



Water Management Resiliency Initiatives

Carolina Maran, P.E., Ph.D., District Resiliency Officer

June 8, 2021

Water Abundance



Photo by Scott Hennessy



Land Use and Water Management



Source: Broward County Historical Commission

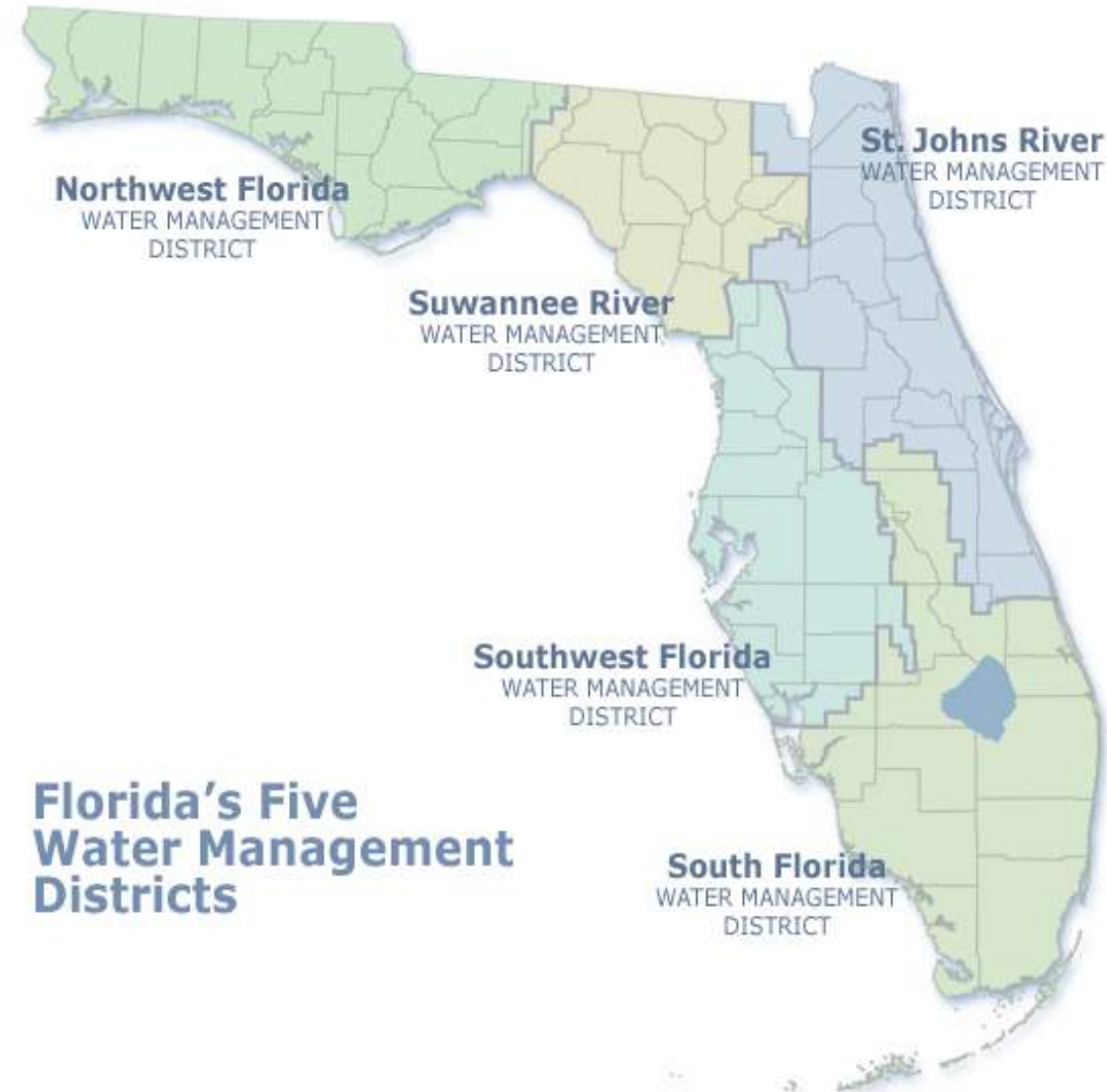


Source: SFWMD

South Florida Water Management District

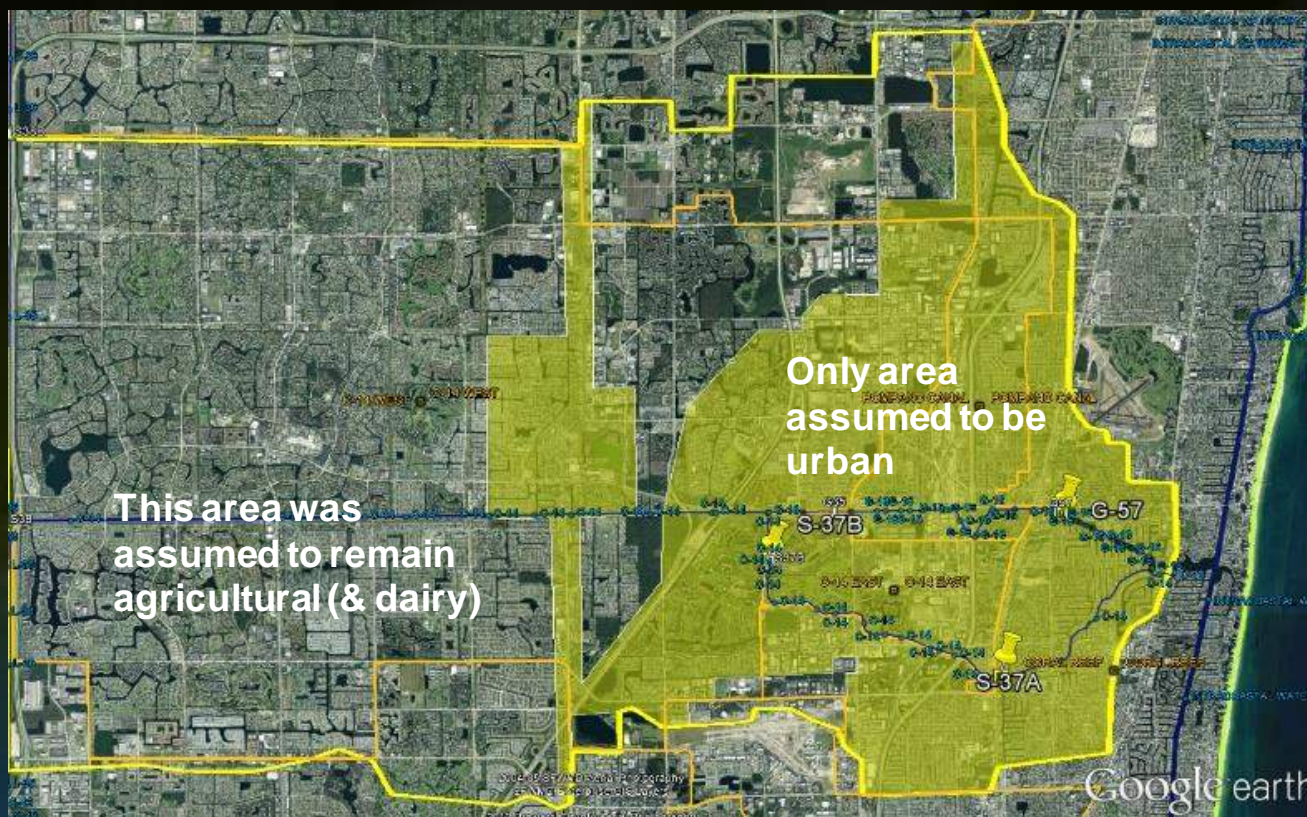
- Created in 1949, oldest and largest of the state's five water management districts
- 16 counties from Orlando to the Florida Keys
- Serves a population of 8.7 million residents
- 2,200 miles of canals; 2,100 miles of levees/berms, 84 pump stations, 778 water control structures and weirs and 621 project culverts

MISSION: to safeguard and restore South Florida's water resources and ecosystems, protect our communities from flooding, and meet the region's water needs while connecting with the public and stakeholders.

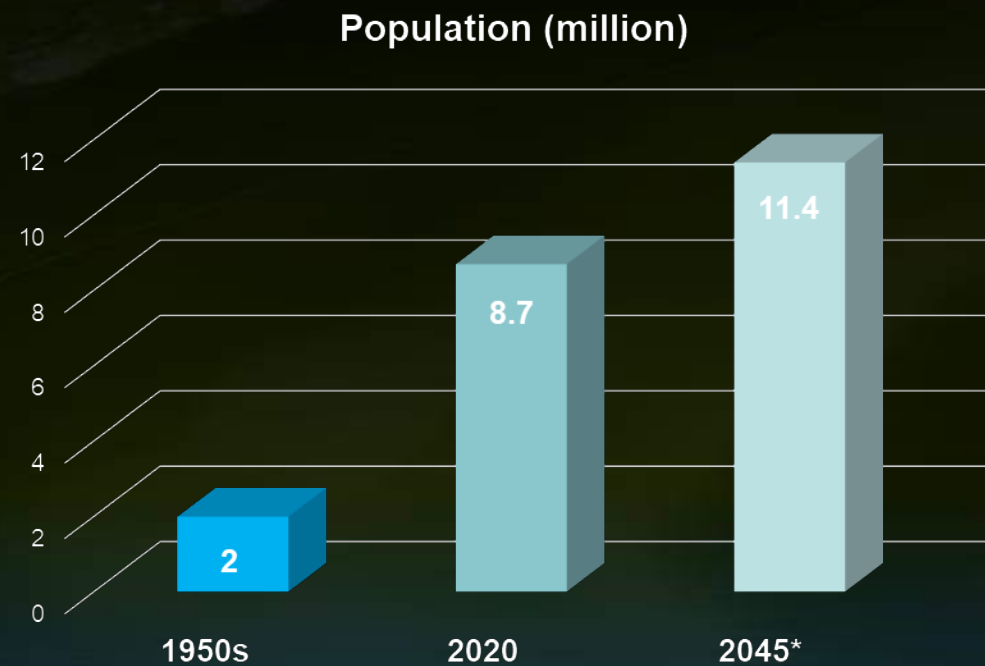


Recognizing Changed Conditions

LAND DEVELOPMENT



POPULATION GROWTH

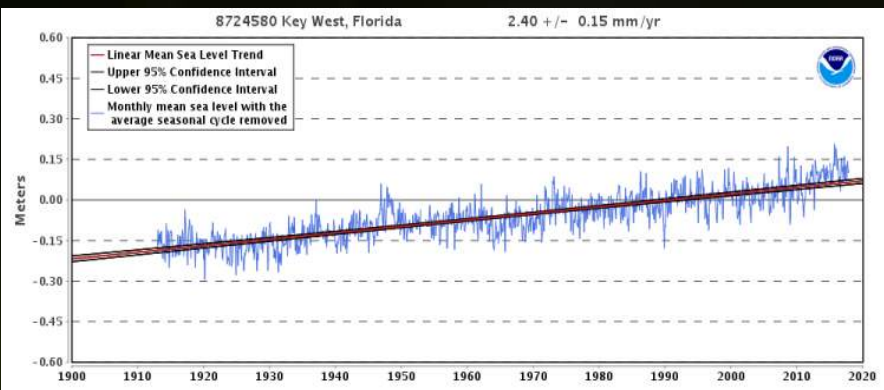


* Estimate taken from BEBR 2017 publication (Median, SFWMD boundaries)

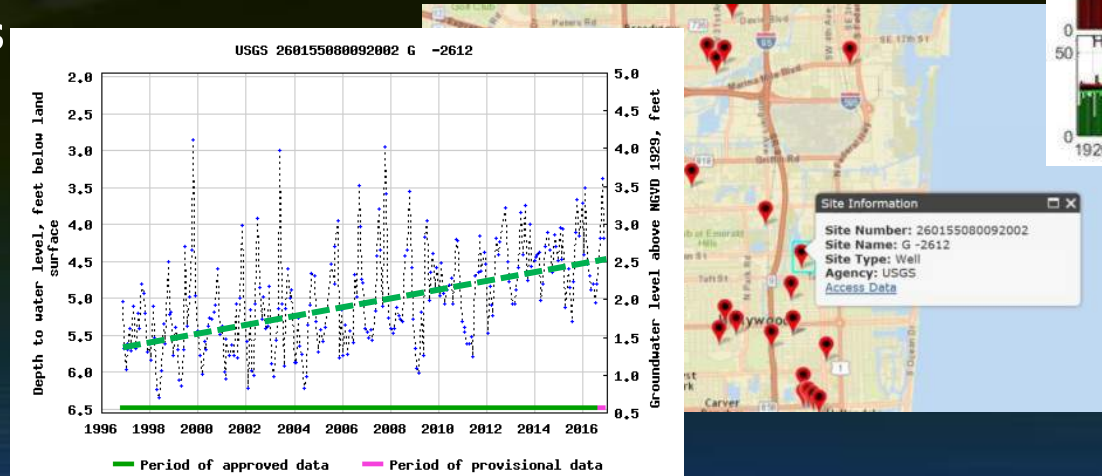
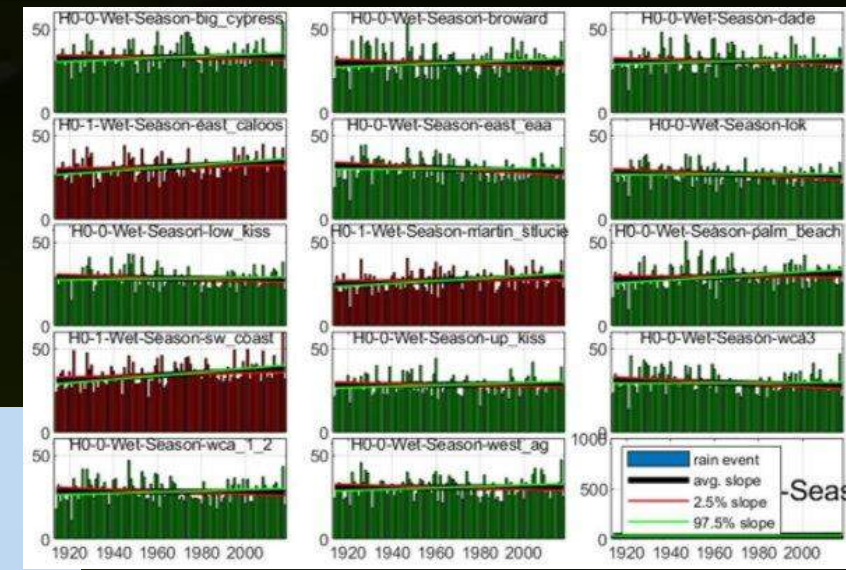
Climate Changed Observed Conditions

