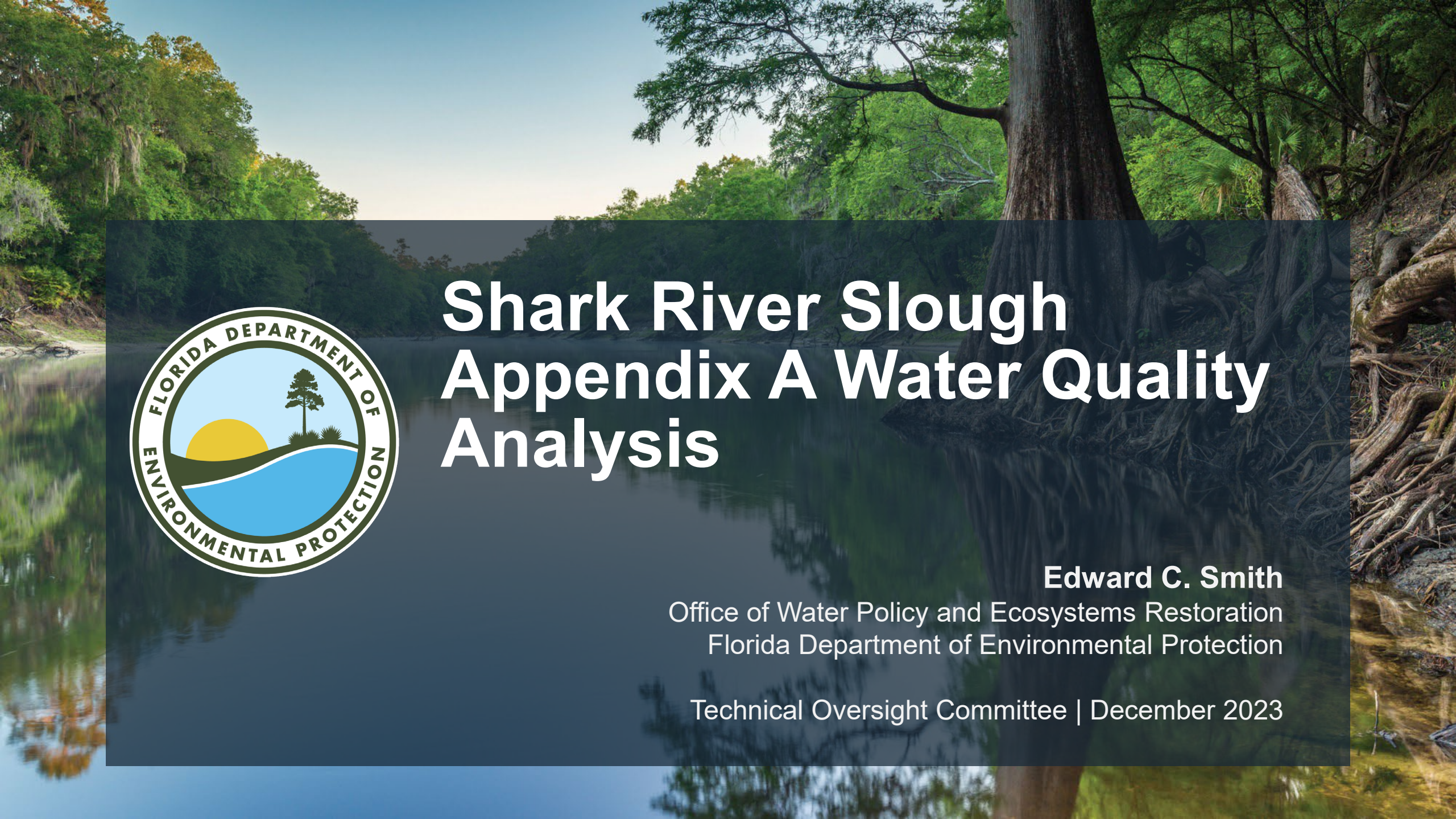

Shark River Slough Appendix A Water Quality Analysis

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Office of Water Policy and Ecosystems Restoration
Florida Department of Environmental Protection

Technical Oversight Committee | December 2023

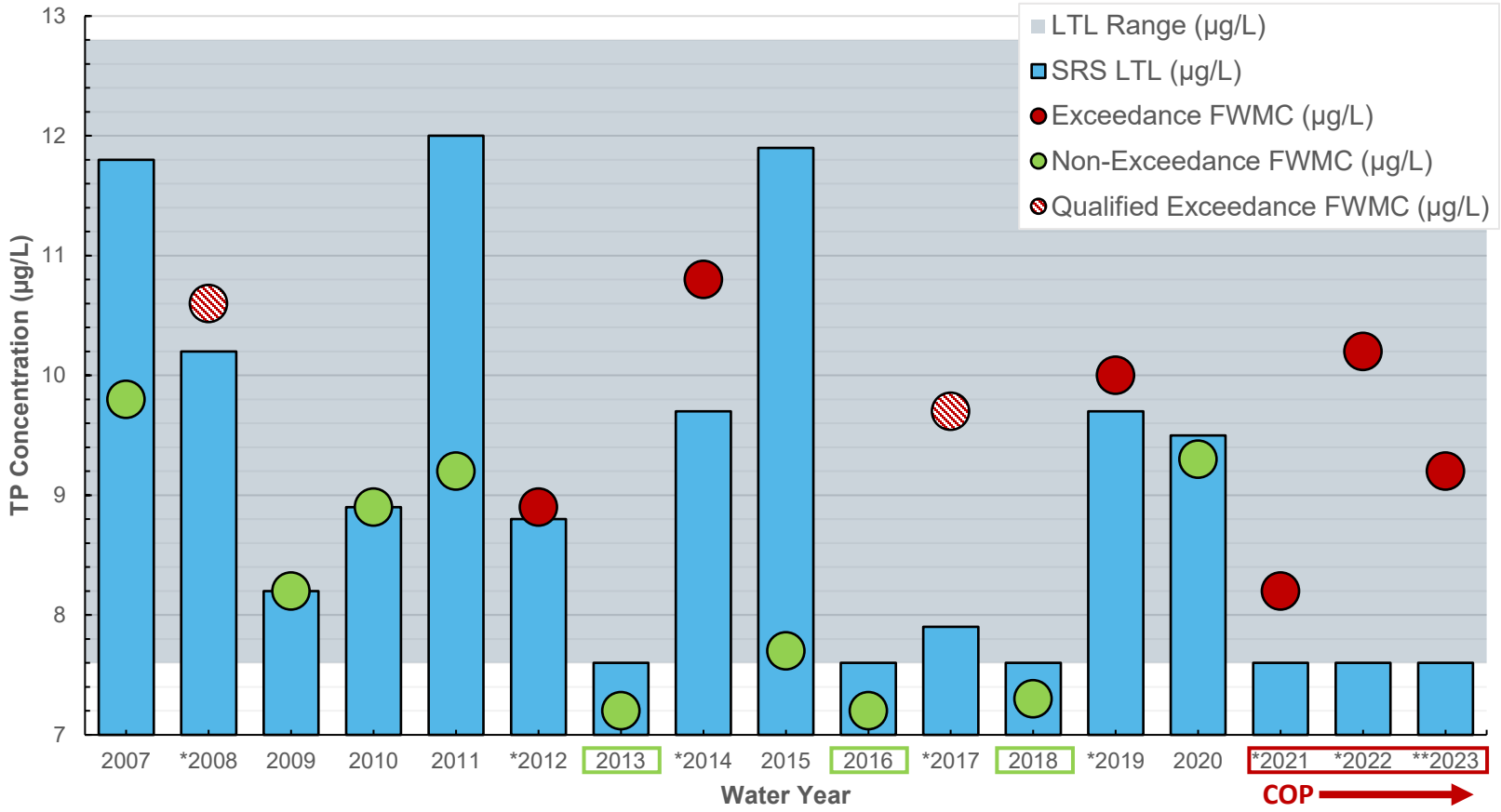
Water Quality Analysis – Outline

History of Exceedances	Exceedance Frequency and Magnitude Water Management Changes
Hydrodynamics of WCA-3A	Western Inflows – S190 & S140 Miami Canal Inflows – S8, S339, S340 Eastern Inflows – S150, S11A-C, S9/S9A
Local Drivers	S333HW Stage – TP Concentration Relationship Low-Stage Water Deliveries

History of Exceedances

Dec. 2023 TOC

LTL Trending Down, FWMC Not Increasing



Series	Kendall's τ	p-value ***	Sen's slope (µg/L/yr)
LTL	-0.42	0.0225	-0.119
FWMC	-0.02	0.9341	<0.001

