Carolina Maran, P.E., Ph.D.
Chief of District Resiliency

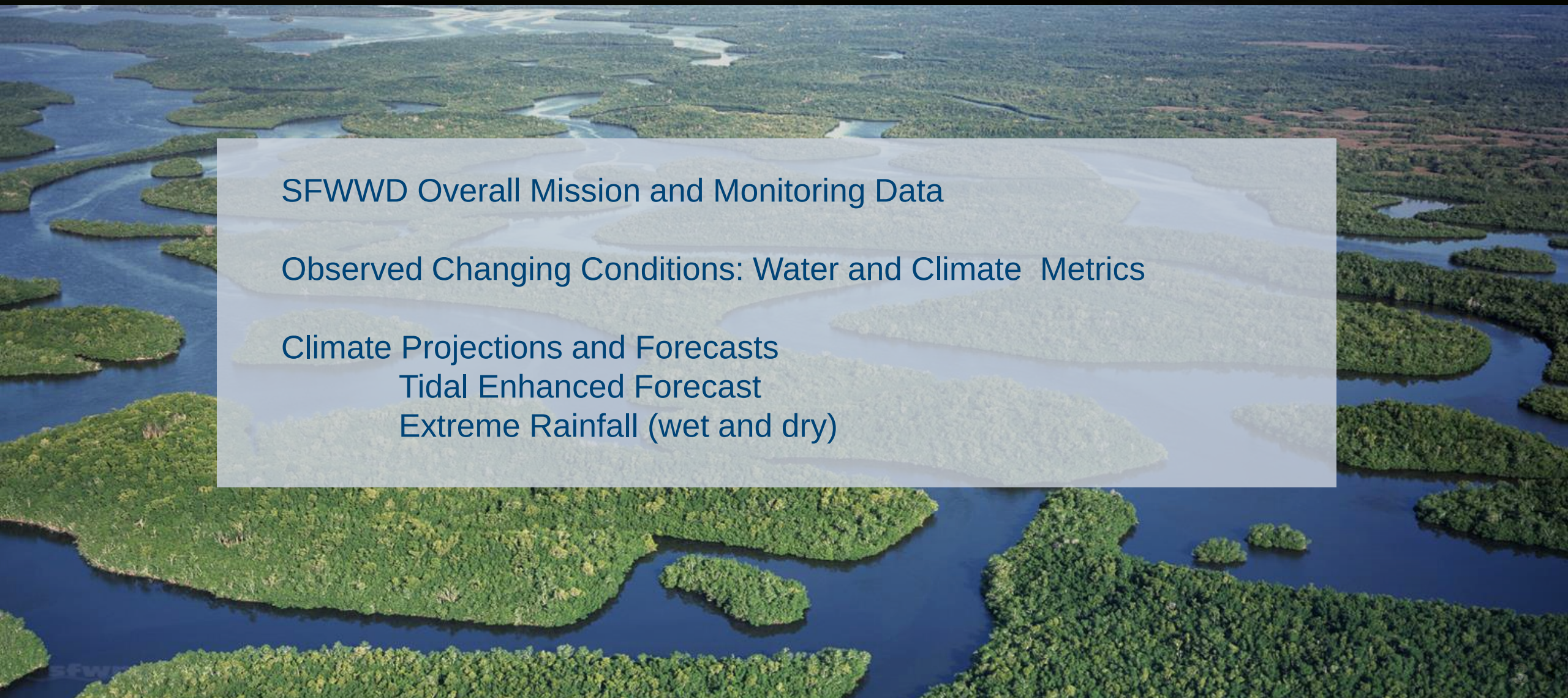
The Importance of Climate Diagnostics and Prediction for Water Resources Management in South Florida: Practitioner Perspective

March 27, 2024

Authors Recognition

- Ana Carolina Coelho Maran, South Florida Water Management District
- Nicole Cortez, South Florida Water Management District
- Tarana Solaiman, South Florida Water Management District
- Todd Kimberlain, South Florida Water Management District
- Jayantha Obeysekera, Florida International University, Sea Level Solutions Center in the Insitute of Environment
- Brian McNoldy, University of Miami, Rosenstiel School of Marine, Atmospheric and Earth Science
- Brian Soden, University of Miami, Rosenstiel School of Marine, Atmospheric and Earth Science
- Nathan Taminger, University of Miami, Rosenstiel School of Marine, Atmospheric and Earth Science
- Michelle Irizarry-Ortiz, U.S. Geological Survey
- John Stamm, U.S. Geological Survey
- Thomas Frazer, Florida Flood Hub for Applied Research and Innovation, University of South Florida

Overview



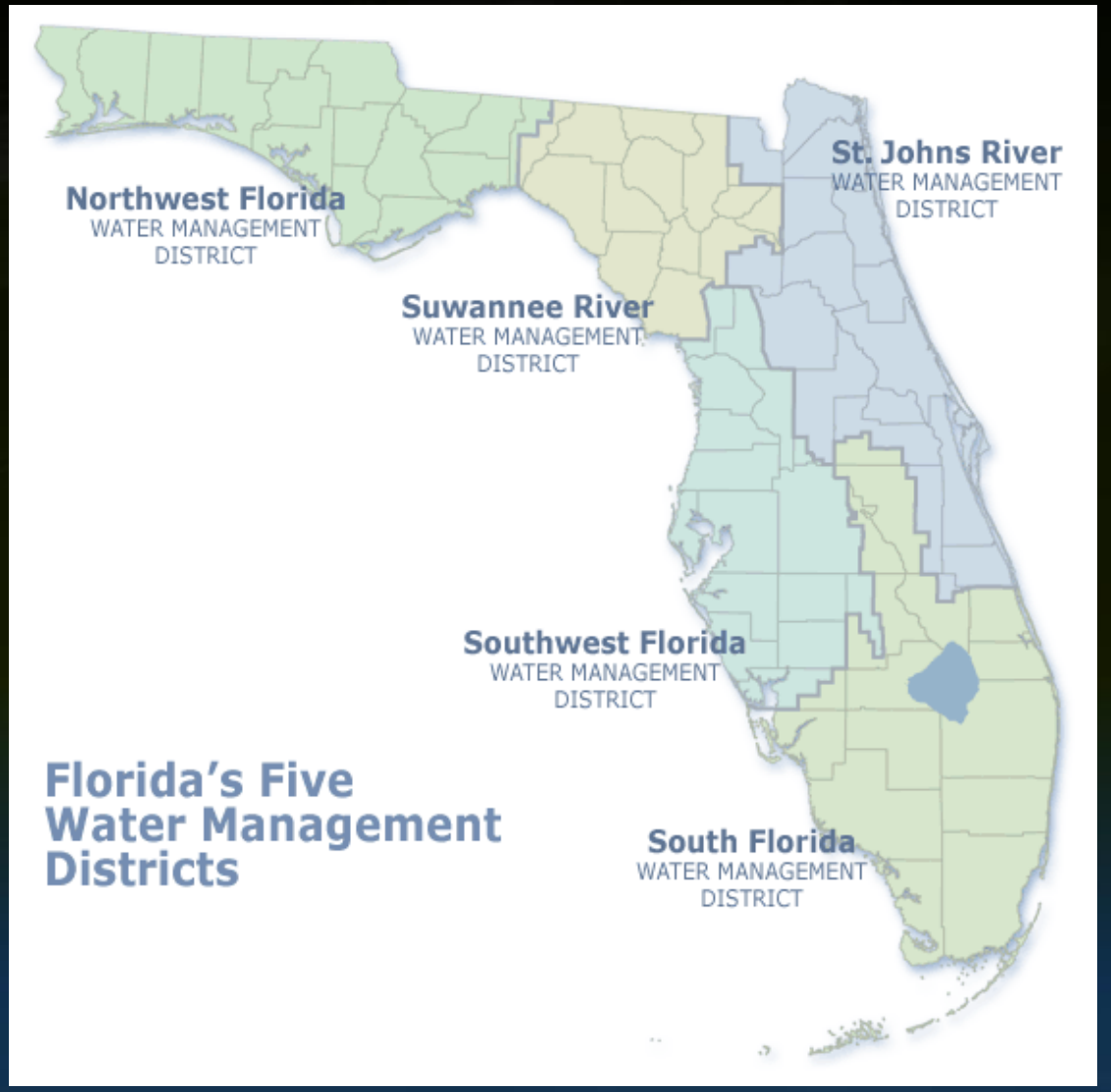
SFWWD Overall Mission and Monitoring Data

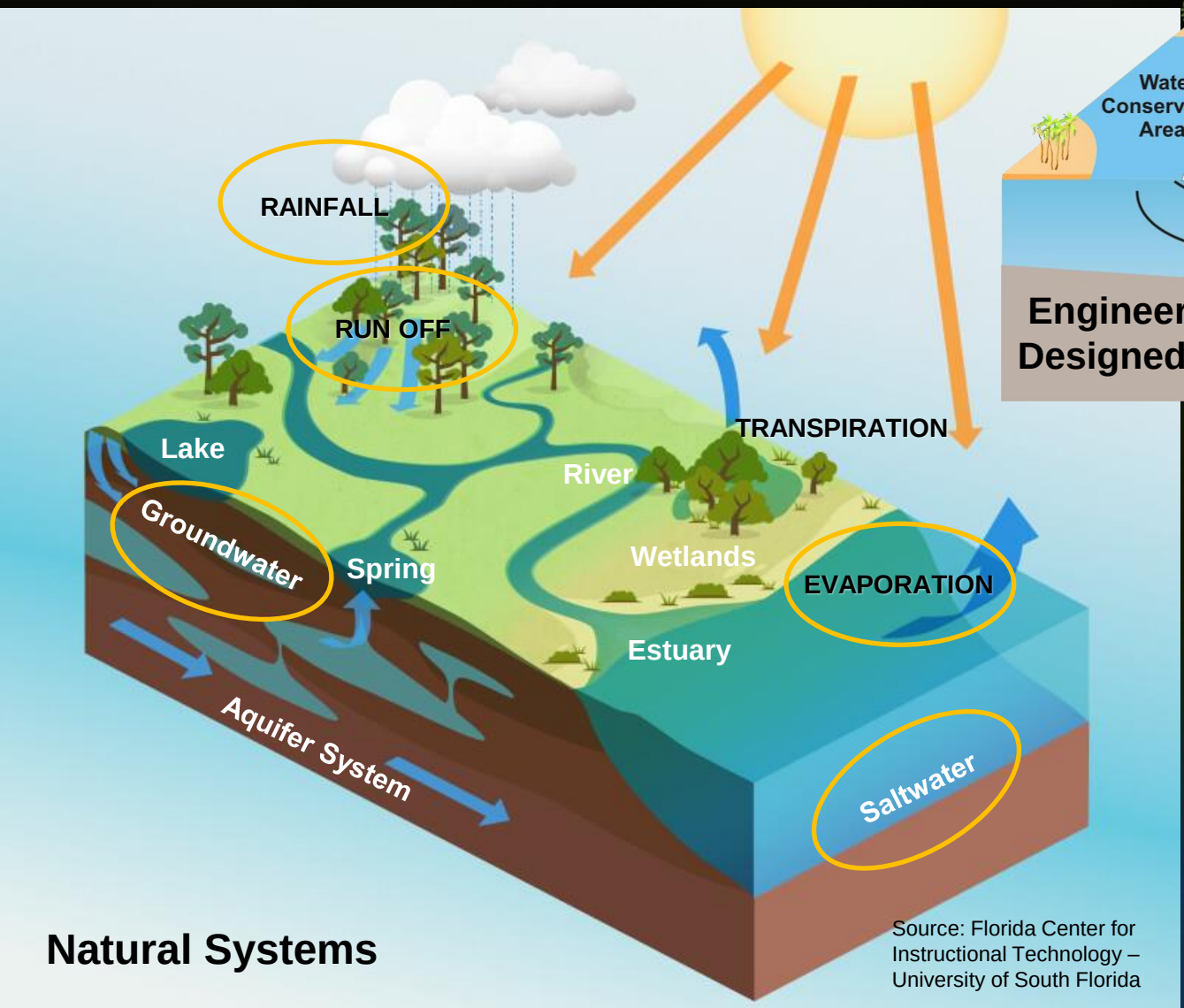
Observed Changing Conditions: Water and Climate Metrics

Climate Projections and Forecasts
- Tidal Enhanced Forecast
- Extreme Rainfall (wet and dry)

South Florida Water Management District

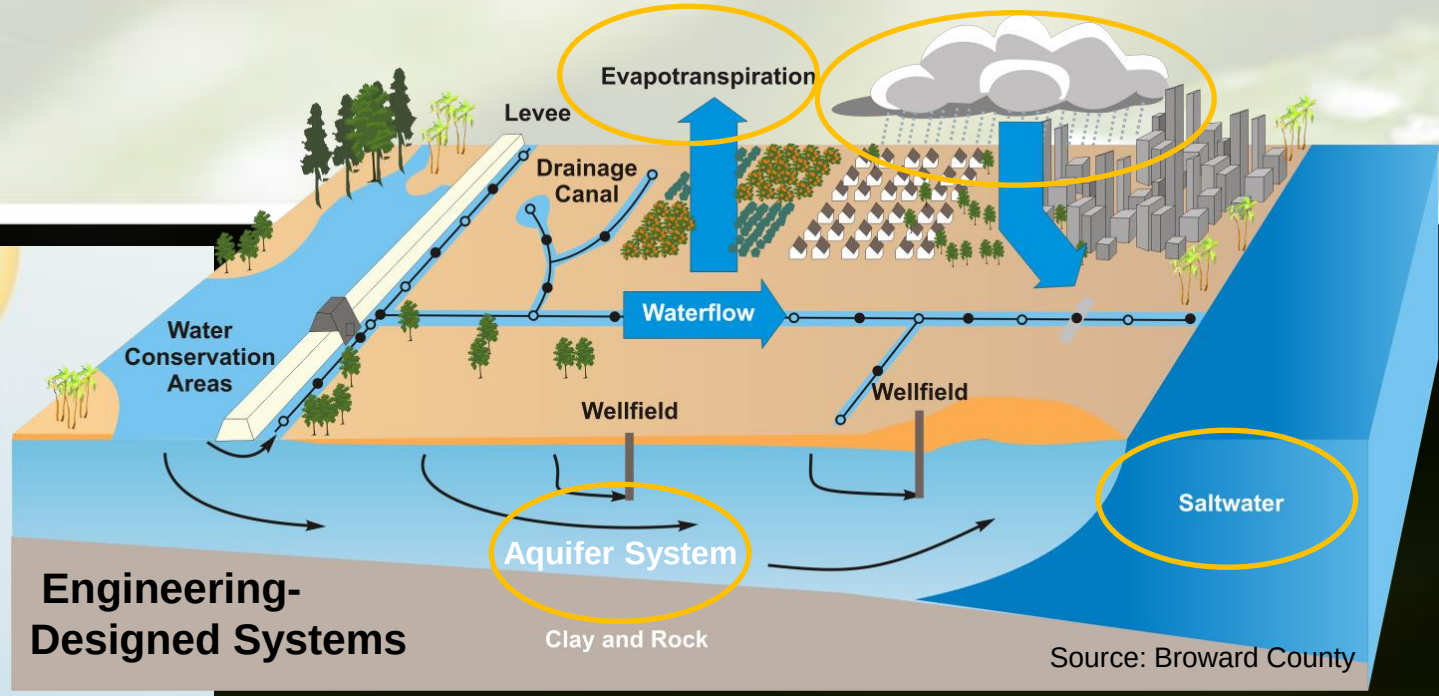
- Created in 1949, oldest and largest of the state's five water management districts
- 16 counties from Orlando to the Florida Keys
- Serves a population of 9+ million residents