SEA LEVEL RISE

MORE EXTREME RAINFALL

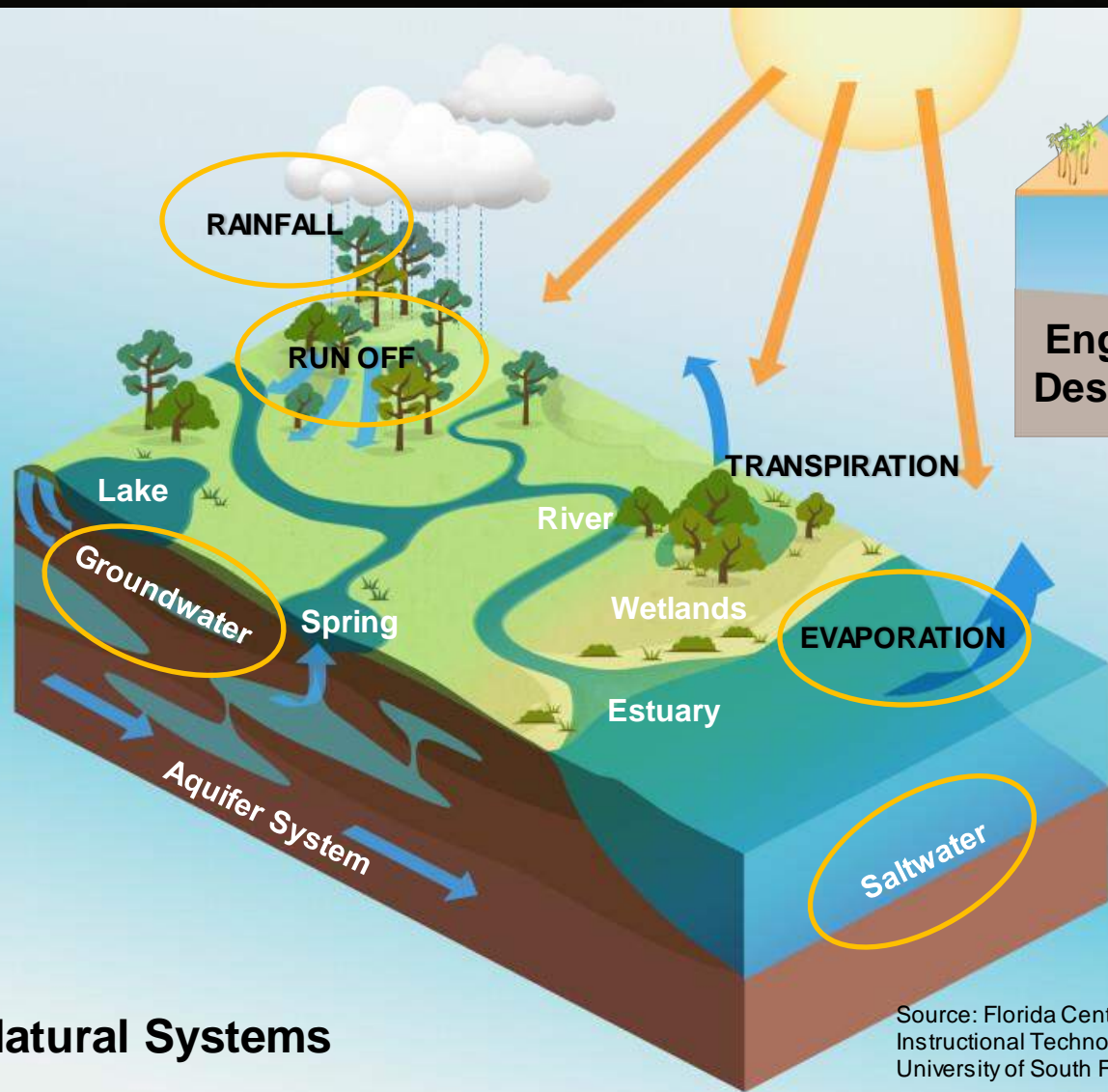


Associated with High Tides



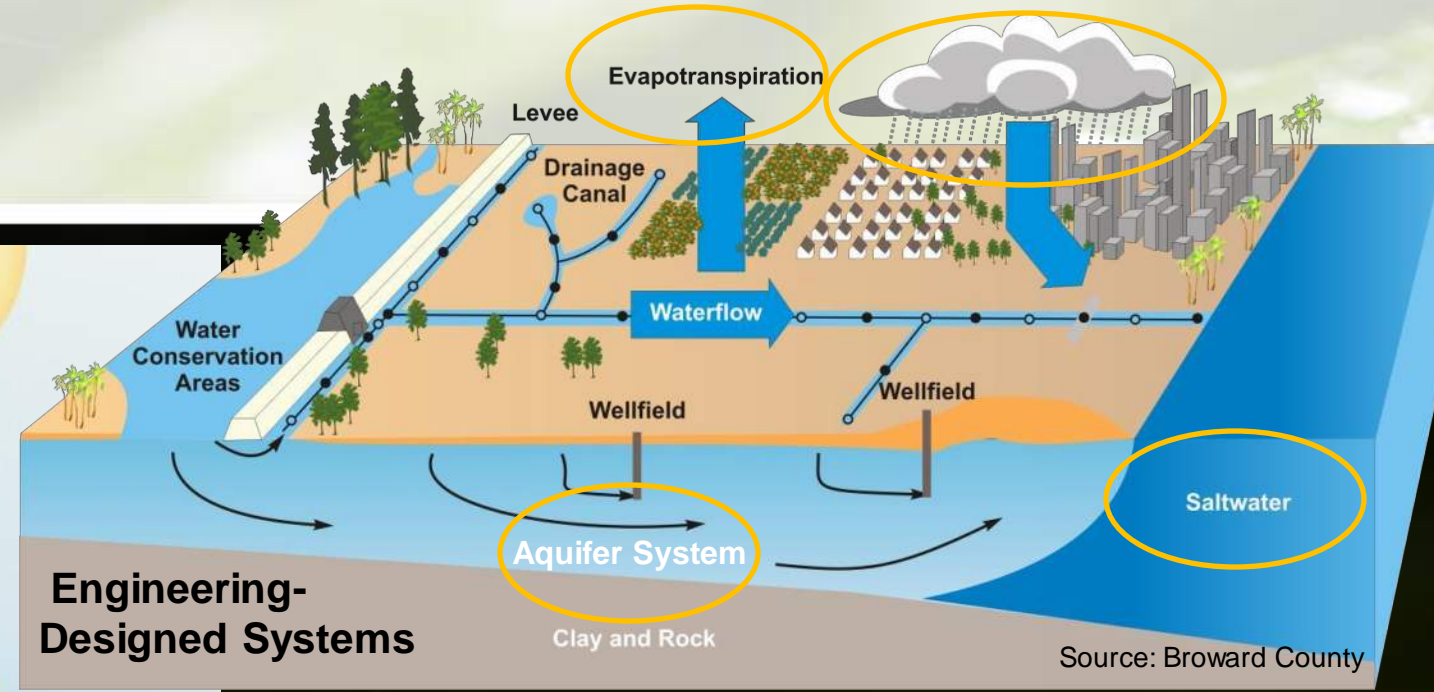
Wet Season Rainfall Trend Analysis Results (by Rainfall Region)

