acre-feet

Provided

0.05 acre-feet

By 871 ft<sup>2</sup> dry retention

25-YR, 3-DAY CONTAINMENT

Required: 2.55' NAVD perimeter

Provided

2.75' NAVD perimeter berm

### SLR Scenario

WSWT: **2.5' NAVD**

WATER QUALITY VOLUME

Required: 0.05 acre-feet

Provided

**0 acre-feet**

By inundated dry retention

25-YR, 3-DAY CONTAINMENT

Required: 3.82' NAVD perimeter

Provided

**Overtopped perimeter berm**

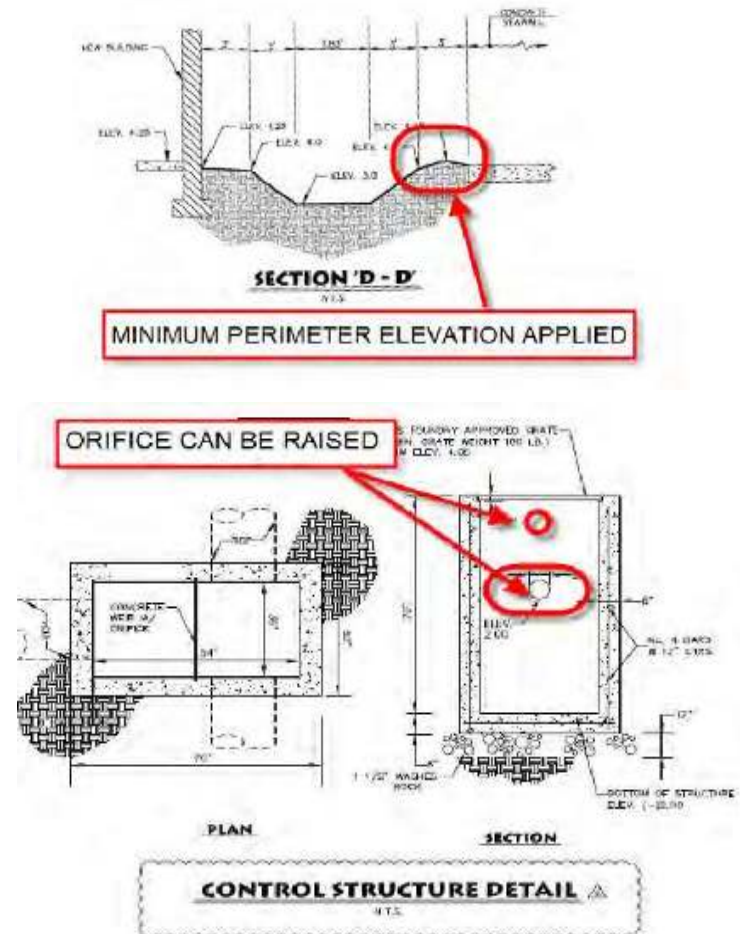


# Surface Water Management

## Design Example 2

### SLR impacts to drainage system

- Dry retention area completely inundated (elevations to the right are in NGVD)
- All soil storage capacity lost
- Perimeter berm no longer contains 25-yr, 3-day
- Offsite discharge though orifice becomes negligible due to submergence by higher tail water