Natural Systems

Source: Florida Center for Instructional Technology – University of South Florida



Engineering-Designed Systems

Source: Broward County

WATER MANAGEMENT SYSTEMS

Data Access: DBHYDRO

DBHYDRO | menu

HYDROLOGIC, PHYSICAL, & OTHER TIME SERIES DATA

- Surface Water
- Meteorological
- Groundwater
- WQ - Sondes/Loads

...**OR** get this data one of these ways:

by Station
by Site Name
by Hydrologic Basin

Get Data

This data is also available via the web map

HYDROGEOLOGIC DATA

Get Data

This data is also available via the web map

WATER QUALITY DATA

Get Sample Data

This data is also available via the web map

GET DATA VIA WEB MAP

OTHER

DBHYDRO Insights (New!)
ET Data and Radar-Based Rainfall Data
Metadata/Reference Tables
Miscellaneous Items and Reports

SFWMD Upgrading from NGVD 29 to NAVD 88 - Vertical Datum Upgrade

To enhance the accuracy of our data, the SFWMD is upgrading the reference system used to measure water elevations in our monitoring network. In the coming months, SFWMD will shift from reporting water elevations in the National Geodetic Vertical Datum of 1929 (NGVD 29) to the North American Vertical Datum of 1988 (NAVD 88). This includes data within the SFWMD?s environmental database for hydrologic, meteorologic, hydrogeologic and water quality data. The upgrade will provide the public and stakeholders more accurate information about levels for waterbodies in our region.

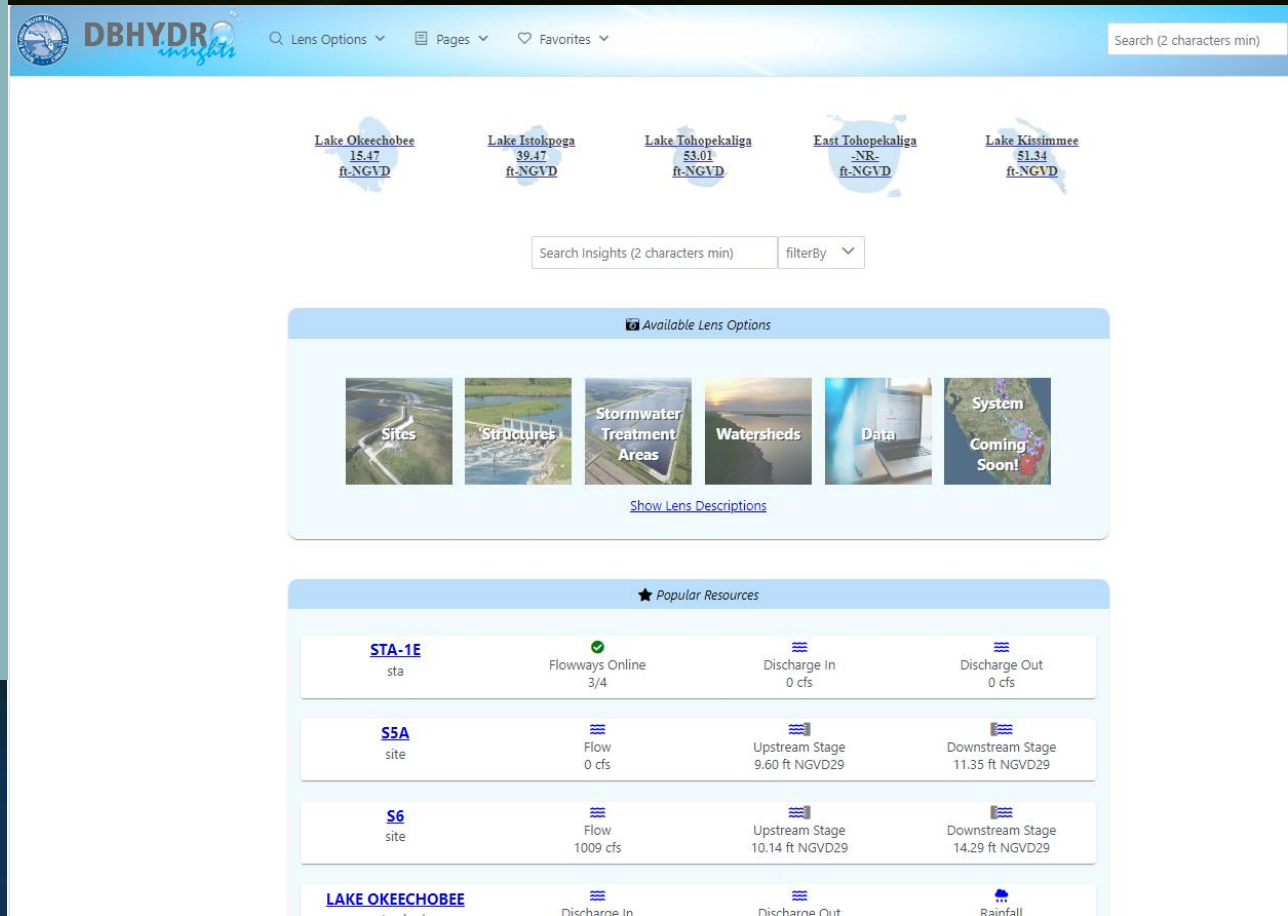
When NAVD 88 is fully implemented in 2024, water measurements will be published exclusively in NAVD 88.

Visit SFWMD.gov/NAVD for more information.

