Project Team:

For Florida Building Commission, BUILDING (STRUCTURAL) Technical Advisory Committee

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Research Professor, Earth & Environment

South Florida Hydrologic Society | August 14, 2019

FIU Institute of Water and Environment
FLORIDA INTERNATIONAL UNIVERSITY

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Project

Funding: Florida Department of Business and Professional Regulation

- **Florida Building Commission**

- **Task: Updating Existing Rainfall Maps**
- **Task: Development of average May-October groundwater level maps (used for evaluating flood risks) through groundwater modeling under future sea level rise scenarios**
- **Task: Evaluation of FBC-related requirements**

FIU Project Team

- **Dr. Jayantha Obeysekera, P.E., Lead PI**
  Director, Sea Level Solutions Center
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- **Martina Rogers**
  Doctoral Student

Outline

- Background
- Task: Update to rainfall extremes
- Task: Groundwater modeling & mapping
- Task: Recommended changes to FBC
- Discussion and feedback

Task: Update Existing Rainfall Maps

- **Evaluate most recent rainfall data and studies available from SFWMD, NOAA, and other agencies (e.g., Miami-Dade County) to develop 100-year rainfall for durations from 1 hour to 3 days. Spatial maps of rainfall produced.**
- **Use extreme value analysis methods to determine design rainfall magnitudes for 100-year return period for various durations. Resulting values mapped across Miami-Dade County using appropriate spatial interpolation methods to produce rainfall loading maps. For further validation, compare with published data from SFWMD and NOAA.**

Task: Update Existing Rainfall Maps

- **Projected future (2050-2079) changes in extreme rainfall:**
  - ✓ **Projected future daily precipitation from University of California (San Diego) Localized Constructed Analogs (LOCA) product, which employed statistical downscaling techniques to spatially downscale and bias-correct CMIP5 global climate model output**
  - **At-site regional frequency analysis used to fit DDF curves to historical data at 12 daily and 14 hourly stations (last 20-30 years up to 2005), LOCA retrospective data (same years as historical data at each station), LOCA projected rainfall (2050-2079)**
  - **Multiplicative Quantile Delta Mapping method used for bias-correction**
  - **Quantile Mapping used for temporal downscaling to sub-daily durations**

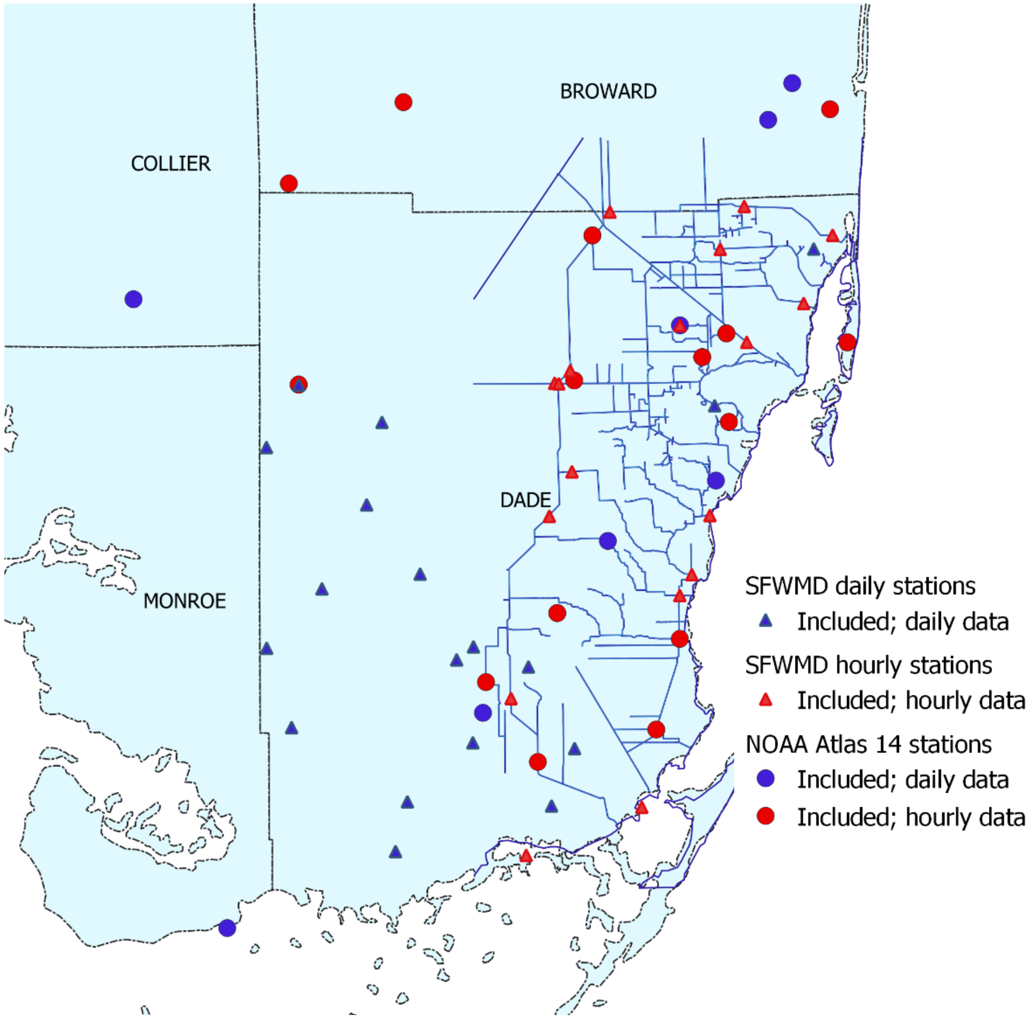
Task: Update Existing Rainfall Maps

- Datasets evaluated:
  - ✓ Annual maximum series of precipitation from NOAA Atlas 14 Volume 9 for durations from 5 minutes to 60 days
  - ✓ Daily and hourly data from South Florida Water Management District (SFWMD)'s DBHydro database
  - Miami-Dade County rainfall data from Miami-Dade Water and Sewer Department (WASD)
  - Florida State University's COAPS rainfall data
  - University of Florida's IFAS FAWN rainfall data
  - GROWER network rainfall data from IFAS

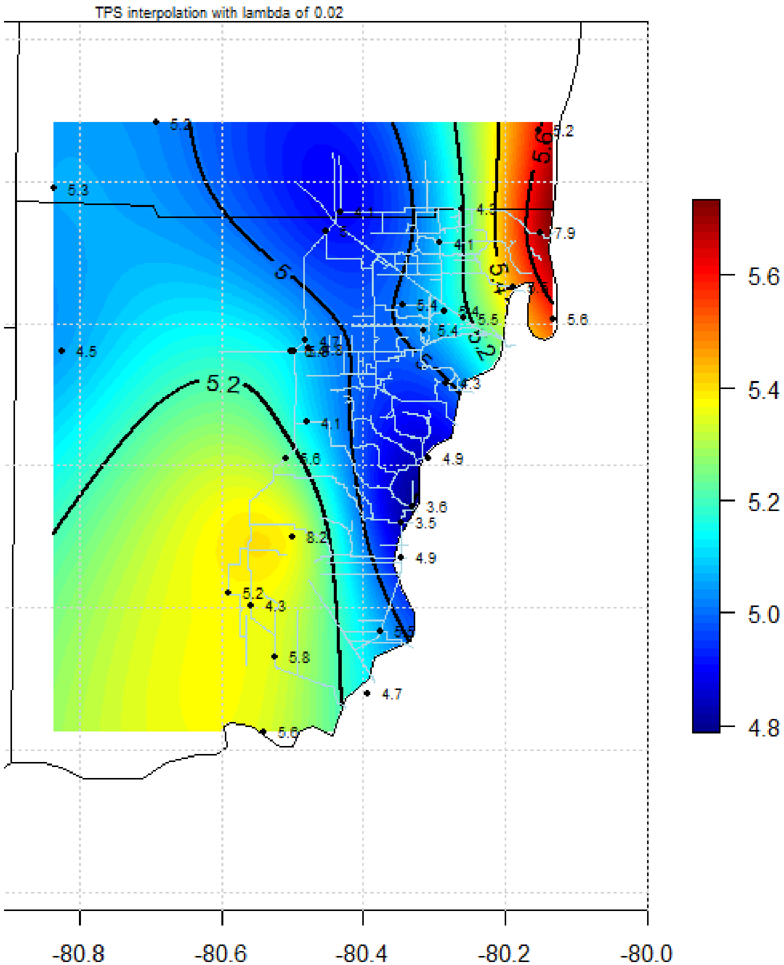
Rainfall Stations in Miami-Dade County

33 hourly and 26 daily stations with at least 20-30 years (most recent up to 2018) of valid annual maximum rainfall for duration of interest

At-site regional frequency analysis method used to fit consistent Depth-Duration-Frequency (DDF) curves to historical data



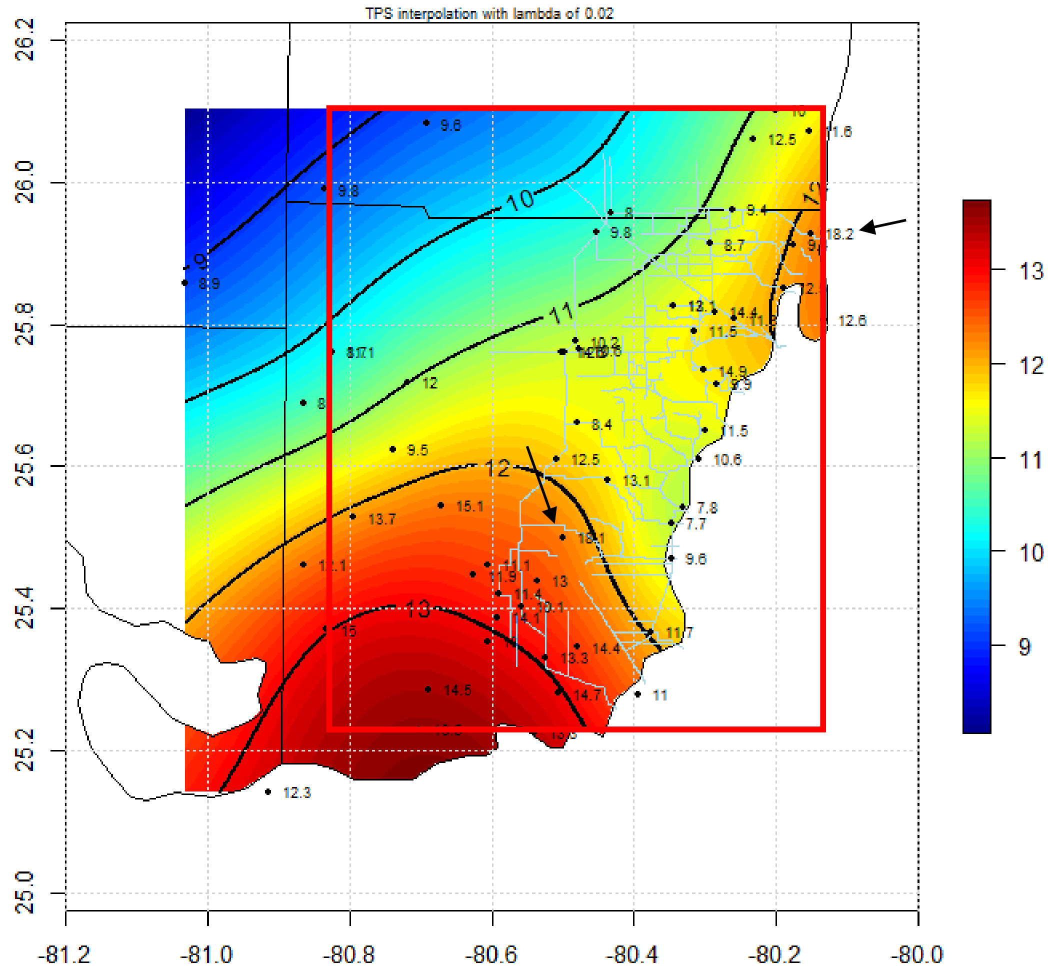
100-year hourly rainfall totals based on historical data



Individual station values: 3.5-8.2 in

Generalized surface (TPS): 4.8-5.7 in

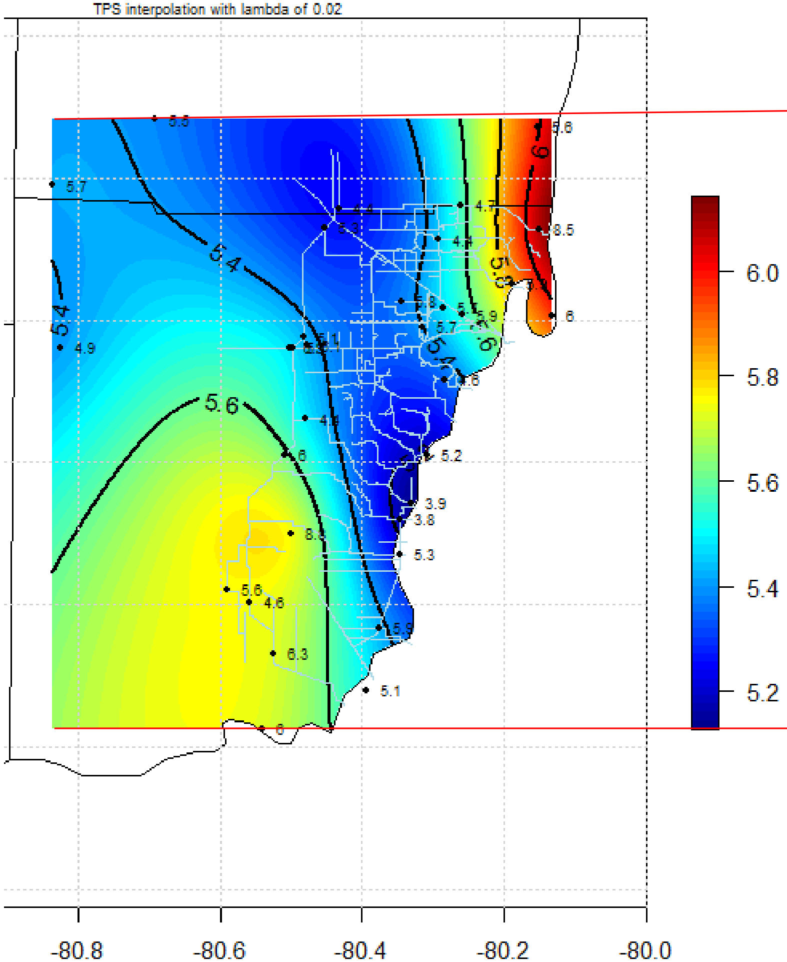
100-year daily rainfall totals based on historical data



