Flood Control Effectiveness Evaluations at South Florida Coastal Structures

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H&H Bureau
SFWMD

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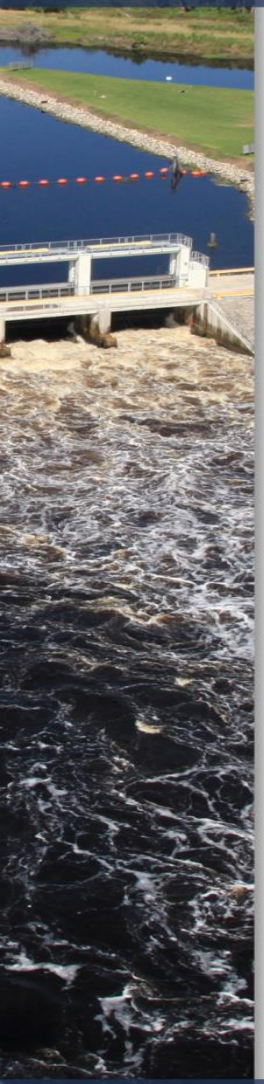
Contributors



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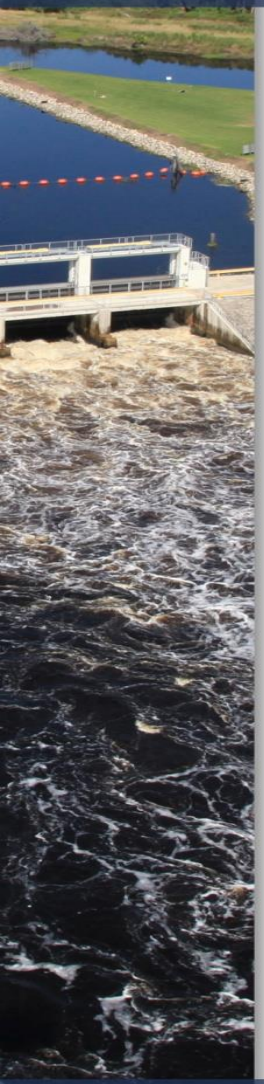
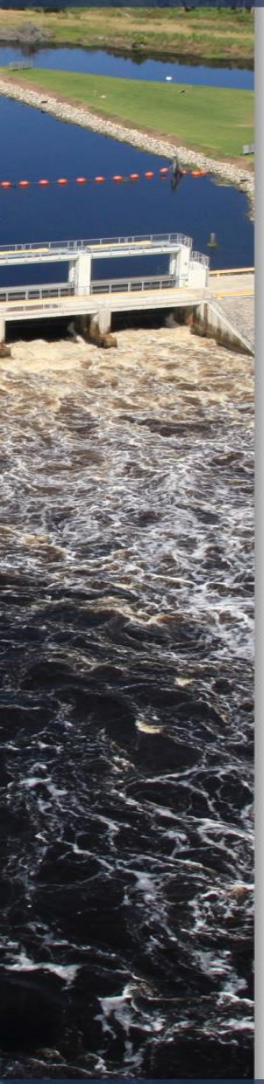
Outline

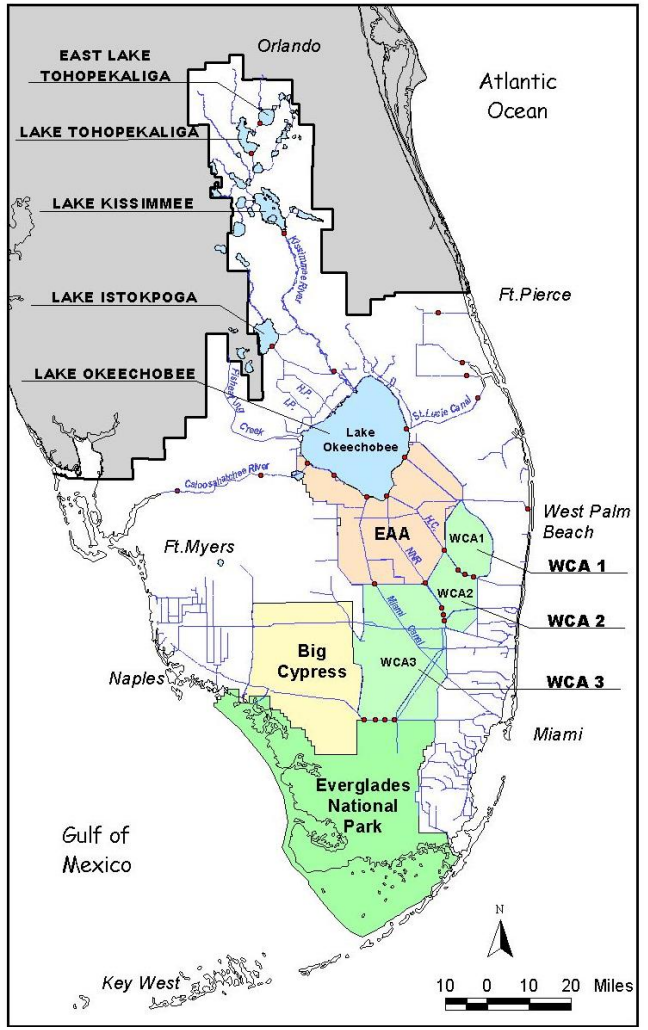


- South Florida Water Management System
- Coastal Structures Functions
  - Operations of coastal structures
- High Tide Events (HTE) at Coastal Structures
  - Frequency of TW > HW design elevation
  - Frequency of TW above or close to HW elevation
  - Frequency of TW is above top of lower canal operating range
- Summary & Conclusion

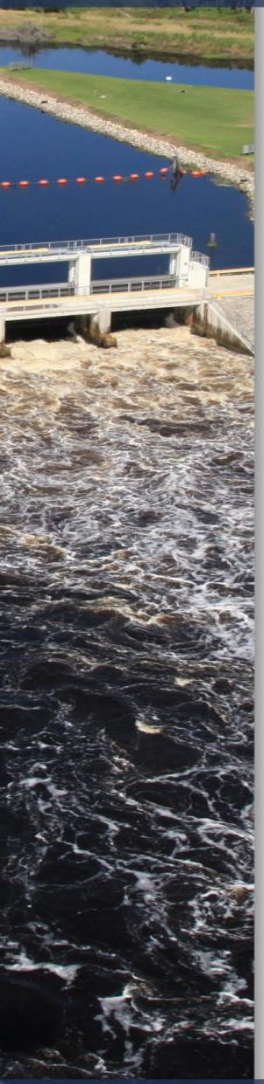
Background



- South Florida Water Management District
  - The largest of five water management Districts in Florida
  - Serves about 9.5 million people in 16 counties
  - Covers area from Orlando to Key West
  - Mission includes flood control, water supply, environmental restorations
- South Florida Water Management System
  - Low relief & flat topography
  - Delicate balance between rainfall and evapotranspiration
  - High ground and surface water interaction
  - Urbanized areas along the coast
  - Significant agricultural areas
  - Protected natural areas such as the Everglades
  - Lake Okeechobee
  - 2,200 miles of canals, 2,100 miles of levees/berms, over 900 water control structures, 98 pump stations and 625 project culverts