# Surface Water Management

## Design Example 2

### SLR Scenario

WSWT: **2.5' NAVD**

WATER QUALITY VOLUME

Required: 0.05 acre-feet

Provided

0 acre-feet

**By inundated dry retention**

25-YR, 3-DAY CONTAINMENT

Required: 3.82' NAVD perimeter

Provided

**Overtopped perimeter berm**

### SLR Adjusted Design

WSWT: **2.5' NAVD**

WATER QUALITY VOLUME

Required: 0.05 acre-feet

Provided

0.05 acre-feet

**By 85 LF exfiltration trench**

85 LF exfiltration trench

25-YR, 3-DAY CONTAINMENT

**Required: 3.14' NAVD perimeter berm**

Provided

3.14' NAVD perimeter berm

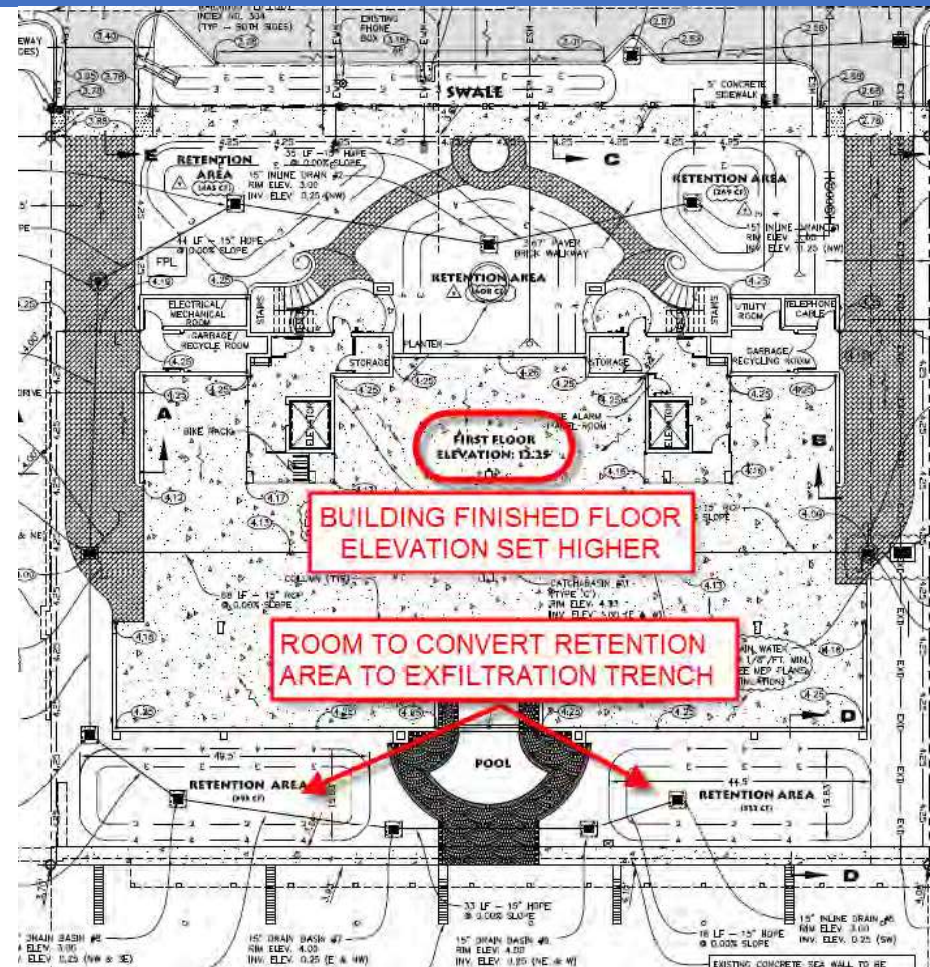
Raise berm and orifice

# Surface Water Management

## Design Example 2

### Changes

1. Portions of the retention area converted to 85 LF exfiltration trench.
2. Raise orifice 2 feet to match the higher water table
3. Raise the perimeter berm 5 inches to bring the 25-yr, 3-day into compliance.