Individual station values: 7.7-18.2 in

Generalized surface (TPS): 8.1-13.7 in

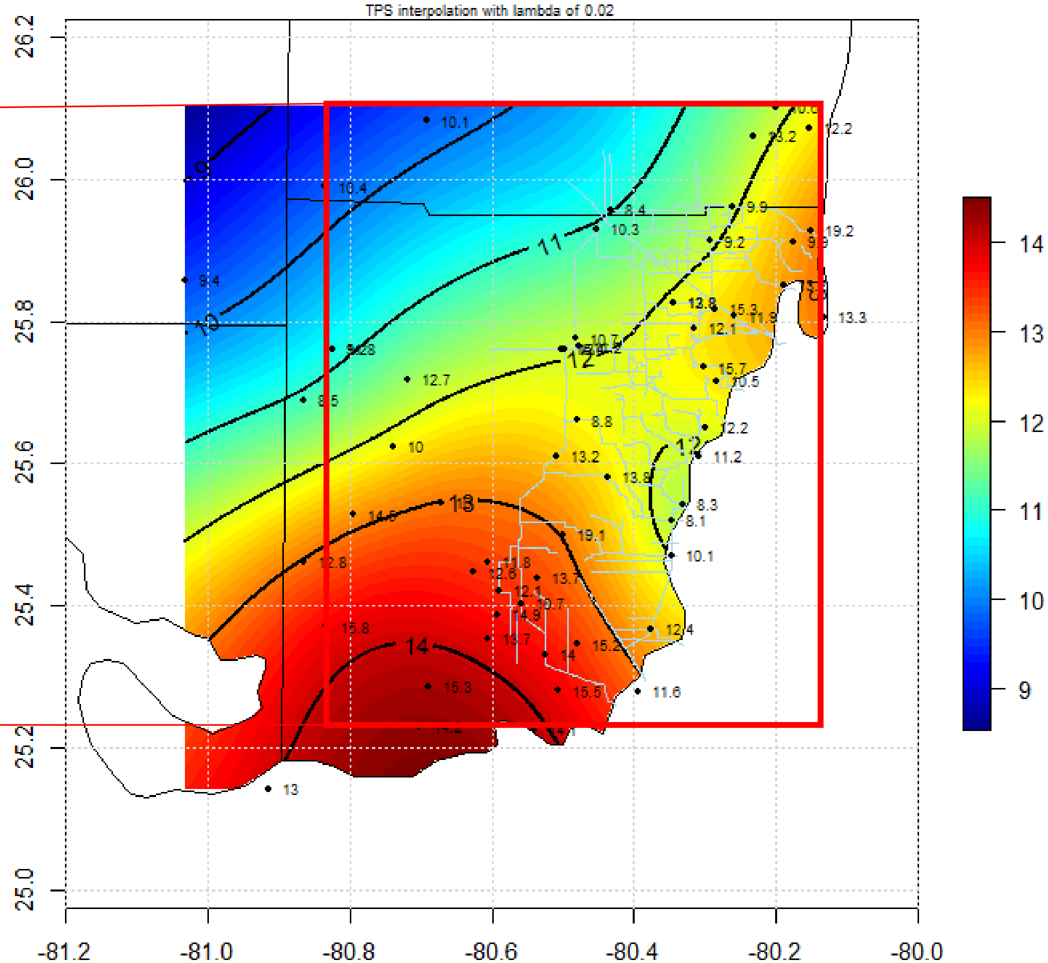
100-year hourly rainfall totals adjusted by median future change from LOCA (+7.1%)



Individual station values: 3.7-8.8 in

Generalized surface (TPS): 5.1-6.1 in

100-year daily rainfall totals adjusted by median future change from LOCA (+5.7%)

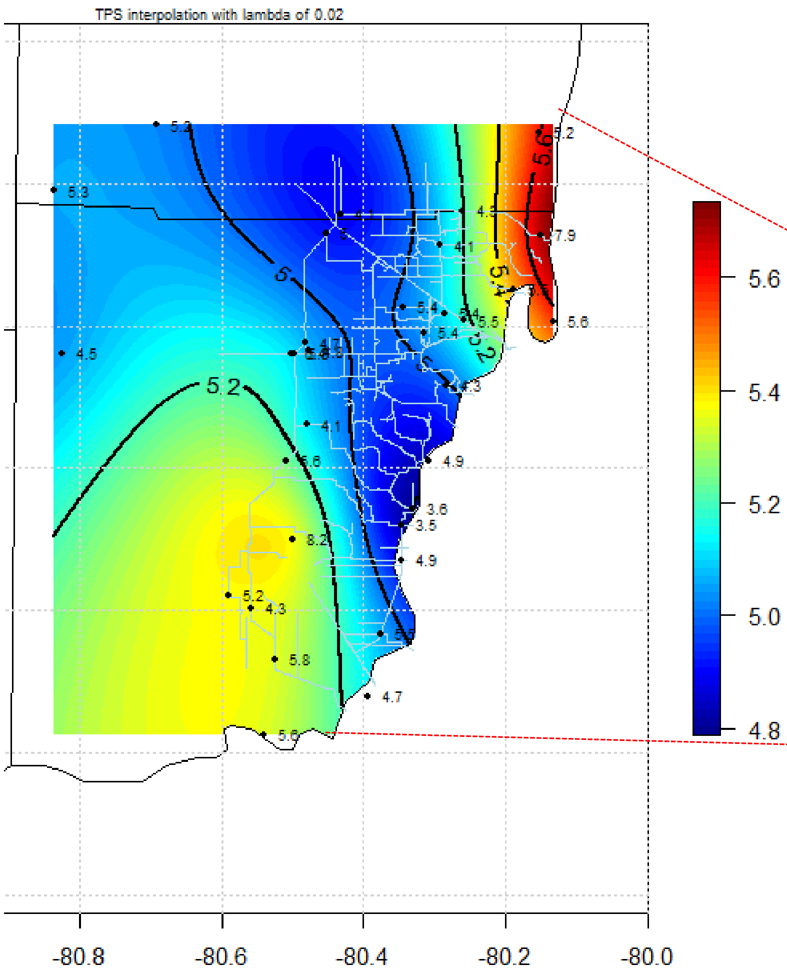


Individual station values: 8.1-19.2 in

Generalized surface (TPS): 8.6-14.5 in

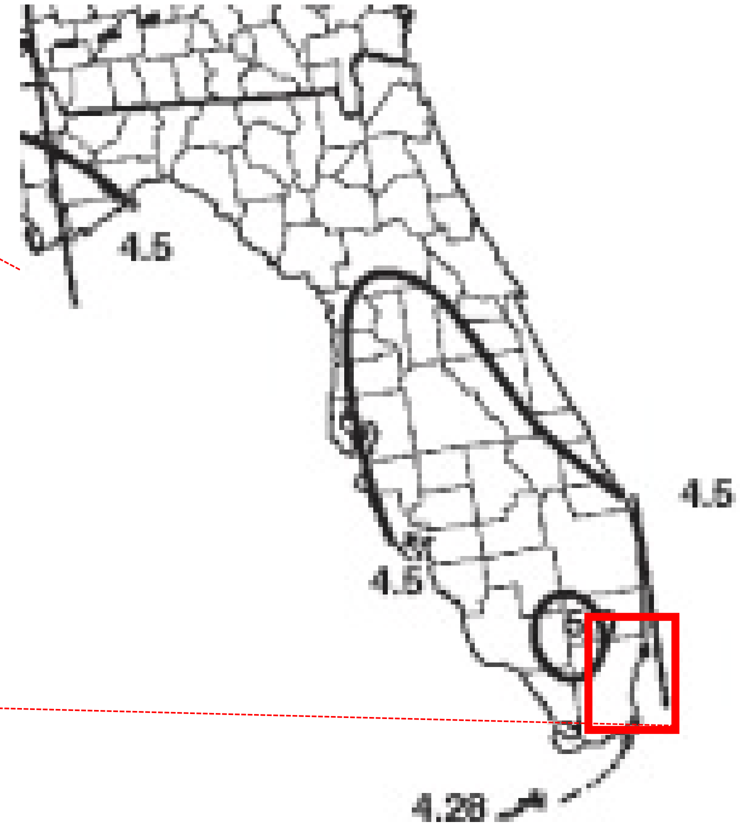
Comparison to Existing Rainfall Maps

100-year hourly rainfall totals



Individual station values: 3.5-8.2 in
Generalized surface (TPS): 4.8-5.7 in

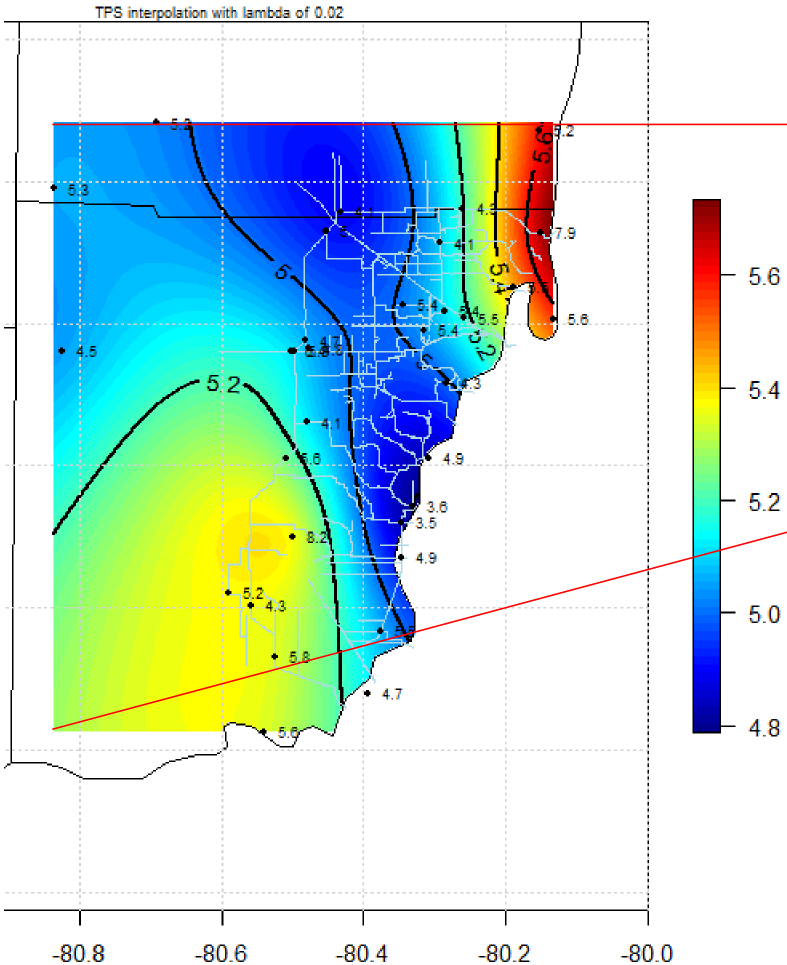
100-year hourly rainfall totals from FIGURE 1106.1 FBC



Source: National Weather Service, National Oceanic and Atmospheric Administration, Washington D.C