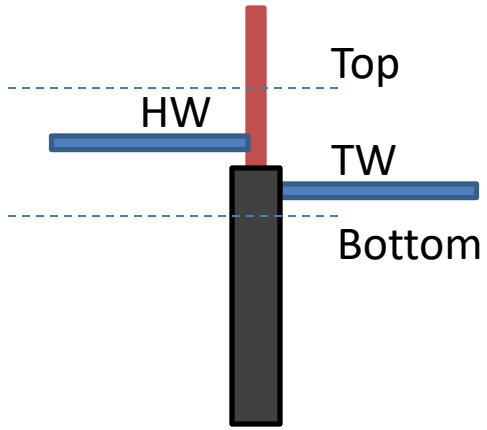


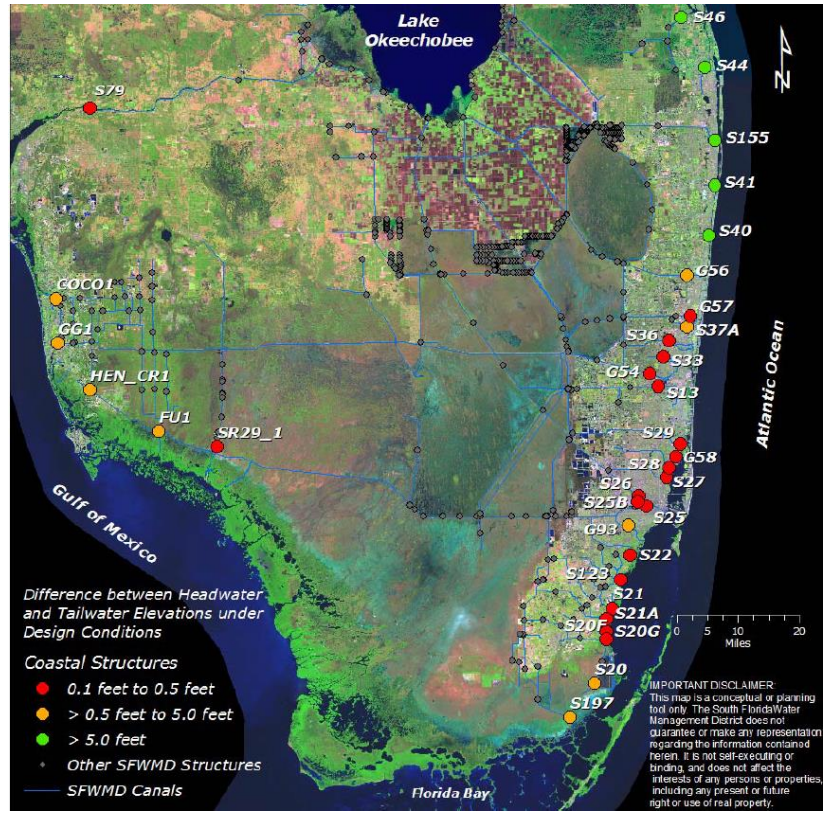
Coastal Structures Functions



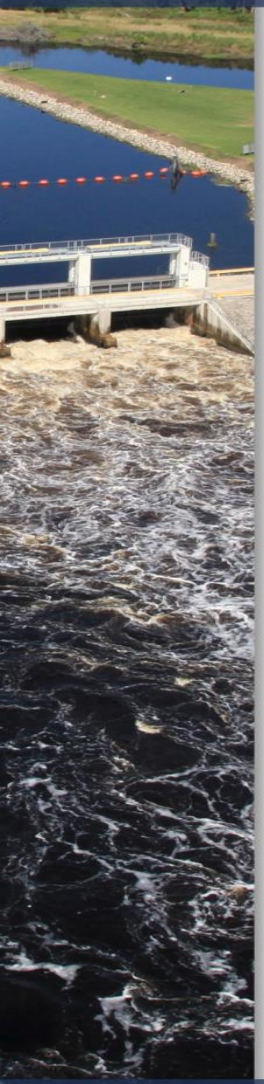
- Coastal structures
  - Terminal water control structures in the primary system
  - Critical for flood control and prevention of saltwater intrusion
  - Gravity driven
  - Require positive hydraulic gradient
  - Reduced discharging capacity at high tide level
- Coastal Structures Operations
  - Utilize seasonal operating ranges
  - Gates open
    - HW > Top Level and
    - HW > TW
  - Gates close
    - HW < Bottom Level or
    - HW < TW

HW: Landside water level
TW: Oceanside water level

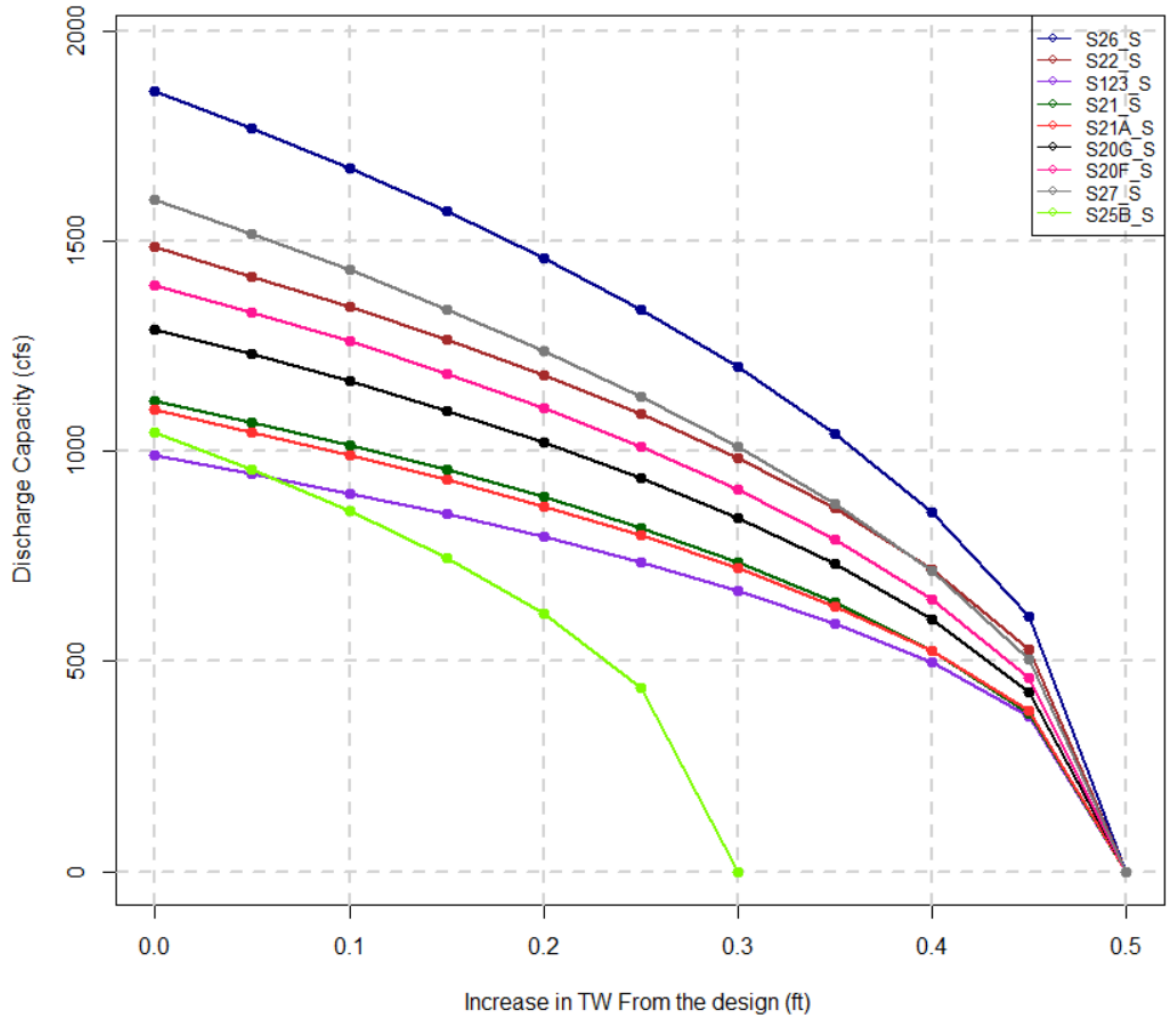




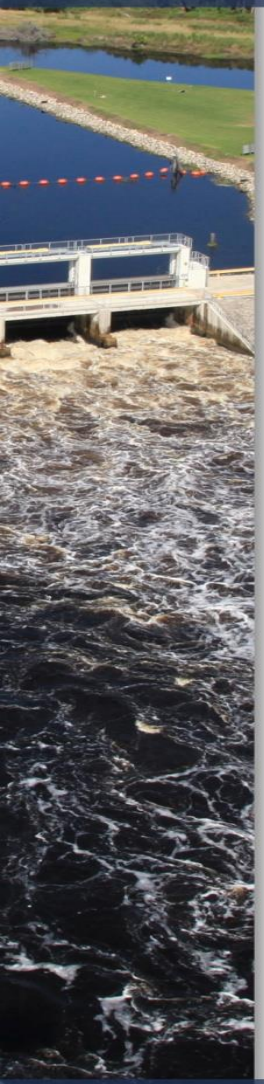
Coastal Structures Discharge Capacities



- Coastal structures discharge capacity
  - Depends on available head
  - Reduces with increase in TW