HIGHER GROUNDWATER



Natural Systems

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



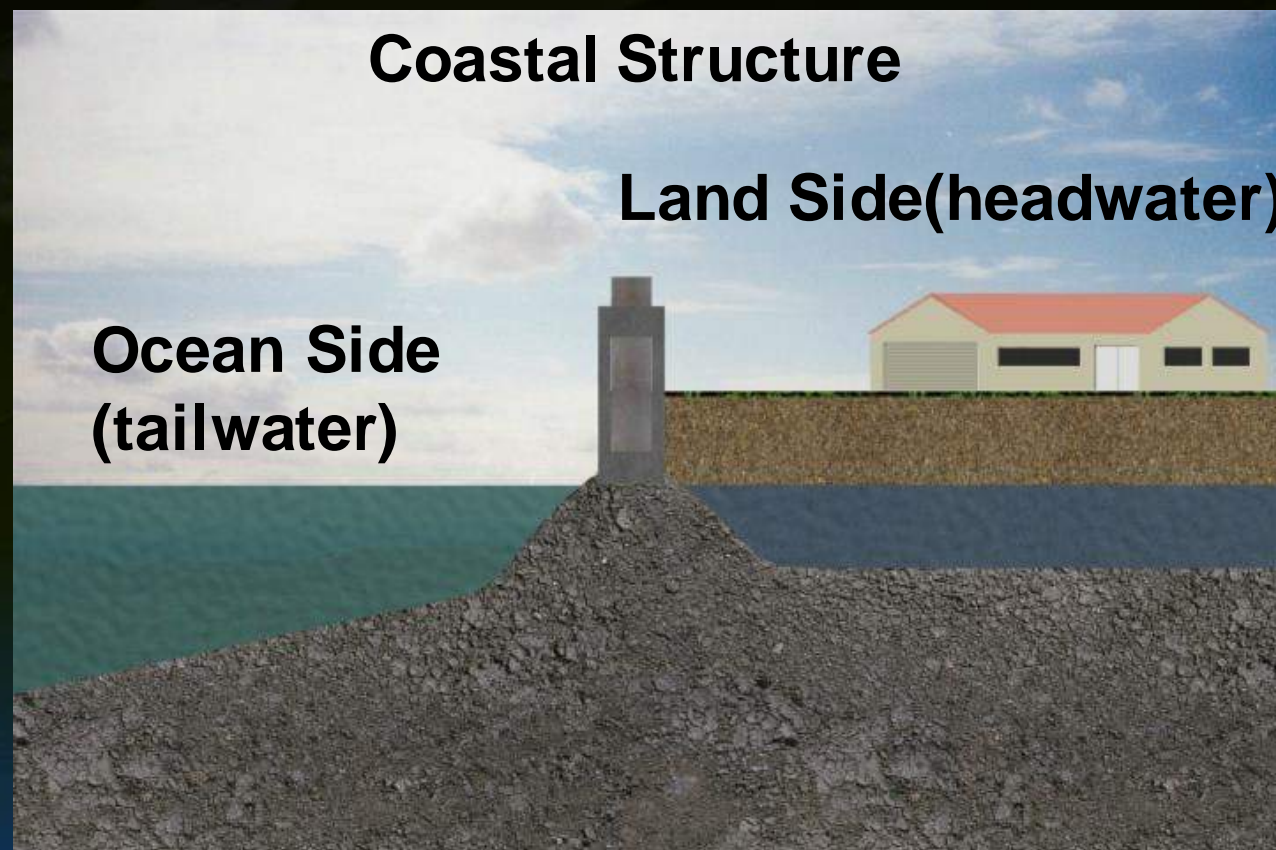
Source: Broward County

CHANGING CONDITIONS IMPACTS OVER WATER MANAGEMENT SYSTEMS

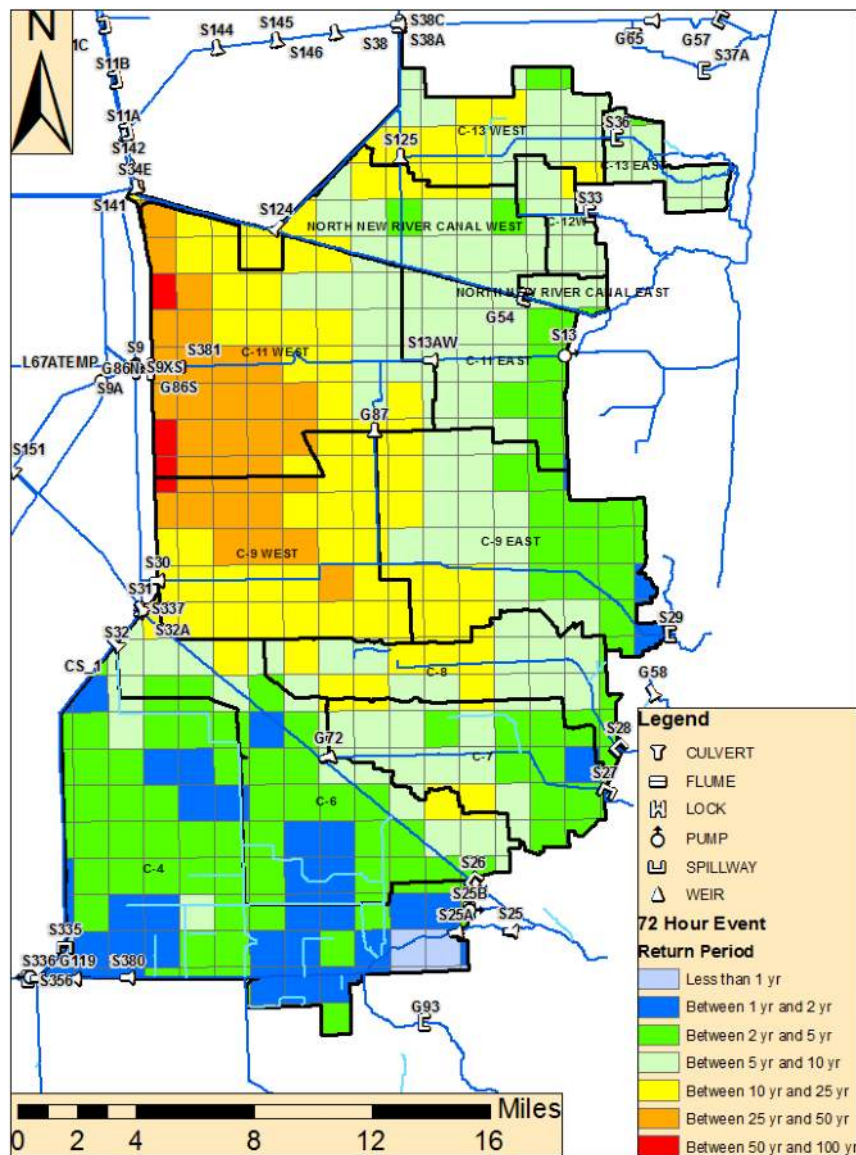
Impacts of Sea Level Rise Already Being Observed



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

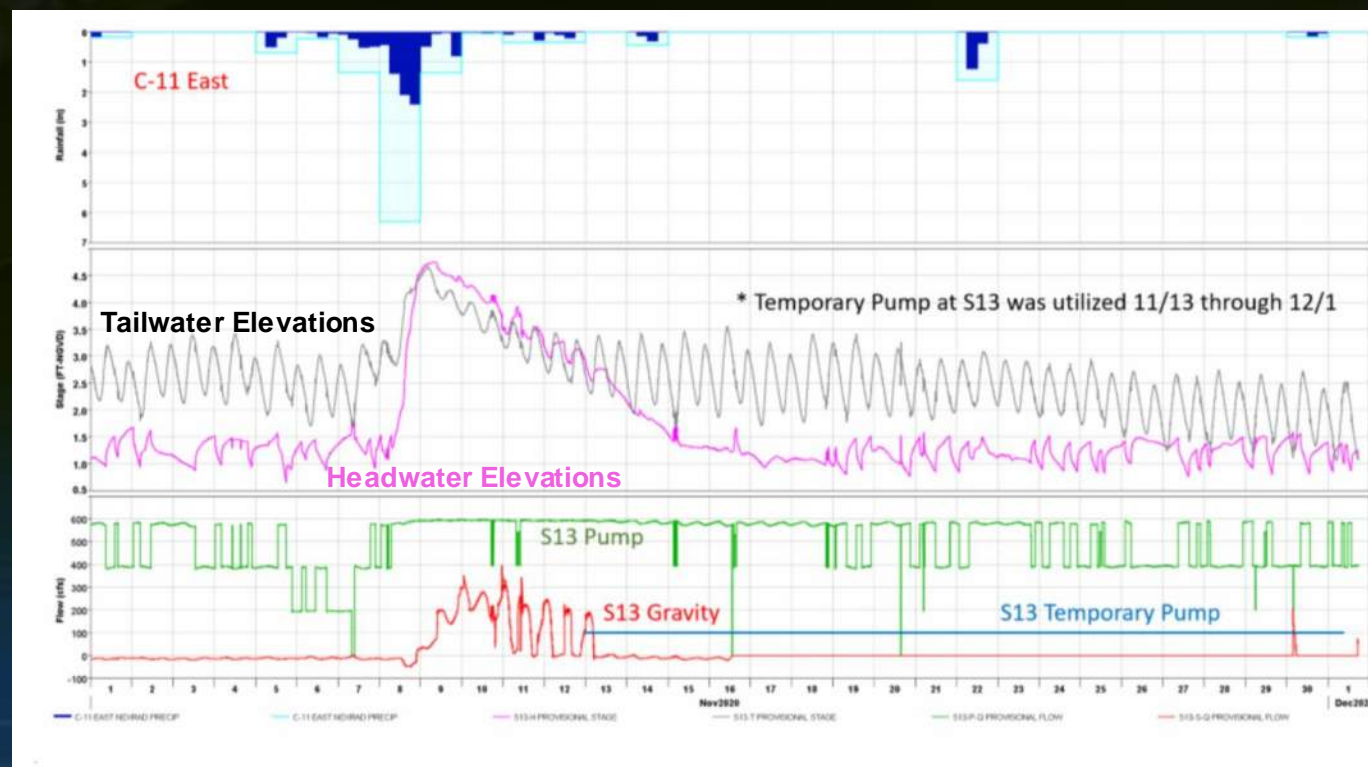


Tropical Storm Eta



December 2020: significant rainfall occurrences in several locations

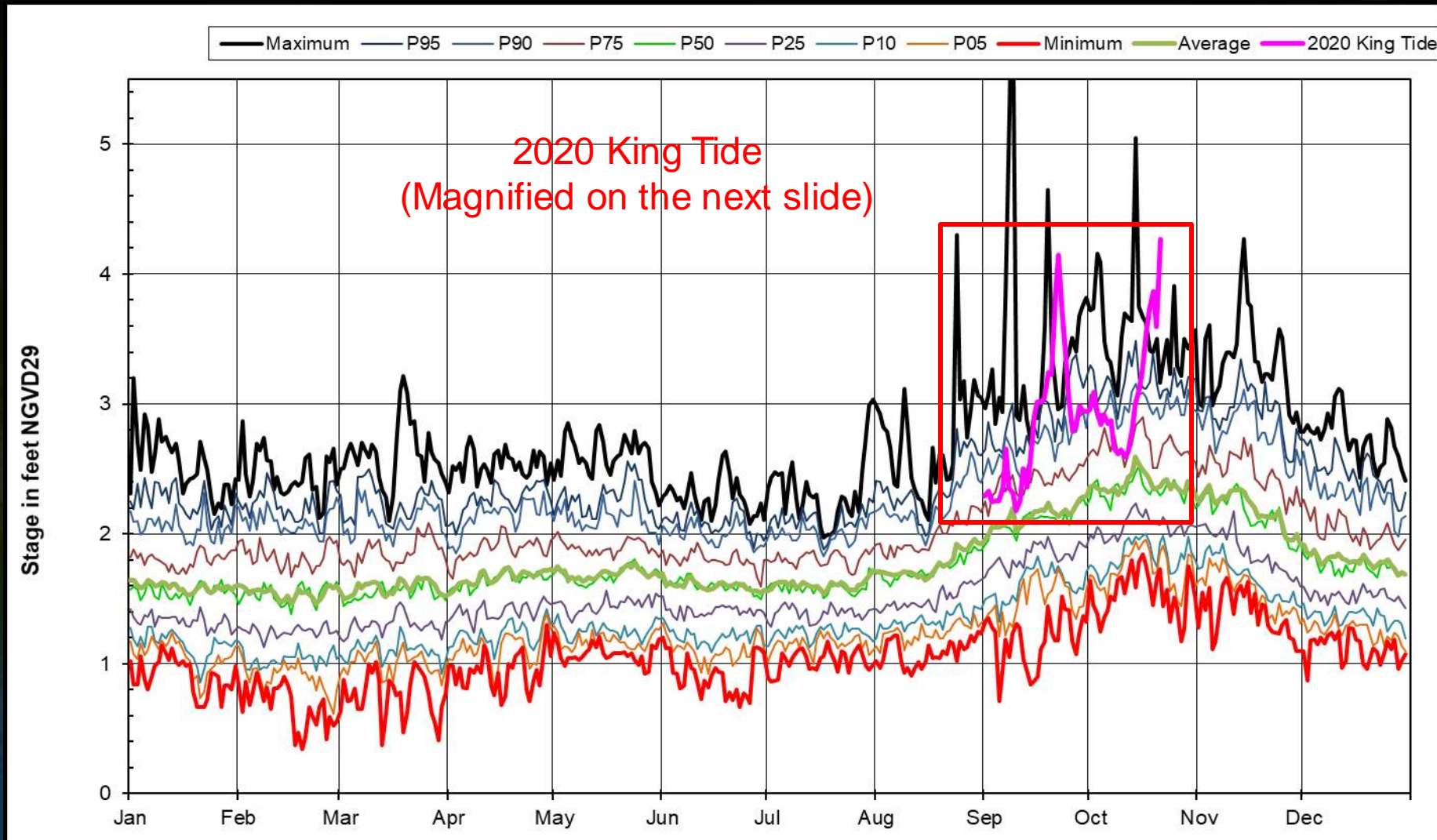
Very wet antecedent conditions



72-hour Rainfall Return Intervals over the Broward and North Miami Counties during TS Eta

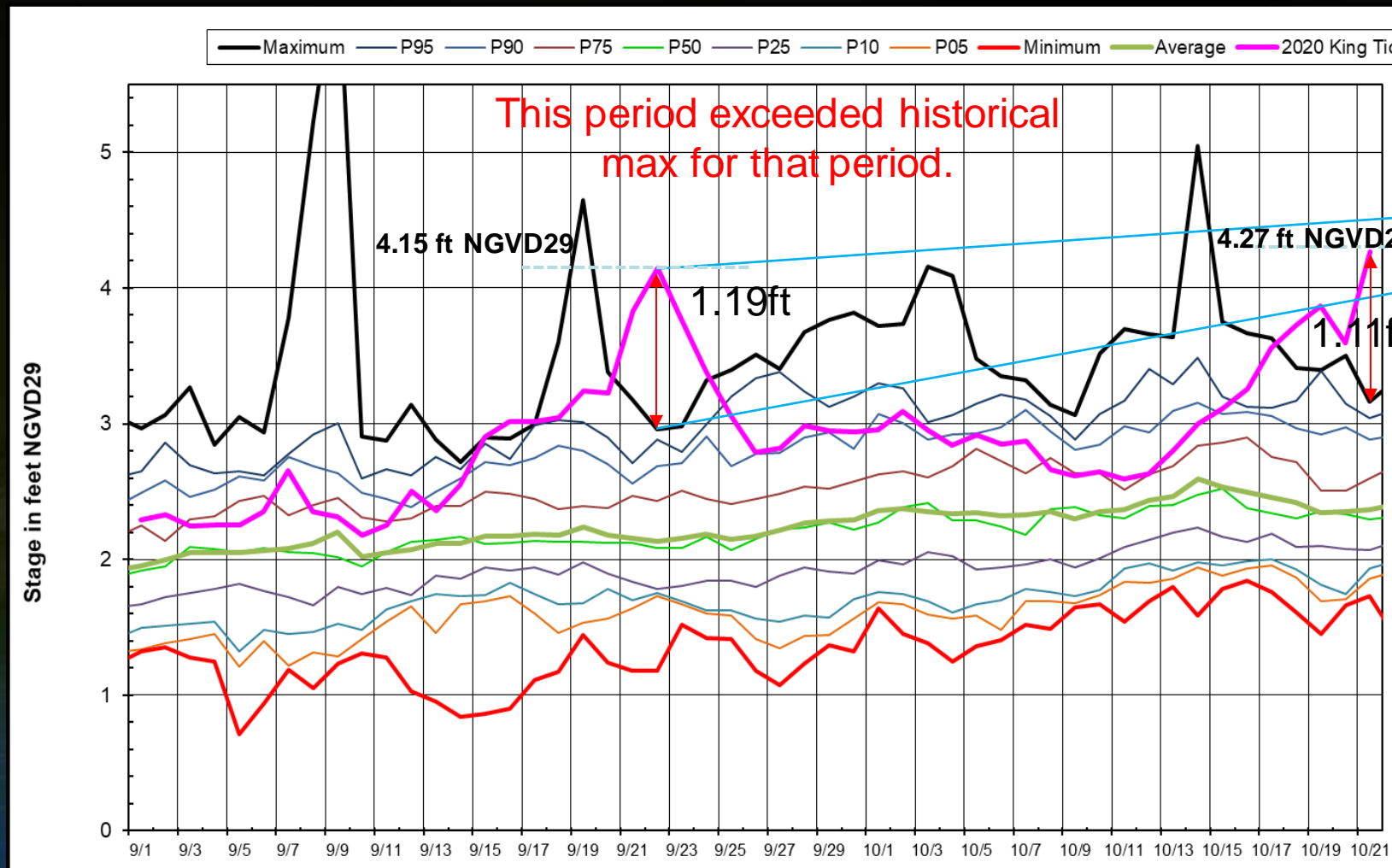
Cyclic Analysis of Maximum Daily TW stages