Comparison to Existing Rainfall Maps

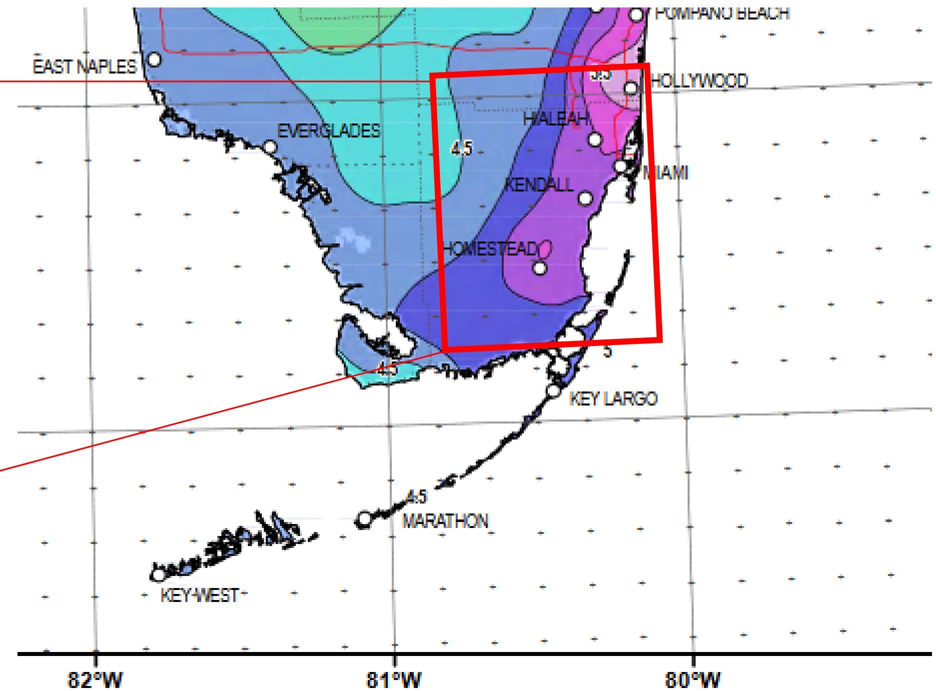
100-year hourly rainfall totals



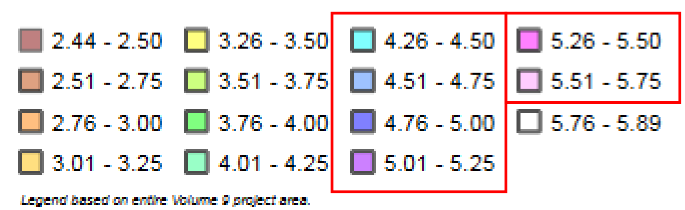
Individual station values: 3.5-8.2 in

Generalized surface (TPS): 4.8-5.7 in

100-year hourly rainfall totals from NOAA Atlas 14 Volume 9

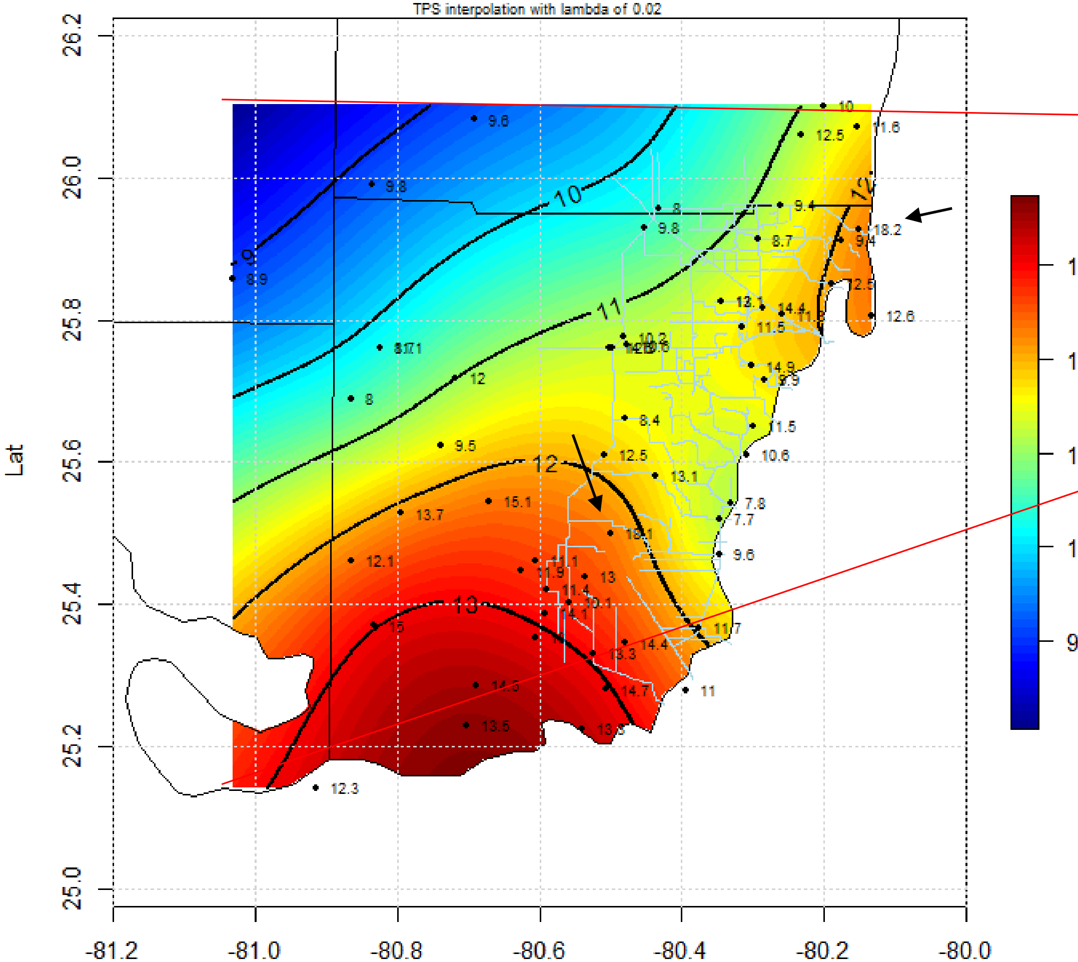


Source: ftp://hdsc.nws.noaa.gov/pub/hdsc/data/se/fl100y60m.pdf



Comparison to Existing Rainfall Maps

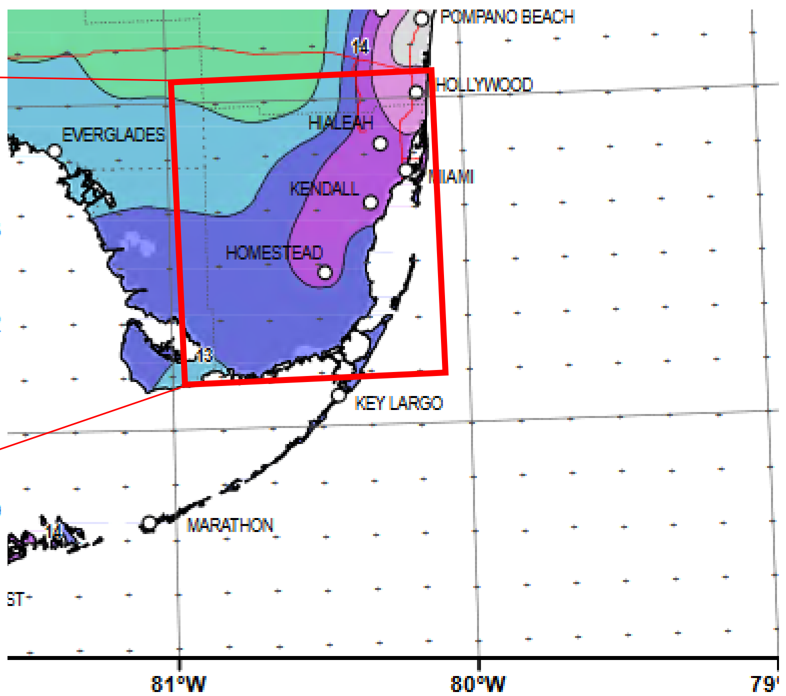
100-year daily rainfall totals



Individual station values: 7.7-18.2 in

Generalized surface (TPS): 8.1-13.7 in

100-year daily rainfall totals from NOAA Atlas 14 Volume 9



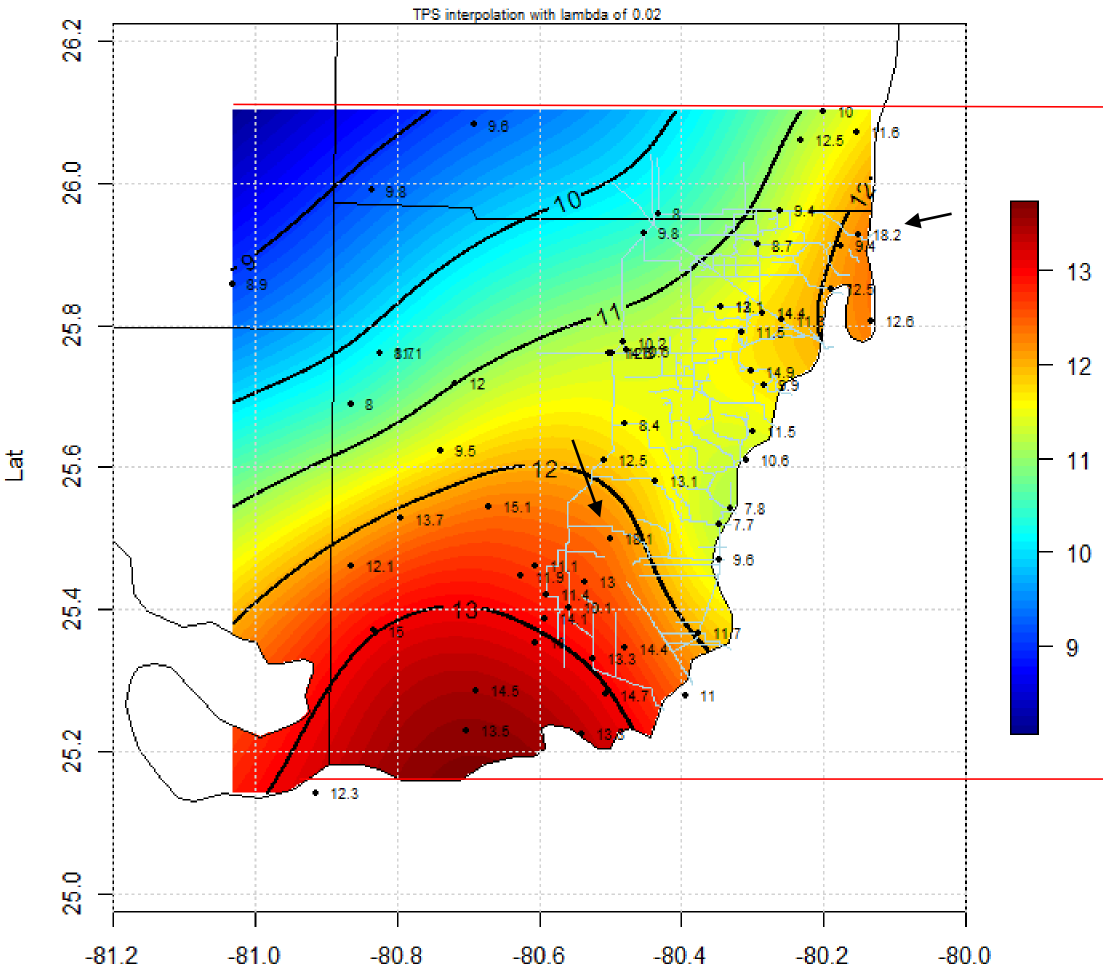
Source:
ftp://hdsc.nws.noaa.gov/pub/hdsc/data/se/fl100y24h.pdf

6.60 - 7.00
7.01 - 8.00
8.01 - 9.00
9.01 - 10.00
10.01 - 11.00
11.01 - 12.00
12.01 - 13.00
13.01 - 14.00
14.01 - 15.00
15.01 - 16.00
16.01 - 16.98

Legend based on entire Volume 9 project area.