Water and Climate Resilience Metrics



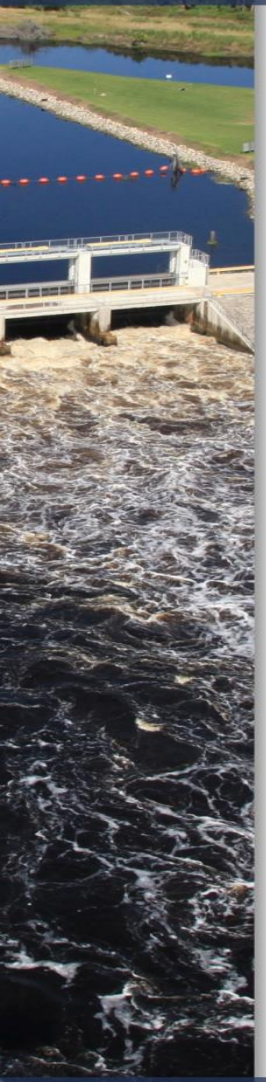
Climate Metrics
Indicators that reflect the primary drivers of observed changes in climate conditions and influence the hydrological cycle.

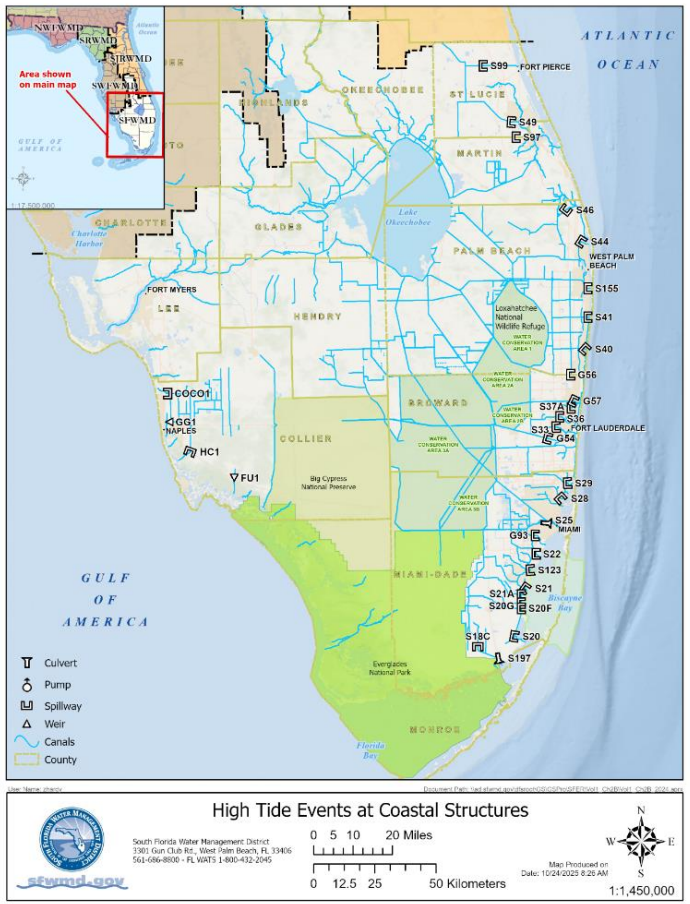
Resilience Metrics
Indicators that represent the observed effects of changing climate conditions. These may be managed or mitigated through water management operations and/or by implementing adaptation strategies.

Phase	METRIC	CATEGORY	TREND ANALYSIS	AUTOMATION
I	Rainfall	Climate	✓[1]	✗
I	Evapotranspiration (ET)	Climate	✓	✓
I	Tidal Elevations at Coastal Structures	Climate	✓	✓
I	High Tide Events (Limited Flood Control Capacity Events)	Climate	✓[2]	✗
I	Groundwater Levels/Elevations/Stages	Resilience	✓	✓
I	Saltwater Intrusion/ Saltwater Interface – Chloride Levels	Resilience	✓[1]	✓
I	Minimum Flows and Minimum Water Levels (MFLs) – Exceedances/ Violations	Resilience	✓	✓
I	Flooding Events	Resilience	✓	✗
I	Water Temperature	Resilience	✓	✓
I	Dissolved Oxygen (DO)	Resilience	✓	✓
I	pH	Resilience	✓	✓
I	Specific Conductance	Resilience	✓	✓
I	Estuarine Inland Migration – Everglades	Resilience	✓	✗
I	Soil Subsidence	Resilience	✓	✗
I	Salinity in the Everglades and Biscayne Bay	Resilience	✓	✗
II	Drought	Climate	✓[2]	✗
II	Freshwater Lens	Resilience	¤	¤
II	Stormwater Volume and Flow	Resilience	¤	¤
II	Algal Blooms	Resilience	¤	¤
II	Atlantic Multidecadal Variability (AMV)	Climate	¤	¤

✓ *Trend analysis and/or tool automation were completed for the metric.*
✗ *Trend analysis and/or automation were not completed for the metric.*
¤ *Trend analysis and/or automation are pending development for the metric.*
[1] *Updated analysis pending publication March 1, 2026.*
[2] *First analysis pending publication March 1, 2026.*