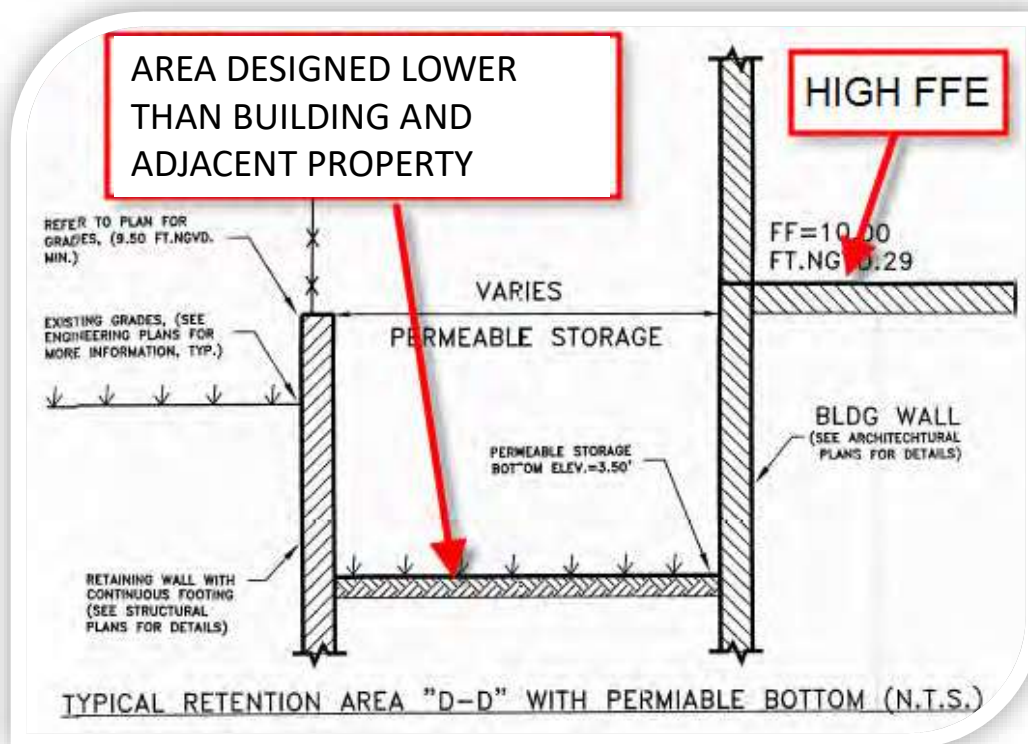


# **Surface Water Management**

## Design Example 3

# Surface Water Management

## Design Example 3



# Surface Water Management

## Design Example 3

### Permitted Conditions

WSWT: **2.5' NAVD**

WATER QUALITY VOLUME

Required: 0.16 acre-feet

Provided

**0.43 acre-feet**

By 357 LF exfiltration trench

100-YR, 3-DAY PRE-POST MAX

Required: 10.05' NAVD

Provided

**10.05' NAVD**

By exfiltration trench and  
surface storage

PARKING LOT (5-YR, 1-HR)

**Required: 6.95' NAVD**

Provided

**7.0' NAVD lowest inlet**

### SLR Scenario

WSWT: **4.5' NAVD**

WATER QUALITY VOLUME

Required: 0.16 acre-feet

Provided

**0.18 acre-feet**

By 357 LF exfiltration trench

100-YR, 3-DAY PRE-POST MAX

Required: 10.05' NAVD

Provided

**12.45' NAVD**

By exfiltration trench

PARKING LOT (5-YR, 1-HR)

**Required: 9.05' NAVD**

Provided

**7.0' NAVD lowest inlet**

Pre-post 100-yr not met.  
Building at 12.5' on stem walls

Parking lot flooded



# Surface Water Management

## Design Example 3

### SLR impacts to drainage system

- Exfiltration trench lost 58% of capacity
  - reduced pressure head
  - reduced unsaturated depth
  - reduced void space
  - changes required use of conservative formula
- Parking lot and other areas of the site inundated
- Failure to meet pre vs post 100-yr, 3-day indicates potential for the site to cause offsite flooding

# Surface Water Management

## Design Example 3

### SLR Scenario

WSWT: **4.5' NAVD**

WATER QUALITY VOLUME

Required: 0.16 acre-feet

Provided

0.18 acre-feet

By 357 LF exfiltration trench

100-YR, 3-DAY PRE-POST MAX

Required: 10.05' NAVD

Provided

12.45' NAVD

By exfiltration trench

PARKING LOT (5-YR, 1-HR)

Required: 9.05' NAVD

Provided

7.0' NAVD lowest inlet

### SLR Adjusted Design

WSWT: **4.5' NAVD**

WATER QUALITY VOLUME

Required: 0.16 acre-feet

Provided

0.18 acre-feet

By 357 LF exfiltration trench

100-YR, 3-DAY PRE-POST MAX

Required: 10.05' NAVD

Provided

**9.76' NAVD**

By drainage well

Add drainage well

PARKING LOT (5-YR, 1-HR)