Comparison to Existing Rainfall Maps

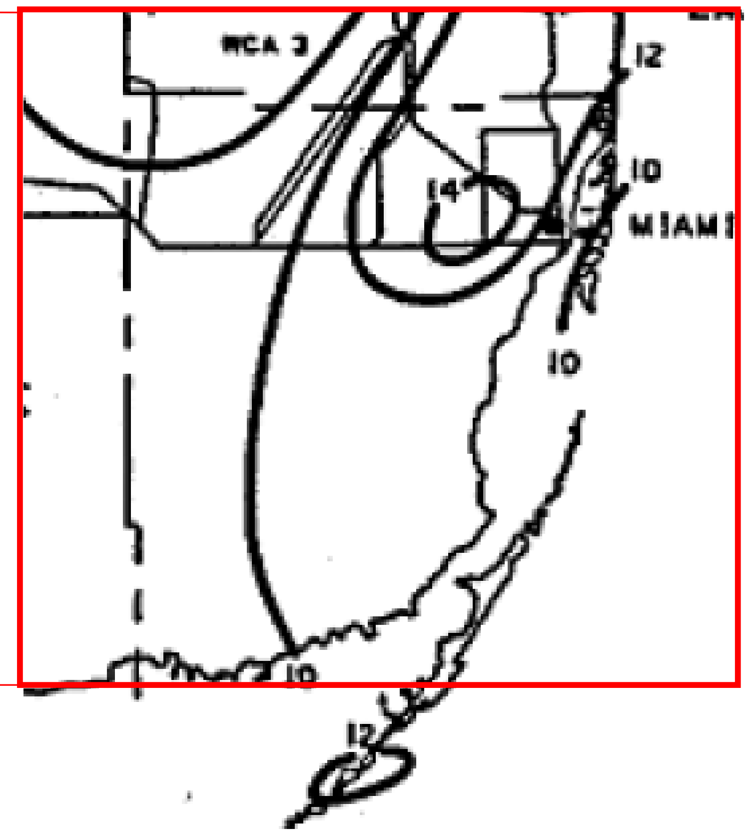
100-year daily rainfall totals



Individual station values: 7.7-18.2 in

Generalized surface (TPS): 8.1-13.7 in

100-year daily rainfall totals from SFWMD



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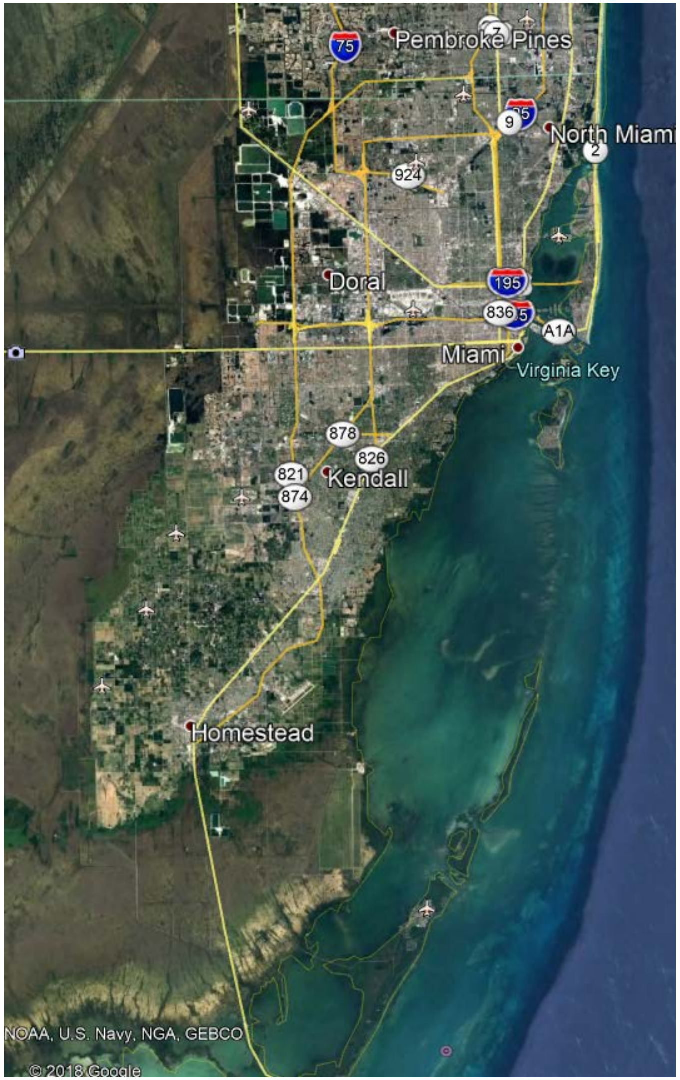
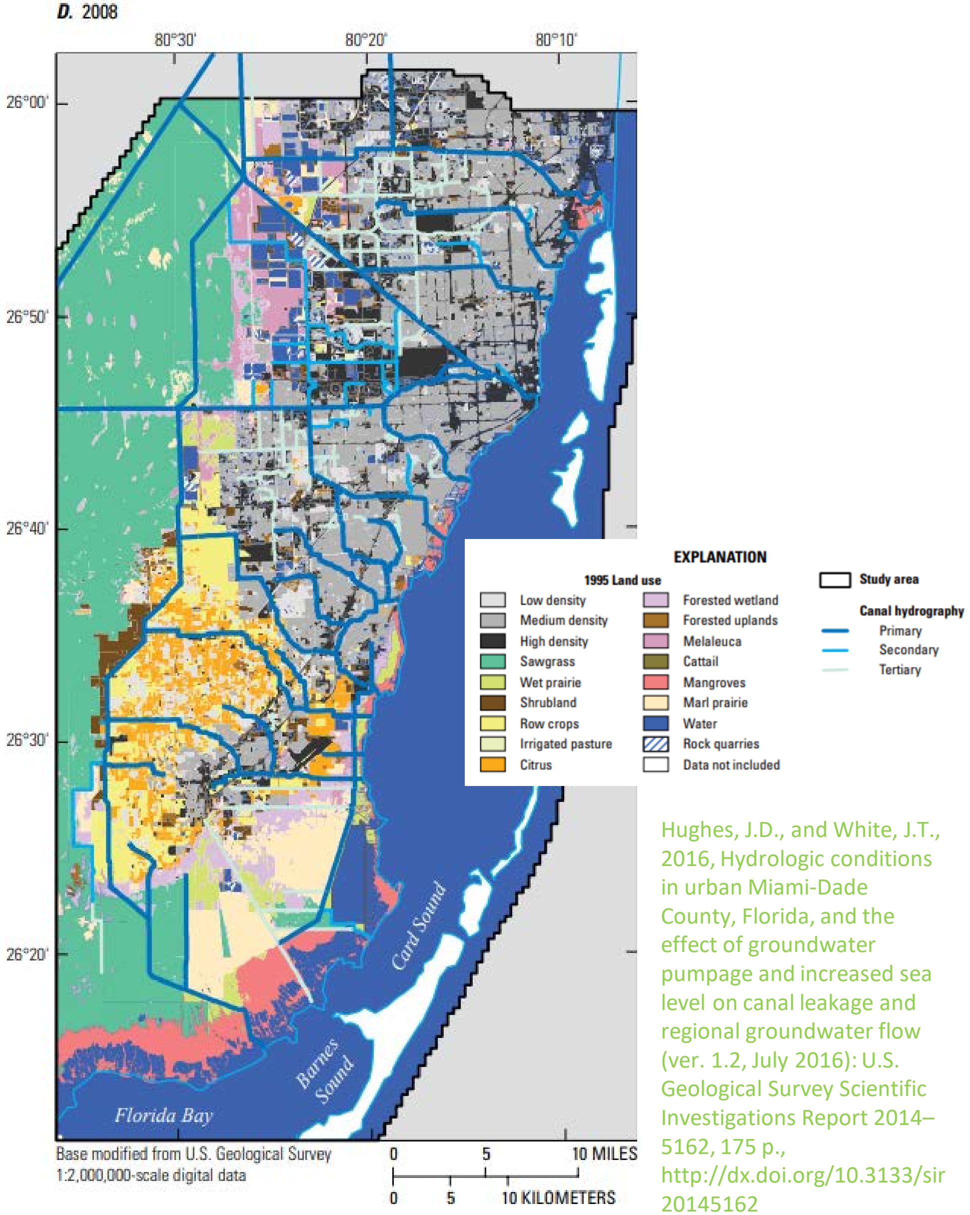
Task: Develop average wet-season groundwater level maps under future sea level rise scenarios

- **Extend USGS groundwater model to create future wet-season (May through October) GIS maps of water-table elevation**
- **Simulate 2060-2069 with current rainfall, future rainfall scenarios, and Unified Sea Level Rise Projections from Southeast Florida Regional Climate Change Compact**

Task: Develop average wet-season groundwater level maps under future sea level rise scenarios

- Two 2060-2069 scenario runs and three sensitivity runs use common assumptions:
  - 2030 land use and DCIA, 2018 permitted quarry lakes, calibrated crop coefficients
  - 2010 septic return flow from USGS scenarios
  - Western boundary water levels in Water Conservation Area 3 and Eastern Everglades National Park from CERP0 SFWMM run
  - Surface water network, structures, and effective gate openings same as USGS 1996-2010 calibration/verification
- Assumptions varied between runs:
  - Future ocean tidal levels shifted along one of two sea level curves – USACE High and IPCC AR5 RCP8.5 Median
  - Future vs. historical potential rainfall and RET patterns
  - No pumpage vs. pumpage based on 2030-2040 projections from USGS Scenario 1

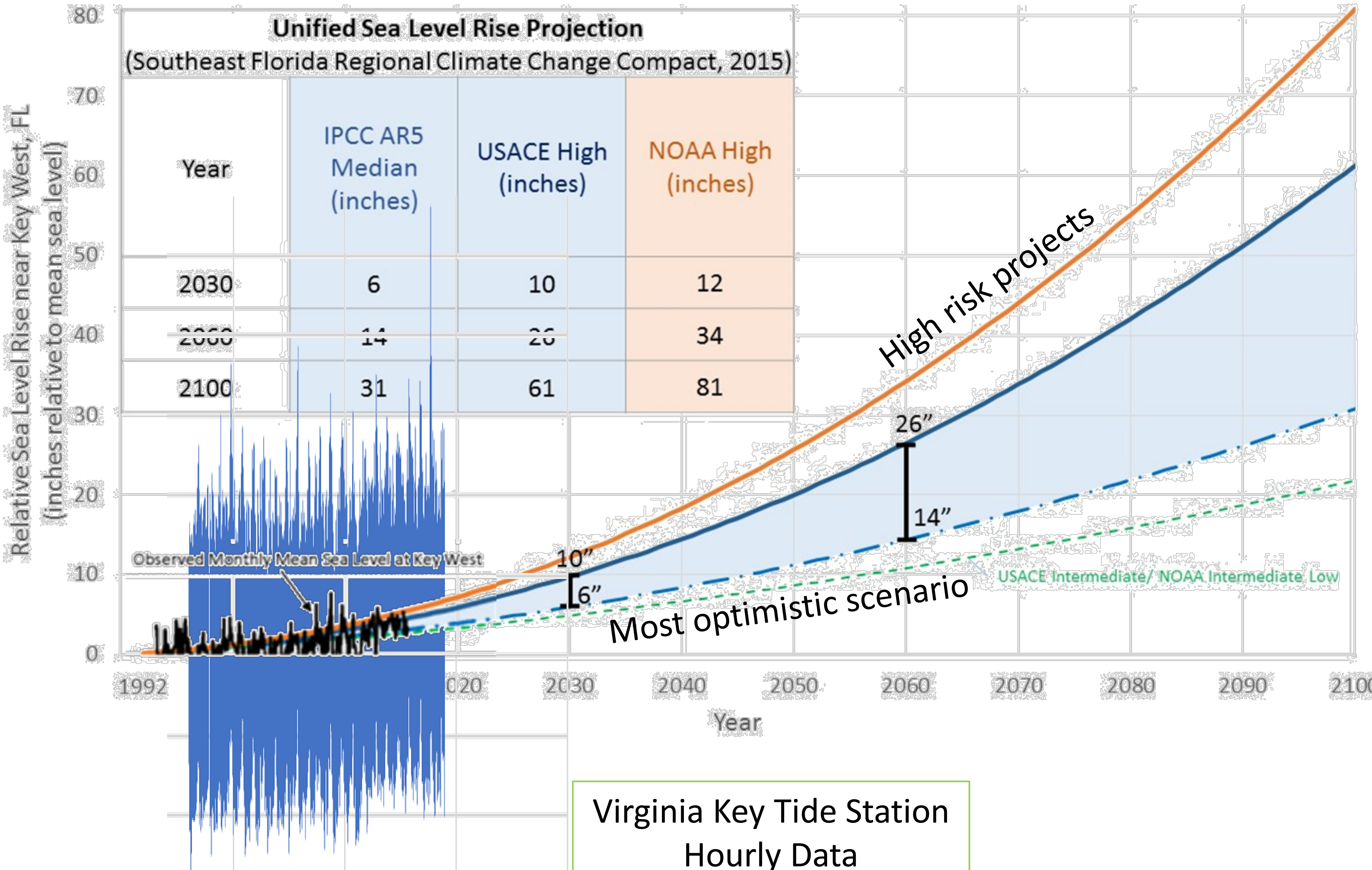




Hughes, J.D., and White, J.T., 2016, Hydrologic conditions in urban Miami-Dade County, Florida, and the effect of groundwater pumpage and increased sea level on canal leakage and regional groundwater flow (ver. 1.2, July 2016): U.S. Geological Survey Scientific Investigations Report 2014–5162, 175 p., http://dx.doi.org/10.3133/sir20145162

Unified Sea Level Rise Projection
(Southeast Florida Regional Climate Change Compact, 2015)

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



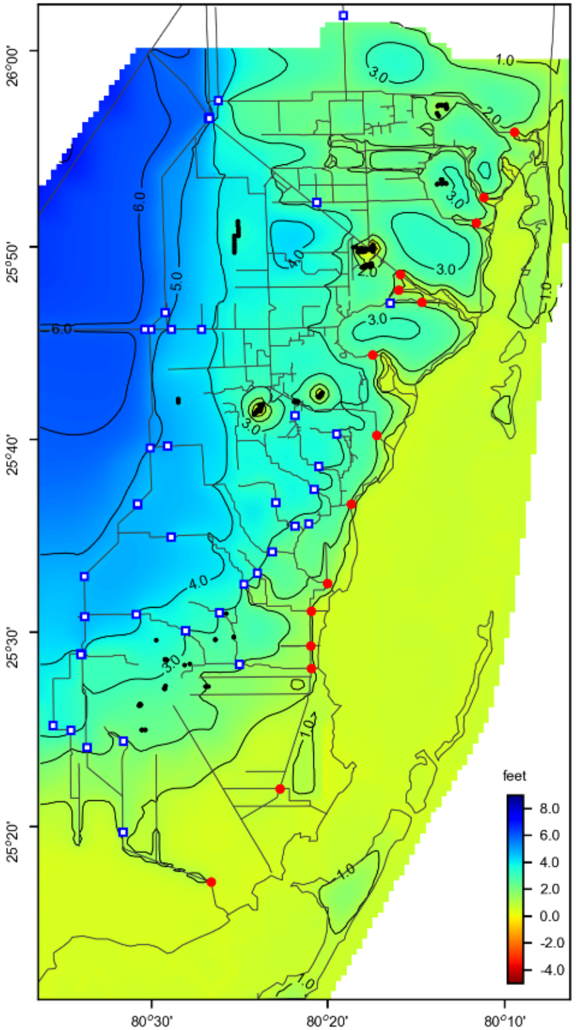
Virginia Key Tide Station Hourly Data

Assumptions for main scenario runs (1 and 2) and sensitivity runs (3-5)