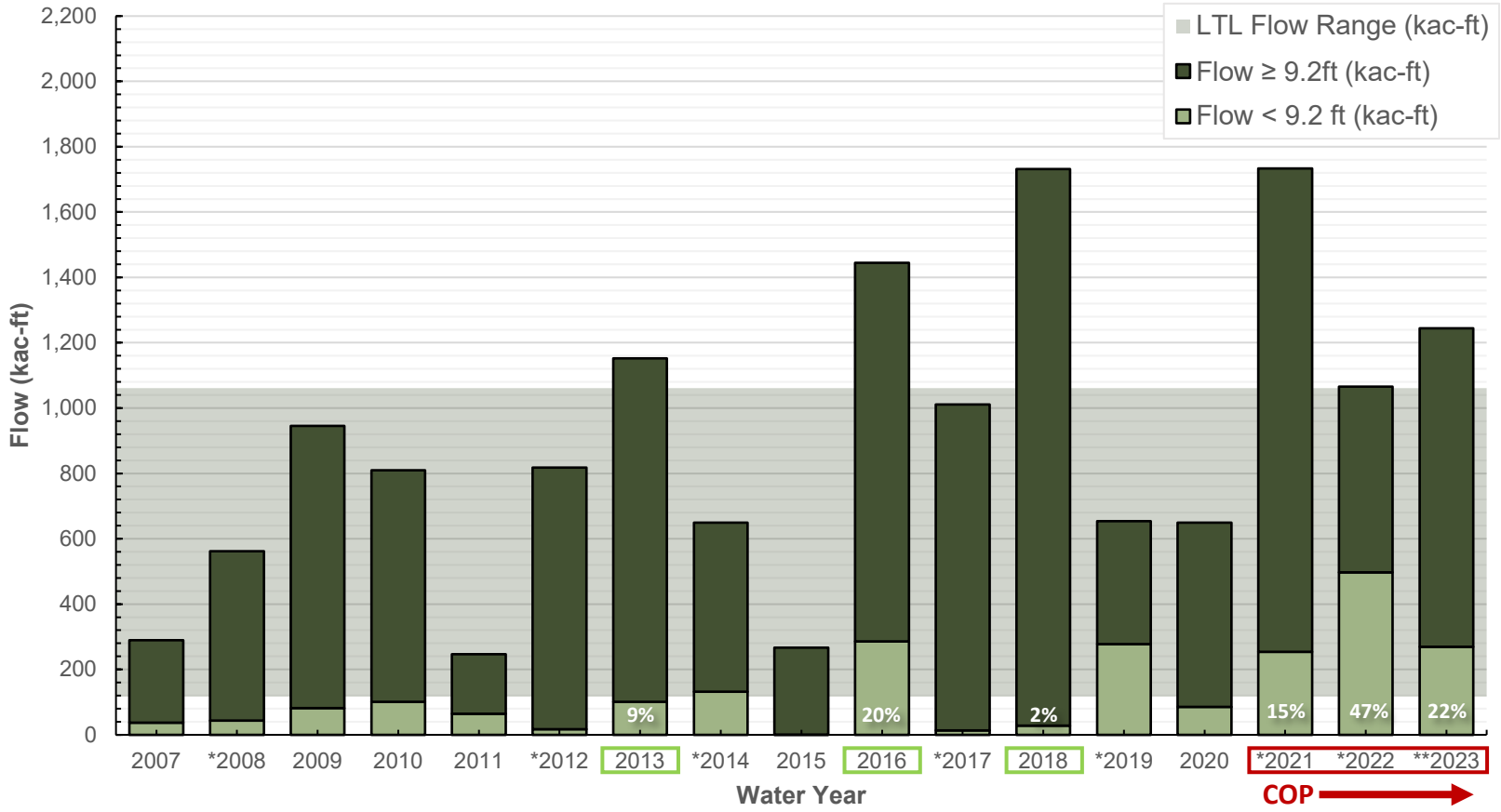
Data from WY 2007-2023

- TP FWMCs have no trend
- LTL has trended significantly downward (p=0.02)
  - At minimum limit (7.6 µg/L) since WY 2021

Increased flows as a result of COP have driven the LTL down to the minimum and the frequency of exceedances has increased

** Exceedance year; ** Provisional data; *** Significance determined at 0.05; Kendall's tau and Sen's slope calculated in R. Note: WY2008 & WY2017 exceedances qualified by the TOC.*

SRS Total Flows & Flows Under 9.2 ft Increasing



Series	Kendall's τ	p-value	Sen's slope (kac-ft/yr)
Total Flow	0.40	0.0273	51
Low-Stage Flow	0.35	0.0518	15

Data from WY 2007-2023

- Total flow has trended upward (p=0.03)
  - Above maximum LTL equation input (1,061 kac-ft) for 5 of last 8 years
- S333HW stage < 9.2 ft flow has also trended upward (p=0.05)***
  - Stage < 9.2 ft associated with higher TP concentrations

The lower the stage, the higher the FWMC – recent years had significant flow at lower stages

** Exceedance year; ** Provisional data; *** Not significant at 0.05 but is significant at 0.1; Kendall's tau and Sen's slope calculated in R.*

Combined Operational Plan (COP)

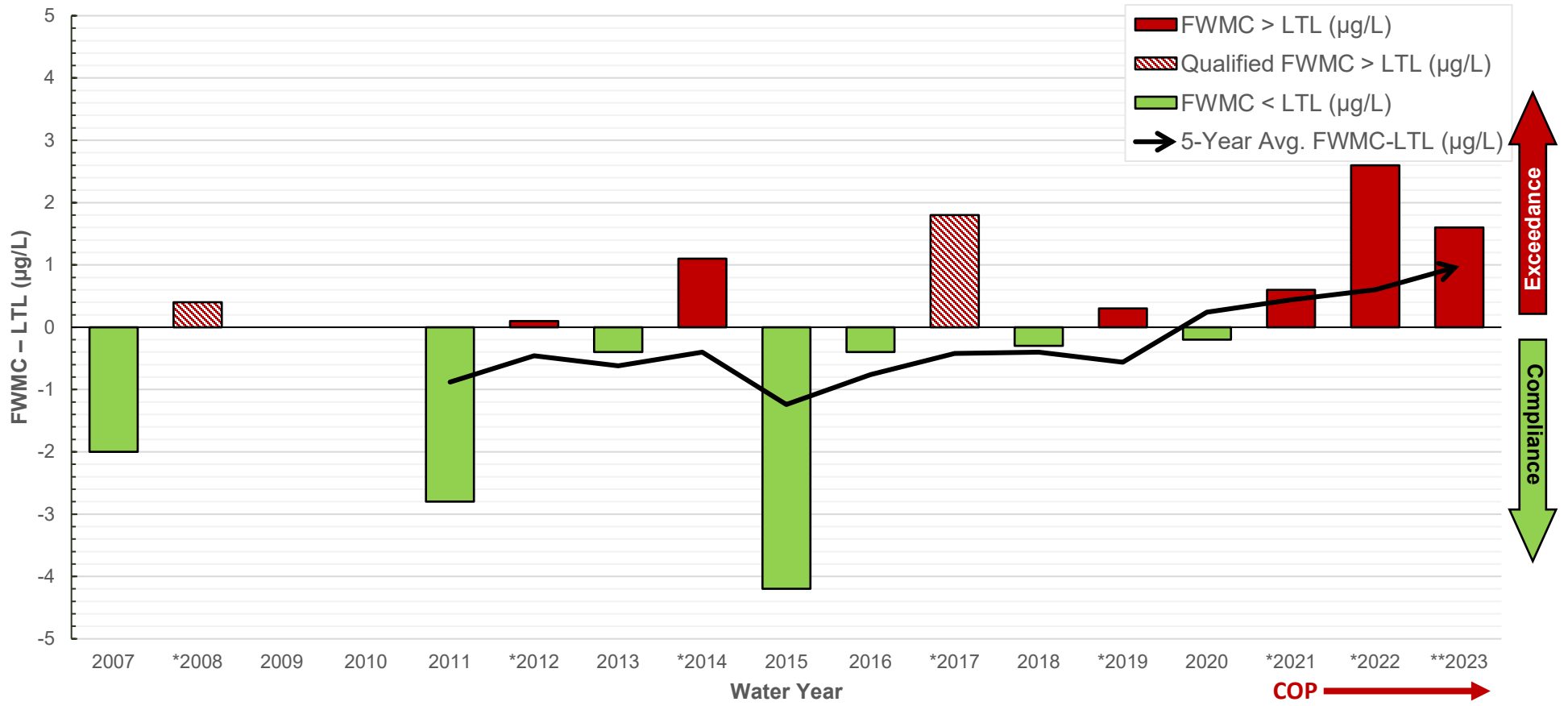
- **COP was designed to…**
  - Improve water deliveries (timing, location, volume) into ENP.
  - Increase flows through Taylor Slough and coastal creeks.
  - Increase dry season flows into eastern Shark River Slough to improve ecological health.

- **COP Final Environmental Impact Statement acknowledged that changed operations would…**
  - Result in increased TP FWMC and decreased LTL.
  - Increase the risk of LTL exceedances.

- **As anticipated…**
  - Dry season water deliveries have been extremely beneficial ecologically to SRS.
  - Exceedances of Appendix A have occurred with increased frequency since COP implementation.