High Tide Events (HTE) at Coastal Structures

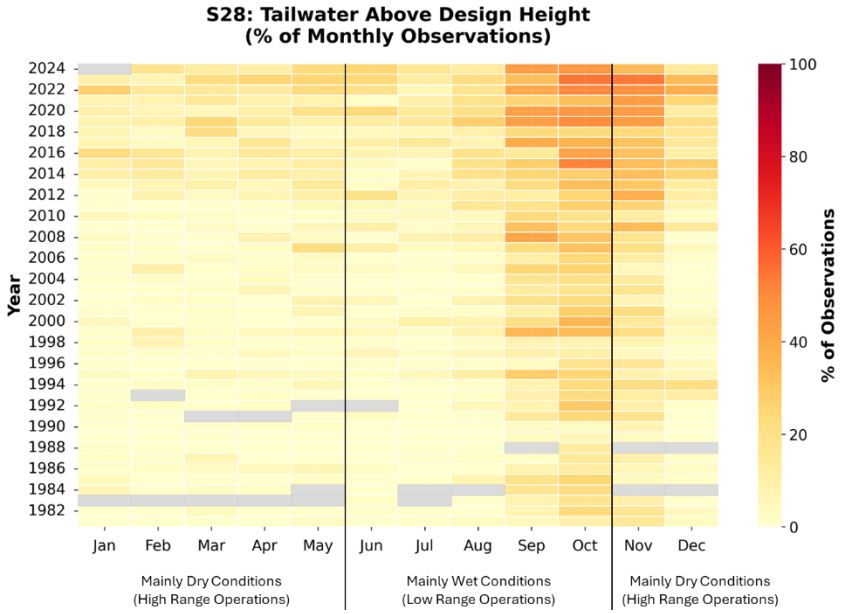


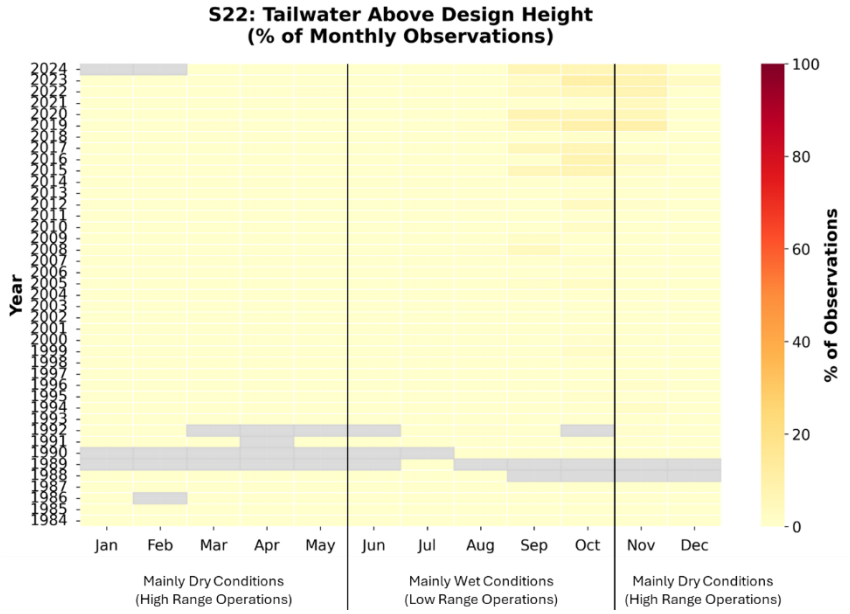


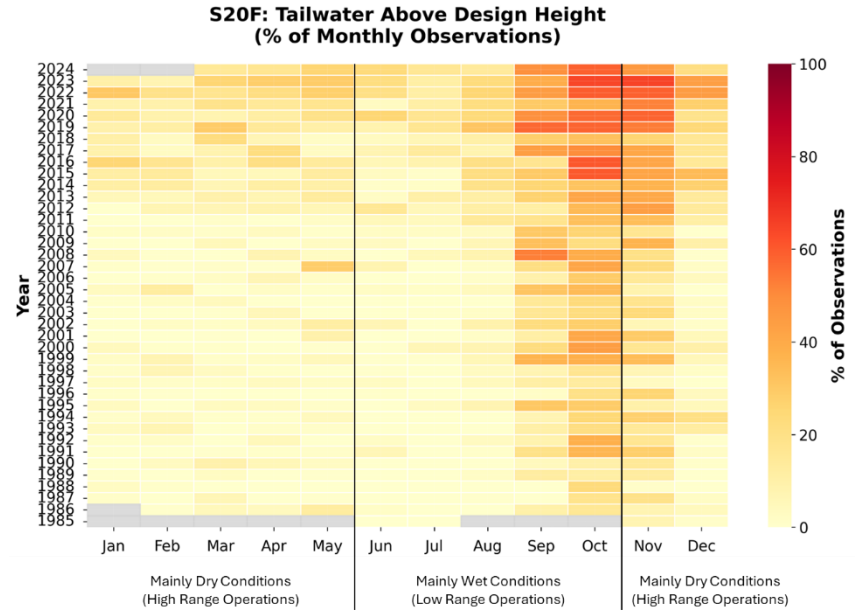
- **Definition:** Occurs when **tailwater (TW)** exceeds or rises within **0.1 ft of headwater (HW)**, prompting structure closure.
- **Types of Analyses:**
  - Tailwater in relation to design headwater level
  - Tailwater in relation to headwater
  - Tailwater in relation to canal operating levels
  - Seasonal trends of HTEs
- **Data Use**:
  - Instantaneous timeseries over the entire period of record from DBHYDRO.

High Tide Events (HTE) at Coastal Structures

The heatmap illustrates the percentage of time each month that the TW was above the HW design elevation.







* Period of record: 23%
* Last 10 years: 38%

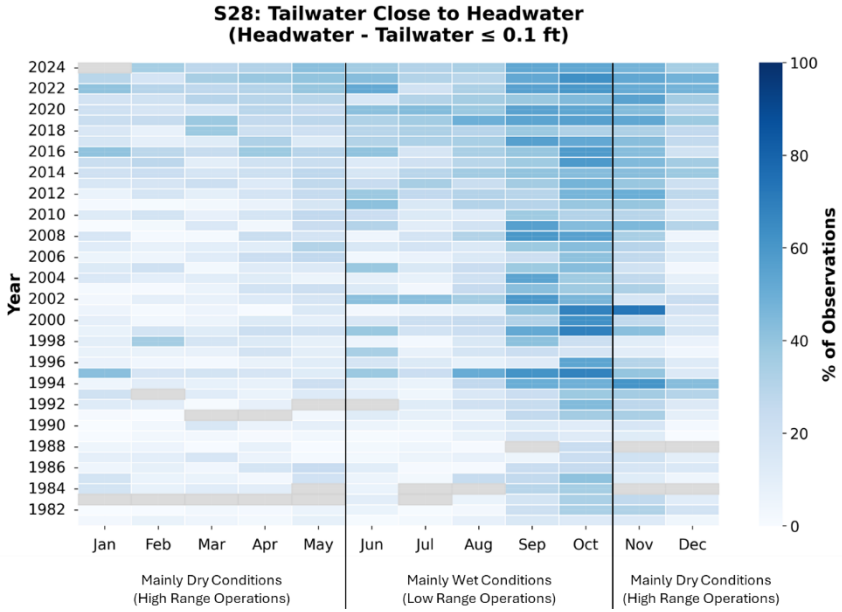
Period of record: 1%
Last 10 years: 4%

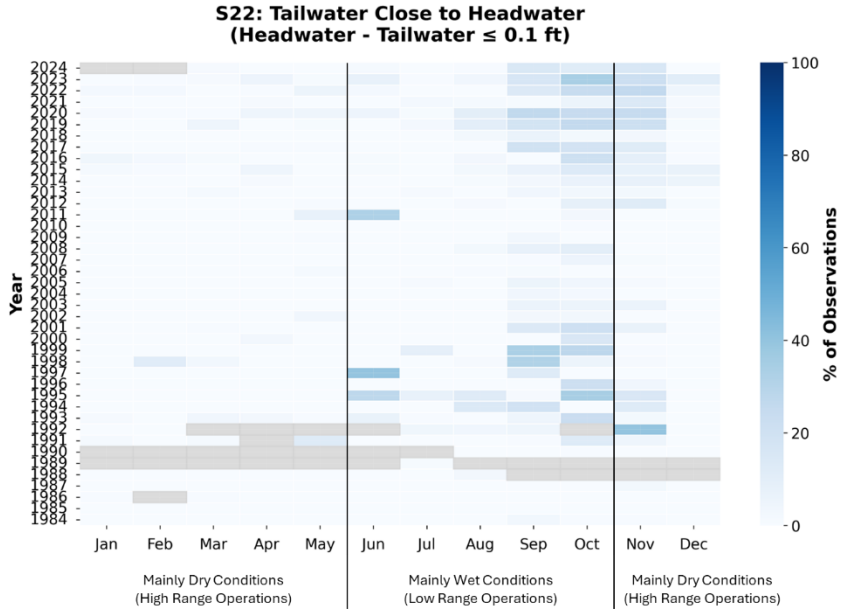
Period of record: 28%
Last 10 years: 46%

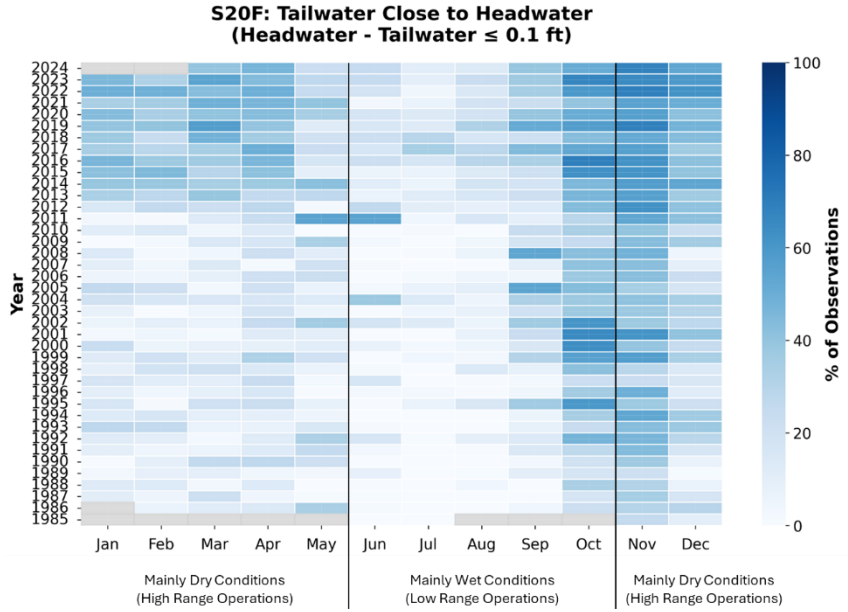
* Results are for September-November (Fall Season)

High Tide Events (HTE) at Coastal Structures

The heatmap illustrates the percentage of time each month that the TW was close or above the HW.