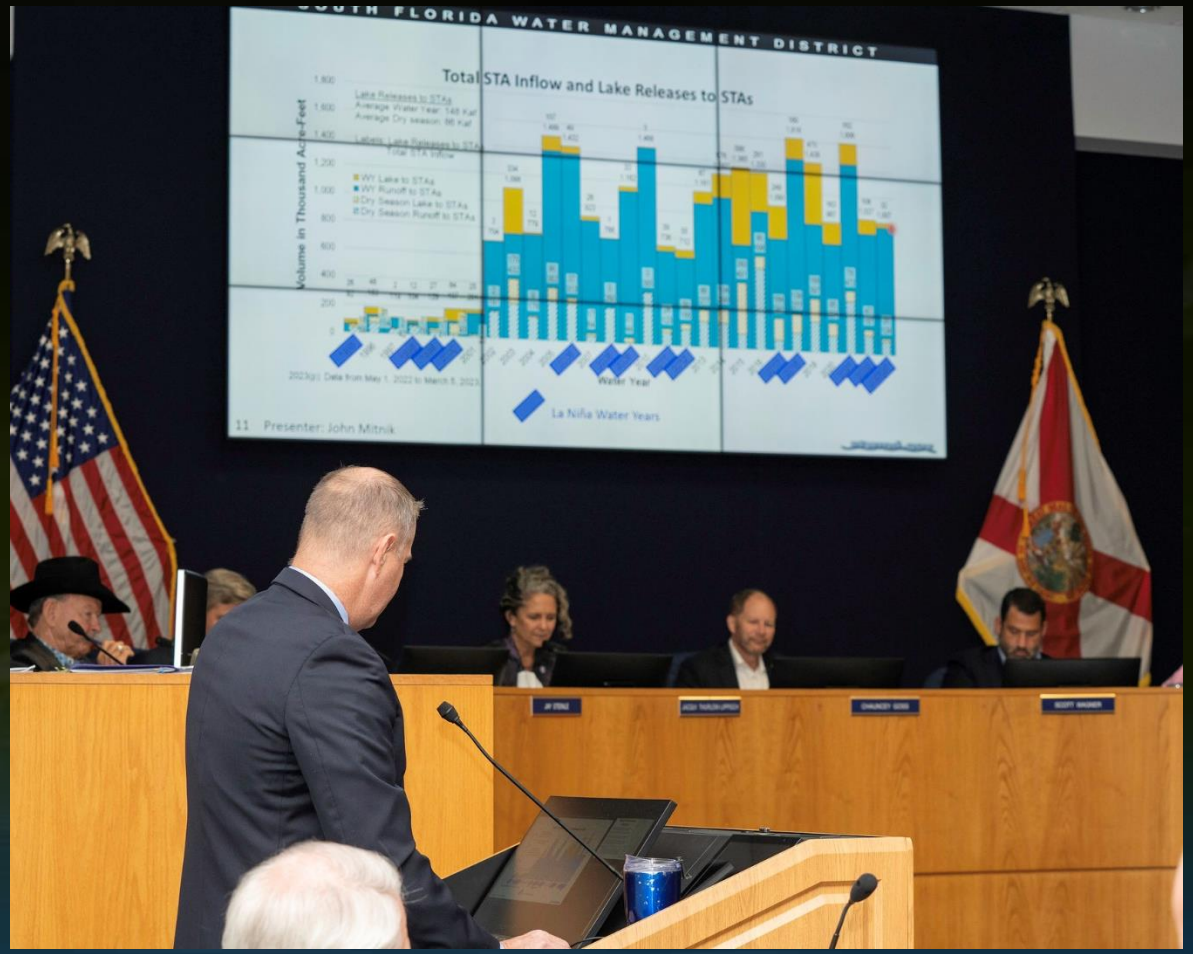
www.sfwmd/gov/dbhydro

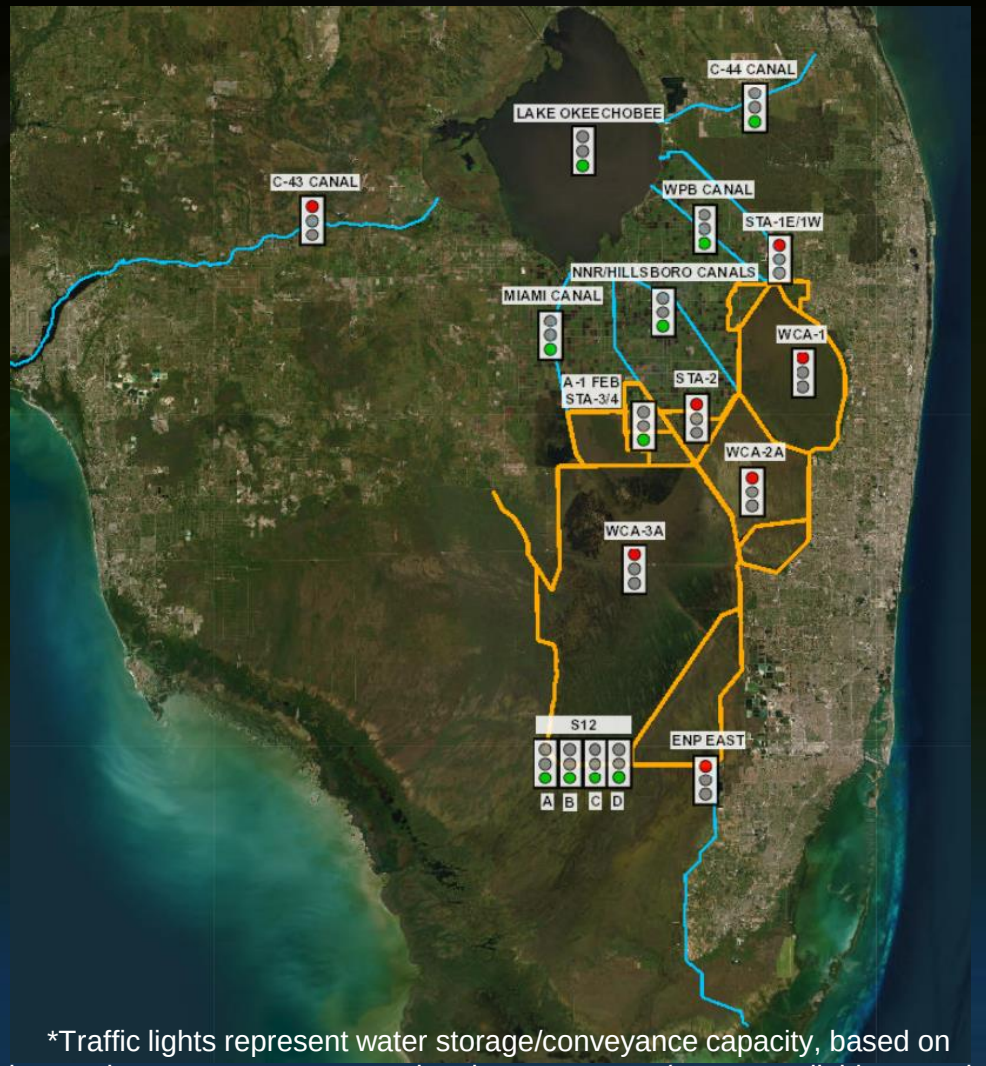
sfwmd.gov

www.sfwmd/gov/dbhydroinsights



Operations: Overall System Status



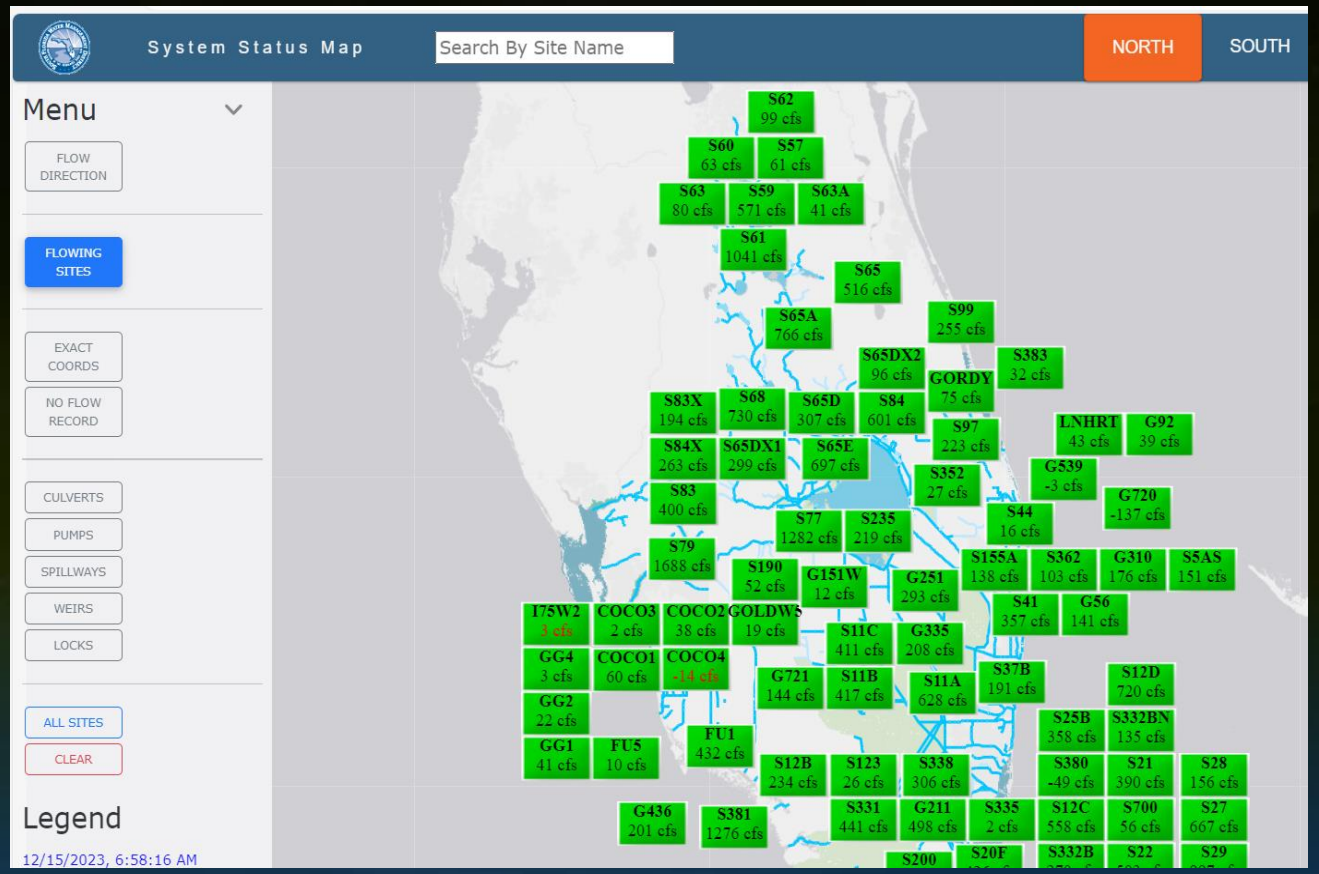


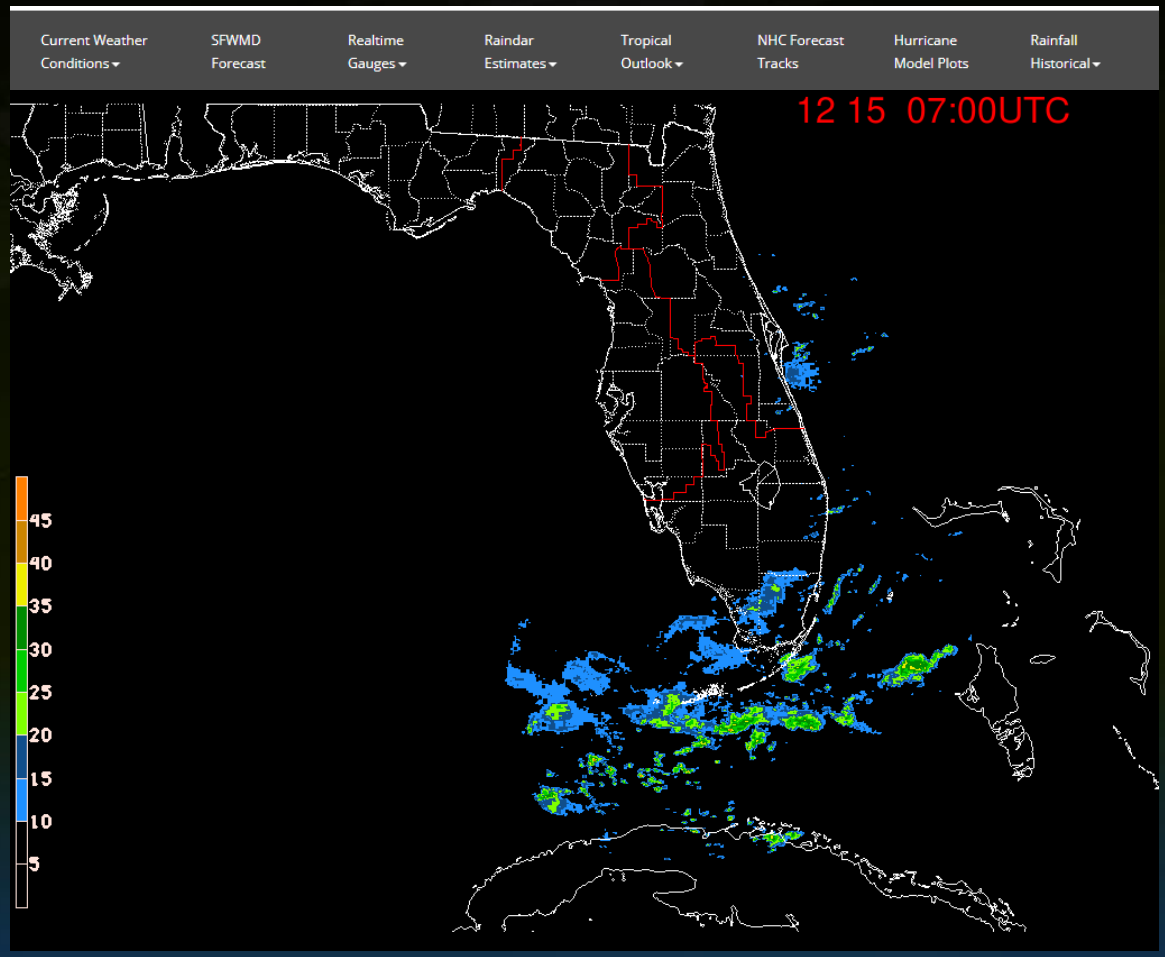
Slide Courtesy Asif Mohamed, SFWMD

*Traffic lights represent water storage/conveyance capacity, based on observed water stages vs operational water targets (green: available capacity)

Operations: Real Time Data

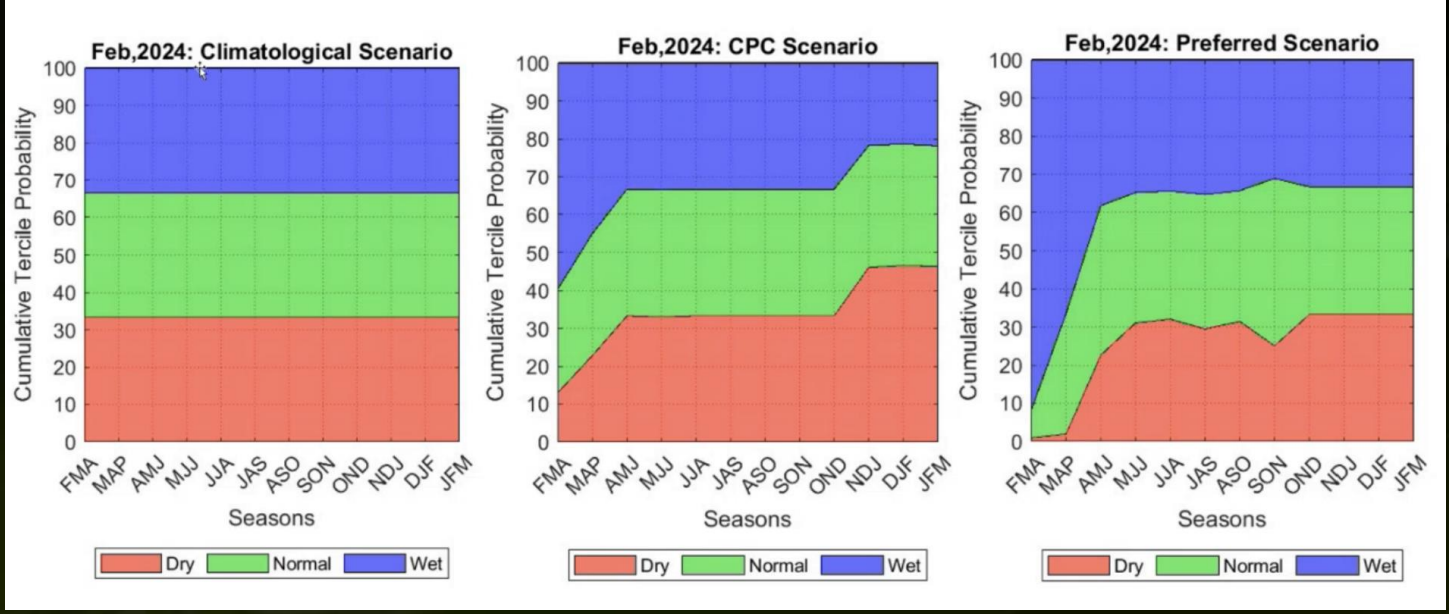
Site Status Reports (sfwmd.gov)



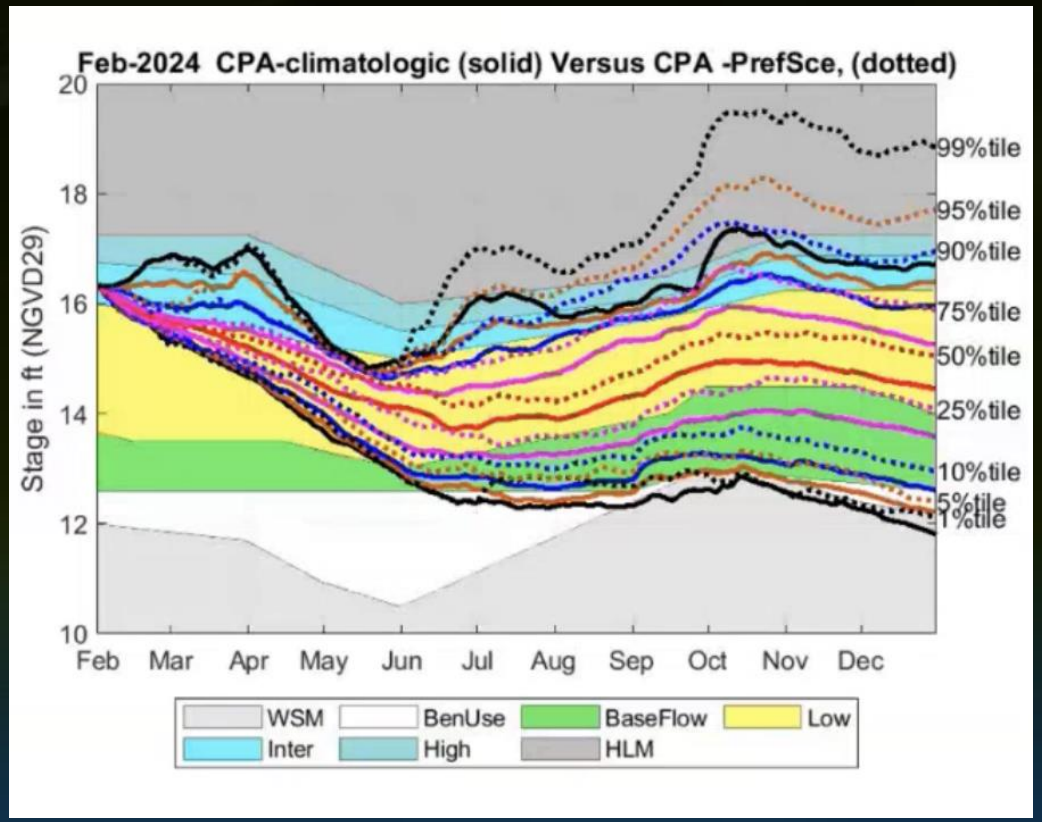


Current Weather Conditions: Florida Radar Loop (sfwmd.gov)

Conditional Position Analysis



Stochastic framework approach to incorporate rainfall outlooks, beyond historical rainfall assumptions

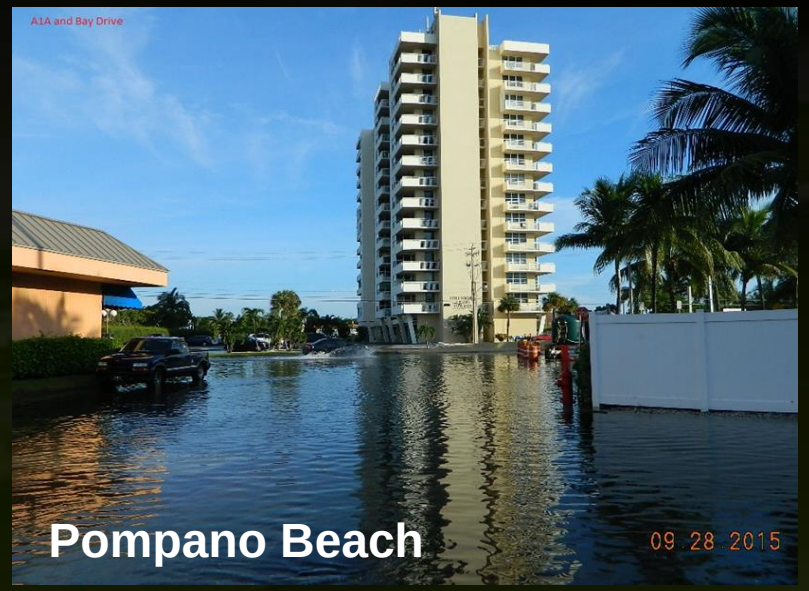


Slide Images Courtesy from Yogesh P Khare, Alaa Ali, Walter Wilcox and Jason Godin, SFWMD