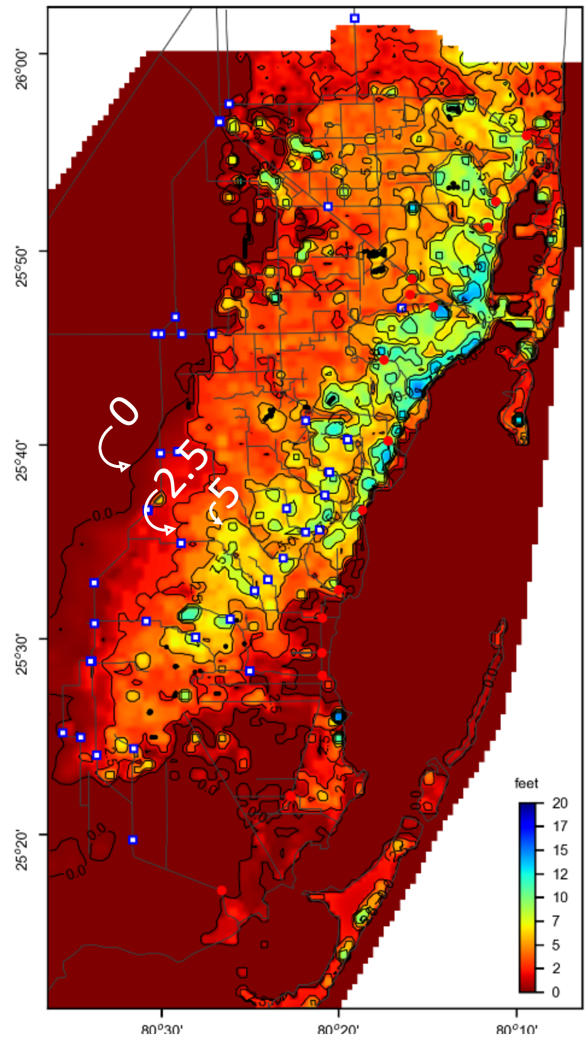
Run short-name	(1) LOW SLR	(2) HIGH SLR	(3) HIGH SLR + NO PUMPAGE	(4) LOW SLR + HIST RAIN/RET	(5) HIGH SLR + HIST RAIN/RET
Rainfall and recharge					
Bias-corrected LOCA rainfall for 2055-2069 (no correction factor applied)					
1996-2010 NEXRAD rainfall with 1.05 correction factor					
Reference evapotranspiration (RET)					
1996-2010 RET from the USGS with 1.05 adjustment factor due to future temperature increase					
1996-2010 RET from the USGS					
PWS pumpage					
No pumpage					
Future Pumpage as in USGS Scen. 1 for 2030-2040					
Tidal boundary condition					
Predicted sea levels for 2055-2069 + SLR from IPCC AR5 RCP8.5 median curve					
Predicted sea levels for 2055-2069 + SLR from USACE High curve					

Average wet season heads (ft NAVD88) (left) and average wet season depth to water table (ft) (right) for Low SLR scenario

Wet season average heads (ft NAVD88) LOW SLR (2060-2069)



Wet season average depth to water table (ft) LOW SLR (2060-2069)



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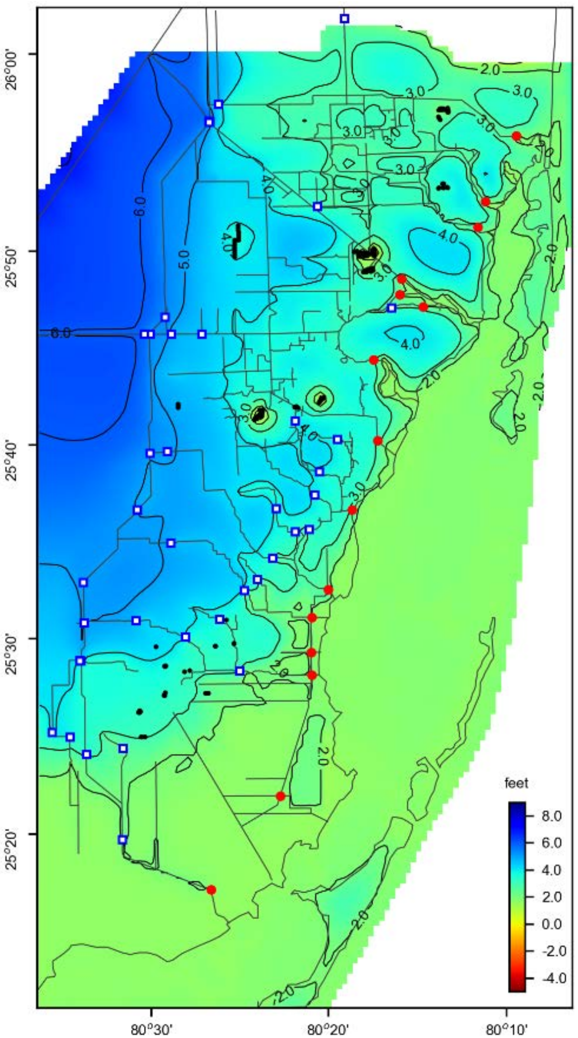
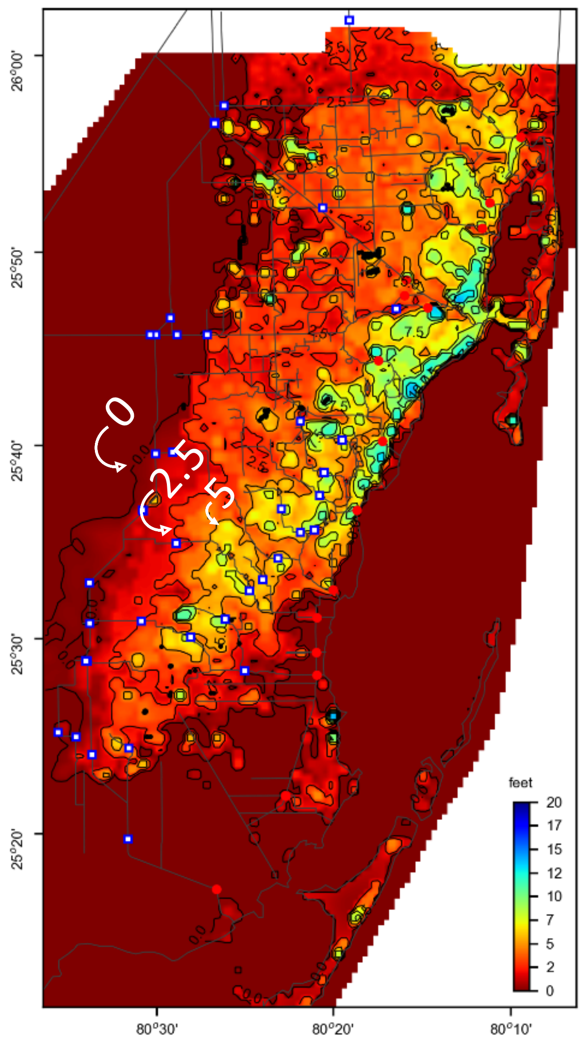
Average wet season heads (ft NAVD88) (left) and average wet season depth to water table (ft) (right) for HIGH SLR scenario

Wet season average heads (ft NAVD88) HIGH SLR (2060-2069)

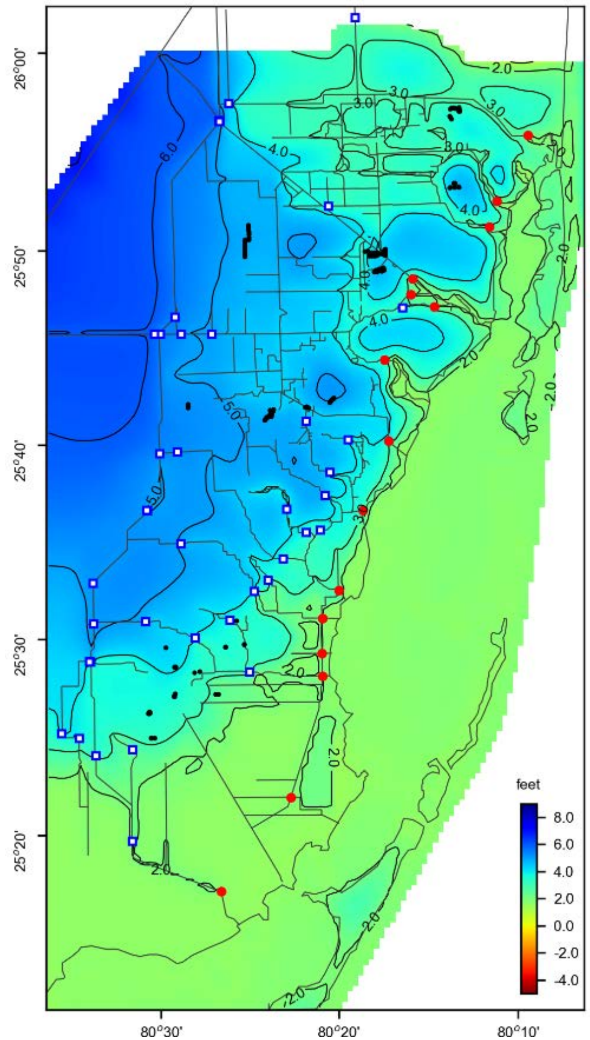


Wet season average depth to water table (ft) HIGH SLR (2060-2069)

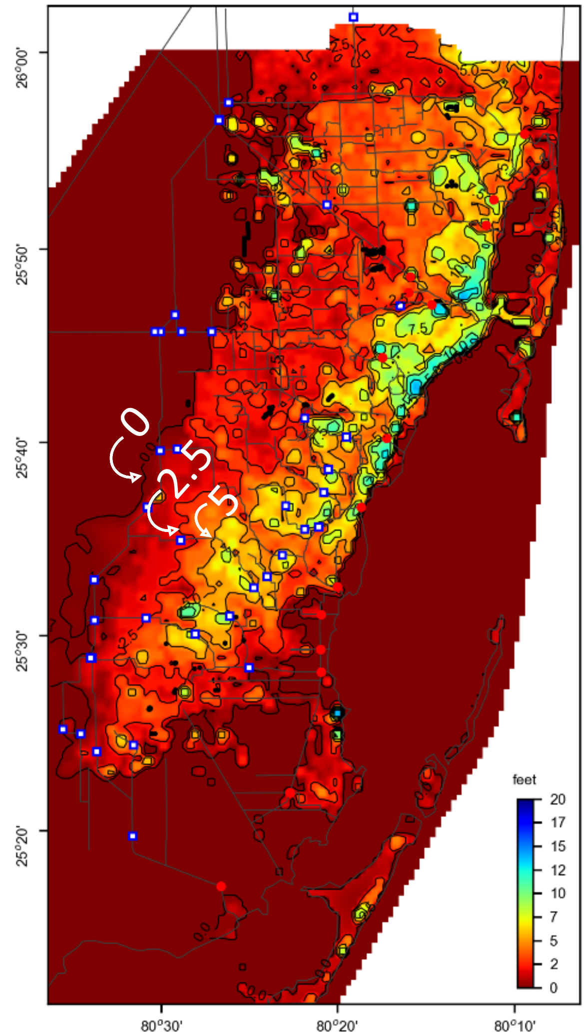


Average wet season heads (ft NAVD88) (left) and average wet season depth to water table (ft) (right) for HIGH SLR + NO PUMPAGE sensitivity run

Wet season average heads (ft NAVD88) HIGH SLR + NO PUMPAGE (2060-2069)



Wet season average depth to water table (ft) HIGH SLR + NO PUMPAGE (2060-2069)



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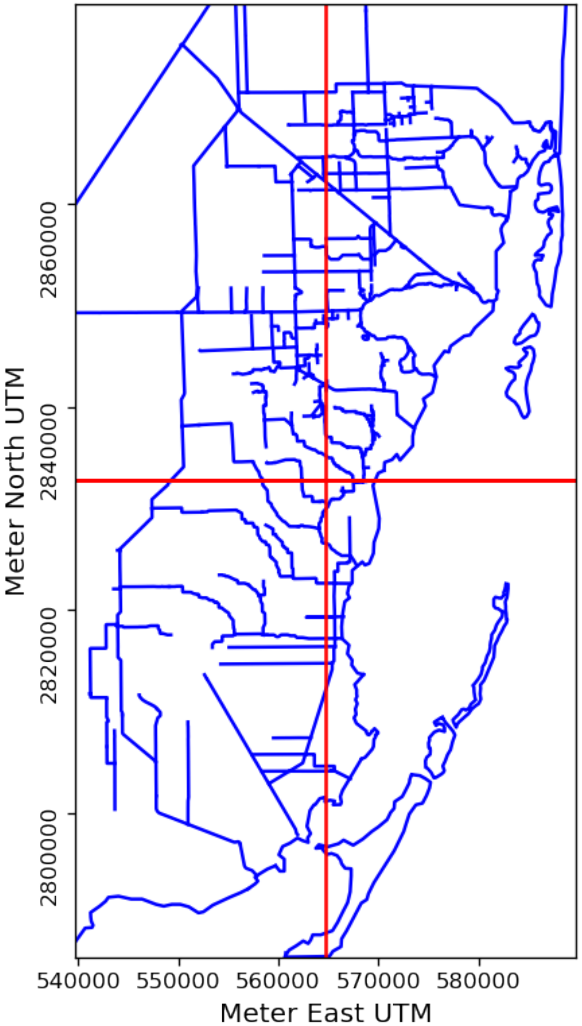
Cross-sections