**Required: 8.22' NAVD**

Provided

**9.0' NAVD lowest inlet**

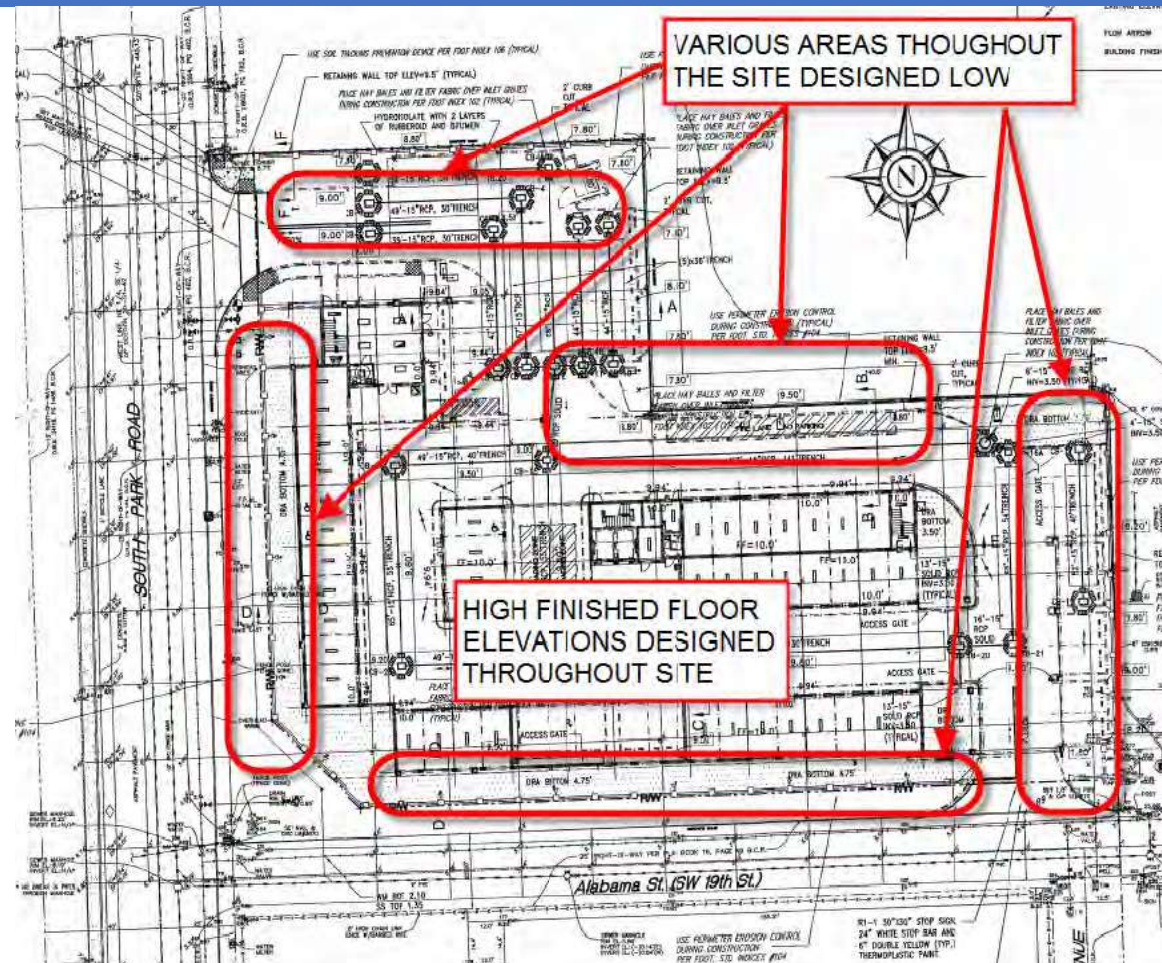
Raise parking lot and offset  
impacts with drainage well

# Surface Water Management Design Example 3

## Analysis

Building floor elevation initially set higher using stem walls to comply with SLR scenario

Exfiltration trench oversized to continue to provide H<sub>2</sub>O quality under SLR scenario





# Surface Water Management

## Design Example 3

### Analysis

Use of stem walls allows:

- areas around the building to be built low to provide surface storage in initial condition
- areas around the building to be raised in SLR scenario to counter the effects of inundation onsite
- Salt water intrusion associated with SLR may allow a drainage well to be used as far west as I-95
- Add drainage well when necessary
  - Offsets impacts of raising the parking lot 2' at SLR conditions even assuming conservative 250 GPM/ft-head