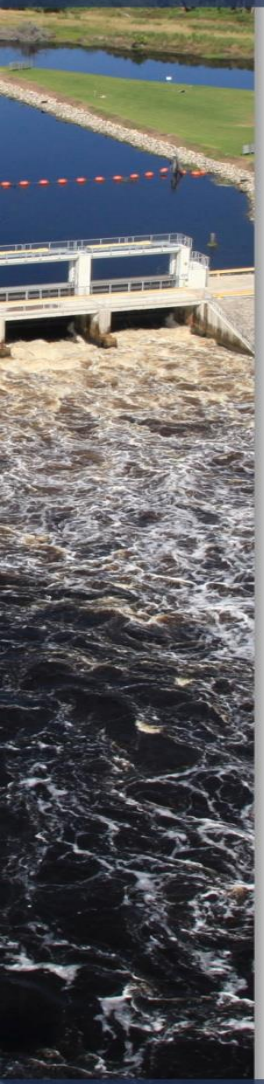
*Period of record: 38%
*Last 10 years: 49%

Period of record: 8%
Last 10 years: 15%

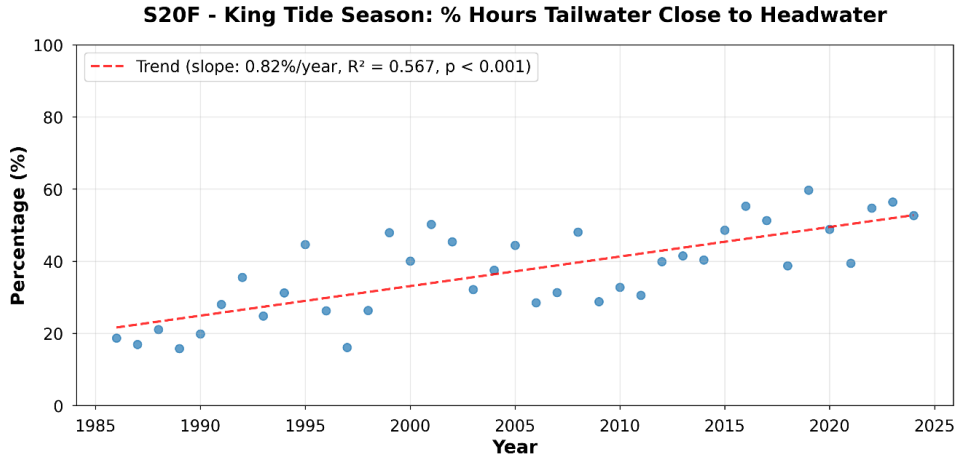
Period of record: 37%
Last 10 years: 50%

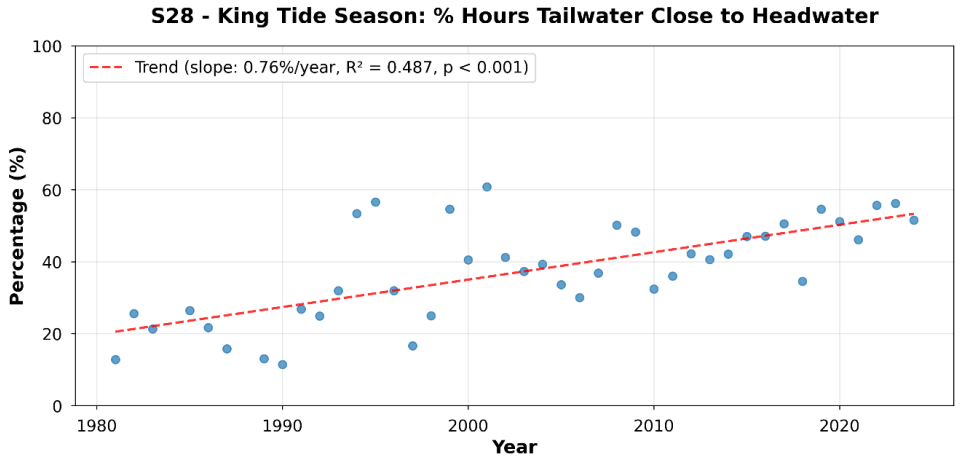
* Results are for September-November (Fall Season)

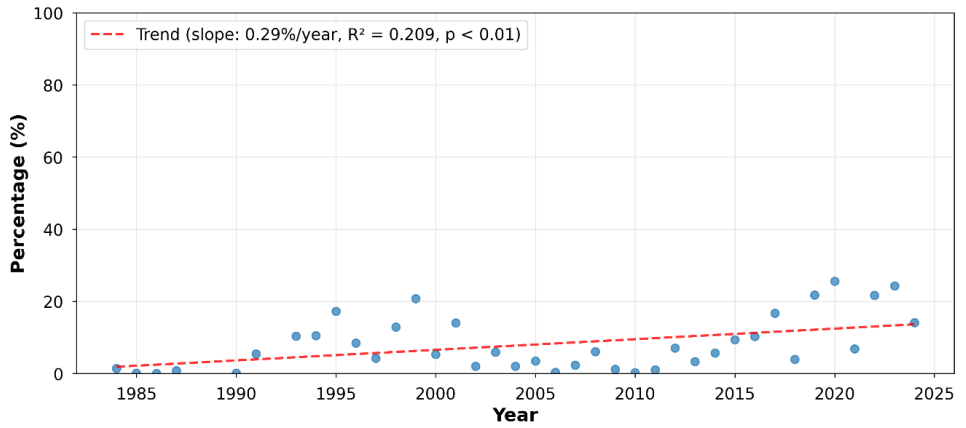
High Tide Events (HTE) at Coastal Structures



- From the HTEs frequency data, the percentage of time that condition was met during each of the seasons was calculated, and a linear trend line was fitted to the data over the period of record (POR).
- During king tide season, structures S-28, S-22, and S-20F exhibited statistically significant upward trends in the percentage of time tailwater elevation was close to headwater elevation (HTEs), with p values below 0.01.