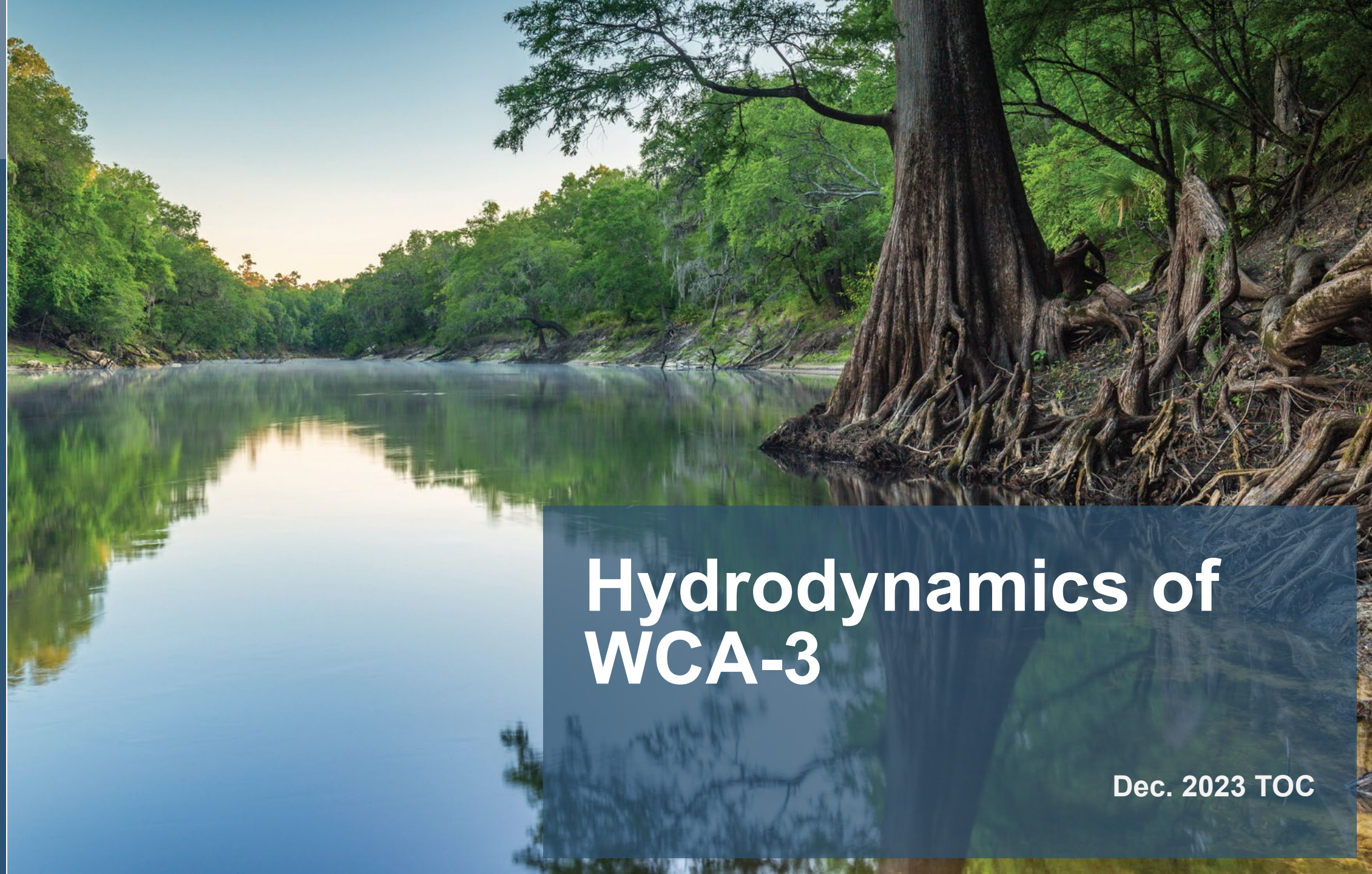
Exceedances of Appendix A have occurred annually since COP implementation

Exceedance Magnitude Increasing Since WY 2019



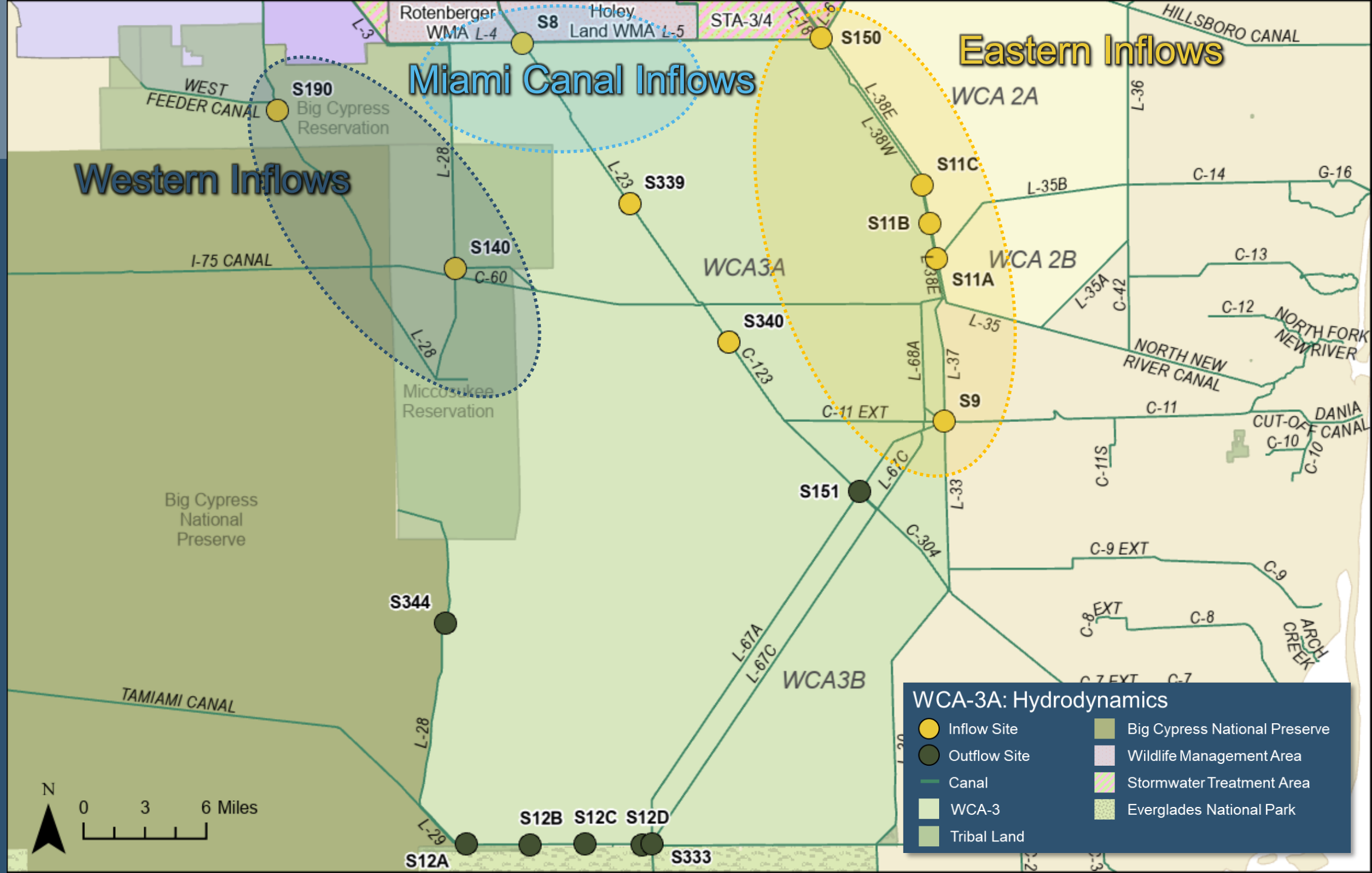
The rolling 5-year average FWMC was less than the LTL until WY 2020

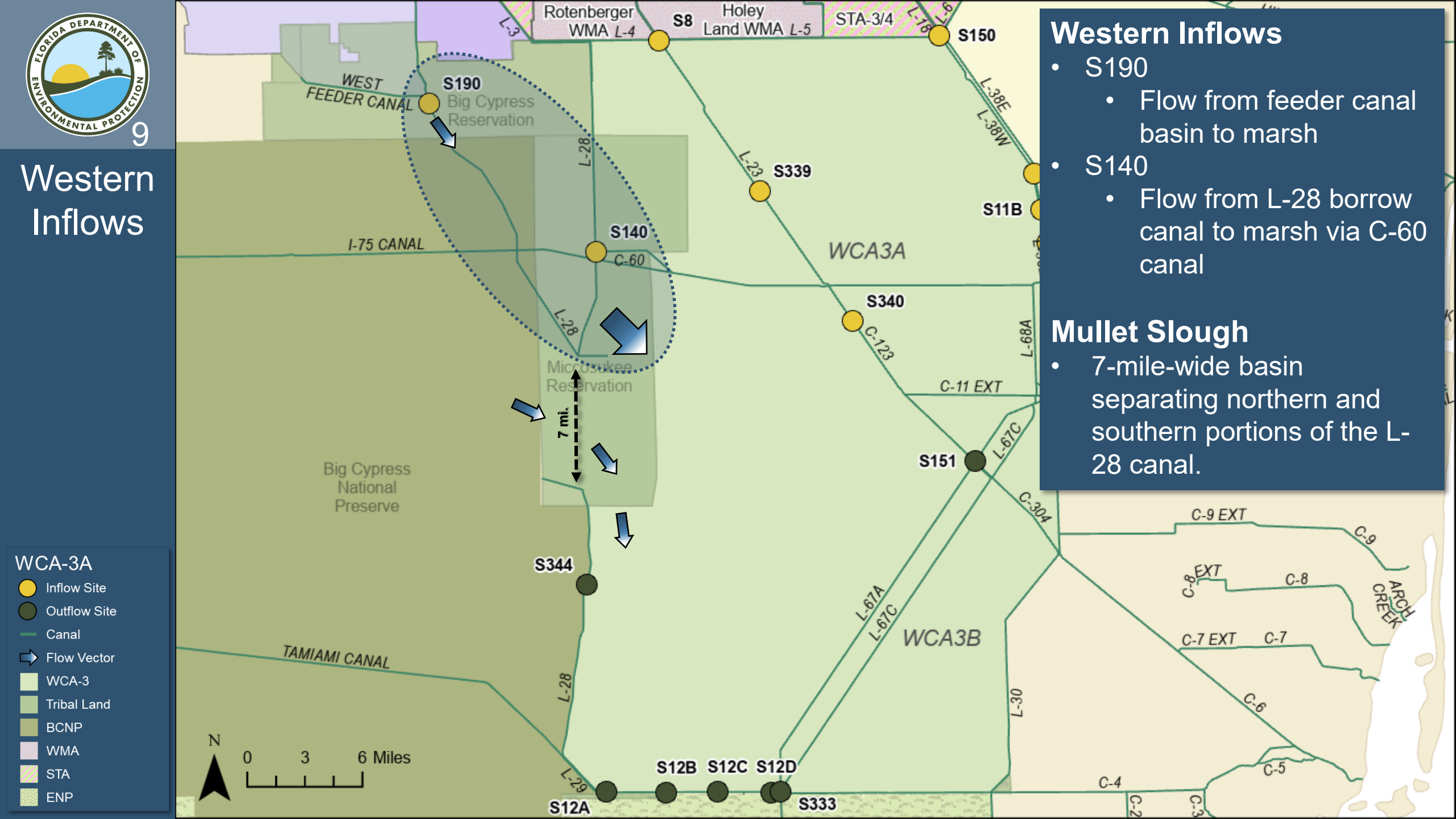
** Exceedance year; ** Provisional data; Note: WY2008 & WY2017 exceedances qualified by the TOC.*