Changing Conditions: Land Use & Development

Changing Climate Conditions: Extreme Rainfall and High Tide Flooding


North Miami



Pompano Beach

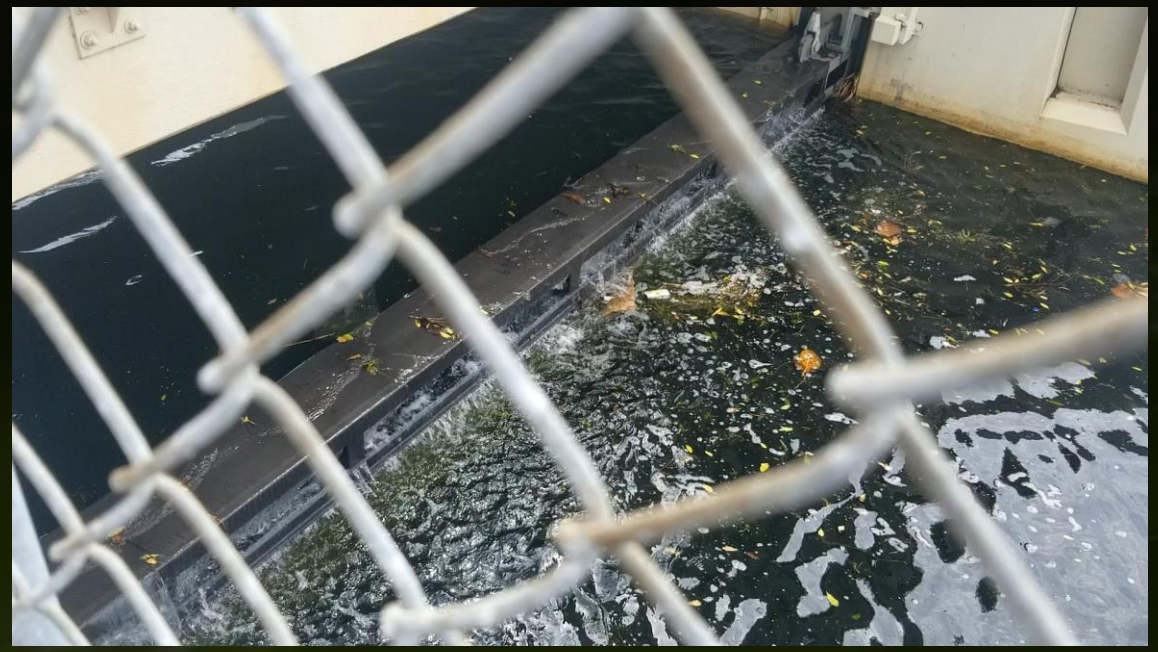

Delray Beach


Sawgrass Mall - Sunrise

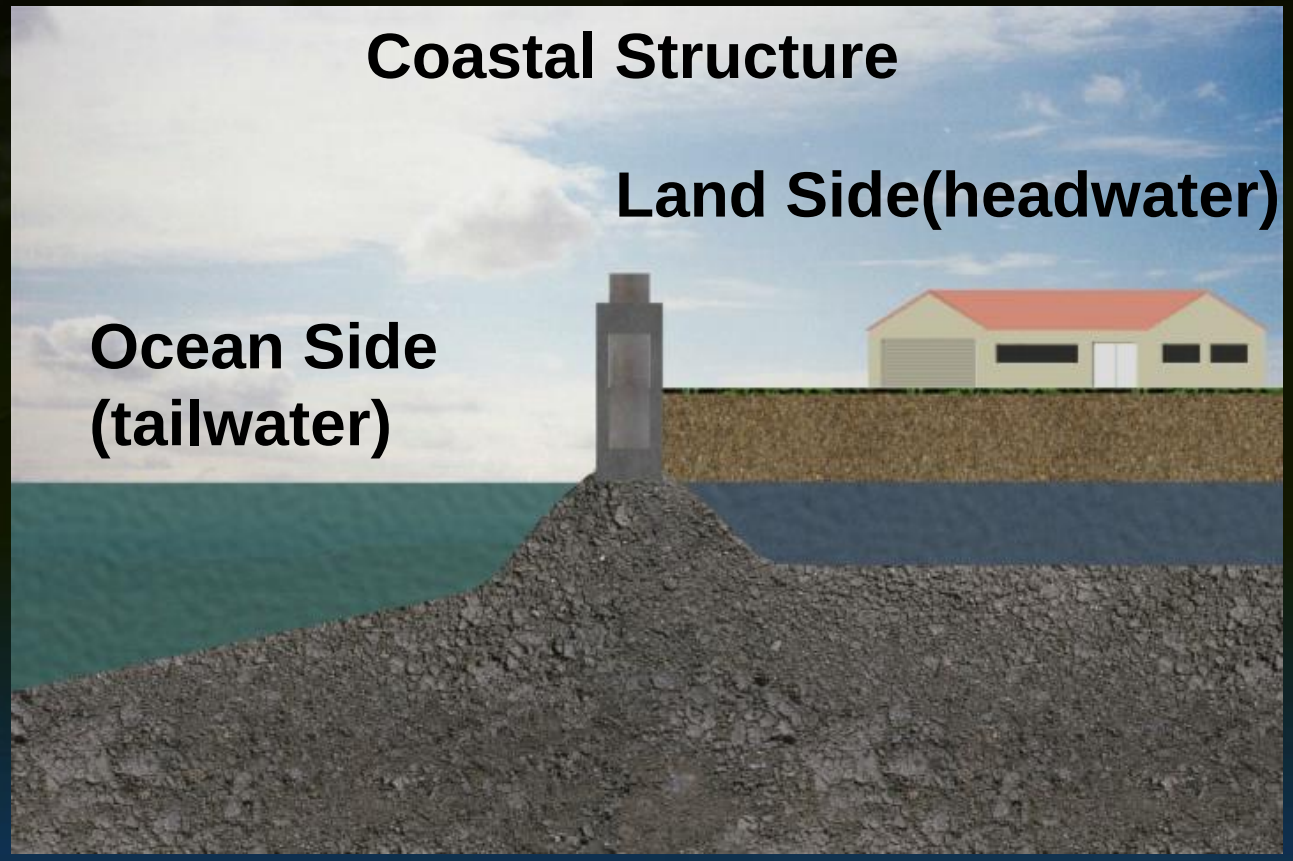

Lantana


Miami Beach

Changing Climate Conditions: Sea Level Rise



October 2019: Gates closed, high tide water reverse flowing over the top



Characterizing Changing Conditions: Emerging Trends in Regional Resiliency

Resilience Metrics Hub

Water and Climate Resilience Metrics

https://sfwmd-district-resiliency-sfwmd.hub.arcgis.com/

sfwmd.gov

Regional Rainfall

Changes in rainfall patterns will impact people and ecosystems by altering the amount of water in our region throughout the year.

Evapotranspiration Trends in South Florida

Evapotranspiration (ET) determines water exchanges between the land, plant communities, and the atmosphere.

Tidal Elevations at Coastal Structures and Sea Level

Flood control and the prevention of saltwater intrusion in South Florida relies heavily on the operation of coastal gravity structures.

Saltwater Intrusion in Coastal Aquifers

The inland migration of saltwater poses a threat to water supply and critical freshwater habitats.

Salinity in the Everglades

The salinization of previously freshwater systems poses threats to several factors.

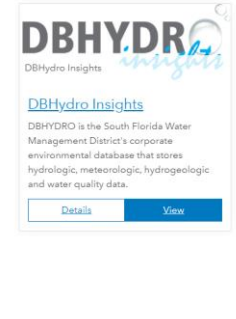
Estuarine and Mangrove Inland Migration

Trends in Estuarine Inland Migration provide insights to the impacts of sea level rise in...

Soil Subsidence in South Florida

Maintaining soil elevations within coastal and intertidal habitats, as sea level changes, is a...

SFWMD Data and Support



DBHydro Insights

DBHYDRO is the South Florida Water Management District's corporate environmental database that stores hydrologic, meteorologic, hydrogeologic and water quality data.

Details | View

SFWMD GIS Open Data Hub

Our Open Data site is where our publicly available spatial datasets can be viewed and downloaded. Additional Web Apps and Story Maps are featured to explore and learn more about the data.

Details | View

Local Agencies' Information

Local Agencies are using their resources to help us understand the potential risks that come with Coastal Resiliency efforts.

Broward County Resiliency Dashboard

Broward County continues to build resilience at a number of scales, internally for government operations, and county-wide through coordination with municipalities and regionally across Southeast Florida.

Details | Main Page

Miami-Dade County Sea Level Rise Strategy

Miami-Dade County faces an unprecedented challenge in the coming decades to adapt to climate change and sea level rise.

Details | Main Page

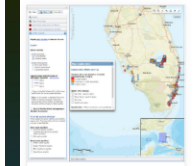
Palm Beach County Office of Resilience

The Office of Resilience (OOR) works to ensure that Palm Beach County remains a great place to live, work, and play while addressing physical, social, and economic challenges including climate change.

Details | Main Page

Federal and State Agencies' Information

Federal and State Agencies are using their resources to help us understand the potential risks that come with Coastal Resiliency efforts.



USGS Water Mapper

This website is designed to conduct automated statistical and graphical analyses on water-level and salinity data collected from sites monitored by the U.S. Geological Survey (USGS) in South Florida

Details | View

FDEP

Florida Resilient Coastlines Program

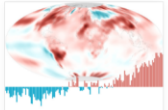
The Florida Department of Environmental Protection is committed to marshaling resources to prepare Florida's coastal communities and habitats for the effects of climate change, especially rising sea levels.

Details | View

NOAA Resilience HUB

This page is a hub for NOAA-related resilience resources. Here you can peruse the agency's related assets, explore ELP-funded resilience projects, and learn more about our grantee community. The ELP Community Resilience Education Theory of Change can also be found on this hub.

Details | View



NOAA Global Climate Dashboard

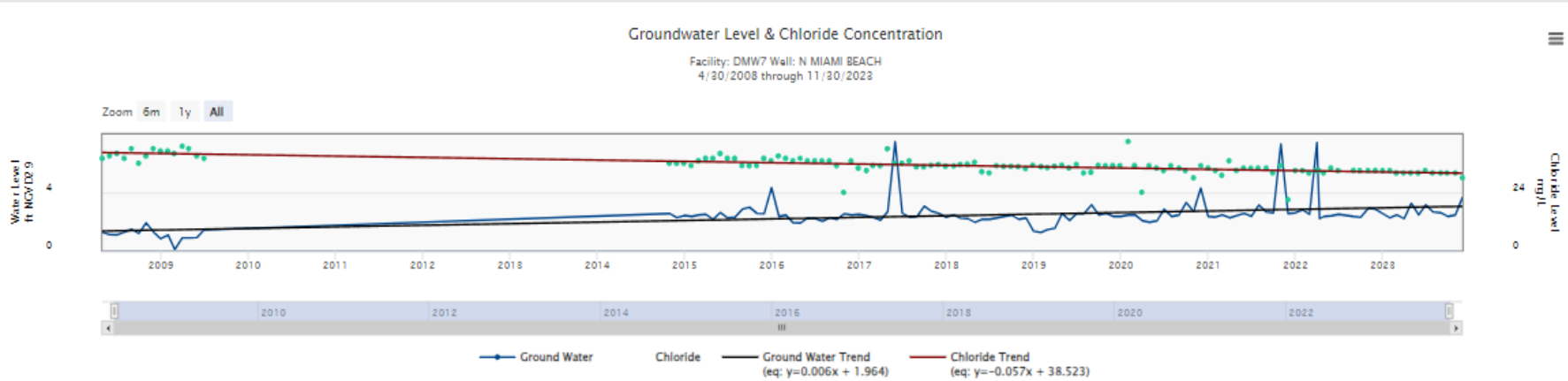
NOAA Climate.gov provides timely and authoritative scientific data and information about climate science, adaptation, and mitigation.

Details | Explorer

N MIAMI BEACH Latitude: 25.923357 Longitude: -80.196091

Permit Number: 13-00060-W
Permitee: CITY OF NORTH MIAMI BEACH
Project: North Miami Beach PWS
Facility Name: DMW7
Aquifer: Biscayne Aquifer

Well Details	
Cased Depth	105 (ft)
Depth	110 (ft)
Pump Intake Depth	0 (ft)
Diameter	2 (in)
X Coordinate (state planar)	920389
Y Coordinate (state planar)	578646
Latitude	25.923357
Longitude	-80.196091
Measuring Point Elevation	n/a
Year Drilled	



Chloride Concentration mg/L
- < 100
- ≥ 100 and < 250
- ≥ 250 and < 1000
- ≥ 1000

P-Values
Ground Water: <0.001
Chloride: <0.001

Ground Water Level
Facility: DMW7 Well: N MIAMI BEACH
Unit: ft NGVD29
4/30/2008 through 11/30/2023

Summary | Statistics | Percentile

Count	Min	Median	Max	Mean	Standard Deviation
125	0.06	2.34	7.48	2.40	1

Chloride Concentration
Facility: DMW7 Well: N MIAMI BEACH
Unit: mg/L
4/30/2008 through 11/30/2023

Summary | Statistics | Percentile

Count	First Date Above 1000	First Date Between 250 & 999	First Quartile	First Result	First Result Date	Last Result	Last Result Date	Max	Mean	Median	Min	Standard Deviation	Third Quartile
125			33	38	4/30/2008	30	11/30/2023	45	35.05	35	21	3.39	37

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ROSENSTIEL SCHOOL of MARINE, ATMOSPHERIC & EARTH SCIENCE

Forecasting Tools: Enhanced Tidal Projections

Project Goals

- Create more accurate tide forecasts (out to ten days) that **account for modern sea level (ocean) and physical factors (atmosphere and ocean) that influence tides**
  - Lake Worth
  - Port Everglades
  - Virginia Key
  - Vaca Key
  - Key West
  - Naples
- Generate real-time forecasts and share with stakeholders

Note:
Currently, NOAA Tide Predictions are astronomical in nature and are relative to mean sea level from 1983 to 2001.

UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL of MARINE, ATMOSPHERIC & EARTH SCIENCE

Forecasting Tools: Enhanced Tidal Projections

5-Step Approach Summary:

1. Raw 6-minute water level observations and predictions from NOAA tides and currents
2. Observation and prediction data clean up (daily max, SLR 19-year linear model, trend removal, departure between sea level adjusted observations and NOAA predictions)
3. ERA5 Reanalysis data (V10, U10, SLP, SST and SWH) clean up; 1x1 degree box average around the station or off the coast of the station
4. Water levels and environmental data combination (removal of +3σ, blank days)
5. OLS regression models (out to ten days, each site): 3-day rolling mean of non-slp environmental variables, last known water level departure, sea level pressure constant empirical adjustment, daily averaged regression coefficients (80% train; 20% test, 10K Monte Carlo simulation)

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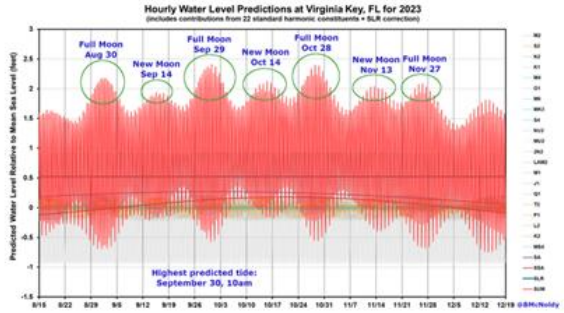
Forecasting Tools: Enhanced Tidal Projections

Weekly King Tide Forecast

The South Florida Water Management District's Tidal Outlook for the forecast period of October 2 through October 9, 2023, is now available. Heightened tidal levels are expected along South Florida's east coast. These enhanced tidal elevations are driven by a combination of meteorological and astronomical factors. Minor to moderate coastal flooding is anticipated to continue through Wednesday, October 4, during high tide along the east coast of the SFWMD region, which includes coastal areas of Martin, St. Lucie, Palm Beach, Broward, Miami-Dade, and Monroe counties. Tidal water levels are likely to quickly subside by Wednesday afternoon.

View the weekly Tidal Outlook HERE.

SFWMD is continuing efforts for the monitoring, operational response and documentation of these events. These weekly updates are intended to be informational for interested stakeholders and the public. If conditions warrant, additional updates may be issued throughout the forecast period.



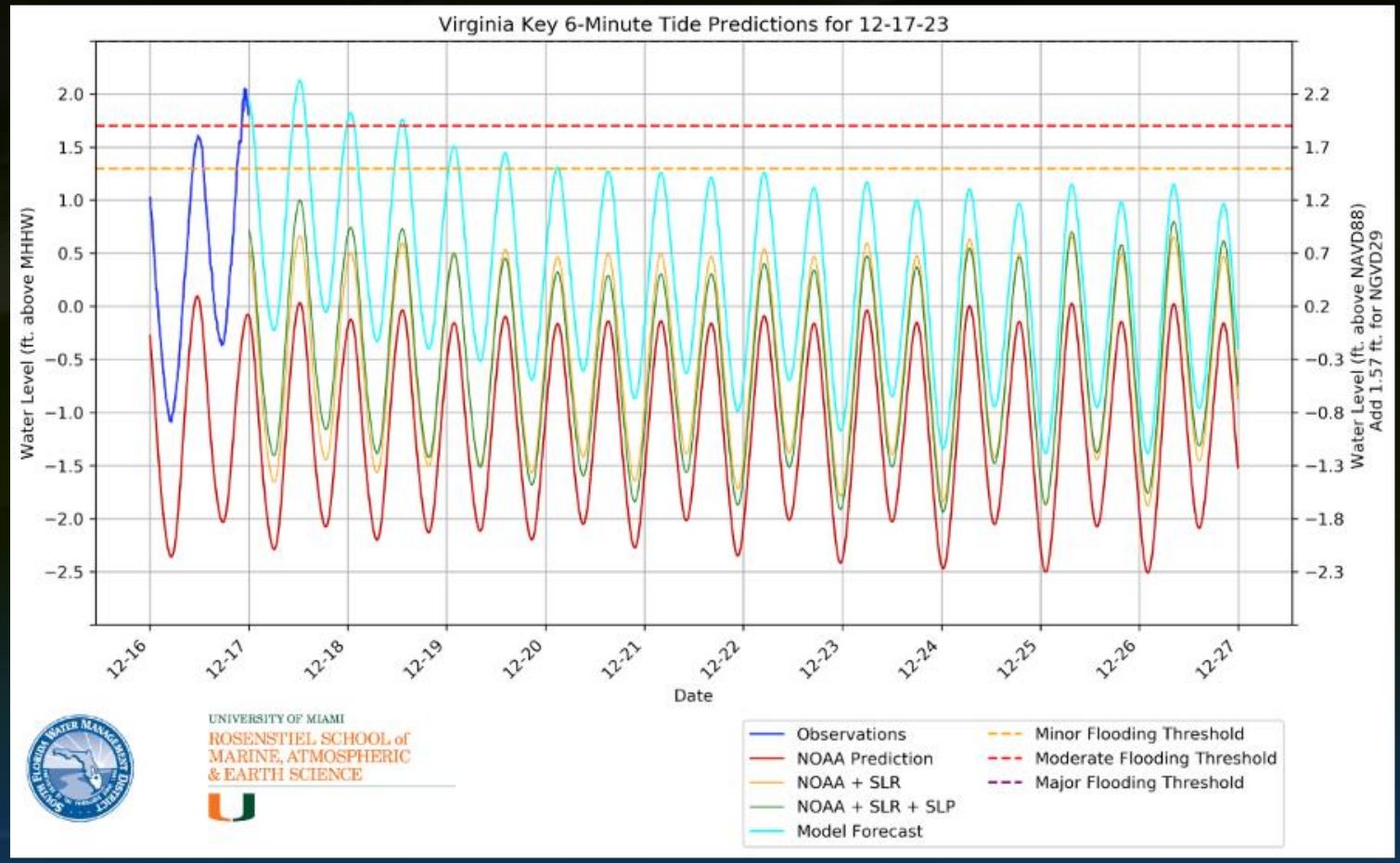
Source: University of Miami

High tides are predicted by the National Oceanographic and Atmospheric Administration (NOAA) to peak above 2.5-3 feet Mean Lower Low Water (MLLW) along the South Florida Coast during the following days in 2023 (peak varies by location):

- September 13-15 (New Moon)
- September 26 to October 4 (Full Moon)
- October 14-19 (New Moon)
- October 24 to November 2 (Full Moon)

...

Weekly Tide Forecast to Local Governments during King Tide Season



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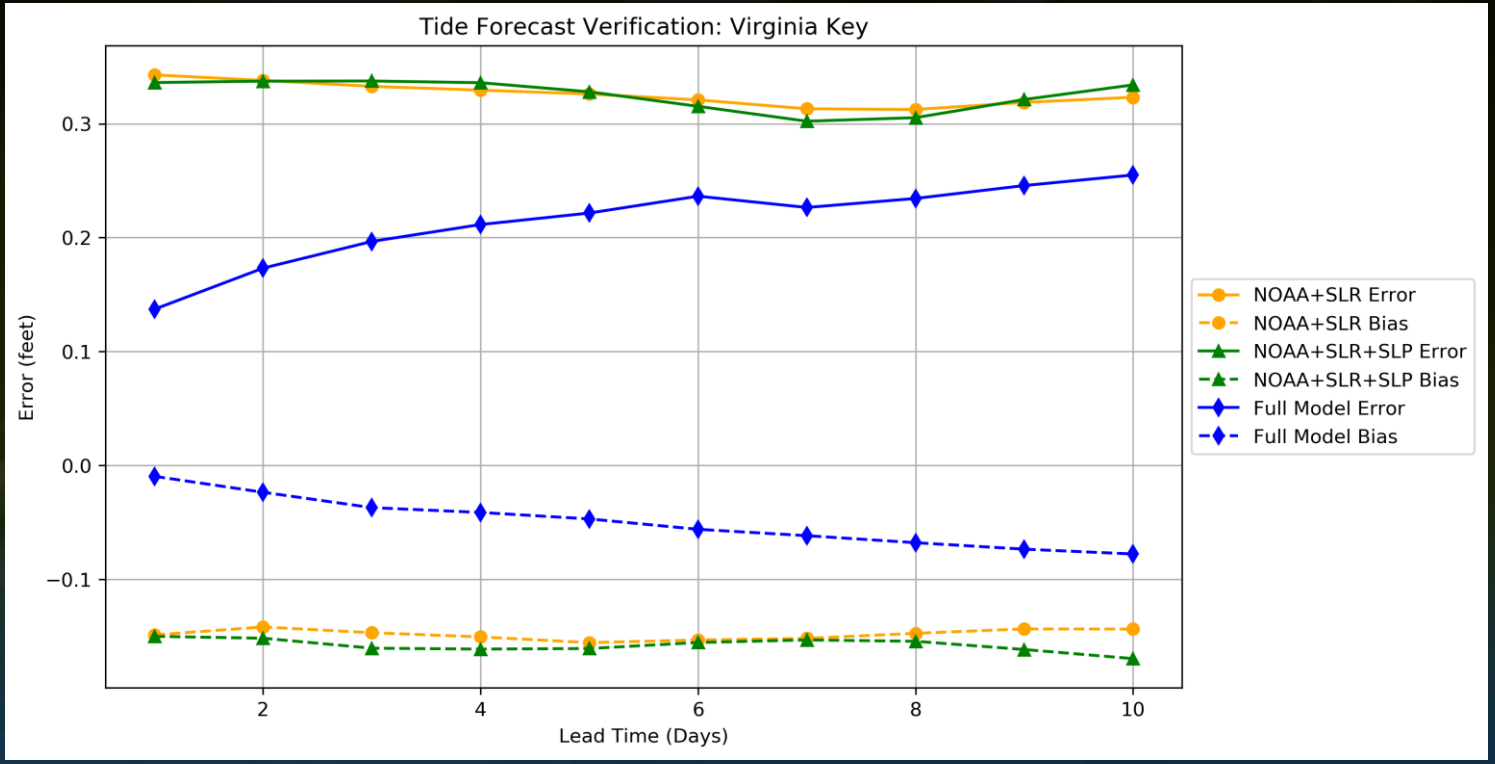
Forecasting Tools: Enhanced Tidal Projections

Virginia Key – Predicted vs. Observed

(170 days of verifying forecasts)



Year 2 – Next Steps:

- Overall Planned Improvements
- Explore use of GFS and ECMWF ensemble data to create probabilistic tide forecasts
- Publish predictions in the SFWMD Resiliency Metric Hub

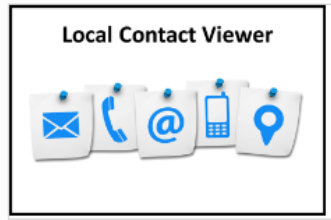
South Florida Flood Information Resource

Search, Visualize, Download, Create, Communicate, Collaborate

Search...

A resource for collecting and consolidating flood observations to help
flood patterns associated with King Tides, Rainfall, Tropical Storms, H

Who to Contract about Flooding in your area: Please select the "Local Contact Viewer" text on the right side of the panel below to launch the contact viewer application. Once the application launches, use the panel on the right side of the application to enter an address or location to be returned contact information.



Local Contact Viewer

Web application to access contact information for drainage districts, municipalities, counties and other organizations responsible for secondary drainage systems.

Share this card

Photos and Flood Observations:

The Document the Floods survey is for stakeholders to capture or upload photos and information about flooding at a location.

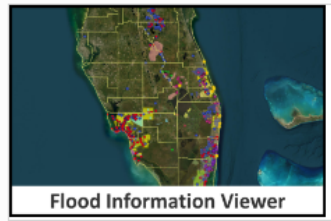
To provide information and photos for past events, please contact Resiliency@sfwmd.gov.

Document the Floods

Public survey to document flood events. Also available at sfwmd.gov\FloodingApp.

Submit / Capture Photo

Flood Documentation: Please select the "South Florida Flood Information Viewer" text on the right side of the panel below to launch the viewer application.



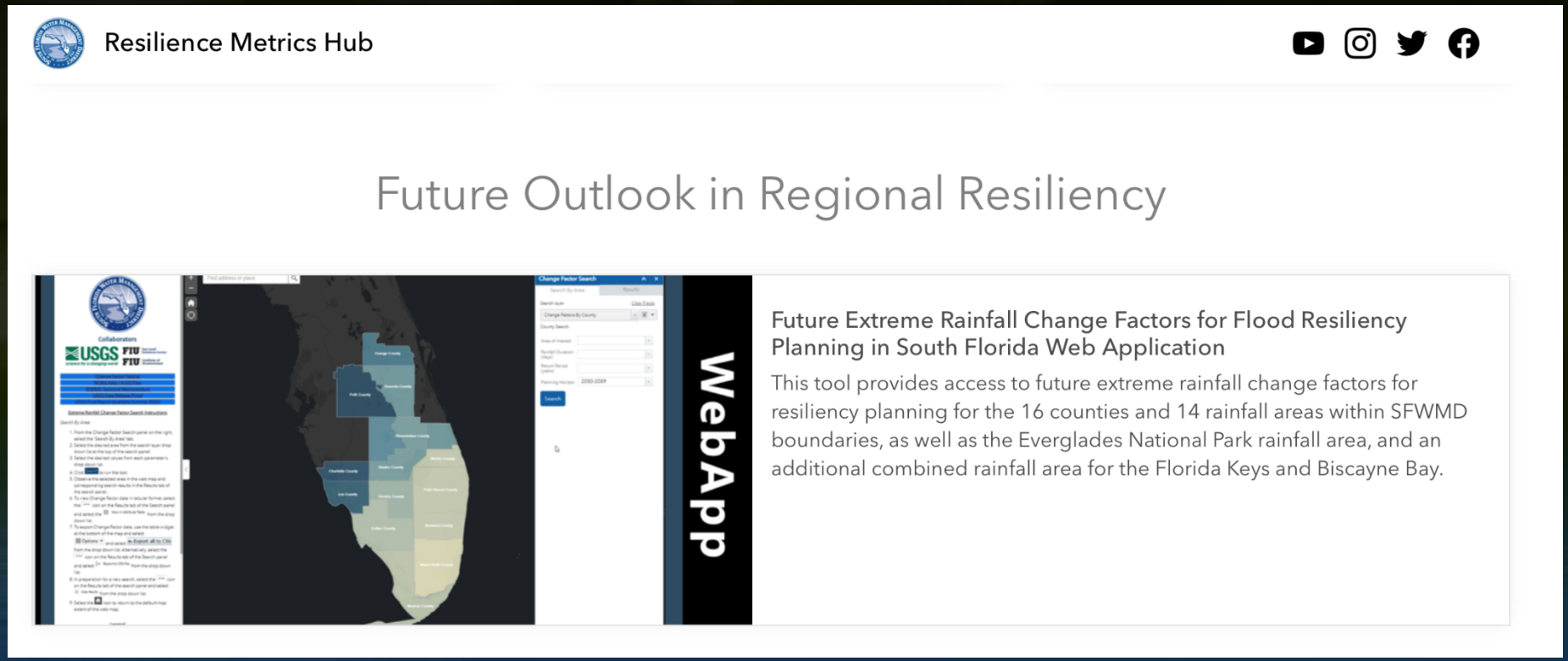
South Florida Flood Information Viewer

Web Application to provide access to the first version of flood documentation compiled as part of the SFWMD Water and Climate Resilience Flood Metric.