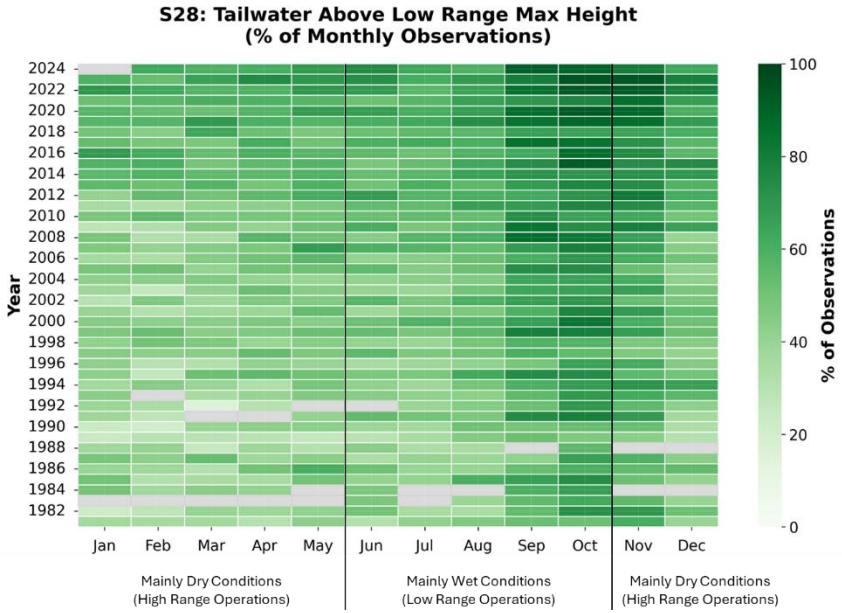


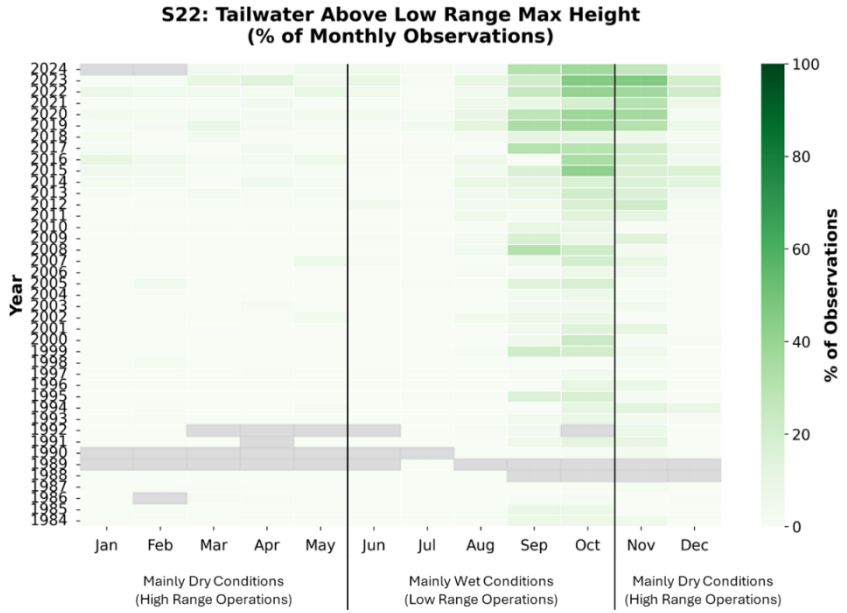


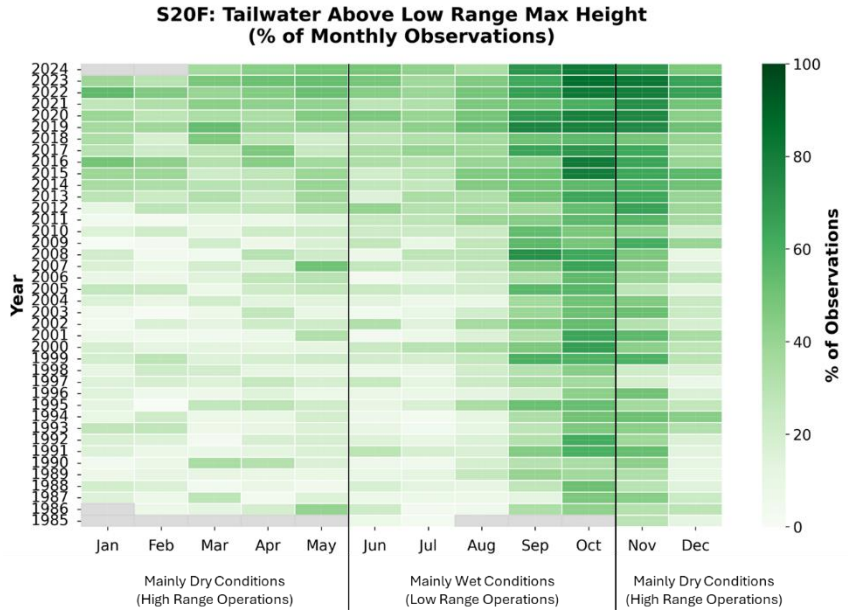


High Tide Events (HTE) at Coastal Structures

The heatmap shows the percentage of time each month when the TW is above the top of low canal operating range.







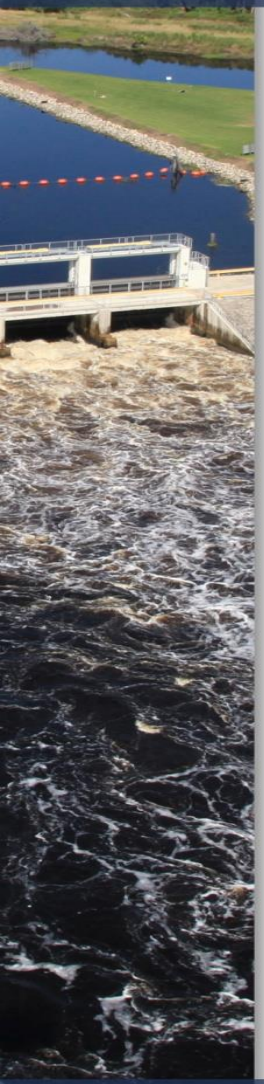
* Period of record: 69%
* Last 10 years: 81%

Period of record: 13%
Last 10 years: 26%

Period of record: 52%
Last 10 years: 68%

* Results are for September-November (Fall Season)

High Tide Events (HTE) at Coastal Structures



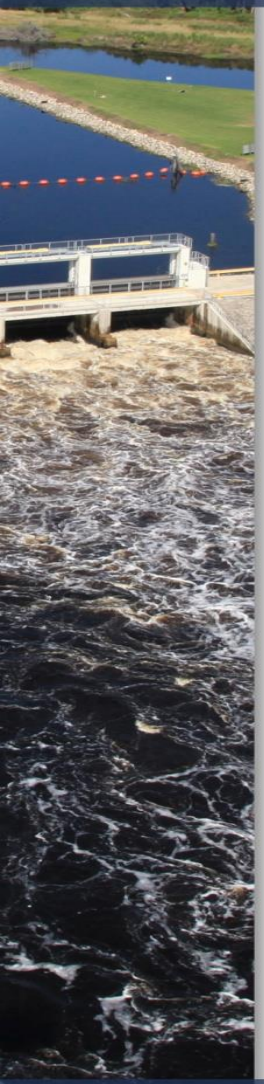
Structure [1]	POR	Average Data Coverage (%)	Design HW Elevation (ft NAVD88)	Design HW-TW Elevation (ft)	HTEs Regression Results [3] (% per year)				HTEs Condition (% of time)			
					SON [2]	DJF [2]	MAM [2]	JJA [2]	SON [2]	DJF [2]	MAM [2]	JJA [2]
St Lucie County (East Coast)												
S-99	1966–2024	94.9	18.54	0.50	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
S-49	1994–2024	99.7	14.81	14.60	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
S-97	1986–2024	99.4	17.02	4.50	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Palm Beach County (East Coast)												
S-46	1996–2016	99.5	11.30	10.60	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
S-44	1982–2024	99.1	7.49	8.90	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
S-155	1987–2024	99.4	6.97	9.50	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
S-41	1985–2024	97.9	6.54	8.30	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
S-40	1985–2024	98.6	6.65	5.50	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Broward County (East Coast)												
G-56	1991–2024	99.3	6.04	0.70	-0.05	-0.01	0.00	-0.05	0.0	0.0	0.0	0.0
G-57	1991–2024	97.8	3.42	0.50	0.00	0.00	0.00	-0.01	0.3	0.0	0.0	0.0
S-37A	1986–2024	98.3	1.42	3.40	0.07	0.01	0.02	0.03	1.9	0.1	0.6	0.7
S-36	1986–2024	97.6	3.72	0.50	0.00	0.00	0.00	0.00	0.6	0.0	0.0	0.1
S-33	1991–2024	99.6	4.32	1.00	0.08	0.01	0.08	0.03	3.2	0.3	1.5	1.6
G-54	1991–2024	98.7	3.00	0.30	-0.02	-0.01	0.00	-0.06	0.8	0.0	0.1	0.1
Miami-Dade County (East Coast)												
S-29	1986–2024	98.8	0.84	0.50	0.17	0.15	0.30	0.22	29.6	6.9	10.2	15.6
S-28	1986–2024	97.6	0.66	0.50	0.76	0.55	0.60	0.76	44.3	19.3	22.1	27.1
S-27	1986–2024	98.8	1.46	0.50	0.27	0.19	0.26	0.32	51.4	27.2	28.7	38.1
S-25	1977–2024	97.5	0.26	0.10	0.69	0.44	0.50	0.67	44.5	19.4	22.2	31.3
G-93	1992–2024	97.2	2.94	1.50	-0.04	0.09	0.06	-0.10	16.7	1.6	2.0	4.7
S-22	1984–2024	98.9	1.66	0.50	0.29	0.05	0.03	0.00	9.3	0.9	0.9	1.7
S-123	1980–2024	97.8	0.47	0.50	0.51	0.13	0.18	0.09	14.6	2.7	4.8	3.2
S-21	1985–2024	99.4	0.43	0.50	0.58	0.25	0.22	0.21	28.8	7.5	6.5	8.2
S-21A	1974–2024	98.4	0.57	0.50	0.86	0.86	0.43	0.40	45.6	28.7	23.3	13.4
S-20G	1985–2024	98.3	0.47	0.50	0.68	0.69	0.85	0.49	43.5	24.8	26.3	14.9
S-20F	1985–2024	99.1	0.37	0.50	0.82	0.98	0.84	0.50	43.6	29.9	28.2	12.6
S-20	1969–2024	94.5	-0.03	0.50	-0.06	0.26	0.41	0.08	24.6	9.2	29.1	8.3
S-18C	1987–2024	99.2	1.74	0.50	2.73	4.15	0.41	2.60	74.6	33.6	12.4	62.4
S-197	1998–2024	98.9	-0.15	0.80	0.43	-0.01	-0.59	-0.06	6.7	1.4	14.2	2.9
Collier County (West Coast)												
COCO1	1995–2024	98.8	5.91	0.65	0.00	0.00	0.00	0.00	0.2	0.0	0.0	0.1
GG1	2005–2024	99.8	5.73	0.10	-0.04	0.00	0.05	0.00	0.6	0.0	0.6	0.3
HC1	2001–2024	99.3	5.33	1.78	0.01	-0.07	-1.14	-0.68	0.0	0.3	11.7	4.1
FU1	1987–2024	95.1	-	-	0.17	0.19	0.82	0.24	4.3	3.8	21.8	7.1