Hydrodynamics of WCA-3

Dec. 2023 TOC


Miami Canal Inflows
Eastern Inflows
Western Inflows
Rotenberger WMA
Holey Land WMA
STA-3/4
S8
S150
S190
Big Cypress Reservation
WEST FEEDER CANAL
S339
S11C
S11B
S11A
S140
S340
S9
S151
S344
S12A
S12B
S12C
S12D
S333
WCA 2A
WCA 2B
WCA3A
WCA3B
Miccosukee Reservation
Big Cypress National Preserve
I-75 CANAL
TAMIAMI CANAL
HILLSBORO CANAL
NORTH NEW RIVER CANAL
NORTH FORK NEW RIVER
CUT-OFF CANAL
DANIA
ARCH CREEK
L-3
L-4
L-5
L-6
L-7
L-8
L-23
L-28
L-29
L-35
L-35A
L-35B
L-36
L-37
L-38E
L-38W
L-67A
L-67C
L-68A
C-11
C-11 EXT
C-11S
C-123
C-13
C-14
C-304
C-42
C-60
C-7
C-7 EXT
C-8
C-8 EXT
C-9
C-9 EXT
C-10
G-16
N
0 3 6 Miles
WCA-3A: Hydrodynamics
Inflow Site
Outflow Site
Canal
WCA-3
Tribal Land
Big Cypress National Preserve
Wildlife Management Area
Stormwater Treatment Area
Everglades National Park



Western Inflows

- S190
  - Flow from feeder canal basin to marsh
- S140
  - Flow from L-28 borrow canal to marsh via C-60 canal

Mullet Slough

- 7-mile-wide basin separating northern and southern portions of the L-28 canal.

Western Inflows: Marsh Interaction

Mullet Slough

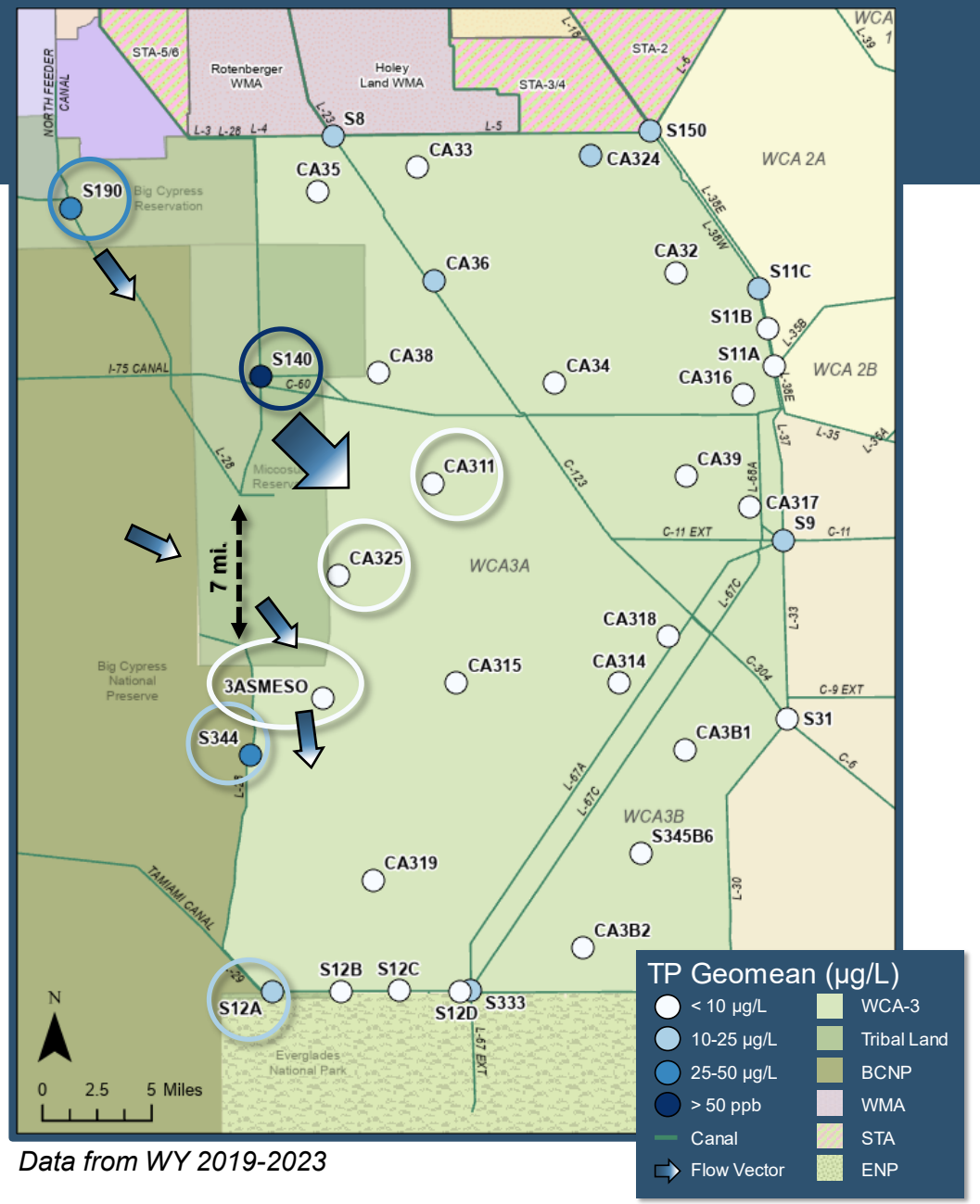
- 7-mile-wide gap within the L-28 canal.

S-190 and S-140

- High-TP inflows that enter the marsh via S190 and S140 reduced before reaching the nearest marsh site.

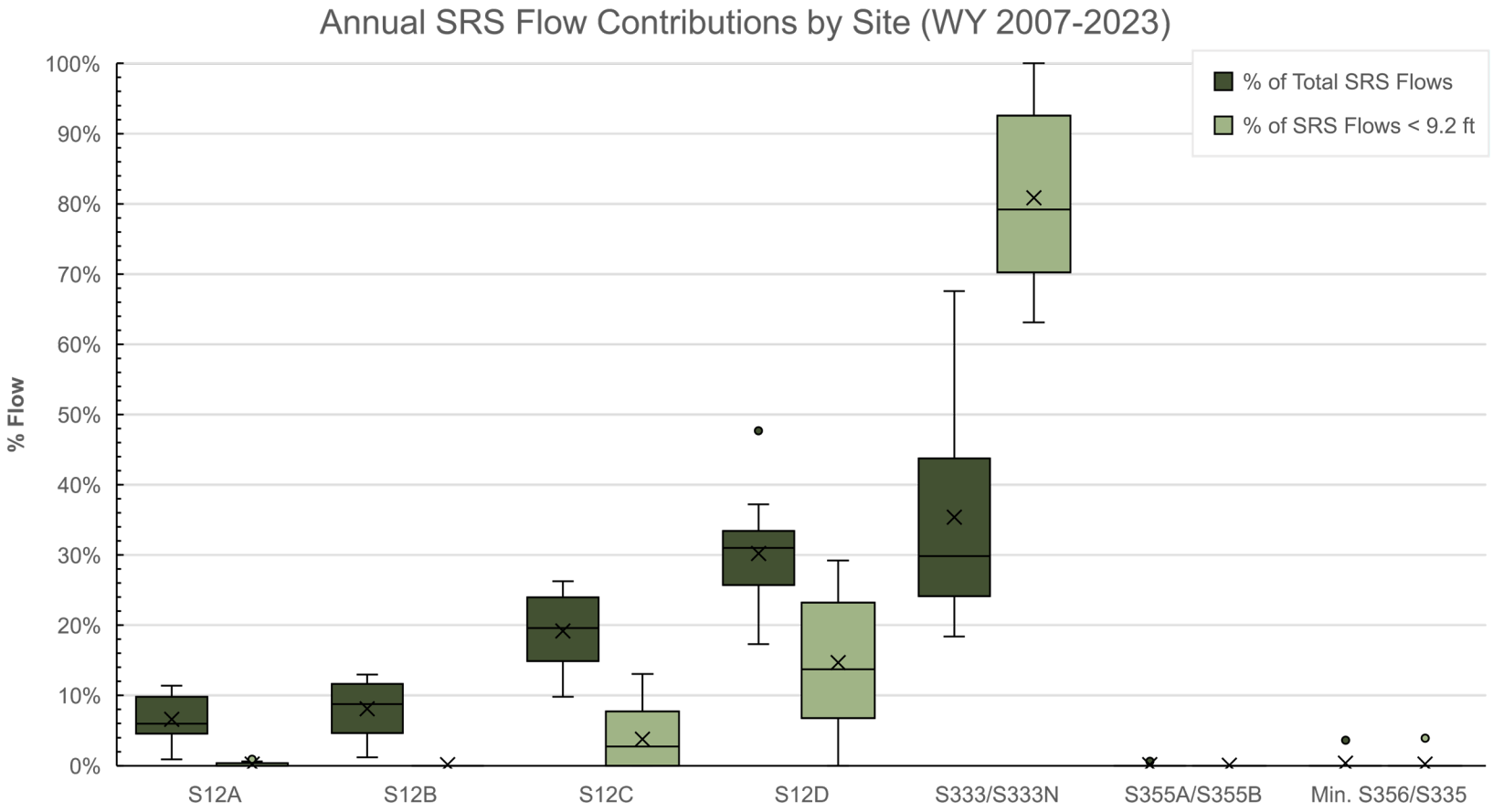
Station	Class	5-Yr TP Geomean (µg/L)	5-Yr WRF TP Geomean (µg/L)
S190	**Inflow**	40.0 ± 24.9	59.3 ± 38.9
S140	**Inflow**	52.2 ± 21.5	54.9 ± 23.0
CA311	**Marsh**	4.4 ± 1.3	N/A
CA325	**Marsh**	4.7 ± 1.7	N/A
3ASMESO	**Marsh**	4.2 ± 1.7	N/A
S344	**Outflow**	25.1 ± 17.2	*
S12A	**Outflow**	18.0 ± 10.2	11.1 ± 4.8

Seasonally screened data from WY 2019-2023; WRF = When recorded flow
** Not enough data*



Data from WY 2019-2023

S12A has Minimal Flow to ENP



- S12A flows make up a small proportion of total flows to SRS.
- S12A is closed during the dry season and does not contribute flow when S333HW < 9.2 ft.
  - Vast majority of low-stage flows are through S333 & S333N

S12A contributes a small proportion of total flow to the LTL equation
S12A contributed no flow when S333HW < 9.2 ft for 12 out of 17 years

Note: Flows from S356/S335 were only counted for years using App. A SRS Method 1.5 (WY2021-2023).