(Jan 1, 1986 – Dec 31, 2019) at S-20F



Cyclic Analysis of Maximum Daily TW stages

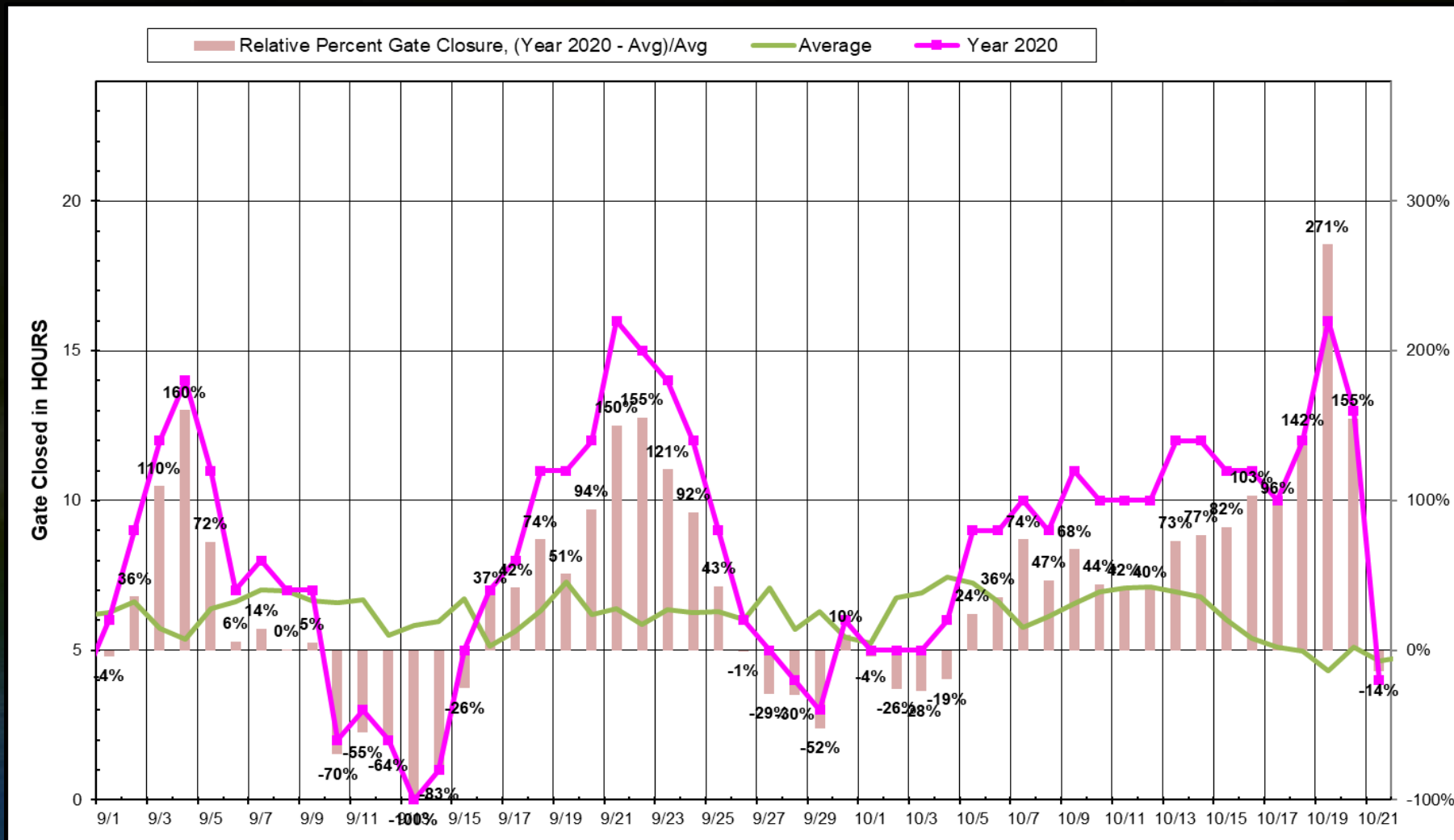
(Jan 1, 1986 – Dec 31, 2019) at S-20F



Date	09/22
2020 King Tide	4.15
Average	2.13
Maximum	2.96
Minimum	1.18
P100	2.96
P99	2.95
P98	2.95
P95	2.88
P90	2.69
P75	2.43
P50	2.08
P25	1.78
P10	1.76
P05	1.73
P00	1.18

Relative Percent Gate Closure

(Year 2020 – Avg)/Avg at S20F , when S-20F HW > 1.7 ft NVGD29



Sunny Day Flooding



Pompano Beach



Delray Beach



Miami Beach



Lantana

Extreme Rainfall Flooding



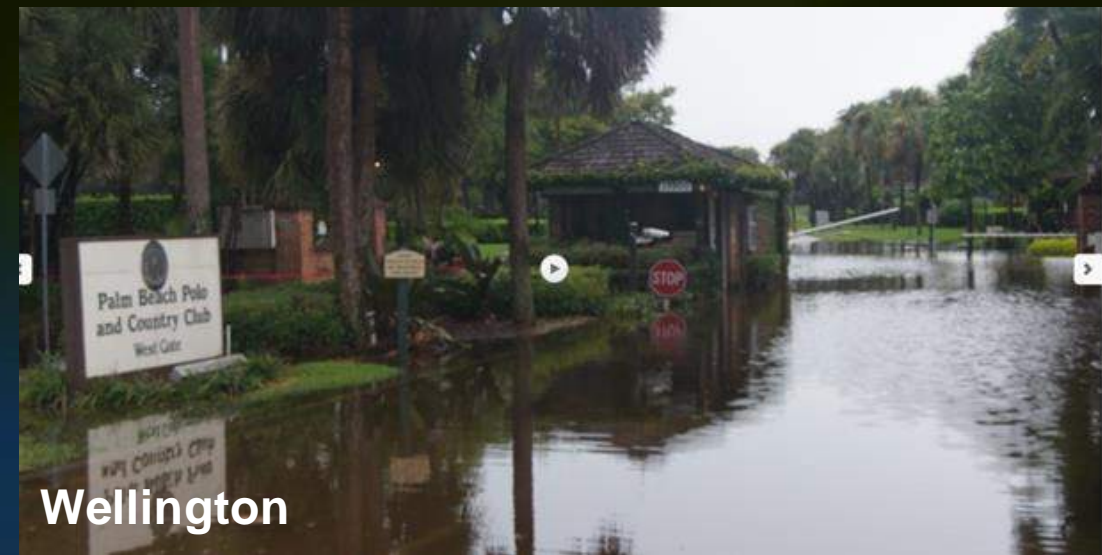
North Miami



Pure Thoughts Horse Rescue - Loxahatchee

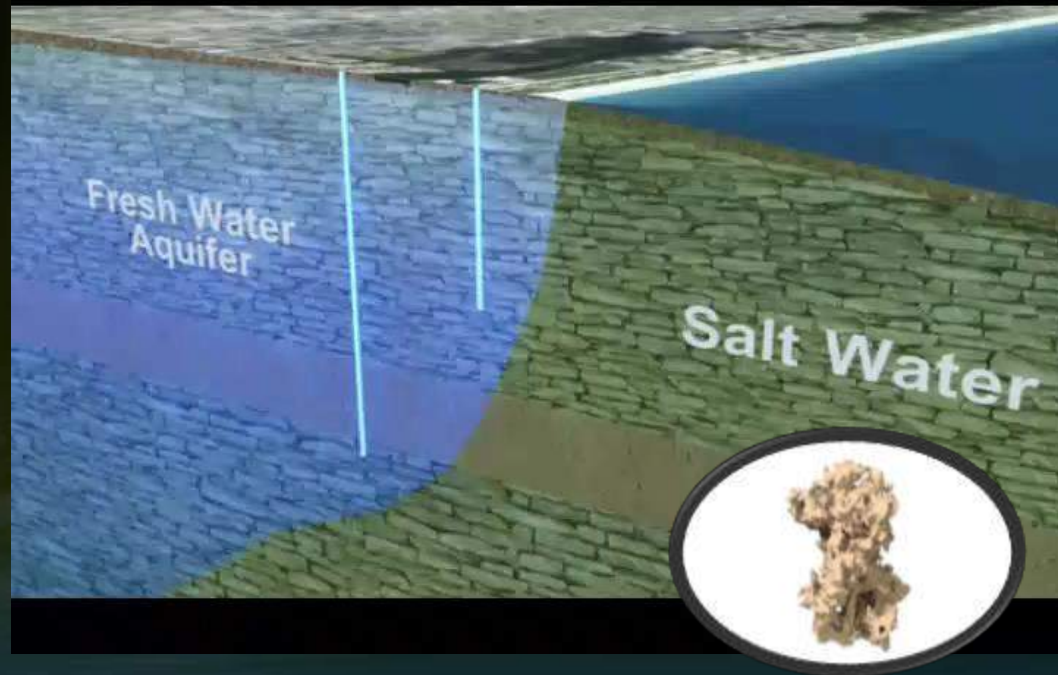


Sawgrass Mall - Sunrise



Wellington

Saltwater Intrusion



Resiliency among District Priority Actions

EXPANDING MONITORING AND DATA ANALYSIS

ADVANCING FUTURE CONDITIONS ASSESSMENTS

HARDENING FLOOD PROTECTION INFRASTRUCTURE

INVESTING IN ALTERNATIVE WATER SUPPLY SOURCES

RESTORING NATURAL SYSTEMS

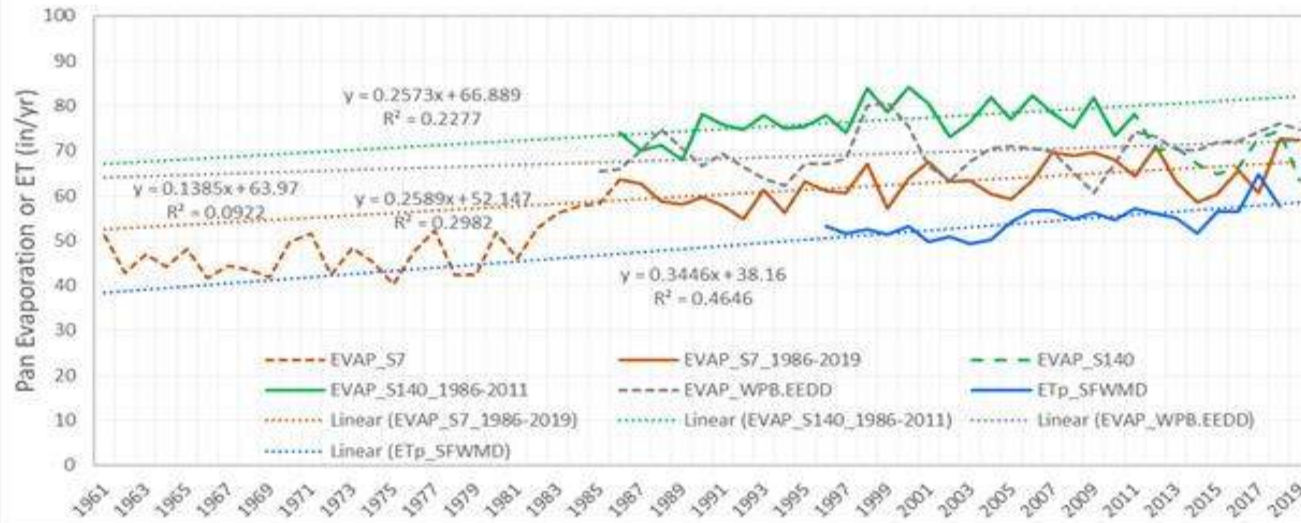
PROMOTING STAKEHOLDER ENGAGEMENT AND OUTREACH