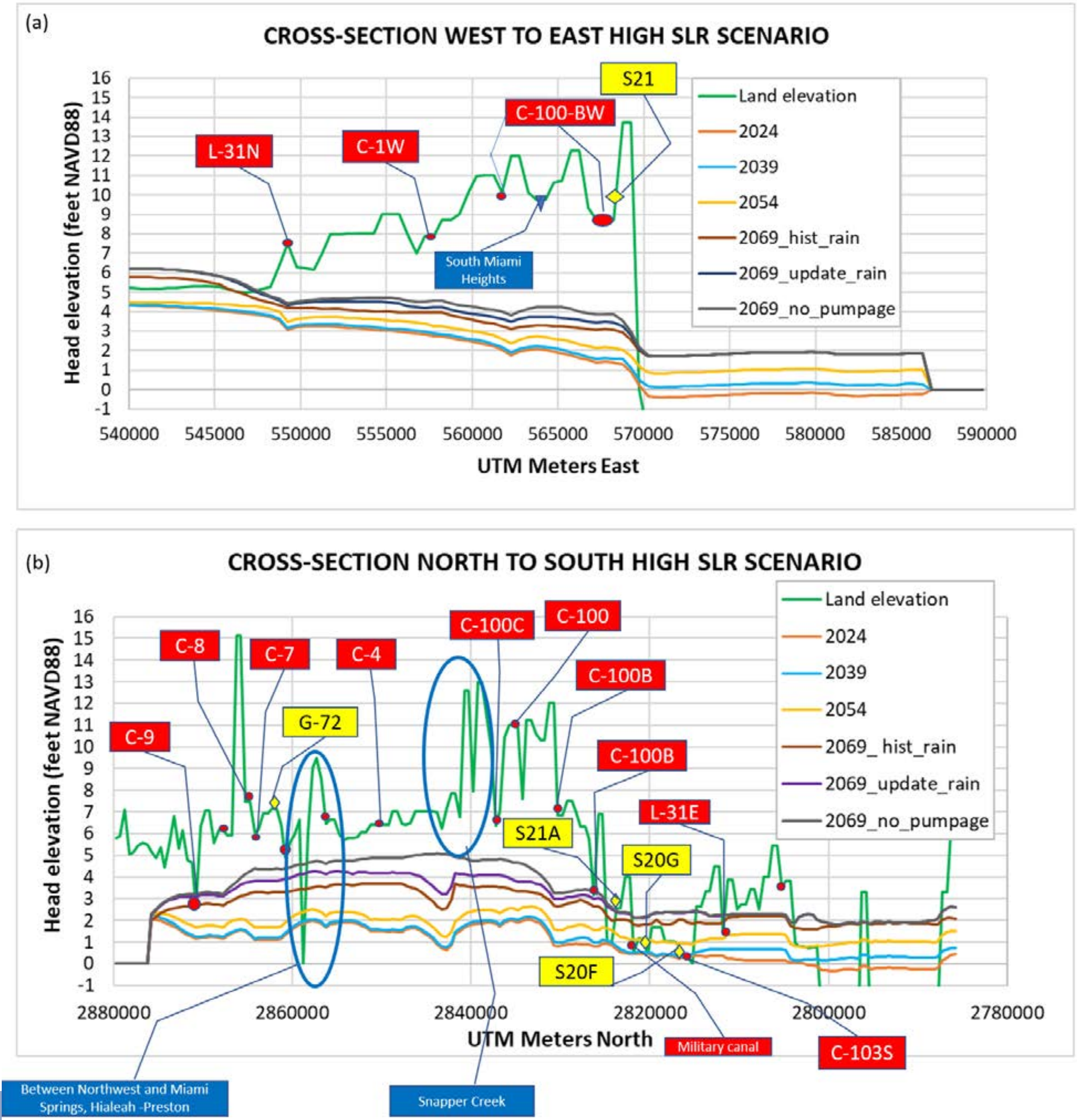
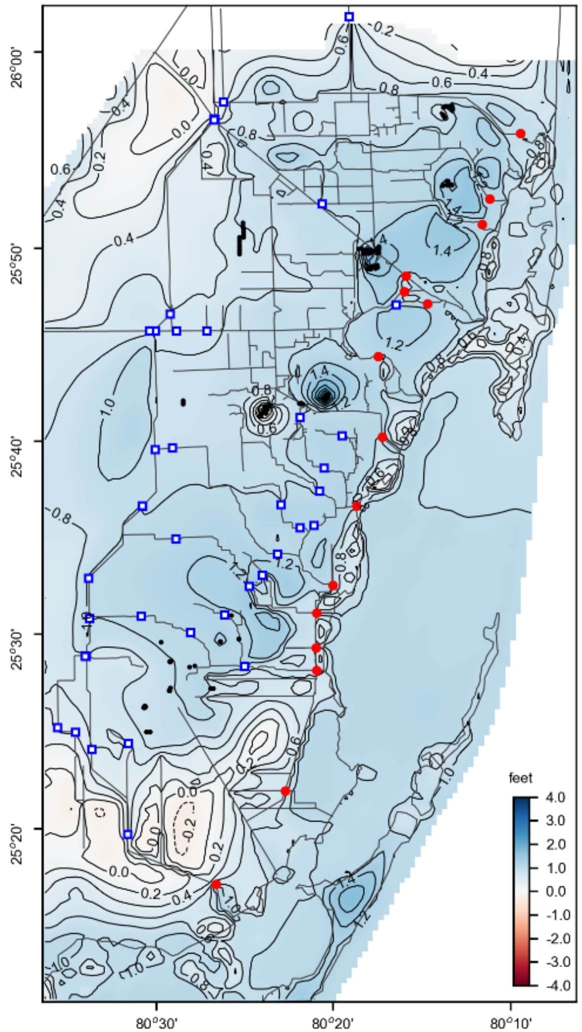


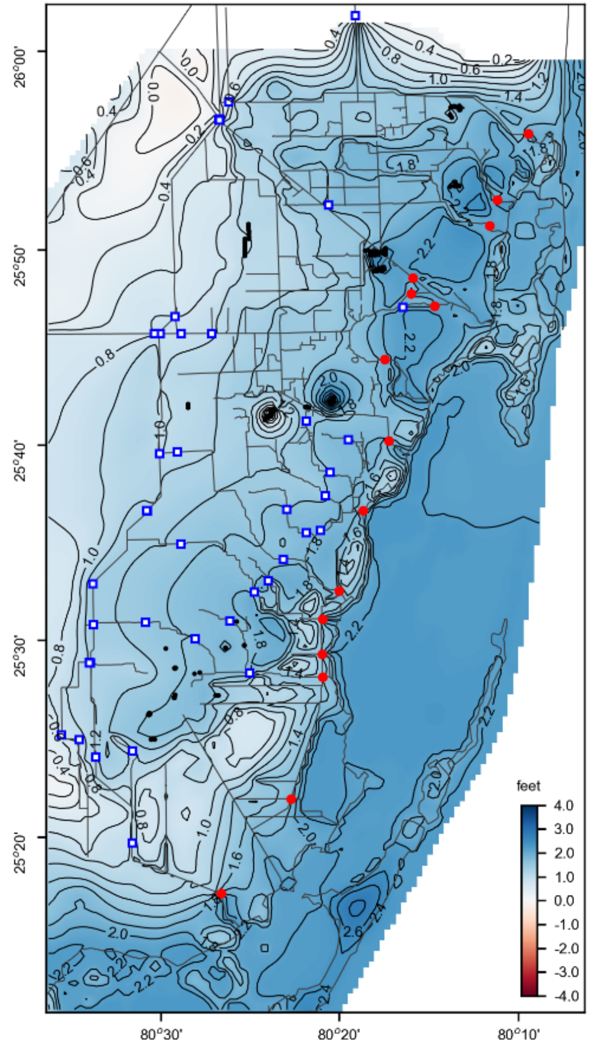
Illustration of GIS Result Retrieval

Difference in average wet season heads (ft) for LOW SLR (left) and HIGH SLR scenario (right)

Difference in wet season average heads (ft)
LOW SLR - CALIBRATION



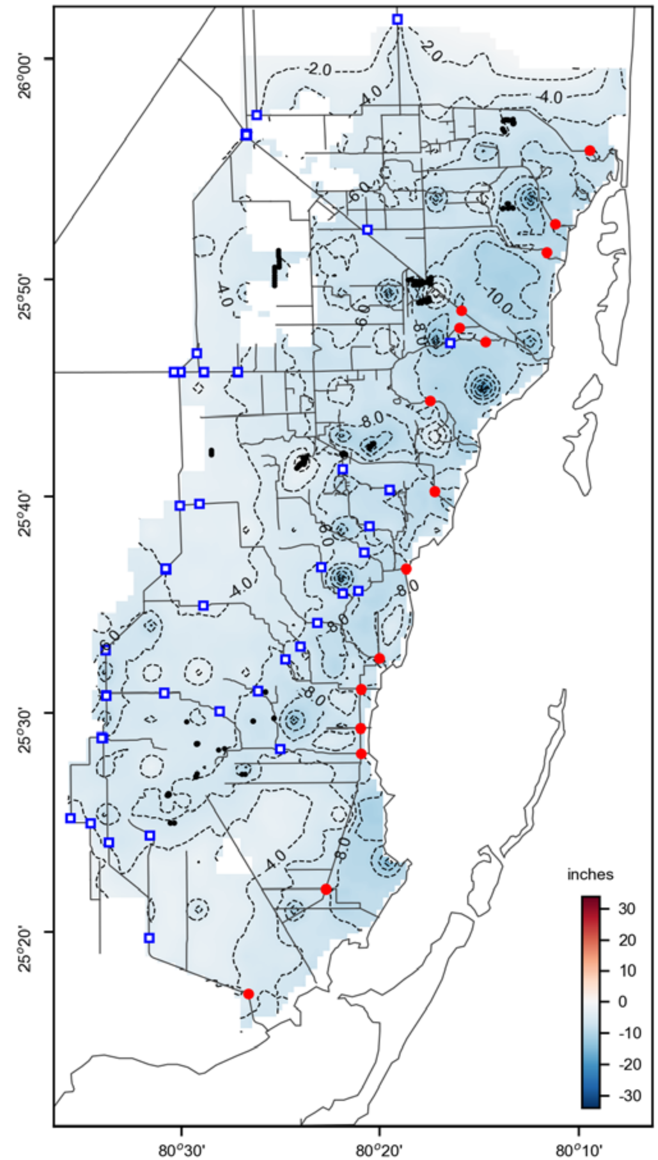
Difference in wet season average heads (ft)
HIGH SLR - CALIBRATION



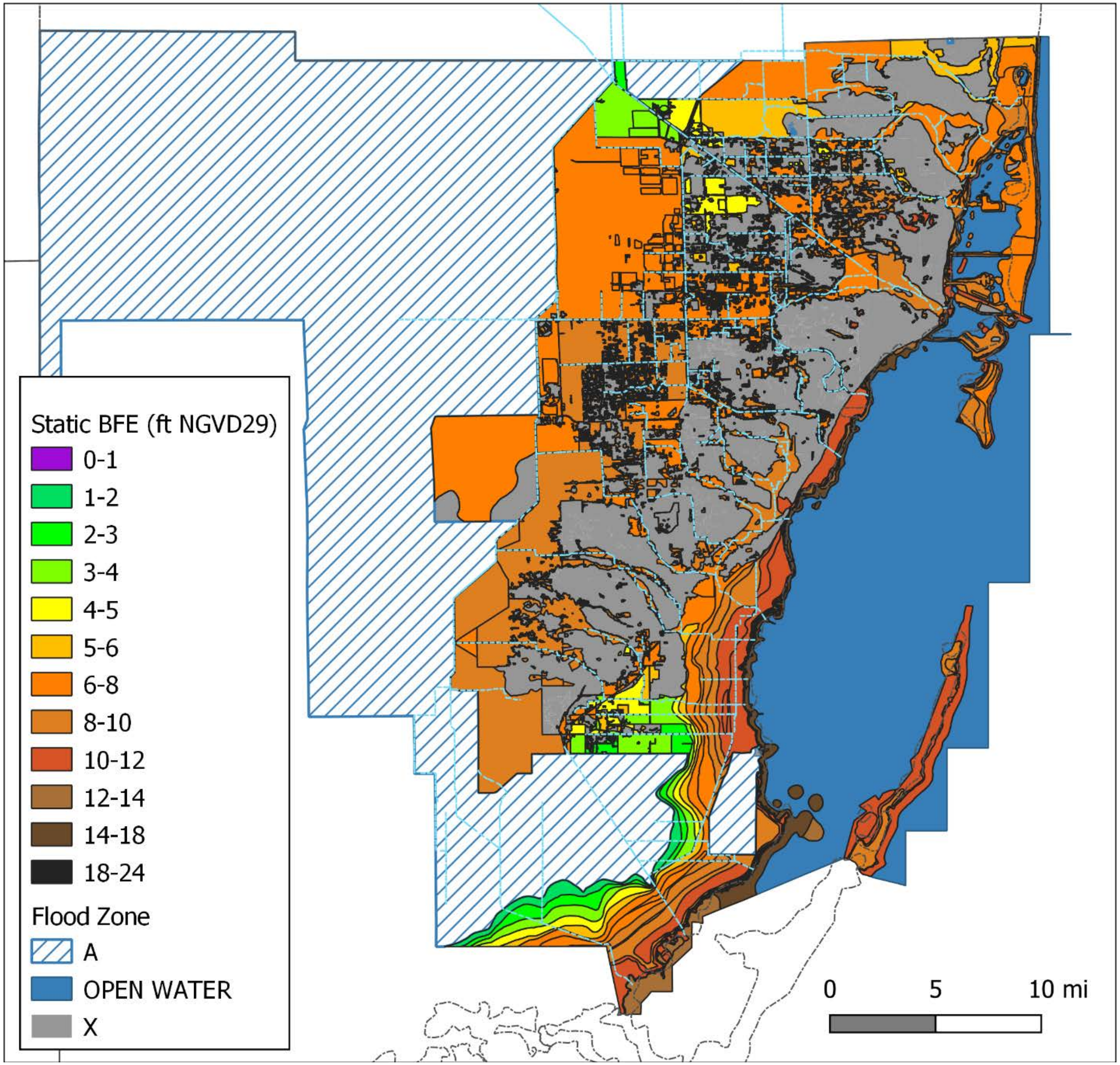
Decrease in soil storage above water table for high SLR Scenario

Loss of soil storage by 2060-2069 calculated as product of specific yield in top layer of the aquifer and net increase in water table elevation from calibration run.
(Quarry lake cells masked out)