Miami Canal Inflows

Miami Canal Inflows

- S8 flow primarily from STAs to Miami canal
- S339 & S340 regulation schedule prevents direct canal flows between S8 and L-67A

Flows > 0 & S333HW Stage	% Days WY 2007-2023	% Days WY 2019-2023
S8	35.4%	46.4%
S339	11.1%	10.2%
S340	10.0%	8.5%
S339 & S340	7.7%	4.0%
S339 & S340 & S8	5.1%	3.9%
S339 & S340 & < 9.2 ft	0.6%	0.2%
S8 & S339 & S340 & < 9.2 ft	0.4%	0.2%

WCA-3A
- Inflow Site
- Outflow Site
- Canal
- Flow Vector
- Barrier to Flow
- WCA-3
- Tribal Land
- BCNP
- WMA
- STA
- ENP

N
0 3 6 Miles

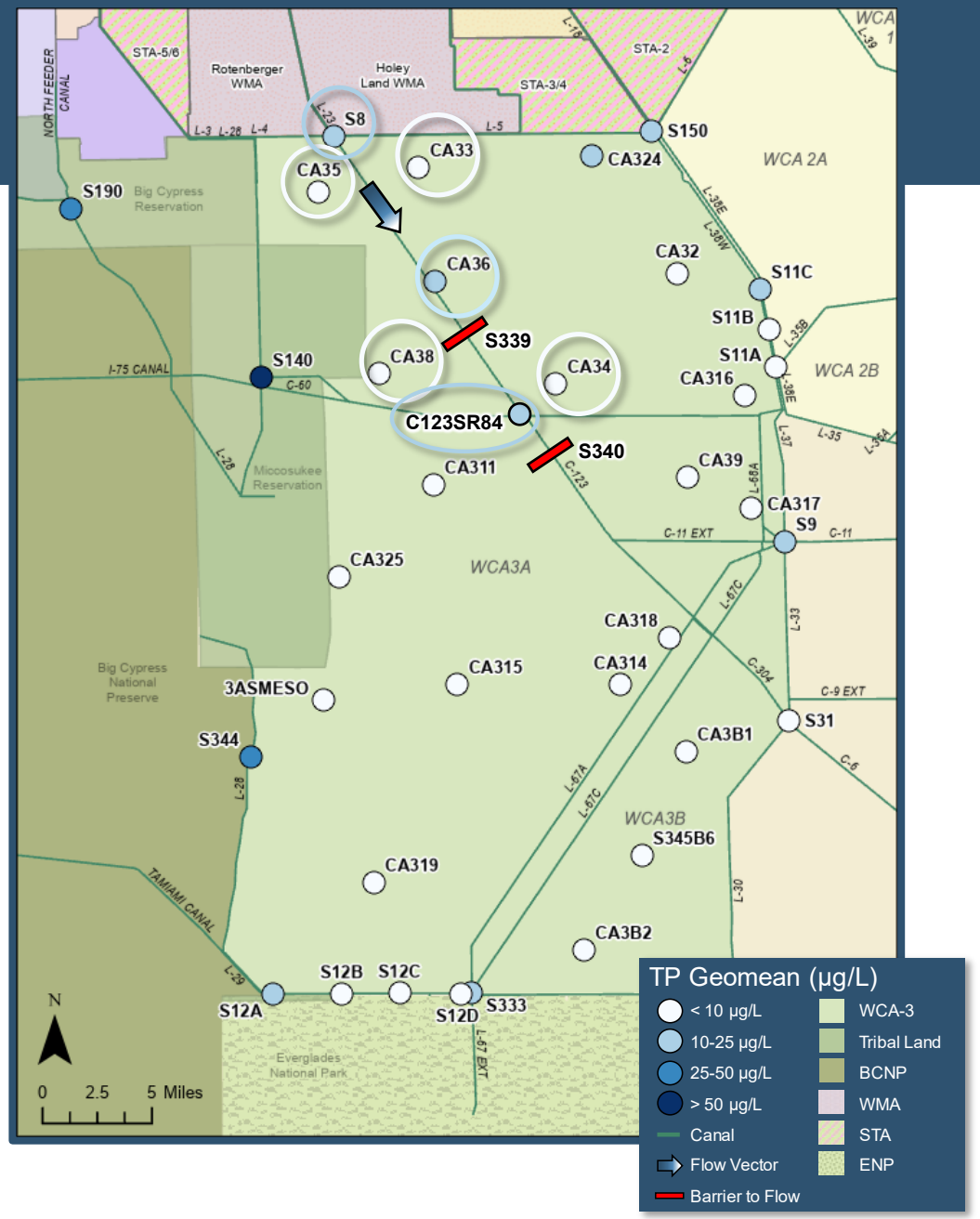
Miami Canal Inflows: Marsh Interaction

Miami Canal

- Cut nearly perpendicular to topographical contours through WCA-3A
  - High canal-marsh interaction

Station	Class	5-Yr TP Geomean (µg/L)	5-Yr WRF TP Geomean (µg/L)
S8	**Inflow**	15.1 ± 4.6	16.9 ± 5.6
CA35	**Marsh**	5.7 ± 1.3	N/A
CA33	**Marsh**	9.2 ± 2.8	N/A
CA36*	**Marsh**	13.2 ± 5.2	N/A
CA38	**Marsh**	5.0 ± 1.9	N/A
CA34	**Marsh**	7.3 ± 2.3	N/A
C123SR84**	**Inflow**	20.4 ± 7.4	N/A

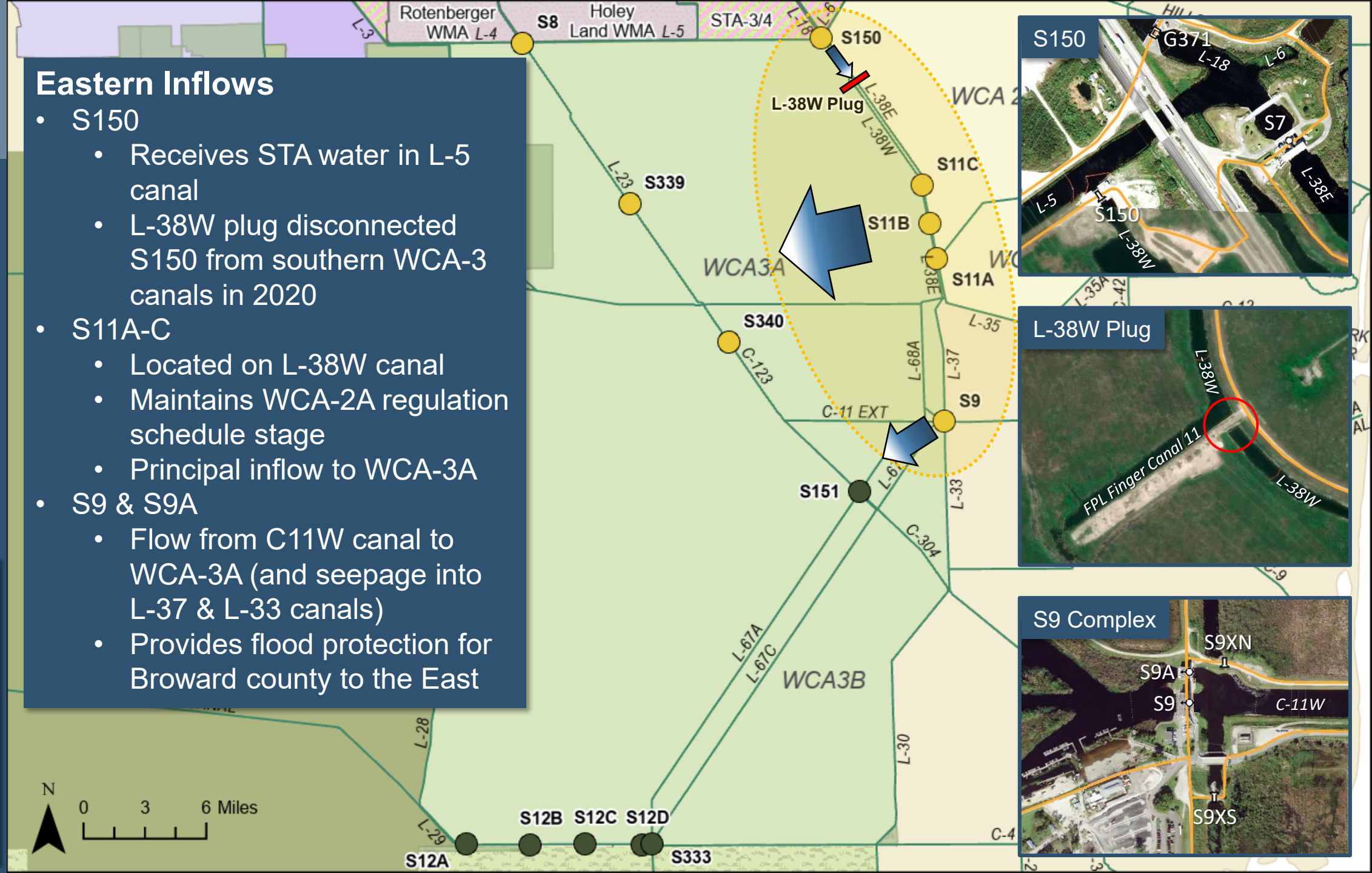
Seasonally screened data from WY 2019-2023; WRF = When recorded flow
** CA36 values based on 5 samples from single valid year*
*** C123SR84 WQ surrogate for S339 & S340*