https://sfresiliency-sfwmdgis.hub.arcgis.com/

Future Extreme Rainfall Projections

Cooperative Agreement between SFWMD, USGS and Florida International University:
Development of change factors to derive projected future precipitation depth-duration-frequency curves

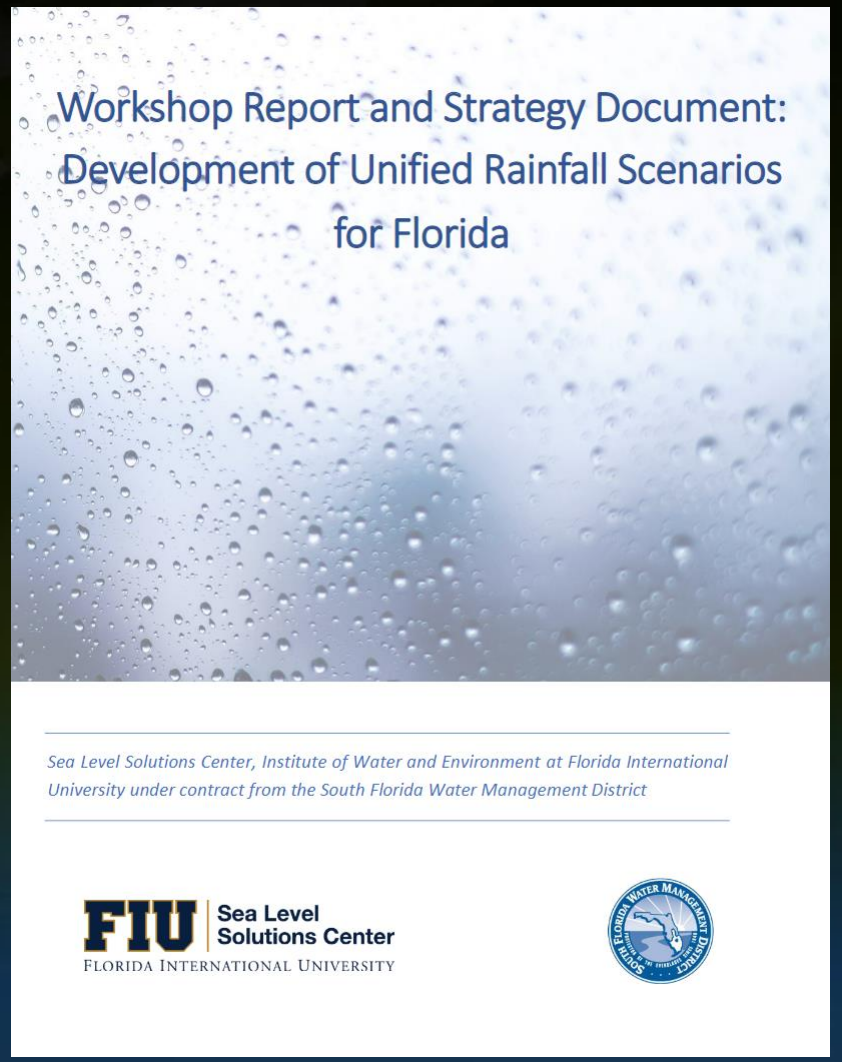


Rainfall Projections

May 2019 Workshop FIU/SFWMD

Shorter-term strategy: rainfall estimates based on available global climate model downscaled datasets

Longer-term strategy: development of a Florida Regional Climate Model to capture particular conditions /mechanisms of rainfall occurrences in our State, including tropical storms and sea breeze contributions, among other important climatic processes.



Future Rainfall Change Factors

USGS
science for a changing world

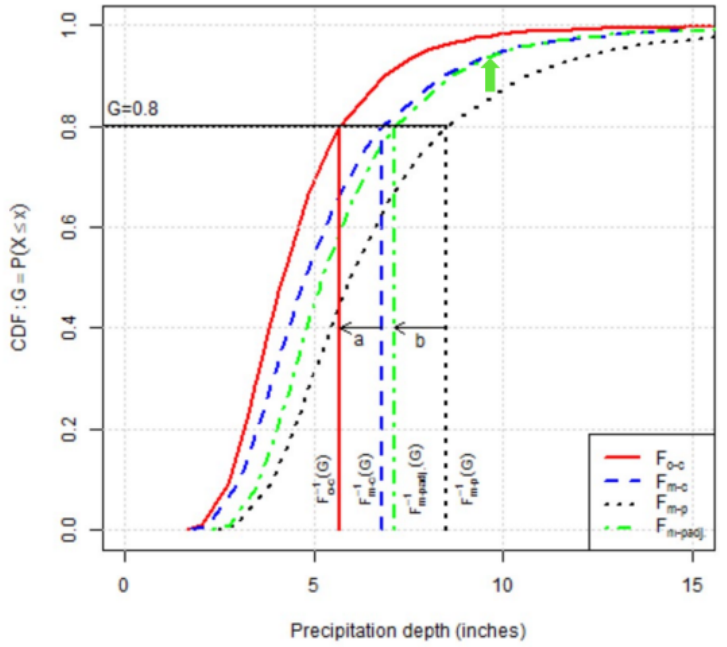
Prepared in cooperation with the South Florida Water Management District

Development of Projected Depth-Duration-Frequency Curves (2050–89) for South Florida

Scientific Investigations Report 2022–5093

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

https://pubs.usgs.gov/sir/2022/5093/sir20225093.pdf



Change Factor Definition from the Multiplicative Quantile Delta Method

$$\hat{x}_{m-padj.} = F^{-1}_{o-c}(G) * \underbrace{\{F^{-1}_{m-p}(G)/F^{-1}_{m-c}(G)\}}_{CF}$$

$F^{-1}_{o-c}(G)$ = Historic Observed Rainfall Term
$F^{-1}_{m-c}(G)$ = Modeled Historic Rainfall Term
$F^{-1}_{m-p}(G)$ = Modeled Projected Rainfall Term

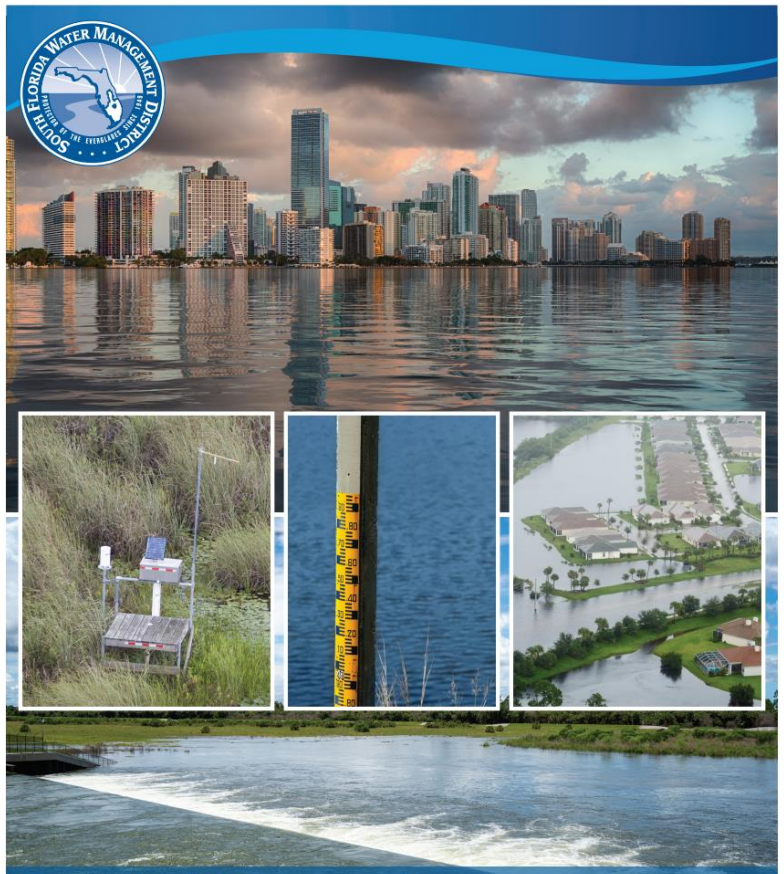
Change Factor (CF) = $F^{-1}_{m-p}(G)/F^{-1}_{m-c}(G)$

Change Factor = Modeled Projected Rainfall / Modeled Historic Rainfall

Future Rainfall = Observed Rainfall * CF

Figure 1. Change factor definition from the multiplicative quantile delta method (Adapted from Irizarry et al. 2016, and as established by Yin et al. 2019).

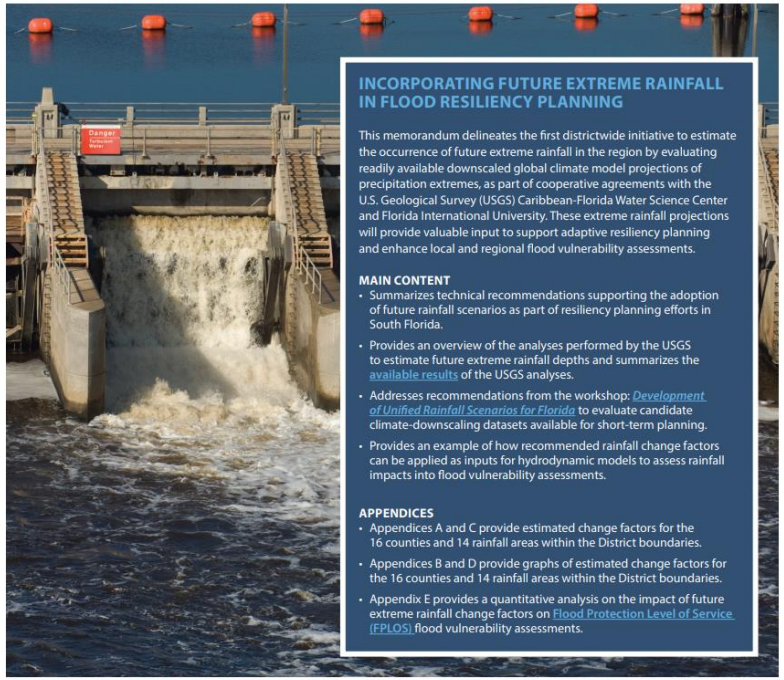
Adoption of Future Extreme Rainfall Change Factors for Flood Resiliency in South Florida



Technical Memorandum:

ADOPTION OF FUTURE EXTREME RAINFALL CHANGE FACTORS FOR FLOOD RESILIENCY PLANNING IN SOUTH FLORIDA

April 27, 2022



INCORPORATING FUTURE EXTREME RAINFALL IN FLOOD RESILIENCY PLANNING

This memorandum delineates the first districtwide initiative to estimate the occurrence of future extreme rainfall in the region by evaluating readily available downscaled global climate model projections of precipitation extremes, as part of cooperative agreements with the U.S. Geological Survey (USGS) Caribbean-Florida Water Science Center and Florida International University. These extreme rainfall projections will provide valuable input to support adaptive resiliency planning and enhance local and regional flood vulnerability assessments.

MAIN CONTENT

- Summarizes technical recommendations supporting the adoption of future rainfall scenarios as part of resiliency planning efforts in South Florida.
- Provides an overview of the analyses performed by the USGS to estimate future extreme rainfall depths and summarizes the available results of the USGS analyses.
- Addresses recommendations from the workshop: *Development of Unified Rainfall Scenarios for Florida* to evaluate candidate climate-downscaling datasets available for short-term planning.
- Provides an example of how recommended rainfall change factors can be applied as inputs for hydrodynamic models to assess rainfall impacts into flood vulnerability assessments.

APPENDICES

- Appendices A and C provide estimated change factors for the 16 counties and 14 rainfall areas within the District boundaries.
- Appendices B and D provide graphs of estimated change factors for the 16 counties and 14 rainfall areas within the District boundaries.
- Appendix E provides a quantitative analysis on the impact of future extreme rainfall change factors on Flood Protection Level of Service (FPLOS) flood vulnerability assessments.