Water and Climate Resiliency Metrics

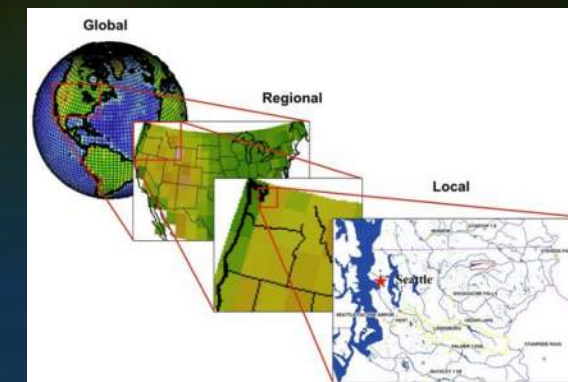
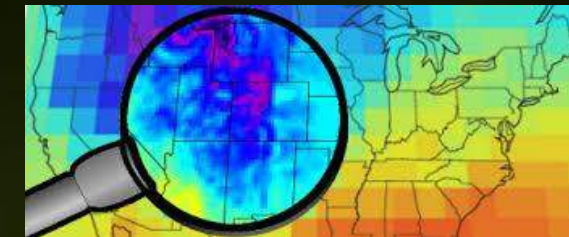
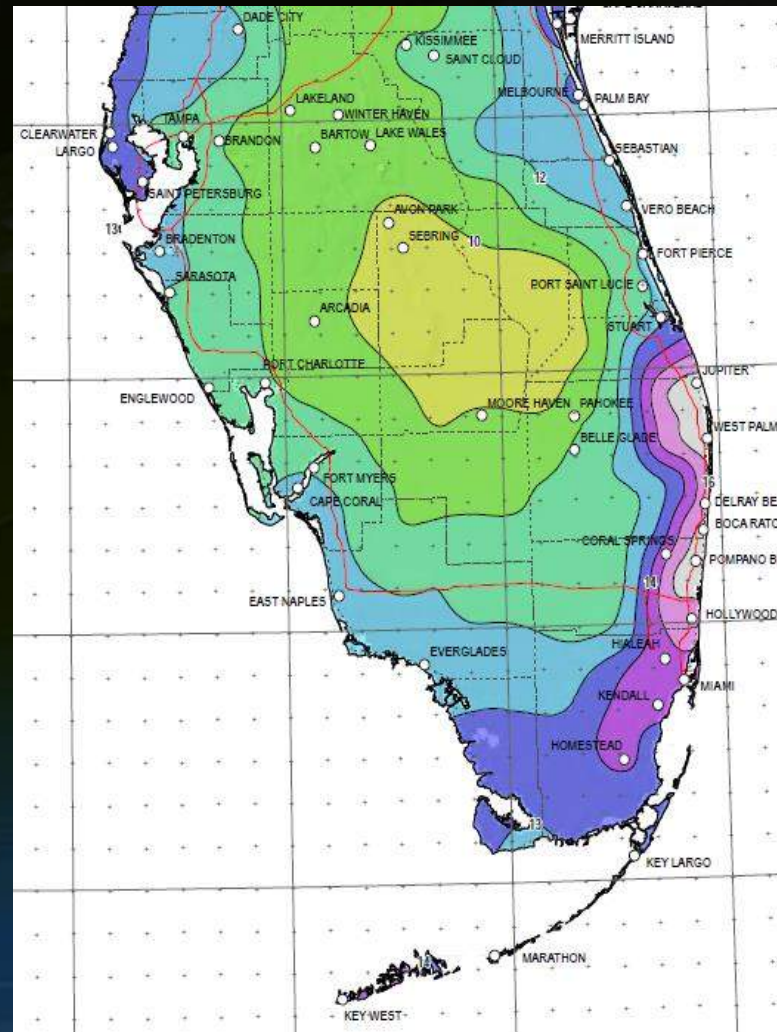
Inform District Resiliency strategies, coordination with partner agencies, and communicate with stakeholders and the general public.

Trend Of Annual EVAP & ET At SFWMD (1961-2019)



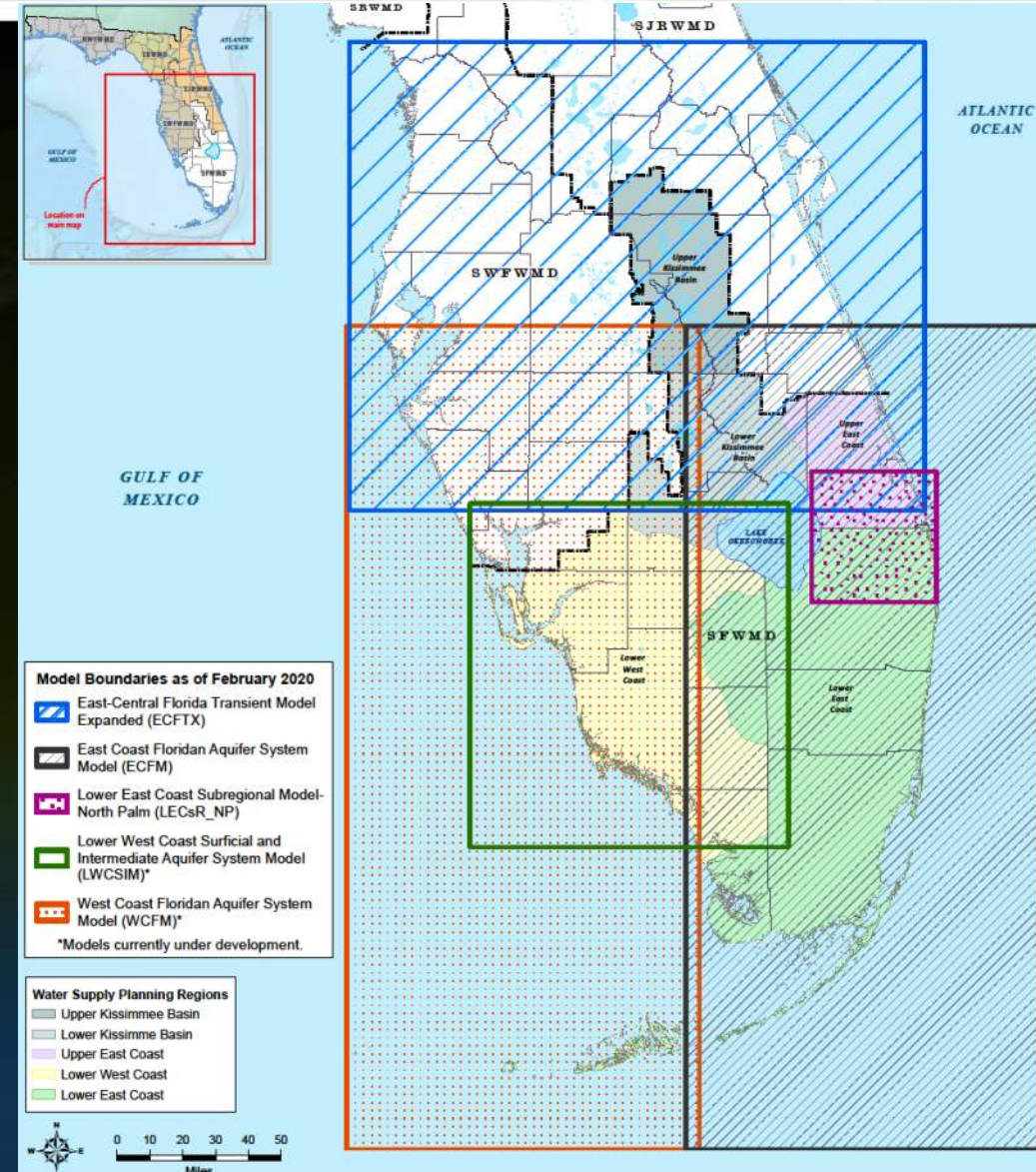
Future Rainfall Projections

- Partnership with USGS & FIU
- Assessment of four pre-selected global climate model downscaling datasets (short-term effort)
- Estimate changes in extreme rainfall by 2070, districtwide, compared to NOAA Atlas 14 Rainfall observations
- Next steps: Florida Regional Weather Forecast Model, under discussion



Water Supply Plans & Monitoring

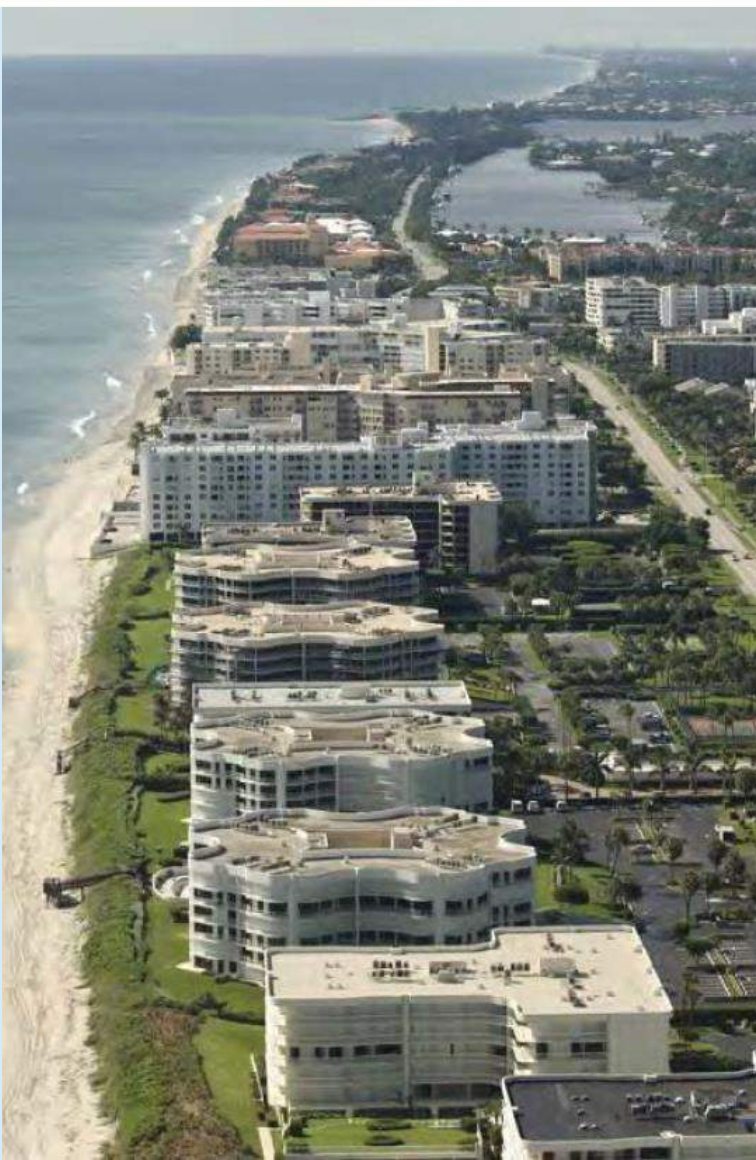
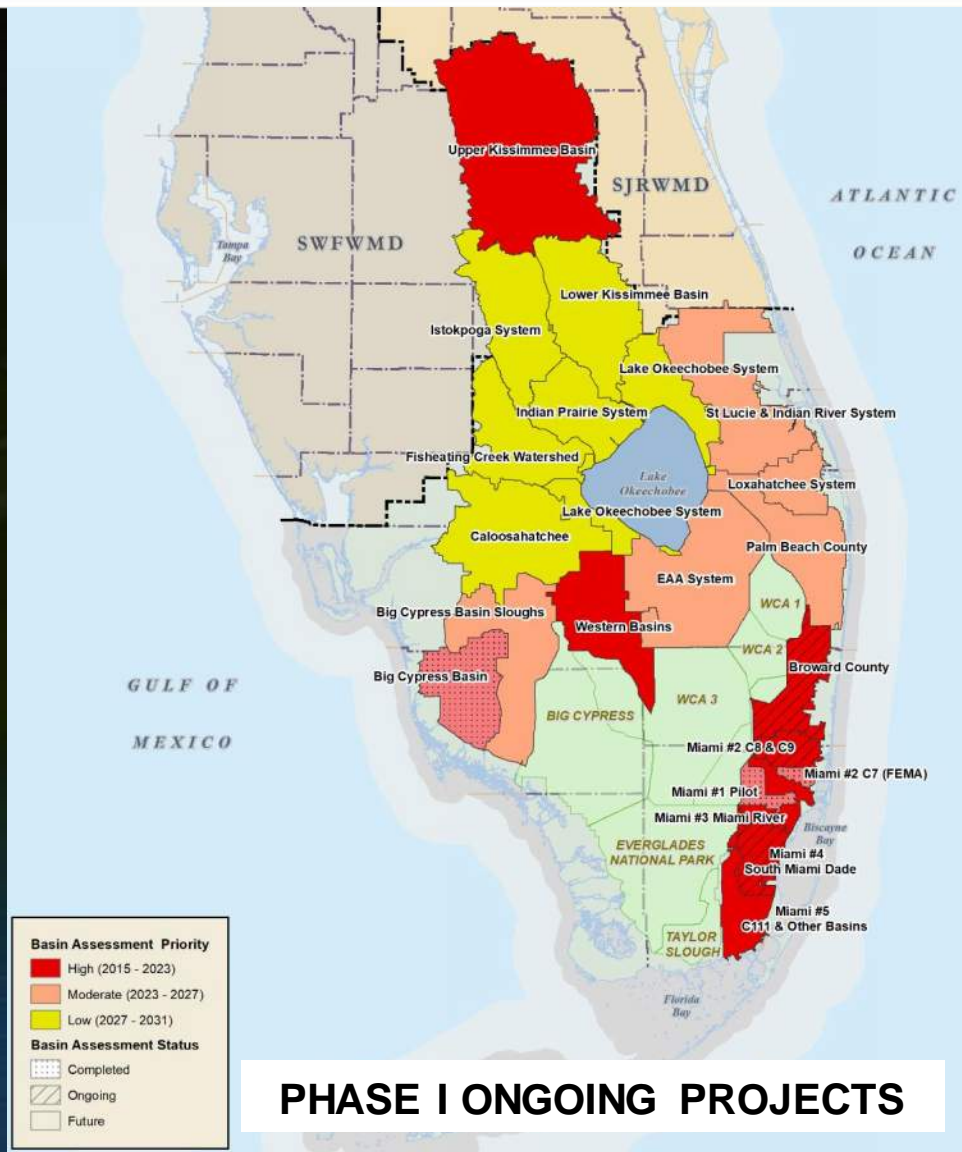
- Addressing Climate Change and SLR and adaptations in Water Supply Plans efforts
- Investing in robust groundwater modeling
- Monitoring and tracking location of the saltwater front (every 5 years)
- Leveraging well network installed for other purposes
- Encouraging conservation and development of alternative water sources