Eastern Inflows

Eastern Inflows

- S150
  - Receives STA water in L-5 canal
  - L-38W plug disconnected S150 from southern WCA-3 canals in 2020
- S11A-C
  - Located on L-38W canal
  - Maintains WCA-2A regulation schedule stage
  - Principal inflow to WCA-3A
- S9 & S9A
  - Flow from C11W canal to WCA-3A (and seepage into L-37 & L-33 canals)
  - Provides flood protection for Broward county to the East



WCA-3A
- Inflow Site
- Outflow Site
- Canal
- Flow Vector
- Barrier to Flow
- WCA-3
- Tribal Land
- BCNP
- WMA
- STA
- ENP

Eastern Inflows: S150 & S11A-C

S150

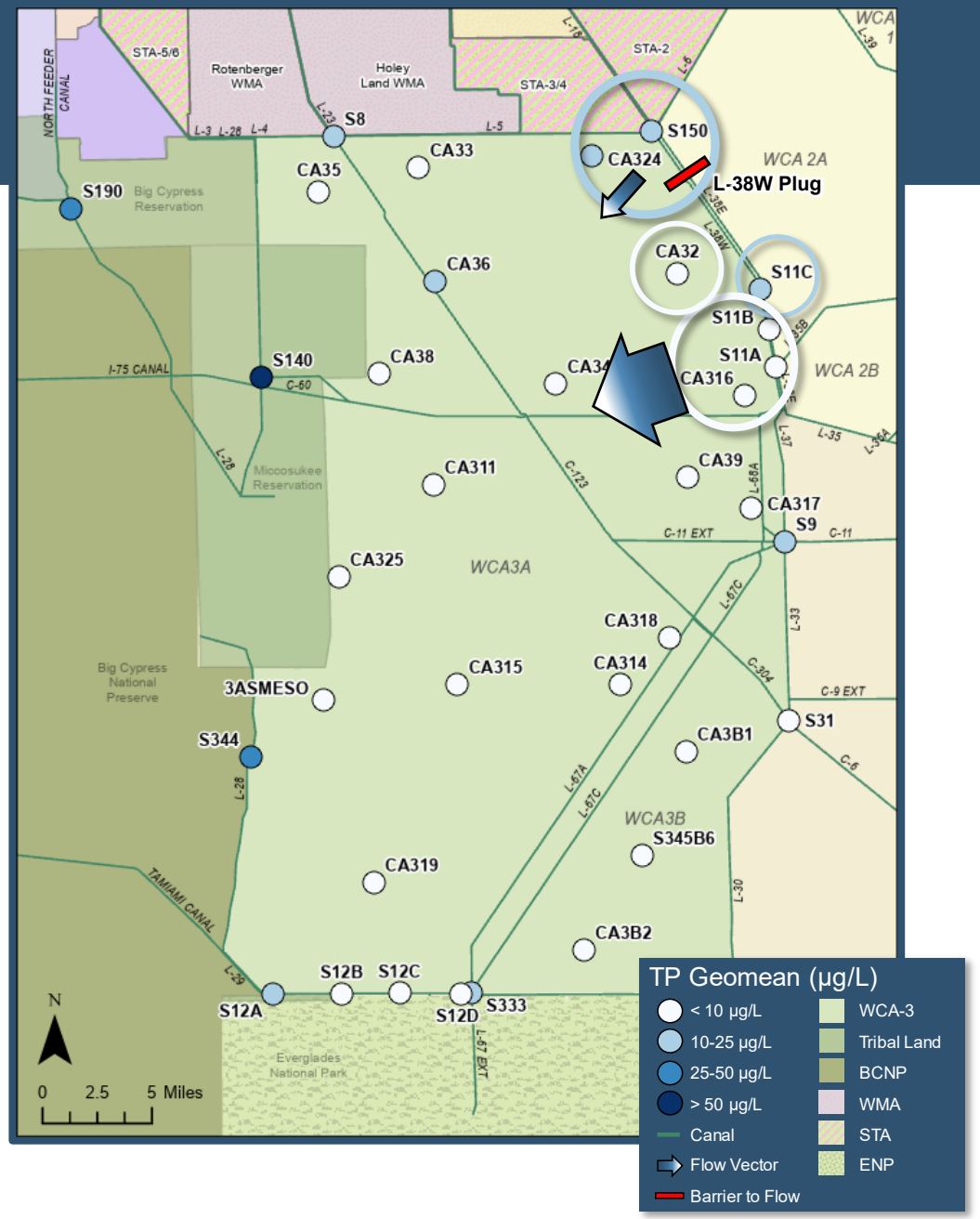
- 2020 plug blocks flows from traveling down L-38W, instead flows into NE WCA-3A marsh

S11A-C

- Majority inflow volume to WCA-3A via marsh

Station	Class	5-Yr TP Geomean (µg/L)	5-Yr WRF TP Geomean (µg/L)
S150	**Inflow**	12.2 ± 3.2	12.0 ± 2.7
CA324	**Marsh**	13.7 ± 4.6	N/A
S11A	**Inflow**	9.4 ± 3.8	7.2 ± 1.5
S11B	**Inflow**	9.0 ± 3.3	8.5 ± 3.0
S11C	**Inflow**	10.4 ± 3.5	9.9 ± 3.3
CA32	**Marsh**	4.8 ± 1.4	N/A
CA316	**Marsh**	6.8 ± 1.2	N/A