[1] Organized by county and sorted north-to-south.

[2] SON: September–November; DJF: December–February; MAM: March–May; JJA: June–August.

[3] Blue and orange values indicate a statistically significant increasing and decreasing HTE overtime, respectively.

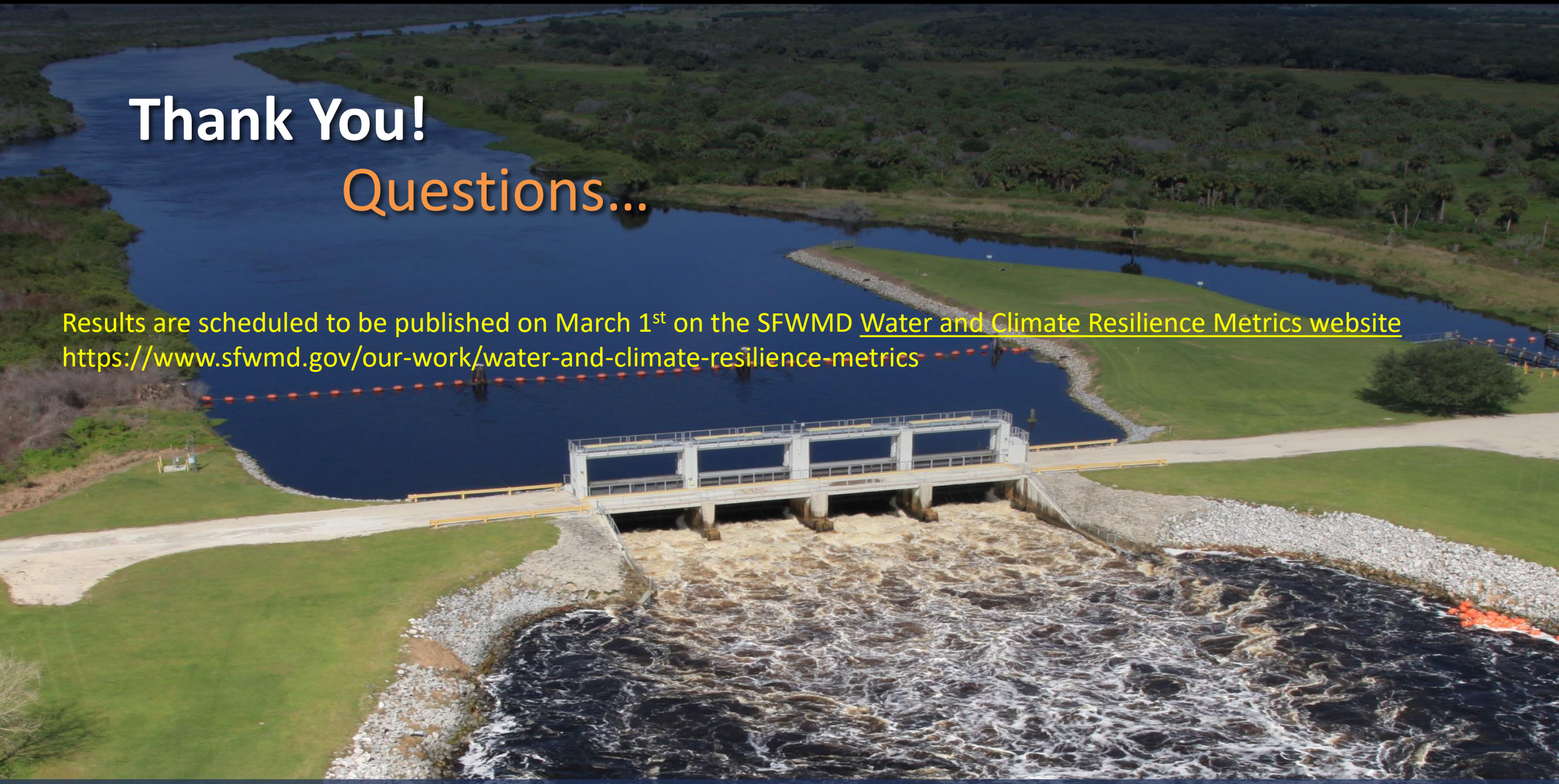
High Tide Events (HTE) at Coastal Structures - Summary



- Coastal structures display considerable variation in both the trends and the percentage of time that the HTEs conditions are met.

- **St. Lucie and Palm Beach counties**
  - Structures consistently maintain design elevations well above tidal levels, resulting in infrequent HTEs.
- **Broward County**
  - Structures S-37A and S-33 showed statistically significant upward trends.
  - Structure S-33 recorded the highest trend and maximum HTEs condition occurrence.
- **Miami-Dade County**
  - Majority of structures demonstrated statistically significant upward trends.
  - Structures S-28, S-27, S-25, S-21A, S-20G, and S-20F experienced HTEs conditions approximately 50% of the time.
- **Collier County**
  - Structures HC1 and FU1 also exhibited statistically significant upward trends.
  - Structure FU1 showed the highest trend and maximum HTEs condition occurrence.

- Results of this study will be used to prioritize coastal structures for mitigation effort.