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ACKNOWLEDGMENTS

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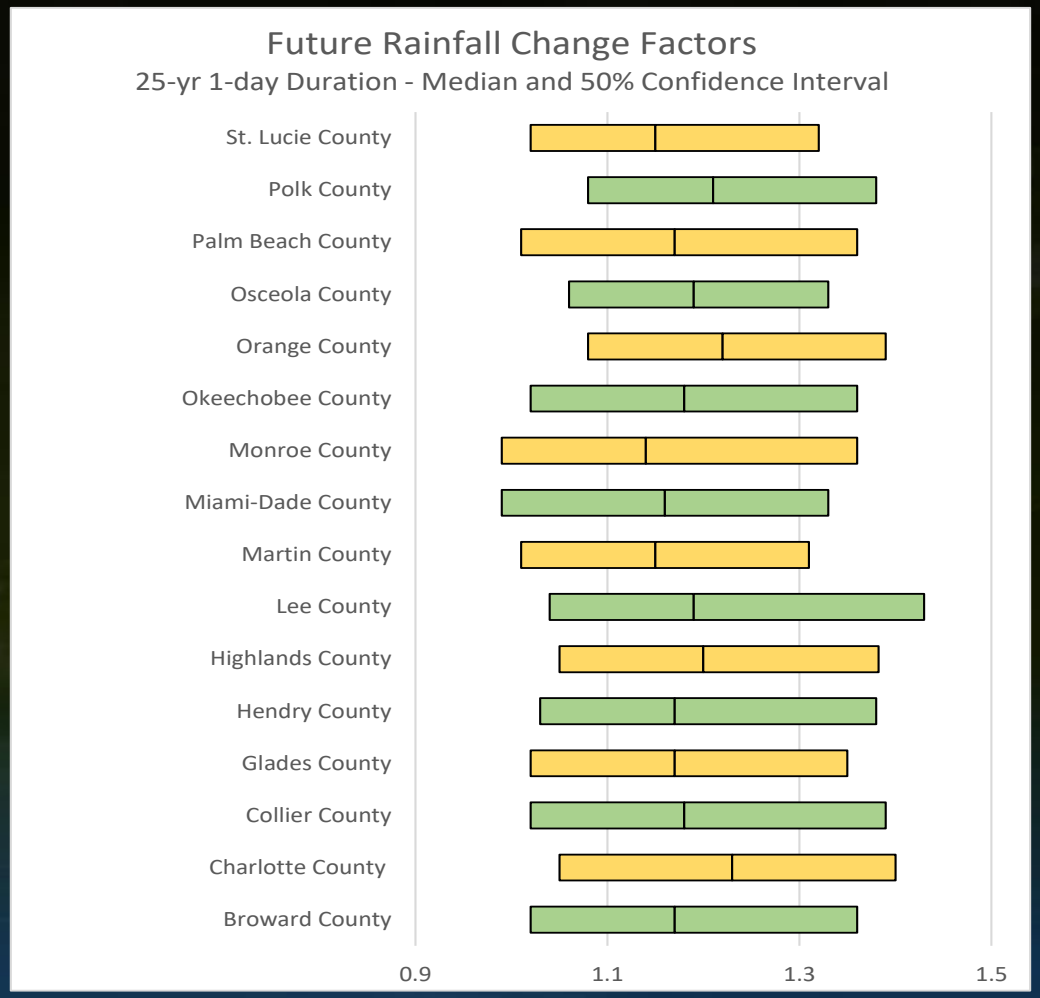
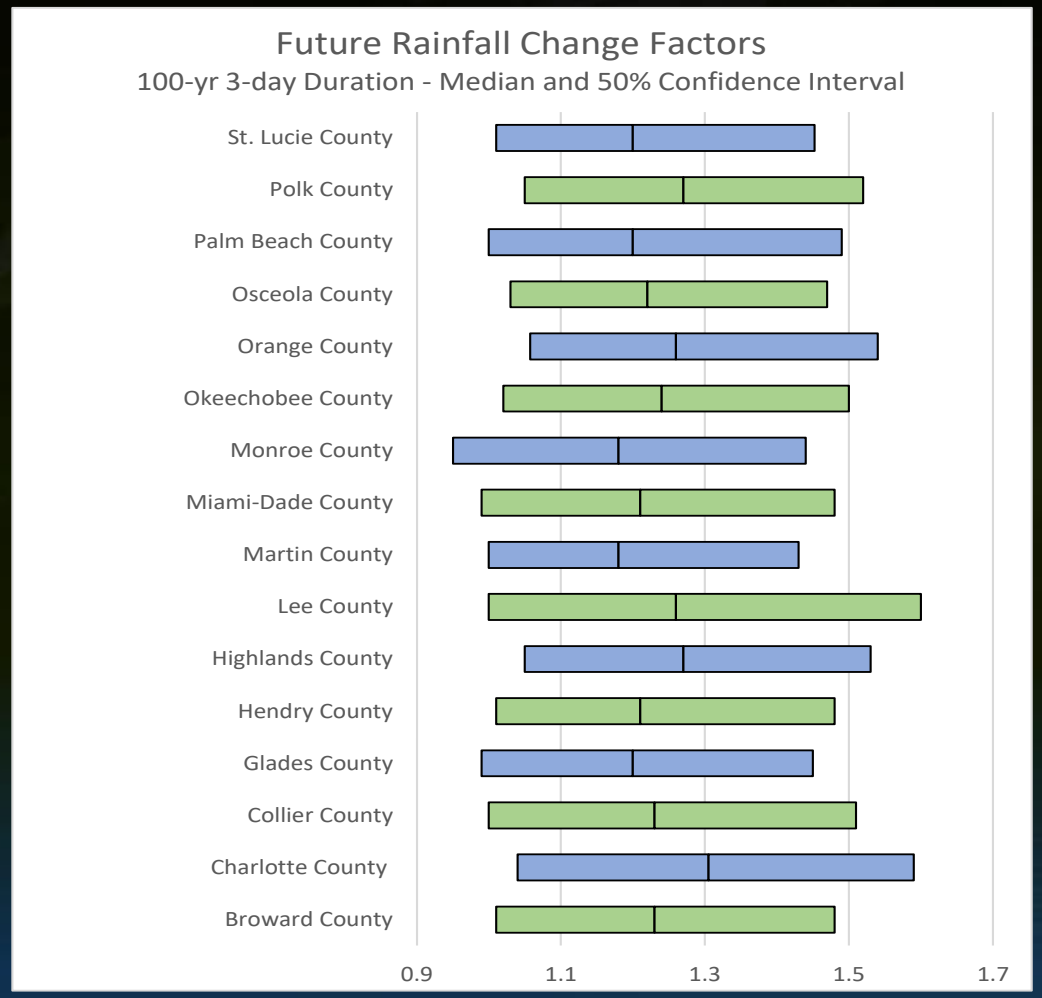
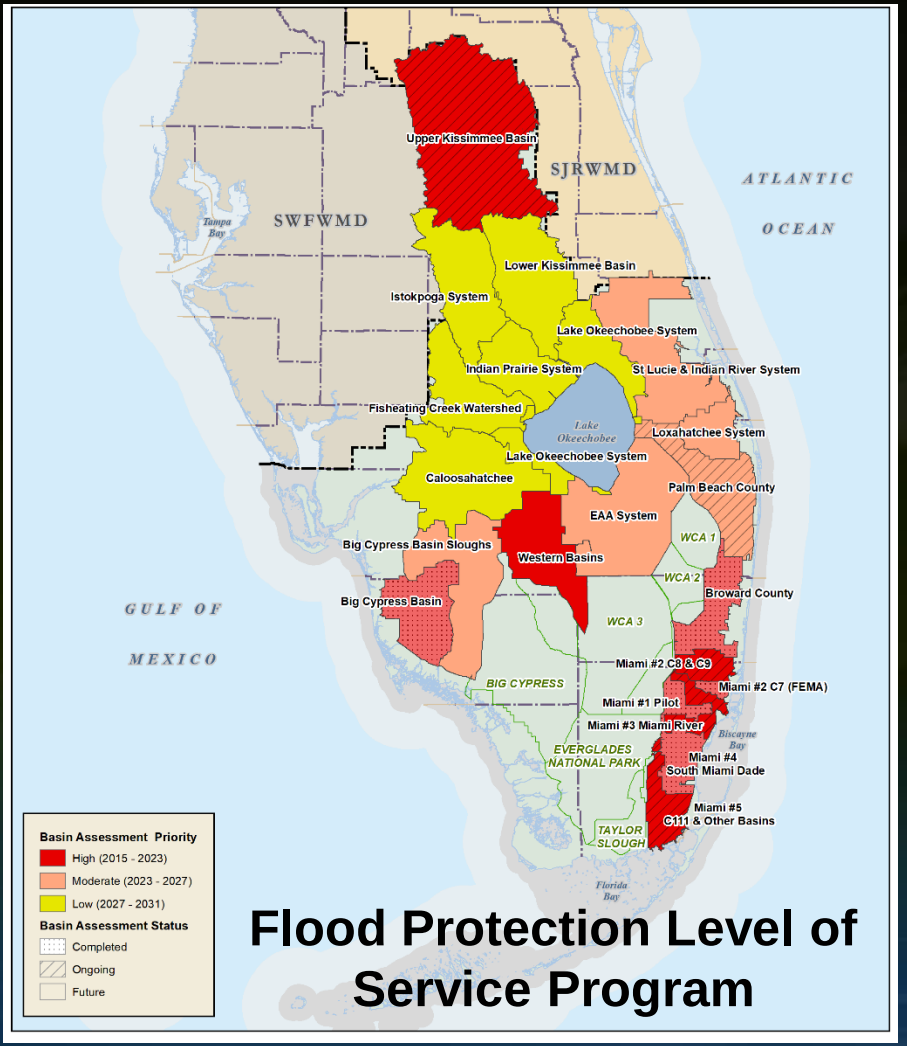
Counties Future Rainfall Change Factors

(median and 25th-75th percentiles, 100-year/3-day and 25-year/1-day)

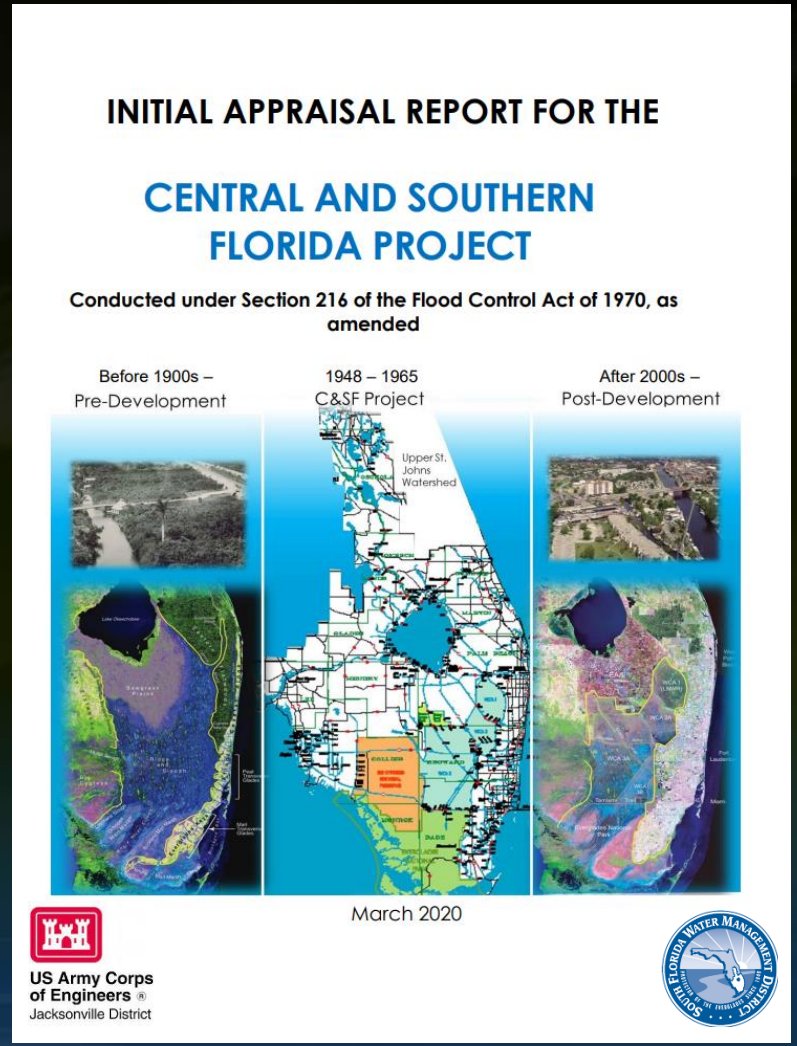


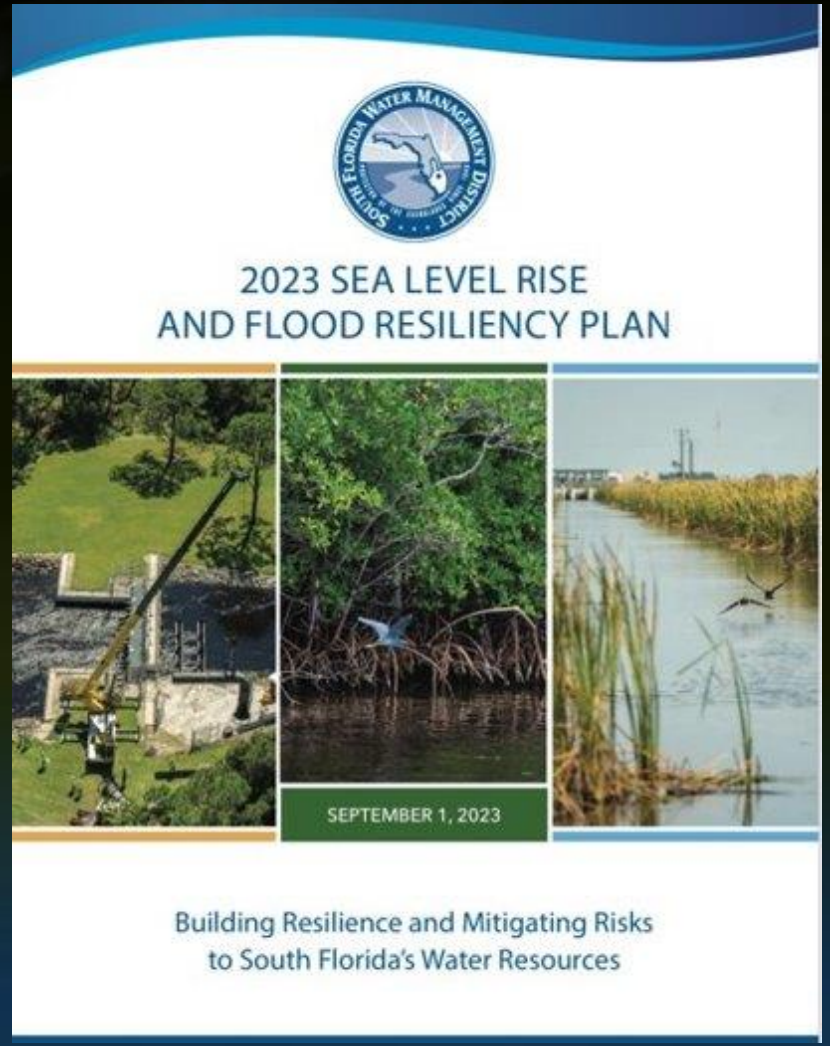


SFWMD's Future Rainfall Needs and Applications – Resiliency Planning



Flood Protection Level of Service Program





Statewide Effort: Florida Flood Hub

SCIENTIFIC AND TECHNICAL WORKGROUPS

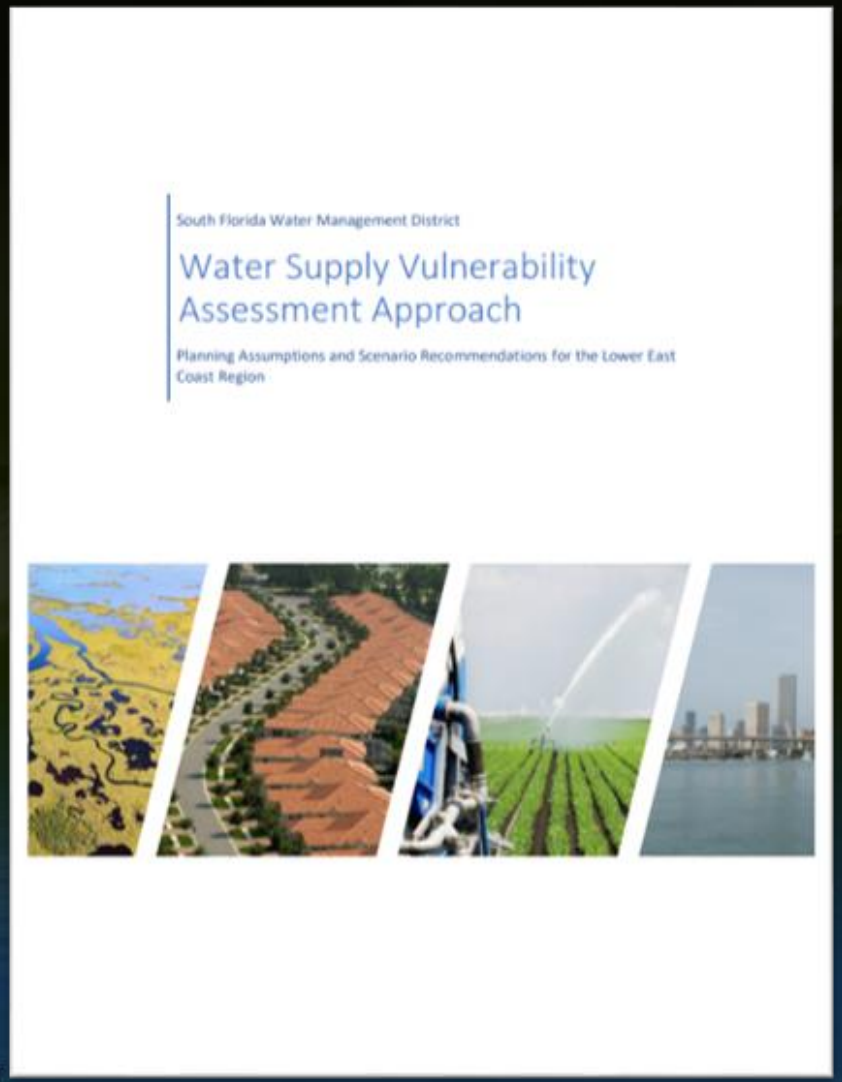
SEA LEVEL RISE WORKGROUP

RAINFALL WORKGROUP

- estimate changes to the depth, duration, and frequency of extreme rainfall events
- improve short-term forecasts and longer-term projections