Seasonally screened data from WY 2019-2023; WRF = When recorded flow



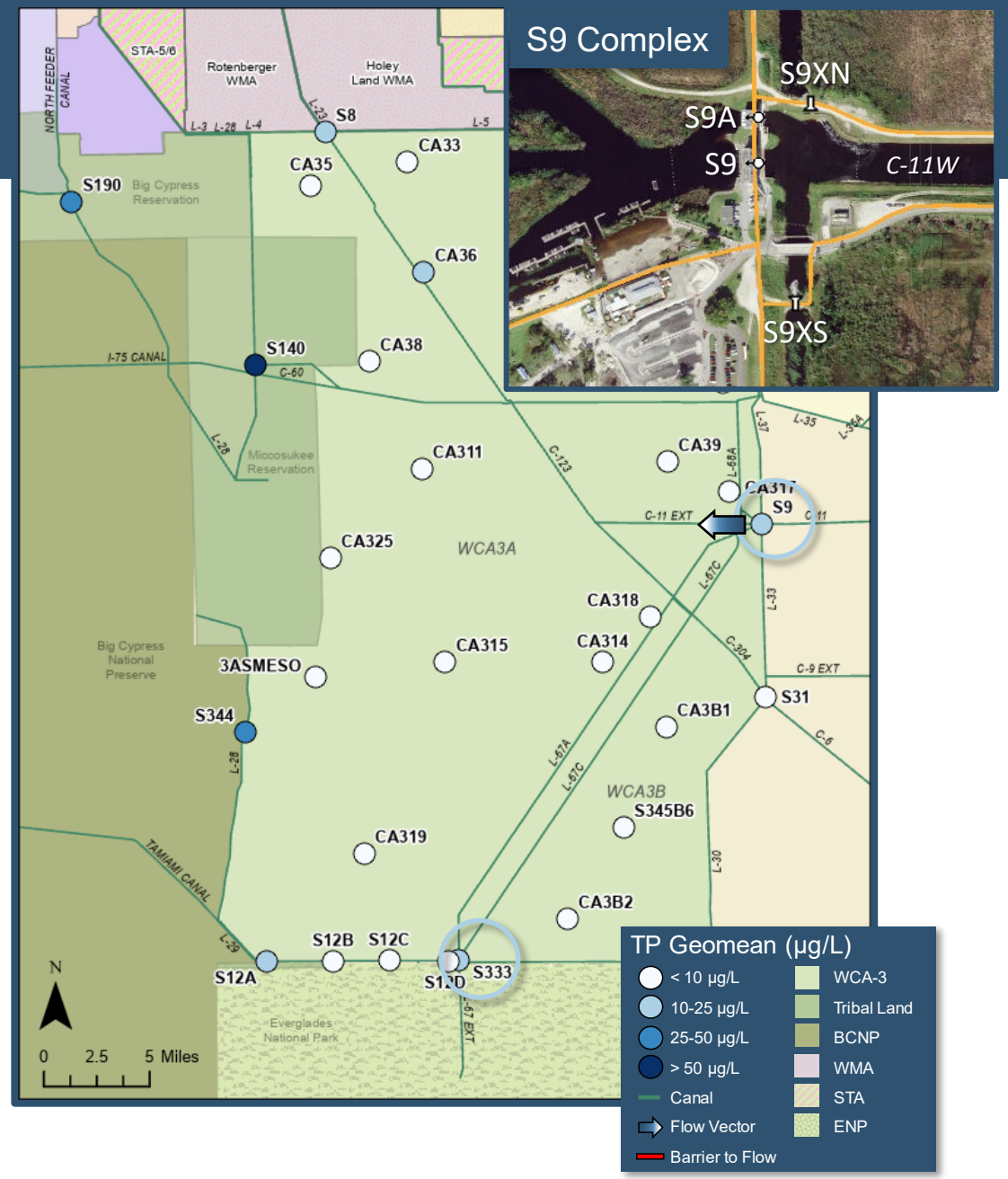
Eastern Inflows: S9 & S9A

S9 & S9A

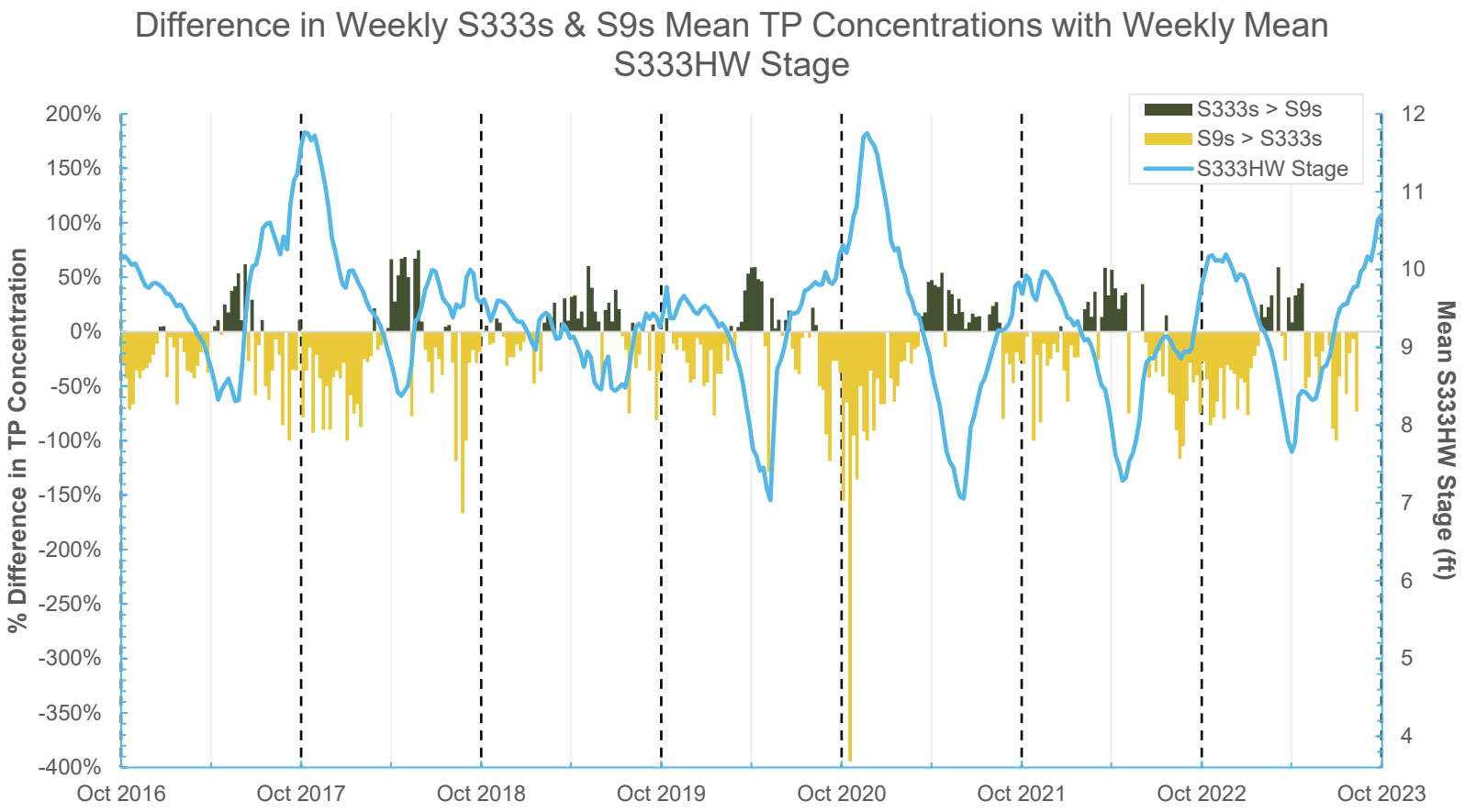
- Flood control pump stations
- Operations generally occur during wet periods when WCA-3A stages are elevated.
- TP concentrations slightly lower and less variable than at S333 & S333N.

Station	Class	5-Yr TP Geomean (µg/L)	5-Yr WRF TP Geomean (µg/L)
S9	Inflow	12.5 ± 4.0	13.3 ± 4.3
S9A	Inflow	13.0 ± 4.8	13.0 ± 5.1
S333	Outflow	14.0 ± 6.4	14.0 ± 6.5
S333N	Outflow	15.3 ± 7.7	14.8 ± 7.0

Seasonally screened data from WY 2019-2023; WRF = When recorded flow



Mean Weekly TP Concentrations at S333s & S9s

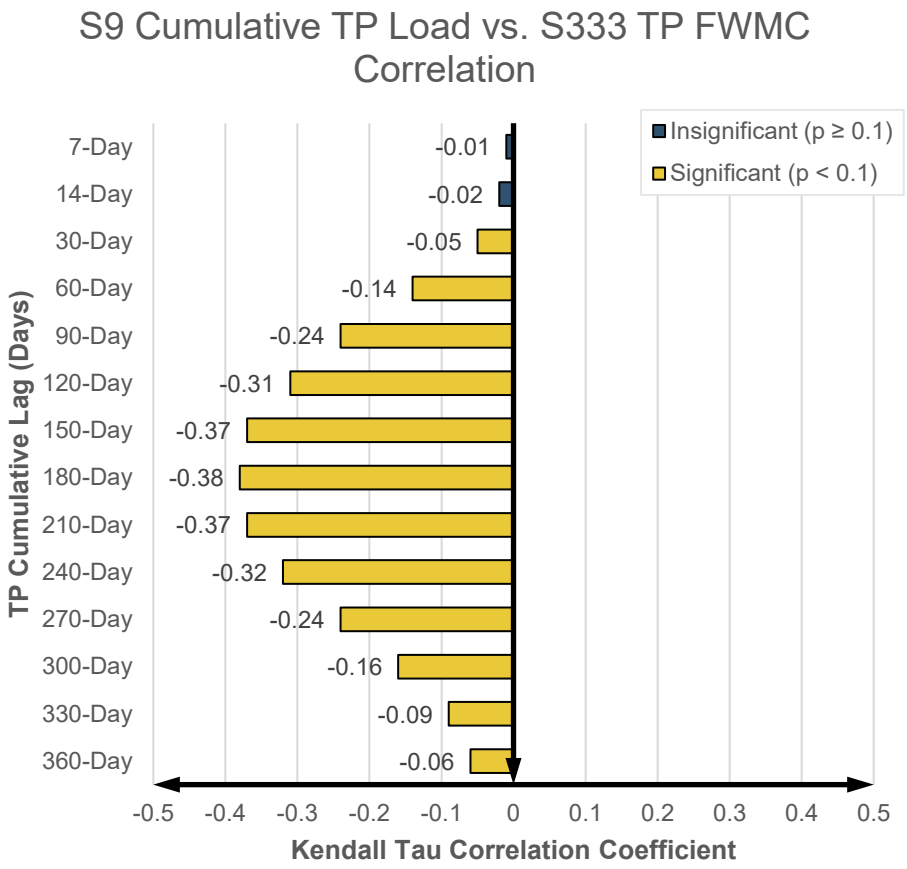


TP Grab Concentrations by Stage

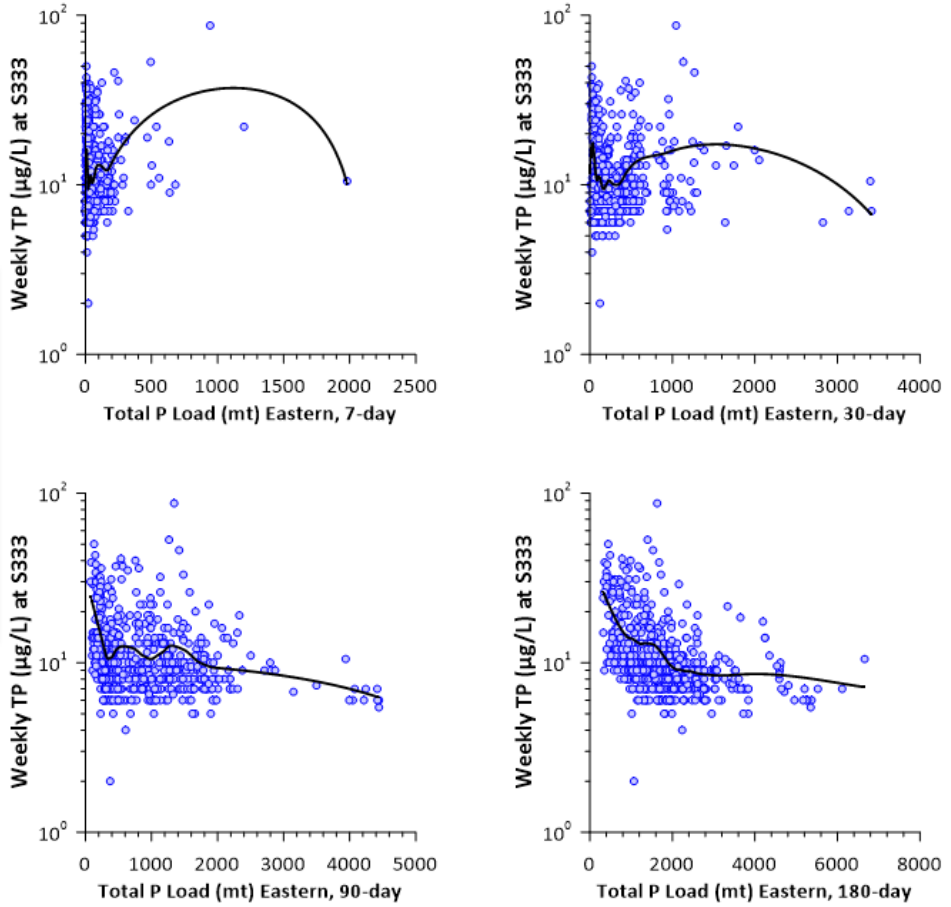
- Above 9.2 ft, S333s TP grabs are on average 36% lower than S9s TP grabs.
- Below 9.2 ft, S333s TP grabs are on average 9% higher than S9s TP grabs.