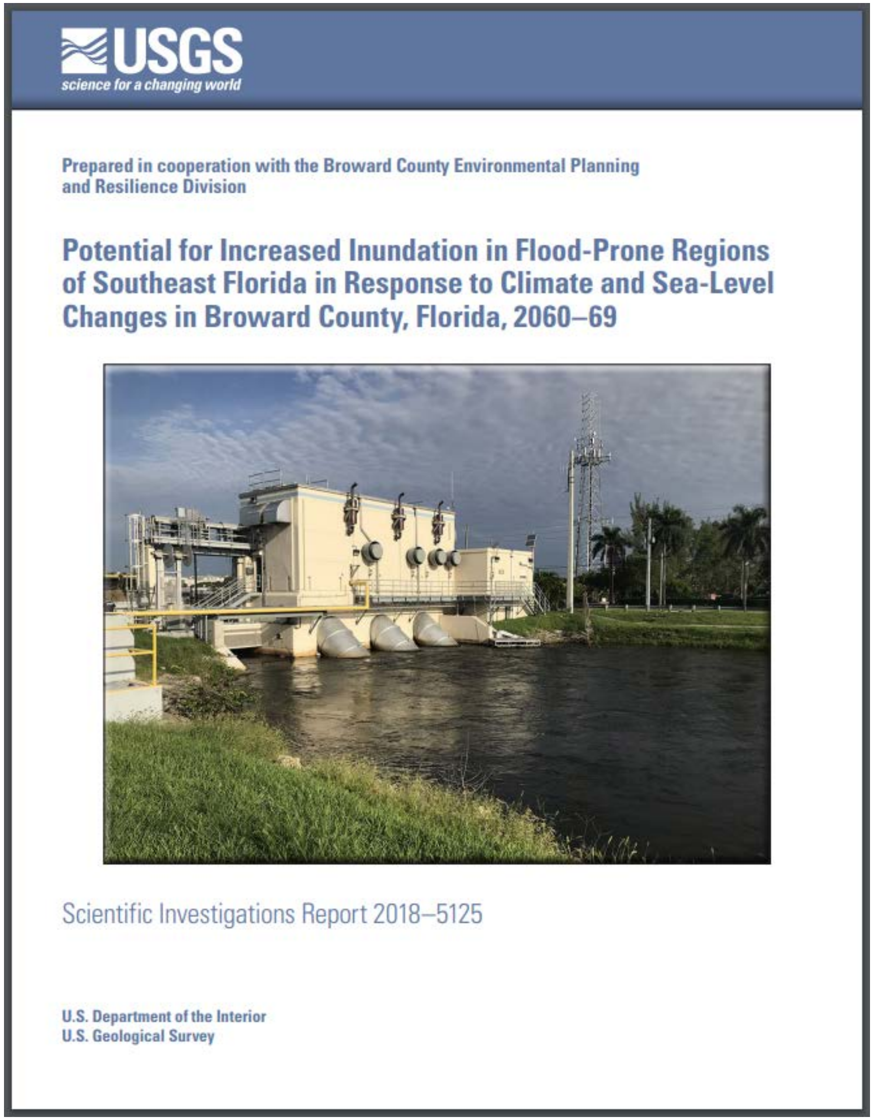
Difference in wet season soil storage
HIGH SLR – CALIBRATION (inches)



Current Static Base Flood Elevations (ft NGVD29) in Miami-Dade County



Future: Connect with Broward County/Boundary Conditions



USGS
science for a changing world

Prepared in cooperation with the Broward County Environmental Planning and Resilience Division

Potential for Increased Inundation in Flood-Prone Regions of Southeast Florida in Response to Climate and Sea-Level Changes in Broward County, Florida, 2060–69

Scientific Investigations Report 2018–5125

U.S. Department of the Interior
U.S. Geological Survey

Decker, J.D., Hughes, J.D., and Swain, E.D., 2019, Potential for increased inundation in flood-prone regions of southeast Florida in response to climate and sea-level changes in Broward County, Florida, 2060–69: U.S. Geological Survey Scientific Investigations Report 2018–5125, 106 p., https://doi.org/10.3133/sir20185125.

Future: Connect with Broward County/Boundary Conditions

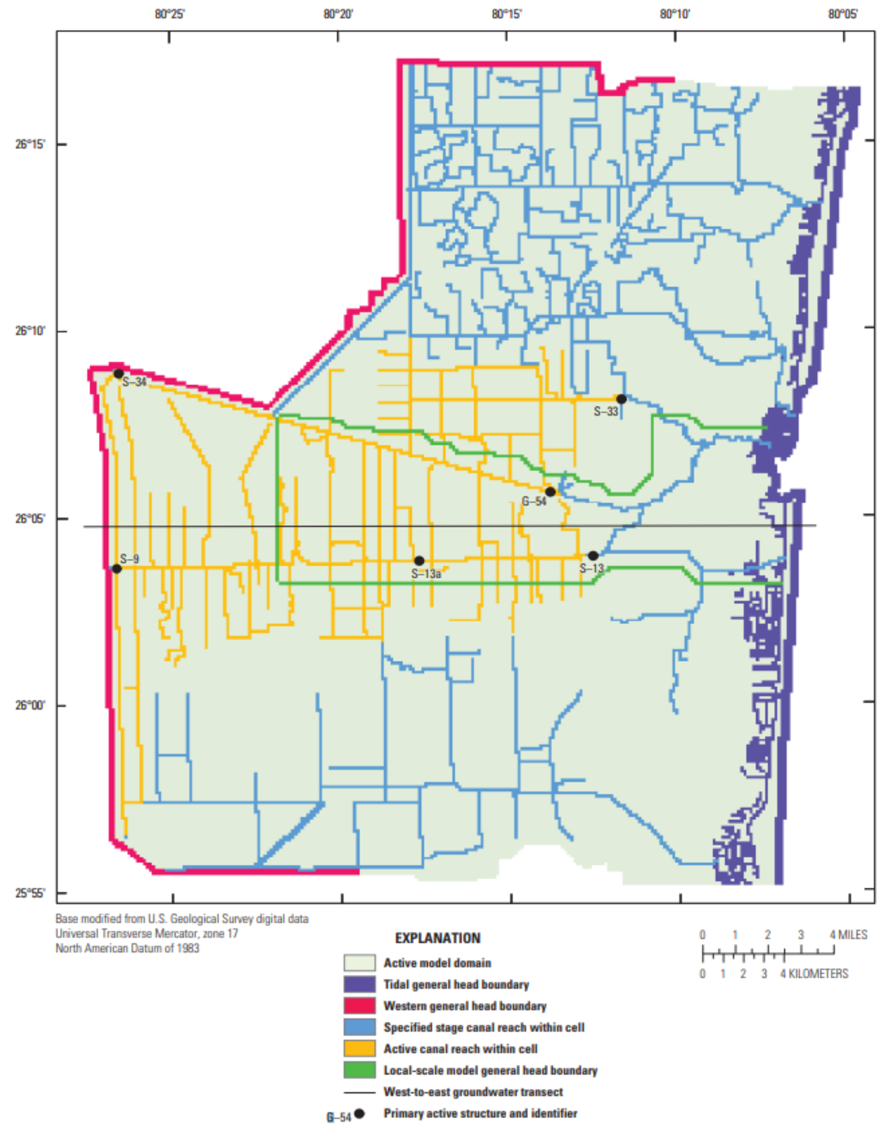
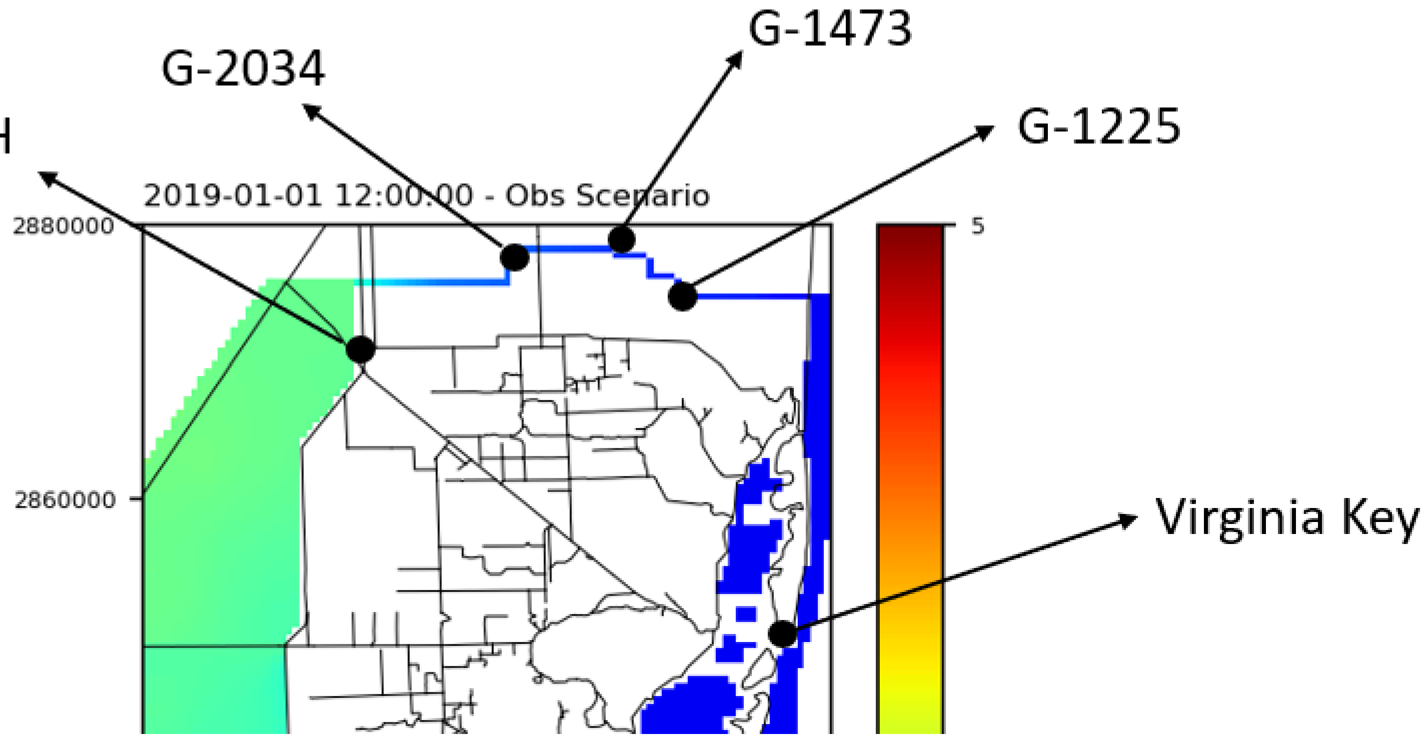


Figure 2. County-scale model area and local-scale model boundaries, Broward County, Florida.

Decker, J.D., Hughes, J.D., and Swain, E.D., 2019, Potential for increased inundation in flood-prone regions of southeast Florida in response to climate and sea-level changes in Broward County, Florida, 2060–69: U.S. Geological Survey Scientific Investigations Report 2018–5125, 106 p., https://doi.org/10.3133/sir20185125.

Future: Connect with Broward County/Boundary Conditions

```
def InterpolateToNorthBoundary(icol, nbndcol, r_nbnd):
    idx0 = 0
    idx1 = 1
    for idx, tcol in enumerate(nbndcol):
        if tcol >= icol:
            idx0 = idx - 1
            idx1 = idx
            break
    icol0 = nbndcol[idx0]
    icol1 = nbndcol[idx1]
    fact0 = 1.0 - ((float(icol) - float(icol0)) / float(icol1 - icol0))
    fact1 = 1.0 - fact0
    return (r_nbnd[idx0] * fact0 + r_nbnd[idx1] * fact1)
```




```
# --read data for north boundary
gwsmpdir = os.path.join(cpath2mod, 'obsref', 'head')
swsmpdir = os.path.join(cpath2mod, 'obsref', 'stage')
gwsites = ['G-2034', 'G-1225', 'G-1473']
gwpos = [1, 2, 3]
swsites = ['S30_H', VAKeySite[VAKey_option]]
swfiles = ['S30_H', VAKeyFiles[VAKey_option].replace('.smp', '')]
swpos = [0, 4]
nbndcol = [32, 44, 75, 90, 98]
h_nghb = np.zeros((num_days + 1, len(nbndcol)), np.float)
h_nghb_avg = np.zeros((len(nbndcol)), np.float)
# --get groundwater data and fill the appropriate column in h_nghb
smp = []
for fn in gwsites:
    gwsmpfile = os.path.join(gwsmpdir, '{0}.smp'.format(fn))
    print('opening...{0}'.format(os.path.basename(gwsmpfile)))
    t = pu.smp(gwsmpfile, load=True, date_fmt='%m/%d/%Y')
    smp.append(t)
for idx, [ipos, site] in enumerate(zip(gwpos, gwsites)):
    print('getting data for...{0}'.format(site))
    fs, d, v = smp[idx].get_site(site)
    ps = pd.Series(np.nan, d_range)
    ps = ps.combine_first(pd.Series(v, index=d))
    ps = ps.interpolate()
    h_nghb[:, ipos] = np.copy(ps[0:num_days + 1])
# --get surface-water data and fill the appropriate column in h_nghb
smp = []
for fn in swfiles:
    swsmpfile = os.path.join(swsmpdir, '{0}.smp'.format(fn))
    print('opening...{0}'.format(os.path.basename(swsmpfile)))
    t = pu.smp(swsmpfile, load=True, date_fmt='%m/%d/%Y')
    smp.append(t)
for idx, [ipos, site] in enumerate(zip(swpos, swsites)):
    print('getting data for...{0}'.format(site))
    fs, d, v = smp[idx].get_site(site)
    ps = pd.Series(np.nan, d_range)
    ps = ps.combine_first(pd.Series(v, index=d))
    ps = ps.interpolate()
    h_nghb[:, ipos] = np.copy(ps[0:num_days + 1])
    # --calculate average north boundary ghb head
for ipos in range(0, len(nbndcol)):
    h_nghb_avg[ipos] = np.mean(h_nghb[:, ipos])
    print('average northern boundary stages:\n  ', h_nghb_avg)
```

Hughes, J.D., and White, J.T., 2016, Hydrologic conditions in urban Miami-Dade County, Florida, and the effect of groundwater pumpage and increased sea level on canal leakage and regional groundwater flow (ver. 1.2, July 2016): U.S. Geological Survey Scientific Investigations Report 2014–5162, 175 p., http://dx.doi.org/10.3133/sir20145162

Future: Connect with Broward County/Boundary Conditions

Adapting Land Use and Water Management Plans to a Changing Climate in Miami-Dade and Broward Counties, Florida

David G. Groves, Debra Knopman, Neil Berg, Craig A. Bond, James Syme, Robert J. Lempert

RAND CORPORATION

Groves, David G., Debra Knopman, Neil Berg, Craig A. Bond, James Syme, and Robert J. Lempert, Adapting Land Use and Water Management Plans to a Changing Climate in Miami-Dade and Broward Counties, Florida. Santa Monica, CA: RAND Corporation, 2018. https://www.rand.org/pubs/research_reports/RR1932.html. Also available in print form.