Flood Protection Level of Service Program

Critical District's strategy for assessing and addressing the impacts of climate change on the flood control mission

- Assess flood protection performance and risks of flood control infrastructure
- Support decision making on prioritizing investment for improvements and adaptation



Examples of Flood Mitigation Solutions



Seawall (protect against surge)



S-26 Forward pump (maintain basin discharge)



C-4 Emergency Detention Basin (increase basin storage)



Raised Canal Banks (conveyance)



C-4 Floodwall



Flap Gate (enhance basin connectivity)



Convertible Flood Barrier (harden infrastructure)

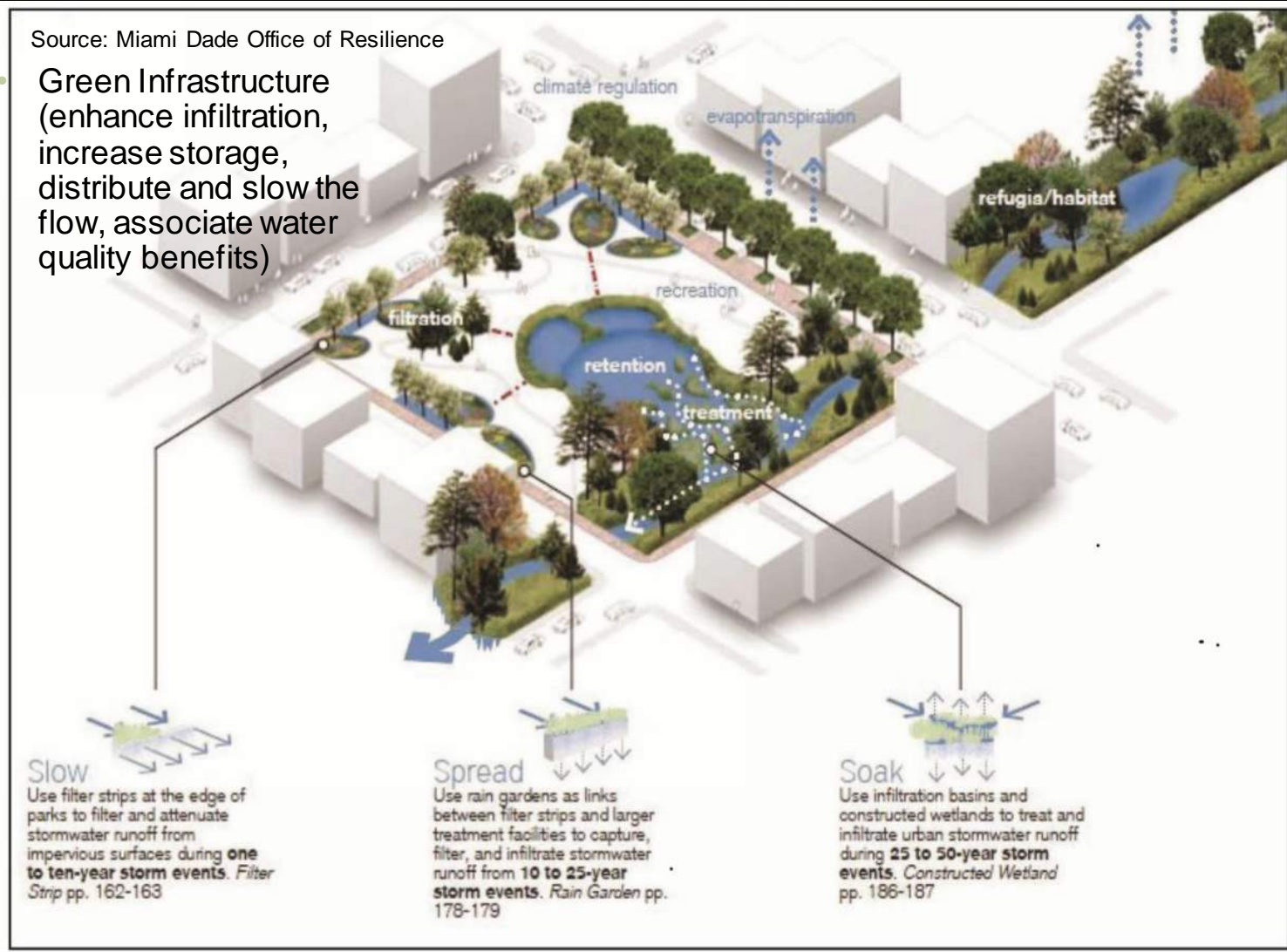
Importance of Basinwide Strategies



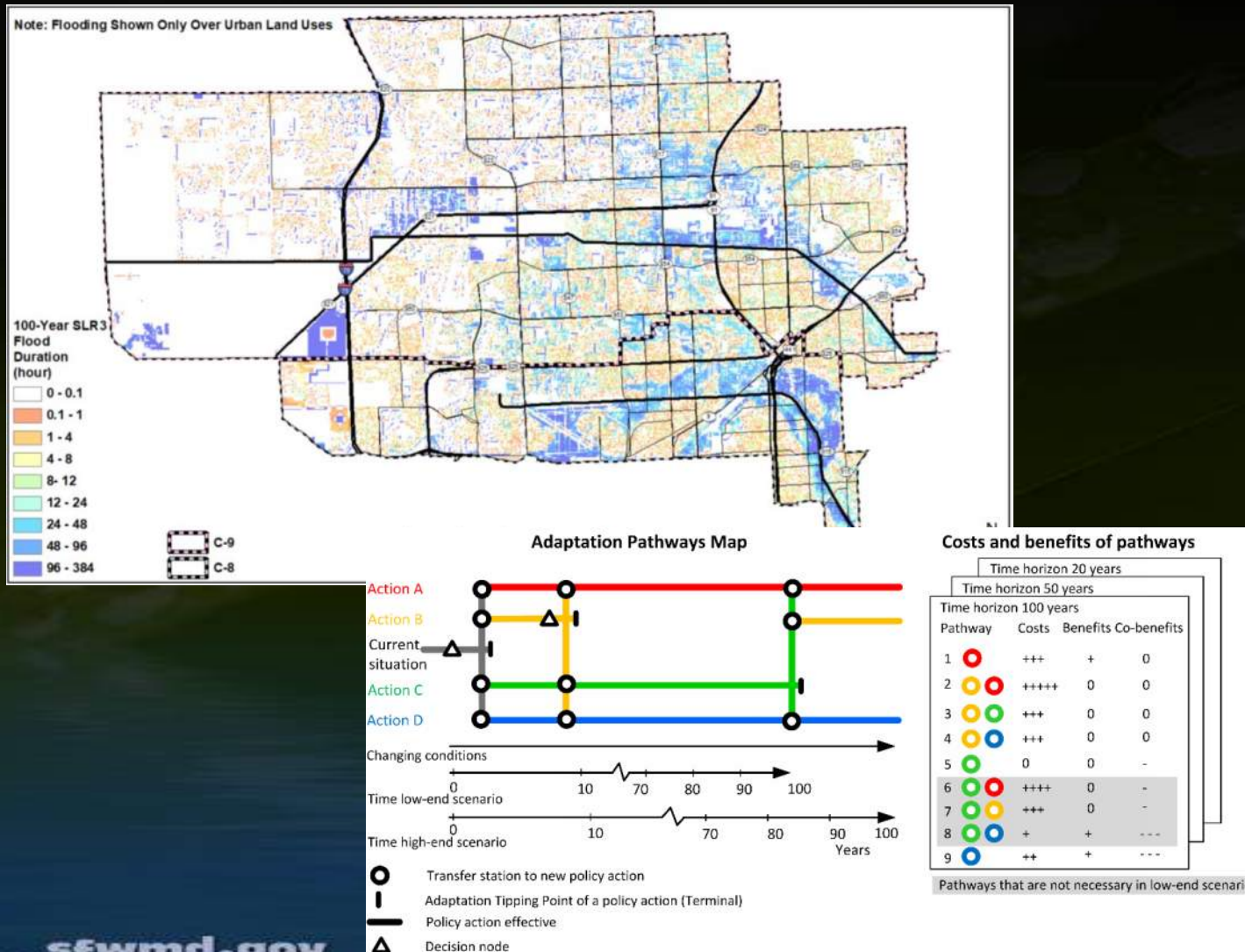
Source: BCB Strategic Plan

Source: Miami Dade Office of Resilience

Green Infrastructure (enhance infiltration, increase storage, distribute and slow the flow, associate water quality benefits)



Phase II: Ongoing FPLoS Projects



➤ C7 Pilot Study Completed in 2017

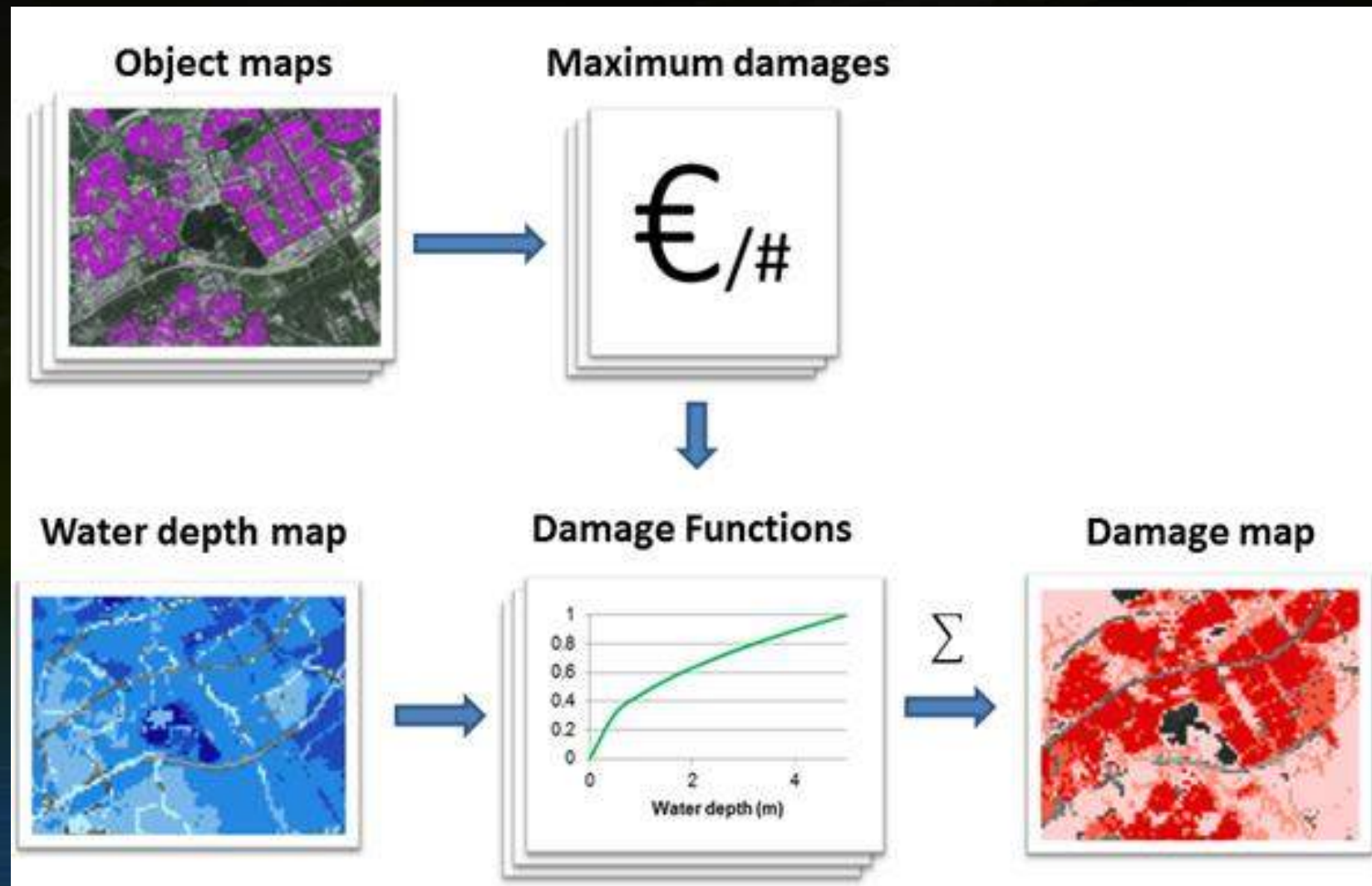
➤ Coming up this Summer: C8 & C9 Basins Flood Adaptation / Mitigation Study - Workshop on Alternative Flood Mitigation Strategies – Basinwide Approach

➤ Utilization of H&H robust modeling tools to estimate potential reduction in flood damage costs


➤ Adaptation pathway planning

Flood Damage Cost Estimate Tool


- Desktop Tool Development
- Flexibility of Scenario Assessment
- Incorporation of the latest science on flood damage functions (FEMA Hazus)
- Allowing for more accurate flood damage assessments
- Strengthening District's planning capacity



Phase III: Ongoing FPLoS Construction Projects



BUILDING FLOOD RESILIENCY AT CRITICAL BASINS IN SOUTH FLORIDA: C-7 BASIN

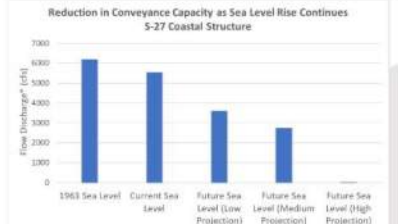


HIALEAH GARDENS, NOVEMBER 2020

South Florida Water Management District (District) is requesting FEMA grant funding to advance flood risk reduction measures for the C-7 Basin, a region of about 275,000 people and 32 square miles, in the northeastern portion of the Miami Dade County. The area drained by the C-7 primary canal is fully developed with primarily residential and commercial uses. The C-7 Canal is the central flood control feature which receives and conveys basin flood waters by gravity through the S-27 Coastal Structure to sea.