Irizarry-Ortiz, M.M., and Dixon, J., 2023, Change factors to derive projected future precipitation depth-duration-frequency (DDF) curves at 242 National Oceanic and Atmospheric Administration (NOAA) Atlas 14 stations in Florida (ver 1.1, September 2023): U.S. Geological Survey data release, https://doi.org/10.5066/P9Q3LEIL.

Extreme Dry Events and Water Supply Vulnerability Assessment



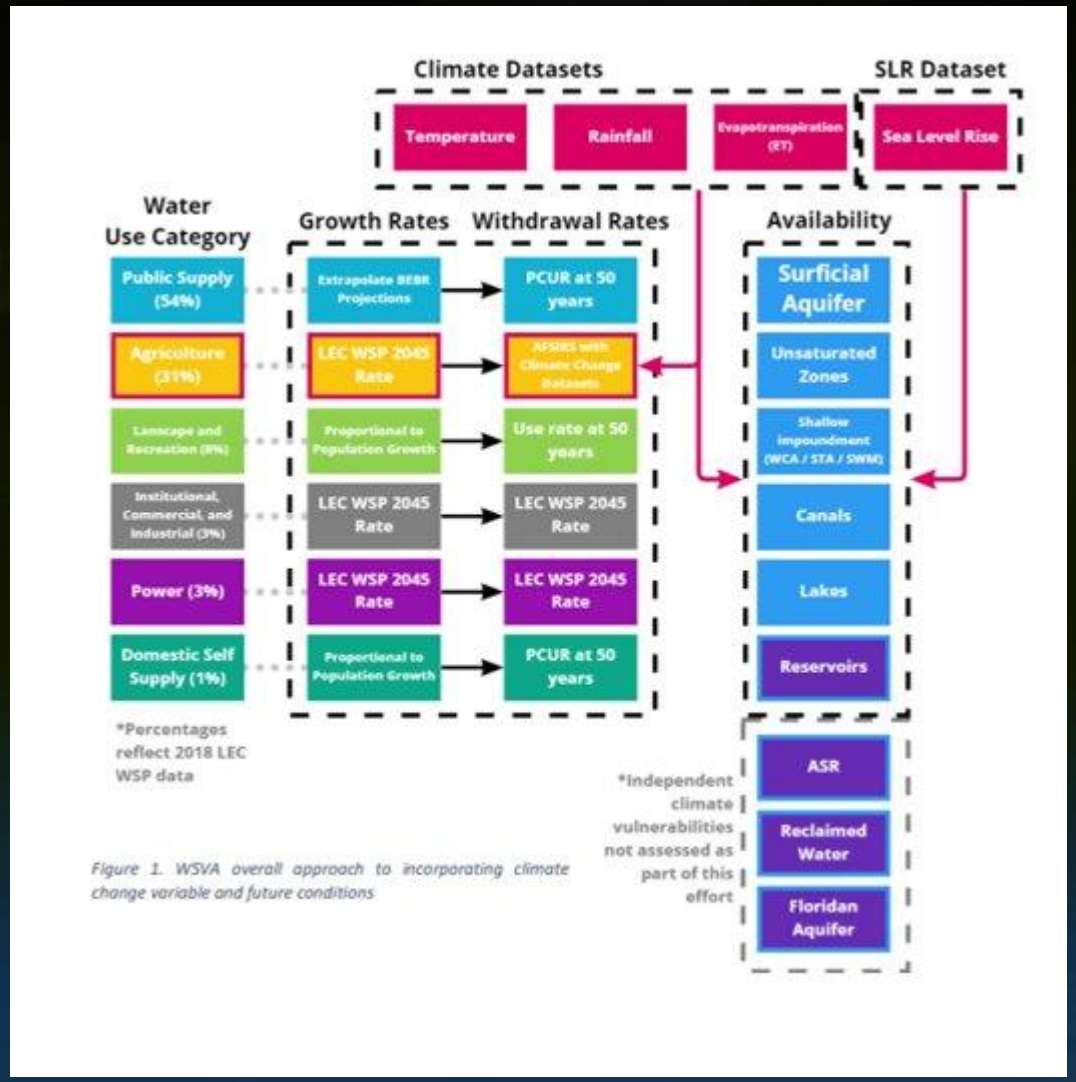


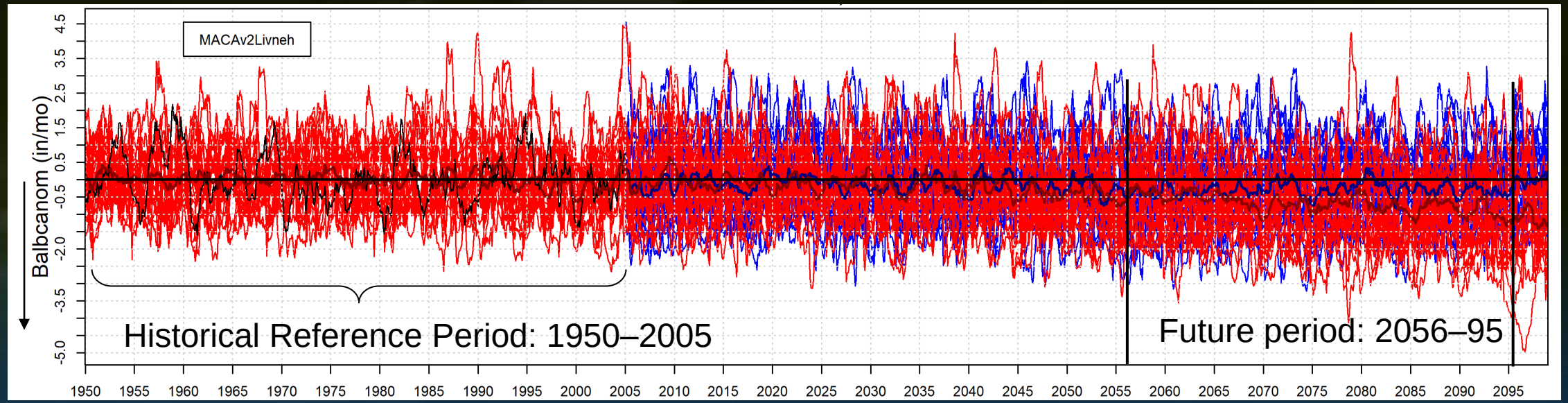
Figure 1. WSVA overall approach to incorporating climate change variable and future conditions

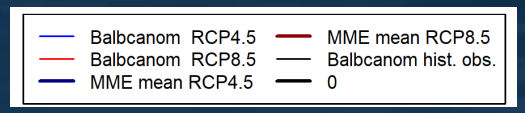
USGS FIU SFWMD Drought Analysis

Timescale-Averaged Balance Anomalies

Monthly Balance = P - RET → Subtract mean historical *balance* for month of the year to get *Balance Anomalies* → Moving average of *Balance Anomalies* over timescale (6, 12 mos.) → *Timescale-Averaged Balance Anomaly*

RCP4.5
RCP8.5



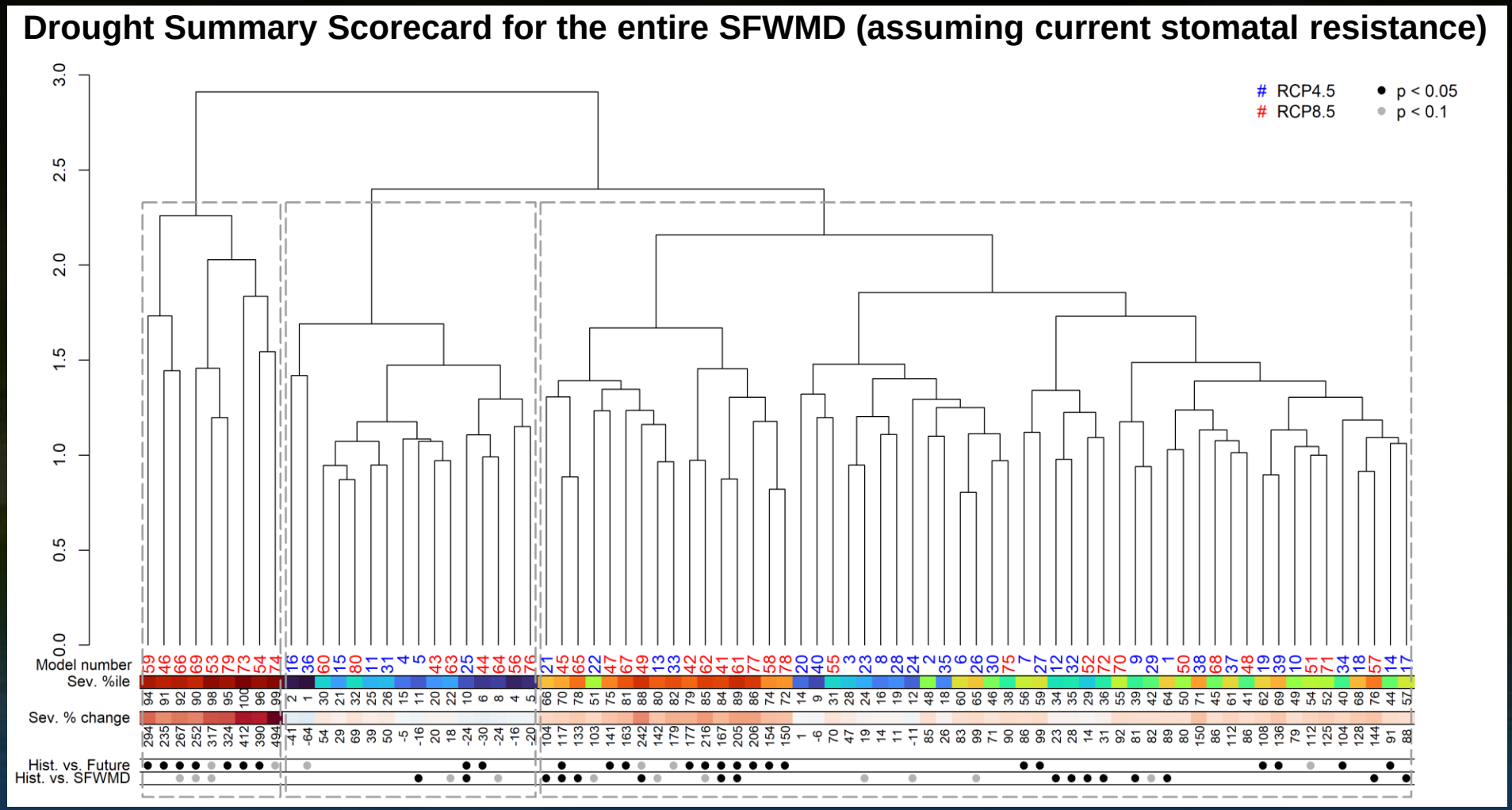


Entire SFWMD

DRAFT RESULTS – UNDER REVIEW

USGS FIU SFWMD Drought Analysis

Drought Summary Scorecard for the entire SFWMD (assuming current stomatal resistance)



DRAFT RESULTS – UNDER REVIEW

Highlights

SFWMD's Water and Climate Resilience Metrics are central for improving regional, and local, resiliency planning.

Observed Trends

- Regional findings equates to local insights – e.g. ET/Rainfall, Flood Occurrences

Future Projections

- Accounting for extremes to respond now while planning long-term – e.g. Enhanced Tidal Forecasts, Wet/Dry Rainfall

Characterizing evolving conditions, to the best extent possible, is critical for water resources management and improving community resilience in South Florida.

Seeking to broaden partnerships for:

- continued analysis of observed trends;
- identifying influencing factors and analytical correlations;
- refining climate-informed monitoring; and
- developing approaches for refined future climate projections and projections development.

NOAA's Climate Resilience Regional Challenge

- Link the integration of findings into local and regional risk reduction and resilience planning efforts, going beyond dissemination.
  - ***Detailing how the effort align with existing initiatives and how they will be utilized by communities to bolster resilience.***
- Demonstrate effectiveness in sustaining activities, partnerships, and initiatives in supporting continued outcomes and securing ongoing funding.
  - ***Highlighting the efforts' role in building local capacity, leadership, and fostering continued support.***
- Emphasize the interconnectedness of climate and resilience metrics, illustrating the significance in documenting shifts and capturing system responses post-project implementation.
  - ***Highlighting the unique aspects of the effort in refining data analysis for local and regional perspectives of evolving conditions, informing monitoring in a novel manner.***
- Broaden community engagement beyond academia, through partnerships and fostering the involvement of local and sub-regional organizations, and other stakeholders.
  - ***Providing specifics on benefits to marginalized communities and tribes engaging regarding insights, decision-making, and utilization. Ensuring equitable development and deployment of resilience strategies across all communities in the region.***

Thanks!

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Photo by Paul Krashefski