Task 3: Evaluation of Florida Building Code-related requirements

- **Evaluate Florida Building Code requirements to recommend how results can be incorporated. Specifically, changes to rain loads as applied to figure 1611.1 and figure 1106.1 of the FBC, Plumbing, recommended.**
- **Evaluate how water table maps and revised rainfall maps should be used to update flood loads as applied to Chapters 16 and 31 (Section 3109) of 6th Edition, Florida Building Code (2017), Building, and Chapter 3 (Section R322) of 6th Edition, Florida Building Code (2017), Residential.**
- **Provide recommendations for modifications to Florida Building Code necessary to incorporate updated information on groundwater elevation due to sea level rise and rainfall.**

Relevant Sections of FBC

- Chapter 11, Storm Drainage, also Appendix B of FBC-Plumbing.
- Chapter 16, Structural Design, of the 6th Edition (2017) Florida Building Code (FBC), Building; Sections 1605 Load Combinations, 1610 Soil Lateral Loads
- Section 1611, Rain Loads (Figure 1611.1), of FBC, Plumbing;
- Section 1612, Flood Loads, of FBC, Building
- Chapter 18, Soil & Foundations, sections 1803 Geotechnical Investigations, 1804 Excavation, Grading & Filling, 1805 Damp proofing & Waterproofing, 1806 Presumptive Load-Bearing Values of soils, 1807 Foundation Walls, Retaining Walls & embedded Posts & Poles, 1808 Foundations, 1809 Shallow Foundations, 1810 Deep Foundations
- Chapter 3, Section R322 Flood Resistant Construction, of FBC, Residential
- Chapter 31, Section 3109 Structures seaward of a coastal construction control line, of FBC, Building
- Any other Chapters of Florida Building Code that may be affected by sea-level rise and changes to extreme rainfall.

Approach

- **We reviewed sections of code relevant to rain and flood loads, with regard to how changes in rainfall and scenarios of higher sea level influence groundwater table elevations and flood elevations.**
- **For each section (chapter or specific element of FBC defined in scope), we reviewed existing code, considered results of data analyses relevant to section, conducted additional literature research where possible, and provided key recommendations.**
- **We reviewed sections of ASCE 24 and ASCE 7 as necessary and relevant.**
- **In addition to key recommendations, we offered specific text edits to existing code.**
- **Our evaluation also resulted in recommended areas of priority research.**

Rain Loads

Context for evaluation:

- **Rain loads contribute to design specifications of a structure through weight of water and drainage of water from structure's roof.**
- **Rain loads applied to building and plumbing are interconnected, as the size of the drainage system determines how fast water can drain from a roof, influencing the potential for structural failures.**
- **But also, structural considerations for rain loads extend to the combination of loads that must be computed by combining rain load with other loads to a structure.**

Rain Loads

Relevant sections of Code:

FBC – Plumbing

- **Chapter 11, Storm Drainage**
- **Figure 1106.1**

FBC - Building

- **Chapter 16, Structural Design**
- **Figure 1611.1**

Rain Loads - Key recommendations

- **Code already encourages use of approved local weather data. Research priorities related to design of secondary drainage system were identified.**
- **Recompute flow capacities provided in Tables 1106.2 and 1106.3 with large roof areas using the new rain load data.**

Flood Loads

<u>Context for Evaluation</u>:

Buildings and other structures and portions thereof shall be designed to resist Load Combinations (dead, earthquake, fluid, flood, lateral earth pressure, roof and floor live, rain, snow, self-straining, wind speed and pressure loads, Section 1605).

Foundation walls and retaining walls shall be designed to resist lateral soil loads (Section 1610).

Flood loads apply to buildings and other structures located in areas prone to flooding, as defined on a flood hazard map (Section 1612; ASCE 7-05, Chapter 5).

Flood loads for structural systems of buildings or other structures are designed, constructed, connected, and anchored to resist floatation, collapse, and permanent lateral displacement due to action of loads due to flooding associated with design flood and other loads in accordance with load combinations (ASCE 7-05, Chapter 5).

Design and construction of structures seaward of coastal construction control line (CCCL) or seaward of the 50-foot setback line. Flood resistant construction and Storm Drainage for plumbing are also covered. The FBC Residential, adopts with amendments, the International Residential Code (2015), with provisions for flood-resistant construction.

Flood Loads

<u>Relevant sections of code</u>:

FBC - Building

- **Chapter 16, Structural Design**
  - **Section 1605 - Load Combinations**
  - **Section 1610 - Soil Lateral Loads**
  - **Section 1612 - Flood Loads of Building**
- **Chapter 18, Soil & Foundations**
  - **Section 1803 Geotechnical Investigations**
  - **Section 1804 Excavation, Grading & Filling**
  - **Section 1805 Damp proofing & Waterproofing**
  - **Section 1806 Presumptive Load-Bearing Values of soils**
  - **Section 1807 Foundation Walls, Retaining Walls & embedded Posts & Poles**
  - **Section 1808 Foundations**
  - **Section 1809 Shallow Foundations**
  - **Section 1810 Deep Foundations**
- **Chapter 31, Special Construction**
  - **Section 3109 Structures seaward of a coastal construction control line**

Flood Loads

Relevant sections of code:

FBC – Residential

- **Chapter 3**
  - **Section R322 - Flood Resistant Construction**

FBC – Plumbing

- **Chapter 11, Storm Drainage**
  - **Section 1101 General**
  - **Section 1102 Materials**
  - **Section 1103 Traps**
  - **Section 1105 Roof Drains**
  - **Section 1106 Size of Conductors, Leaders and Storm Drains**
  - **Section 1107 Siphonic Roof Drainage Systems**
  - **Section 1108 Secondary (Emergency) Roof Drains**
  - **Section 1109 Combined Sanitary and Storm Public Sewer**
  - **Section 1110 Controlled Flow Roof Drain Systems**
  - **Section 1111 Subsoil Drains**
  - **Section 1112 Building Subdrains**
  - **Section 1113 Sumps and Pumping Systems**
- **Appendix B**

Flood Loads - Key recommendations (I)

- It is recommended that V-zone and coastal A-zones be used as a proxy to delimit the below grade areas delimit areas where code should regulate use of saltwater corrosion-resistant materials, following ASCE 24.
- To accommodate analytical uncertainties and multiple sources of flooding not accounted for in FEMA FIRM, notably in coastal A-zone, it is recommended that at least one foot be added to the ASCE 24 elevation requirements provided in Tables 2.1 and 4.1 and the higher water surface elevation used to delineate additional land area that would be inundated if the water rose to BFE plus 2 or 3 feet.
- The additional land area that would be inundated if water rose to these elevations could be used to delineate a “future” flood hazard area to guide local floodplain requirements.

Flood Loads - Key recommendations (II)

- Currently, the FBC Section 1804.5 does not allow fill in coastal high hazard areas and coastal A zones "**unless the fill is conducted and/or placed to avoid diversion of water and waves toward any building or structure**". A Florida-specific provision in Sec. 1612.4.1 modifies ASCE 24 to permit dry floodproofing (nonresidential only) in Coastal A Zones **if wave loads, erosion and local scour are accounted for in the design**. It is recommended that the FBC be modified to fully treat Coastal A Zones (when Limit of Moderate Wave Action is delineated) as coastal high hazard areas (Zone V) under conditions where riverine flooding (floodway) intersects Coastal A zones and/or V zones to ensure the placement of fill and "cumulative effect of encroachment into a floodway, when combined with all other existing and anticipated flood hazard area encroachment, does not increase the design flood elevation more than 1ft at any point" (*cf*. 1612.3.2 and 1804.5).

Flood Loads - Key recommendations (III)

- It is recommended that the FBC provide standardized approaches or make reference to the standard approaches it recommends for use for groundwater control (Section 1804.5).
- To ensure the most up-to-date sea-level rise projections are being taken into consideration for design of flood elevations, it is recommended that there be a harmonized procedure for developing a unified projection for each region of the State, that is updated every 5 years and mandated for use in the FBC.
- It is recommended to mandate use of depth to groundwater maps, updated every 5 years, to specify where installation of septic tanks should be prohibited (*cf.* R322.1.7), to comply with Section 101.3. where FBC provides for “minimum requirements for reasonable safety, public health and general welfare”. Coordinate with FDEP and FDOH.

Flood Loads - Key recommendations (IV)

- ASCE 24 is not referenced consistently across the volumes. Some sections specifically reference guidance presented in ASCE 24, whereas other sections do not.
- It is recommended to add to list of elements in section 1803.6: 1) date of last geotechnical investigation, 2) if water table is not encountered, location of nearest well and water table depth at time of geotechnical investigation, to a cross-referenced benchmark, 3) whether the fill materials may be exposed to shrinking/swelling, and included in special design and construction provisions, 4) in foundation recommendations, type and design considerations for shrinking/swelling and salinity, and 5) document municipal regulations on setback and clearance and alternate design criteria recommendations.

Flood Loads - Key recommendations (V)

- With regard to provisions for Special Detailed Requirements Based on Use and Occupancy, it is recommended that the following text be added in 453.2:
  - “Exception: Educational facilities in flood hazard areas must comply with this code or the floodplain management ordinance of the municipality having jurisdiction.”
  - After “Section 1013.38, *Florida Statutes*.”: “Consistent with 105.14, permit issued on basis of a sworn affidavit shall not extend to flood load and flood resistance requirements of the Florida Building Code.”
- It is recommended to add definitions missing from Section 202 for clarity: “return period” and “combined total storm tide elevation”.
- It is recommended that, like section R322.1.8, new, relevant FEMA publications on flood-resistant materials be referenced throughout.

Rain Loads - Recommended Areas of Priority Research

- Determine rainfall rate maps for different return intervals, at least 15-min, 100-yr, and compare with 1-hr, 100-yr for the State, for both historical and recent. After which, new code language that the higher of the 100-yr, hourly rainfall rate or 100-yr, 15-minute rainfall rate be applied for the secondary drainage system could be reconsidered.

Flood Loads – Recommended Areas of Priority Research (I)

- Determine and apply a method to provide a scientific-basis for design flood elevations, based on uncertainties in flood frequency analyses, hydraulic modeling, increasing sea level, expected watershed development, changing rainfall patterns, and sources of flooding unaccounted for by FEMA BFE.
- Evaluate whether and under what conditions the inland boundary of the coastal A-zone (LiMWA) and V zone designations are appropriate as a proxy to delimit the below grade areas where code should regulate the use of saltwater corrosion-resistant materials.

Flood Loads – Recommended Areas of Priority Research (II)

- Develop test cases for “future” flood hazard area maps that could be used to apply floodplain requirements to development by adding 1 foot to the ASCE 24 elevation requirements provided in Tables 2.1 and 4.1 and then use that higher water surface elevation to delineate additional land area that would be inundated if the water rose to BFE plus 2 or 3 feet.
- Advancements in experimental facilities and modeling warrant review, and possible update, of load combinations that include flood and recommended flood load factor applied in V- and coastal-A zones (see p.256, C2.3.3. for a discussion of determination of flood load criteria).

Flood Loads – Recommended Areas of Priority Research (III)

- New research may be needed to compute and evaluate the cumulative flood hazard area encroachment via fill when riverine floodways intersect with Coastal A zones/V zones or areas inland of V zones using different storm tide elevations or BFE +2 or +3 feet, depending on occupancy, as the coastal boundary condition (*cf*. 1612.3.2 and 1804.5). Dry floodproofing under these conditions may also warrant evaluation of cumulative flood hazard area encroachment.
- Given the critical nature of Flood Design Class 4 structures, it is recommended that a study be conducted on the cost-benefit of reducing the substantial improvement/damage percentage criteria (<50%).

Flood Loads – Recommended Areas of Priority Research (IV)

- For combined total storm tide elevation value, we do not know to what extent uncertainties in analyses and modeling and sources of flooding are determined (*cf*. Section 3109). It is recommended that a study be conducted to evaluate:
  1. how the combined total storm tide flood elevation for a 100-yr return period compares with flood elevations determined using other approved methods, and
  2. how the combined total storm tide flood elevation for a 500-yr return period compares with BFE and DFE and conduct a cost-benefit for use in Flood Design Class 4 structures.
- We also recommend where the CCCL does not align with V zones, an assessment of how increasing inland extent of the CCCL to include V-zones reduces potential structural damage. Based on the results of these studies, further code changes may be warranted.

Thank you!

We are grateful for the support of the Florida Building Commission Structural Technical Advisory Committee for the opportunity to conduct this work.