As evidenced during the recent Tropical Storm Eta, sea level rise is limiting the ability of these central flood control features to convey flood waters. Serious flooding events occurred at C-7 Basin, with near 100-year rainfall volumes, and higher sea levels impeding the S-27 Coastal Structure to deliver those volumes to the sea.

The proposed projects at C-7 Basin include local and regional flood mitigation measures to reduce flood risk exacerbated by sea-level rise during the frequent times that the flow gates at S-27 Coastal Structure are impeded or closed during high tide.



*Flow discharge rates at peak of 2-yr storm surge, average over tide cycle, S-27 spillway with design headwater and tailwater


Retrofitting the structure with forward pumps, so flood waters can be conveyed at higher sea levels, is necessary to provide flood control now and into the future. A significant associated benefit is the protection of water supply sources (including the Biscayne Aquifer – a sole source aquifer) in the Basin, by retrofitting the structure to prevent sea water overtopping at the gates resulting in saltwater intrusion.

More specifically, the District, in partnership with the Miami-Dade County, is proposing the implementation of innovative regional flood mitigation measures consisting of the installation of 500 cubic feet per second forward pumps at the S-27 coastal structure to maintain basin discharge levels while sea levels rise, and integrating with improvements to the top of bank elevation of secondary canals under Miami-Dade County control within the C-7 Basin, to enhance canal conveyance. The proposal also includes drainage enhancements at one of the most vulnerable and lower income community – Larchmont Gardens Area.


The proposed flood mitigation measures, also recommended as part of the 2015 FEMA funded Pre-Disaster Mitigation Study, will be completed in 36 months, upon grant funding approval. The total cost is estimated at \$62.3 million, including S-27 structure hardening costs, and a calculated benefit cost ratio of 1.9. The projects will reduce flood risk under sea-level rise by restoring flow discharge rates, compared to future risk without any measures.

The organizations that are partnering with the District in this proposal include:

- Miami Dade County
- City of Miami
- Deltares USA
- The Nature Conservancy
- The U.S. Army Corps of Engineers

BUILDING FLOOD RESILIENCY AT CRITICAL BASINS IN SOUTH FLORIDA: C-9 BASIN

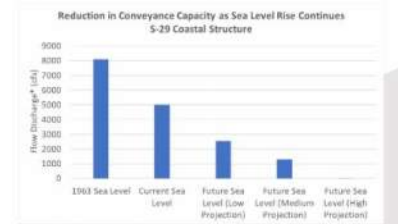


PEMBROKE PINES, NOVEMBER 2020

South Florida Water Management District (District) is requesting FEMA grant funding to advance flood risk reduction measures for the C-9 Basin, a region of about 450,000 people and 100 square miles, in the southern portion of Broward County and northeastern portion of the Miami Dade County. The area drained by the C-9 primary canal is fully developed with primarily residential and commercial uses. The C-9 Canal is the central flood control feature which receives and conveys basin flood waters by gravity through the S-29 Coastal Structure to sea.

As evidenced during the recent Tropical Storm Eta, sea level rise is limiting the ability of these central flood control features to convey flood waters. Serious flooding events occurred at C-9 Basin, with above 100-year rainfall volumes, and higher sea levels impeding the S-29 Coastal Structure to deliver those volumes to the sea.

The proposed projects at C-9 Basin include local and regional flood mitigation measures to reduce flood risk exacerbated by sea-level rise during the frequent times that the flow gates at S-29 Coastal Structure are impeded or closed during high tide.



*Flow discharge rates at peak of 2-yr storm surge, average over tide cycle, S-27 spillway with design headwater and tailwater

Retrofitting the structure with forward pumps, so flood waters can be conveyed at higher sea levels, is necessary to provide flood control now and into the future. A significant associated benefit is the protection of water supply sources (including the Biscayne Aquifer – a sole source aquifer) in the Basin, by retrofitting the structure to prevent sea water overtopping at the gates and reduce saltwater intrusion.

More specifically, the District, in partnership with the South Broward Drainage District, is proposing the implementation of innovative regional flood mitigation measures consisting of the installation of 750 cubic feet per second forward pumps at the S-29 coastal structure to maintain basin discharge levels while sea levels rise, and integrating with the replacement of three (3) existing control structures with adjustable sluice gates within S-5 sub-basin, the installation of emergency sluice gates into the C-9 Canal within S-3 and S-5 sub-basins, the installation of basin inter-connect at sub-basins S-3 and S-7 and upgrades to existing secondary pump stations.

The total cost of the proposed flood mitigation measures, to be completed in 36 months upon grant funding approval, is estimated at \$64.8million, including S-29 structure hardening costs. The calculated benefit cost ratio is 2.06. The projects will reduce flood risk under sea-level rise by restoring flow discharges, compared to future risk without any measures. Partnering organizations include: the South Broward Drainage District, the U.S. Army Corps of Engineers (USACE), the Nature Conservancy, and Deltares USA.

Additional storage options in the C-9 Basin are being advanced in partnership with the USACE, as part of the Comprehensive Everglades Restoration Plan. The Broward County Water Preserve Areas Project will be providing additional storage, as well as reducing damaging discharges of runoff from developed areas into the Everglades Water Conservation Area 3A, and prevent excessive seepage out of the Everglades, further providing flood risk reduction benefits in the basin, associated with water quality improvements.



- FEMA BRIC Proposals: S-29 AND S-27 forward pump and additional basinwide mitigation strategies

➤ FY21 Budget: Funding to Initiate Design

➤ Funding Alternatives to advance full implementation

➤ Looking to increment pump sizes, in partnership with the State

Structure Inspection Program

- Regular O&M needs as primary driver of District's CIP Program
- Major half-life refurbishment needs
- Addressing resiliency needs as CIP projects are being advanced
- Do not work on the same structure twice

FY20 SIP S28



Structure Inspection Program

S28
SPILLWAY
MIAMI Field Station
South C&SF
C-8
of Gates: 2
Lifting/Pumping Mechanism: Cable Drum, Description: Roller



inspection summary/issue identification

FY20 Update to FY15019 – (Updated 1-31-20)

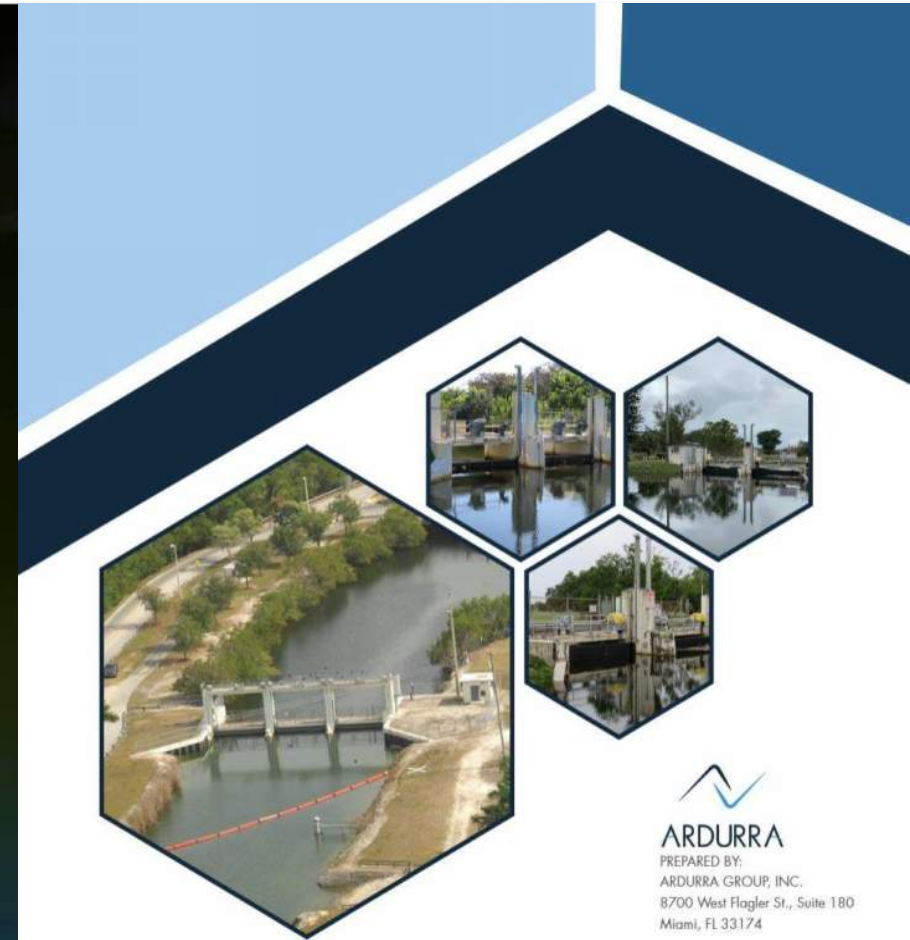
S-20F Major Half-Life Refurbishment		Date: 1-31-2020
Structure Type: Spillway	Field Station / Contact: Homestead / Sean Smith	Priority Score: 17.02
		Priority Level: 2
Inspector Information		
Lead Inspector: Tim Kunard	Inspection Date: 1-6-20	Phone: 561-852-6305
Previous Inspection Date: 2-12-15	Previous Inspector: Gary Dunmyer	
F/S Superintendent: Sean Smith	F/S Bureau Chief: Jesus Carrasco	
Signature: <i>[Signature]</i>	Signature: <i>[Signature]</i>	
Structure Details		
Description: Spillway	# Gates: 3	# Pumps: 0
	# Borels: 0	Lifting Mechanism: Hydraulic

Figure 1 – Aerial image of the S20F Structure site



Coastal Resiliency Study

- Preliminary assessment of five control structures and recommended flood hardening strategies to a selected one
- Assess operational and flood control vulnerability to sea level rise and storm surge
- Identify and recommend hardening measures, design criteria and operational changes



Coastal Resiliency Study

Miami-Dade County

March 2021



ARDURRA

PREPARED BY:
ARDURRA GROUP, INC.
8700 West Flagler St., Suite 180
Miami, FL 33174

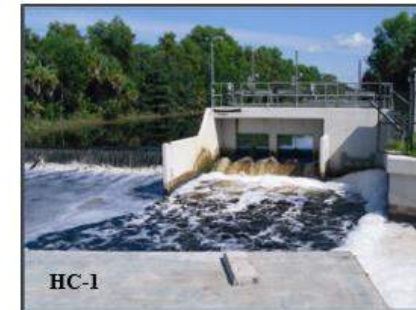


PREPARED FOR:
SOUTH FLORIDA WATER
MANAGEMENT DISTRICT
3301 Gun Club Road,
West Palm Beach FL 33406

Low-lying Tidal Structure Assessment Objectives

- Evaluate the impact of sea level rise combined with storm surge
- Determine the effectiveness of each structure to provide flood protection
- Rank each structure with respect to its susceptibility to SLR and storm surge

Low-lying Tidal Structure Assessment Susceptibility to Sea Level Rise and Storm Surge



December 2020

Hydrology and Hydraulics Bureau
South Florida Water Management District



sfwmd.gov

Results

Category I

(2-yr/5-yr surge)

Category II

(25-yr surge, =<0.5ft SLR)

Category III

(25-yr surge, >0.5 to 1 ft SLR)

Category IV

(25-yr surge, >1 to 2ft SLR)