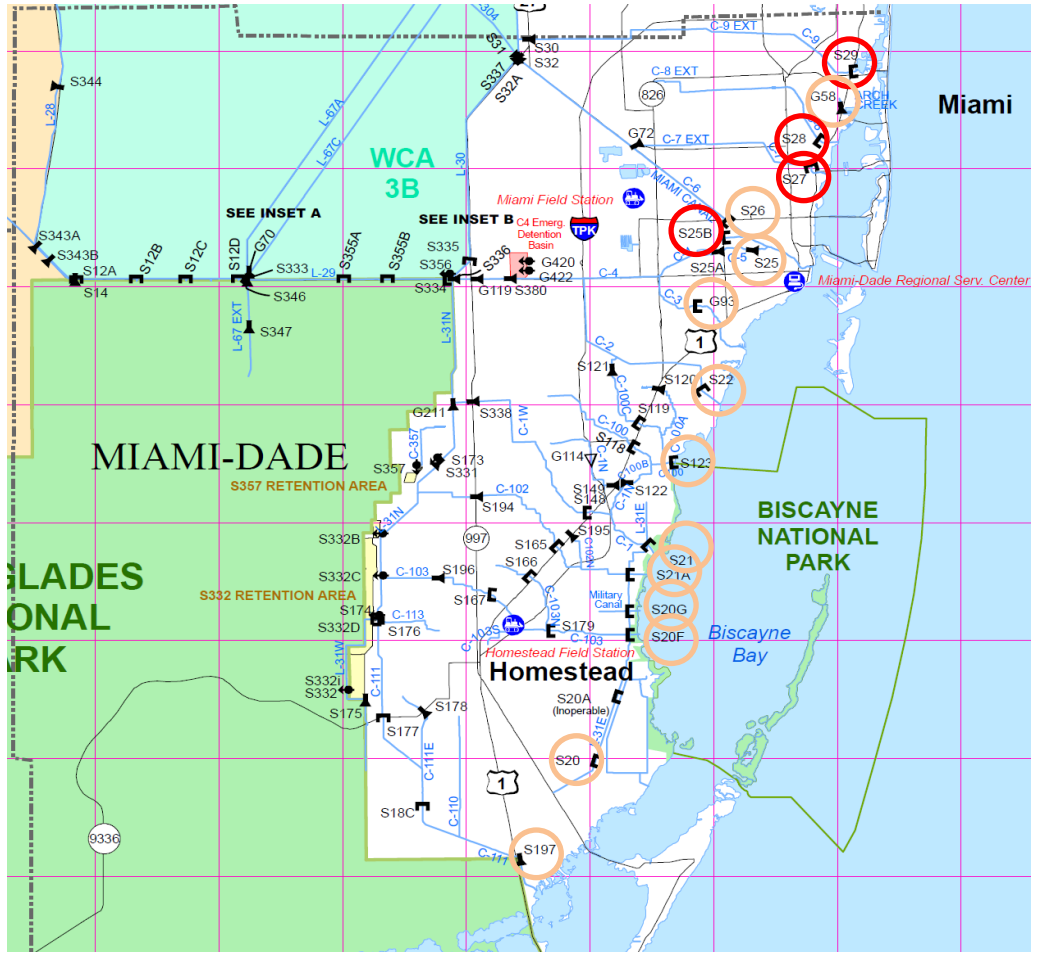
Thank You!

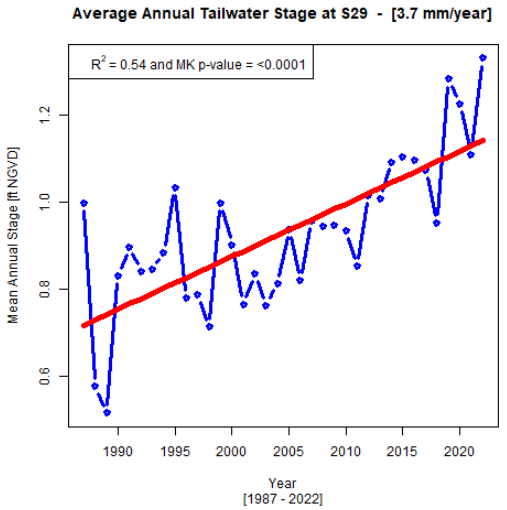
Questions…

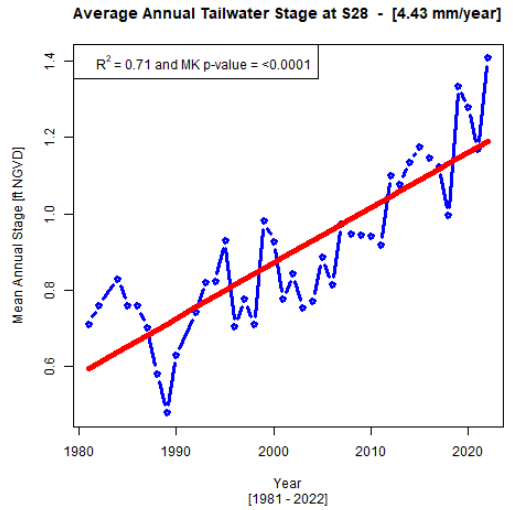
Results are scheduled to be published on March 1st on the SFWMD Water and Climate Resilience Metrics website
https://www.sfwmd.gov/our-work/water-and-climate-resilience-metrics

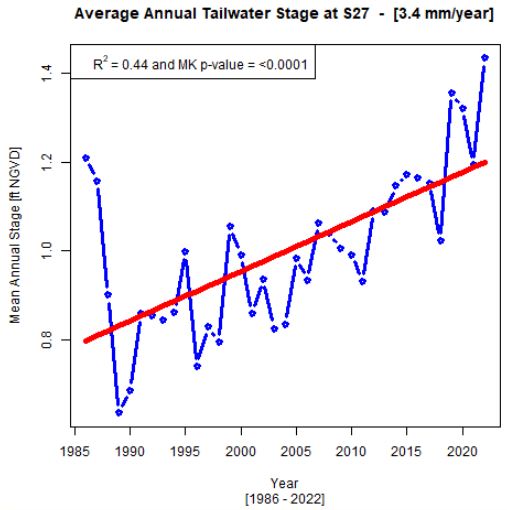
Water Level Trends – Climate Metric

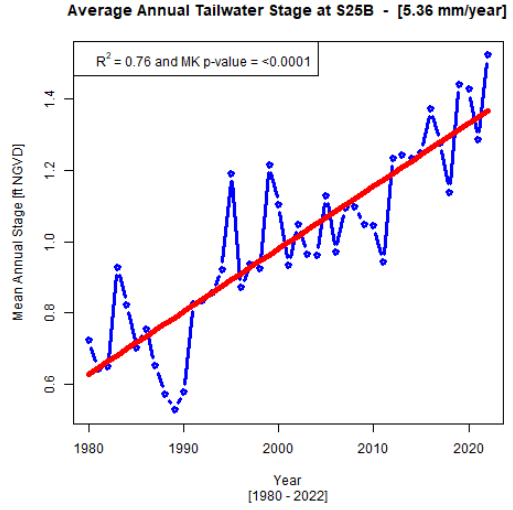
- Miami-Dade County



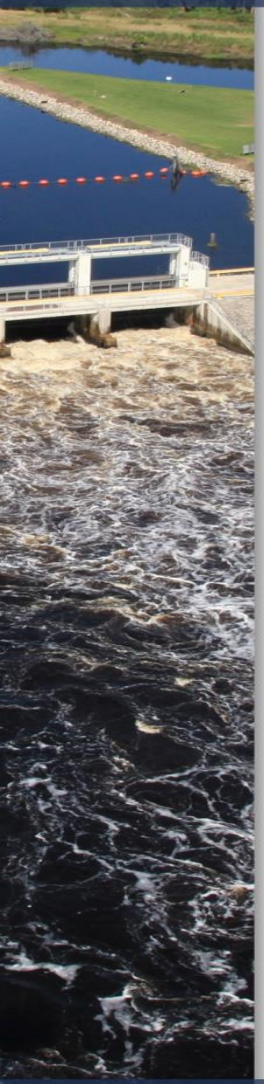








High Tide Events (HTE) at Coastal Structures



- With hourly values of HW and TW, the difference is plotted as a time series. If the TW is within 0.1 ft or above the HW (defined to be an HTE), the data point for that hour is colored red.
- At S-28 and S-20F, the condition is satisfied almost continuously.