Category V

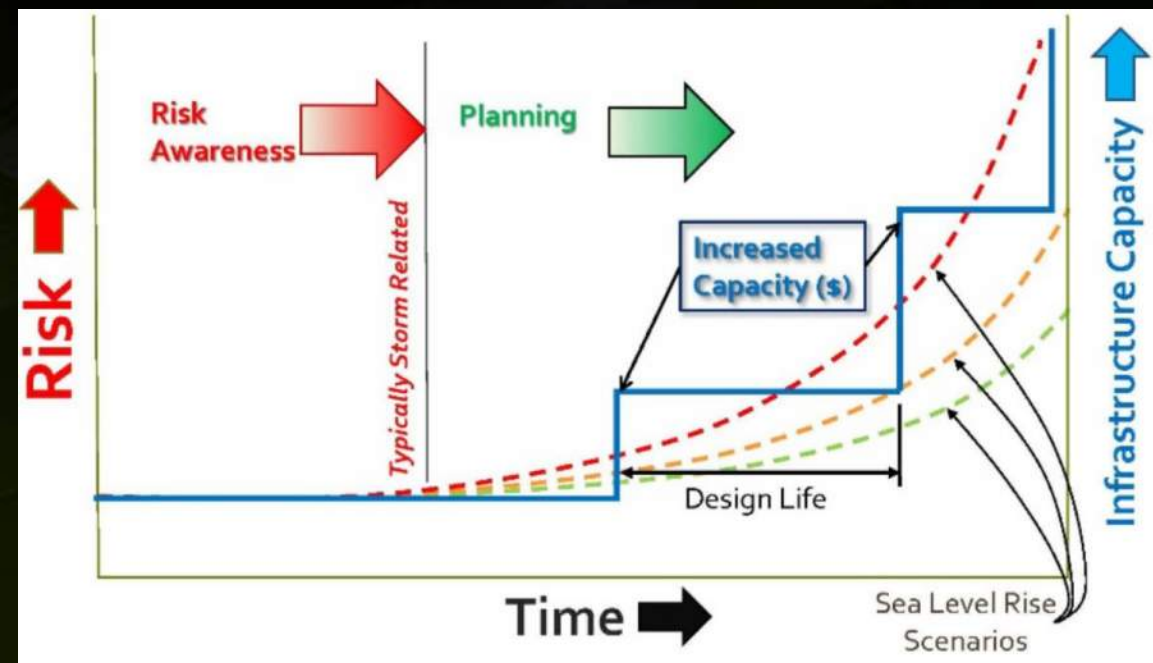
(25-yr surge, >2 to 3ft SLR)

Category VI

(50-100yr surge)

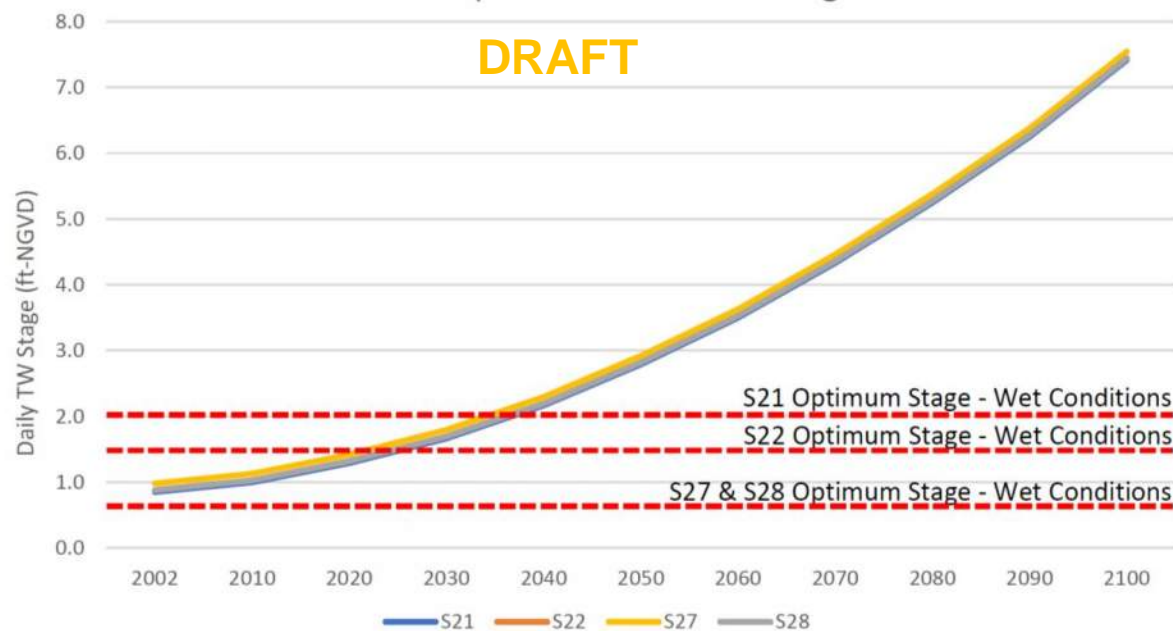
Structure ID	HW max breakpoint (ft NGVD)	HW max daily average stage (ft NGVD)	Bank full elevation (ft NGVD)	Design discharge Q (cfs)	Design HW (ft NGVD)	Design TW (ft NGVD)	Return Period of Failure	SLR that would cause out of bank flooding (normal ops, CSL+)	SLR that would cause out of bank flooding (gates open, CSL+)	Category
S25	5.5	4.1	4	320	1.8	1.7	2	CSL	CSL	Category I: bank-full elevation could be reached under a 2-yr or 5-yr surge condition
S20	4	3.5	2.5	450	1.5	1	2	CSL	CSL	
HC1	6.62	3.71	5.89	780	6.63	4.85	2	CSL	CSL	
GG1	7.1	6.28	7	4625	7	6.9	2	CSL	CSL	
G58	5.35	2.92	5.06	300	1.6	1.1	2	0.38	0.38	
S27	5.1	3.5	4.5	2800	3.2	3	5	0.09	0.26	
S28	5.11	3.49	4.2	3220	2.3	1.8	5	0.17	0.11	
S25B/S25BPS	5.46	4.43	4.81	2000	4.4	4.1	5	0.22	0.26	
S123	7.45	4.9	5.93	2300	2	1.5	25	0.07	0.24	Category II: bank-full elevation could be reached under a 25-yr surge event with 0.5 ft or less of SLR
S79	4.61	5.91	6.72	28900	4.4	3.9	25	0.1	0.1	
S26/S26PS	5.56	3.82	4.73	3470	4.4	3.9	25	0.11	0.13	
S37A	5.87	4.57	5.6	3890	3	2	25	0.18	0.22	
G54	5.6	5.2	5.4	1600	4.6	4.3	25	0.24	0.26	Category III: bank-full elevation could be reached under a 25-yr surge event with >0.5 to 1 ft of SLR
S36	6.15	5.43	5.5	1090	5.3	4.8	25	0.51	0.46	
S21	6.6	4.6	5.3	2560	1.9	1.4	25	0.68	0.19	
G57	8.01	5.323	6.4	375	5	4.5	25	0.7	0.85	
S33	6.26	5.11	6.77	920	5.9	4.9	25	0.93	1.06	
G93	7.18	4.73	6.57	640	4.5	3	25	0.98	1.17	
S29	4.9	3.3	4.4	4680	2.4	1.9	25	1	0.45	
S20F	6.1	4	4.4	2900	1.9	1.4	25	1.15	0.55	
COCO1	8.08	7.28	8.35	1380	6.7	4	25	1.28	1.64	Category IV: bank-full elevation could be reached under a 25-yr surge event with >1 ft to 2 ft of SLR
S22	6.8	3.7	5	1915	3.5	2.7	25	1.53	0.75	
G56	9.13	8.78	9	3760	7.6	6.9	25	2.03	2.15	Category V: bank-full elevation could be reached under a 25-yr surge event with >2 ft to 3ft of SLR
S21A	6.6	5.44	5.6	1330	2.1	1.6	25	2.3	1.5	
S197	4.52	3.78	5.55	2400	1.4	0.6	25	2.7	2.7	
S20G	6.9	4.3	7	900	2	1.5	25	2.78	2.32	
S13/S13PS			3.5	540/540	1.2/2.2-2.2	1.0/6.2-6.6	100/NA	3.0+	3.0+	Category VI: bank-full elevation could be reached under a 50-yr or 100-yr surge event any SLR

Coastal Structures Resiliency



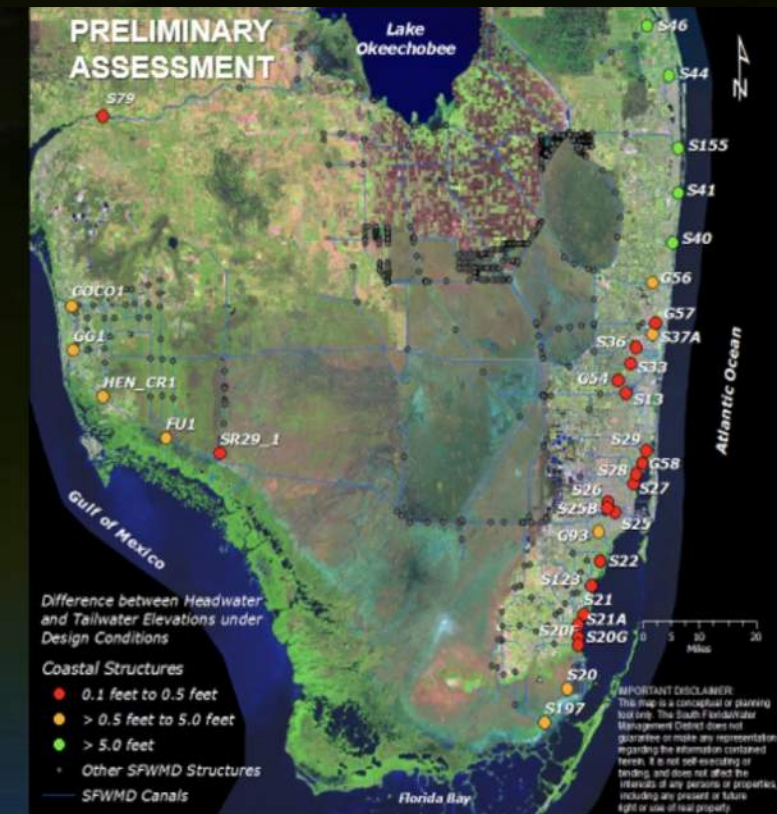
Sea Level Rise Impacts on Headwater Stage Control

DRAFT



USACE/SFWMD C&SF Flood Resiliency Study

- March 2020: SFWMD Governing Board – Local Project Sponsor
- Current request: C&SF Review Study due to changed physical conditions from late 1940s (land development, population increase, climate change, sea level rise)
- Conducted under Section 216 of the Flood Control Act of 1970
- Request for \$6M over 4 years (Phased Approach)
- Initial Appraisal Report approved by Jacksonville and South Atlantic Division Offices
- FY22 Federal Budget: initial \$500K in funding



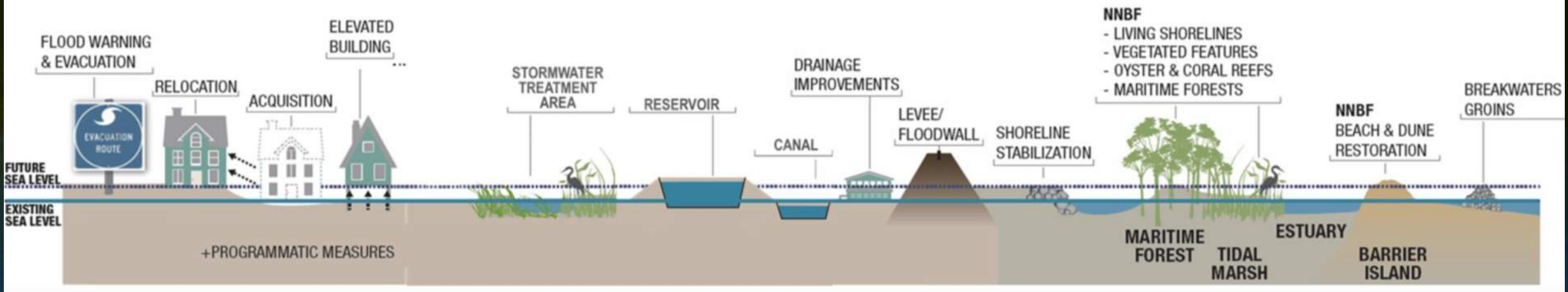
Coordination with USACE

Integrating Inland and Coastal Flood Mitigation Strategies (Compound Flooding)

Coastal Studies: SACS, Back Bay Studies, Beach Restoration + CERP (BBSEER)

POTENTIAL MEASURES TO IMPROVE RESILIENCE AND SUSTAINABILITY

Graphic modified from https://ewn.el.erdc.dren.mil/nbnf/other/5_ERDC-NNBF_Brochure.pdf



Source: USACE

Historic and Largest Florida Flooding and Sea Level Rise Resilience Initiative

- SB1954: Resilient Florida Program
- Over \$640 million available to support efforts to ensure state and local communities are prepared to deal with the impacts of sea level rise, intensified storms and flooding



Resiliency Issues on the Horizon

- There is a problem and there are opportunities
- It will take time and money to solve
- Collaboration is key: solutions span multiple boundaries
- SFWMD is strongly committed to address sea level and other changing climate impacts



Photo by Paul Krashefski

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District Resiliency Officer

South Florida Water Management District

www.sfwmd.gov/resiliency

Thanks!

Discussions?