TP concentrations at S333s tend to be higher than at S9s when stage is low (the critical period) – when stage is high, concentrations at S9s tend to be higher than at S333s

Inverse Correlation between S9 TP Load & S333 FWMC



S9 Complex
Negative Kendall τ indicates S333 TP FWMs are lower when S9 cumulative loads are greater



No positive correlation between S9 cumulative TP loads and S333 TP FWM concentrations could be established, regardless of any lag time

Summary: WCA-3A TP inflows not driving Appendix A exceedances

Western Inflows

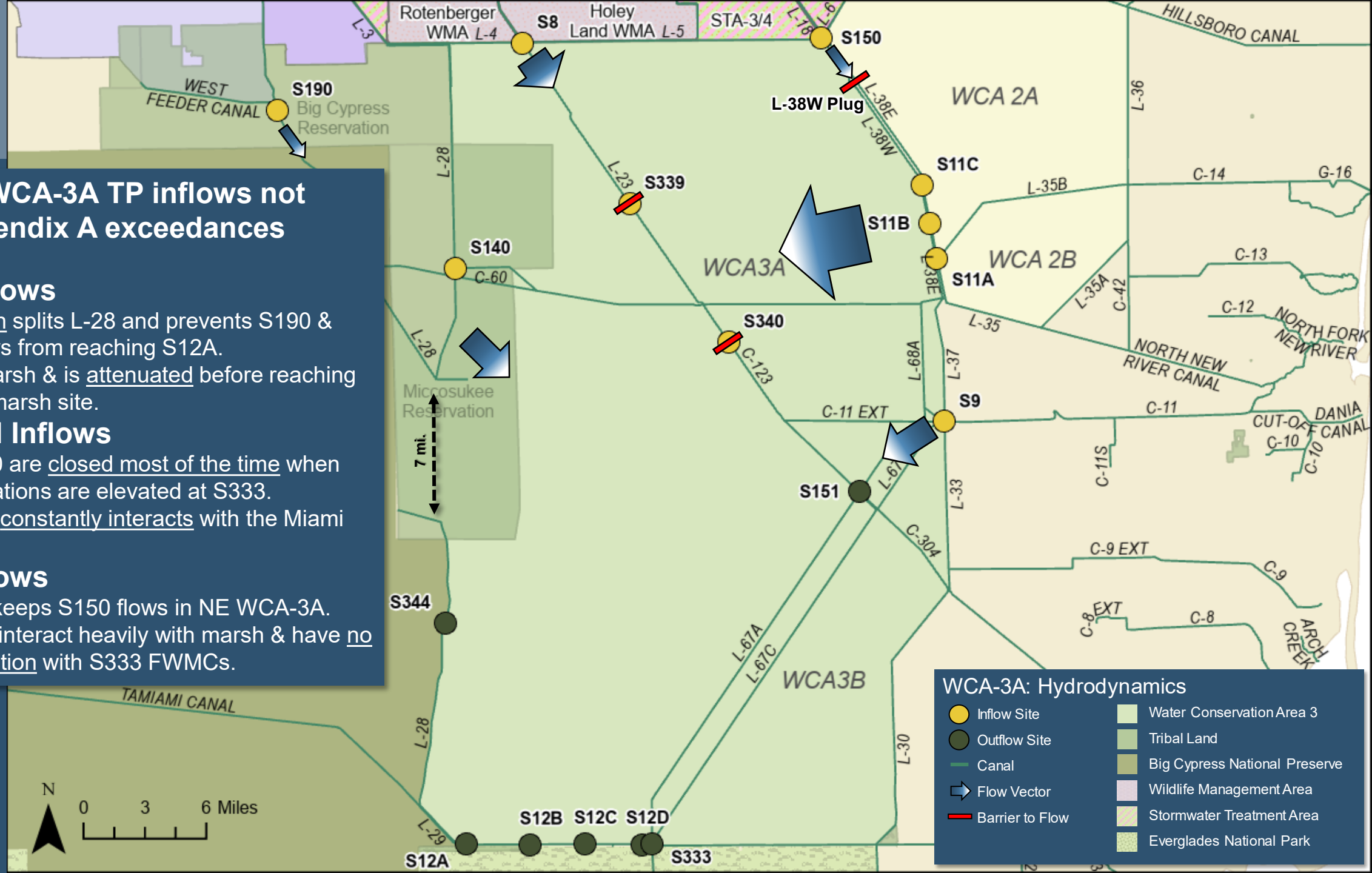
- Mullet Slough splits L-28 and prevents S190 & S140 outflows from reaching S12A.
- TP enters marsh & is attenuated before reaching the nearest marsh site.

Miami Canal Inflows

- S339 & S340 are closed most of the time when TP concentrations are elevated at S333.
- Marsh water constantly interacts with the Miami Canal.

Eastern Inflows

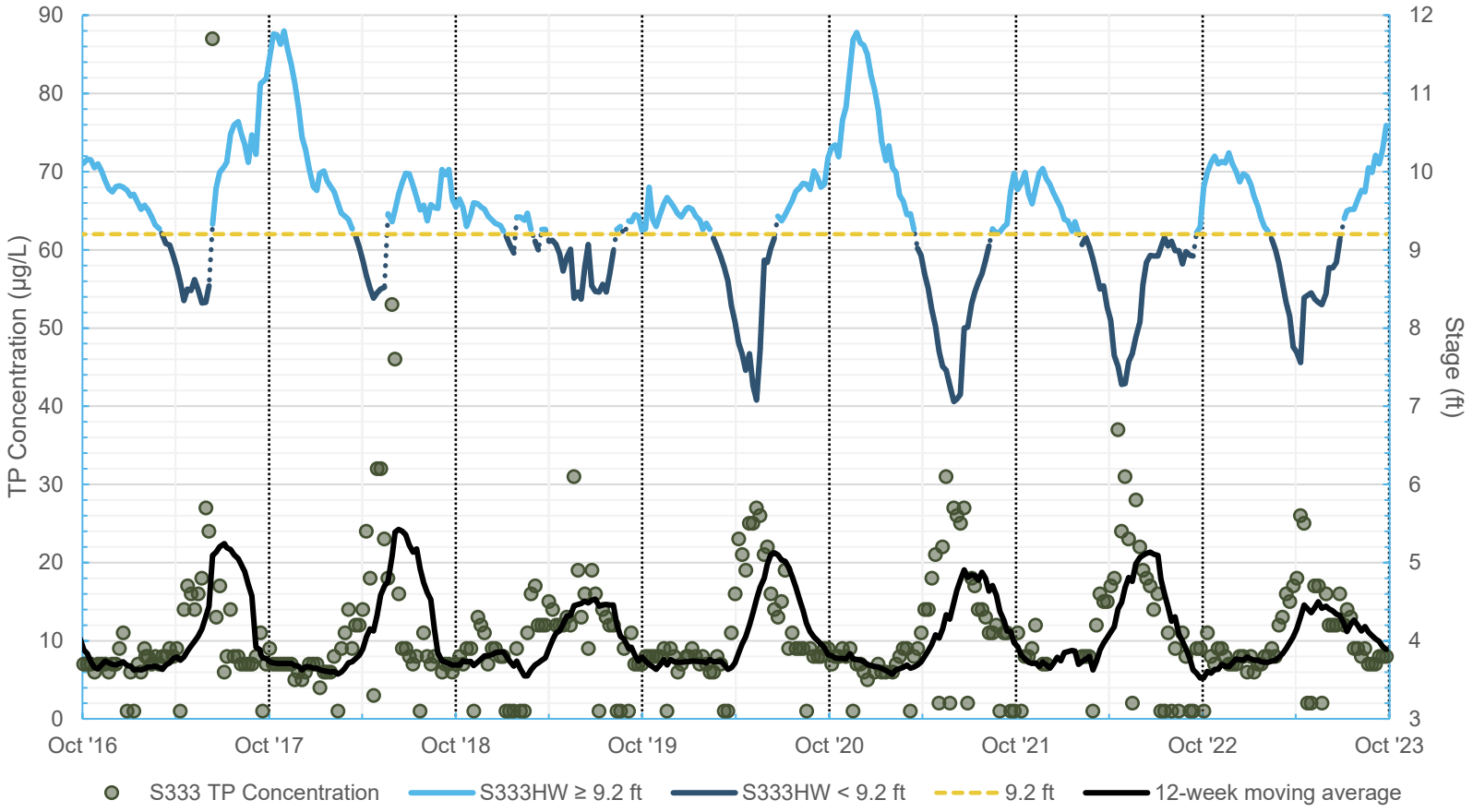
- L-38W plug keeps S150 flows in NE WCA-3A.
- S9 TP loads interact heavily with marsh & have no direct correlation with S333 FWMCs.



Local Drivers

Dec. 2023 TOC

High S333 TP Concentration Correlates to Low S333HW Stage



S333 TP Concentration-Stage Correlation (WY2007-2023)

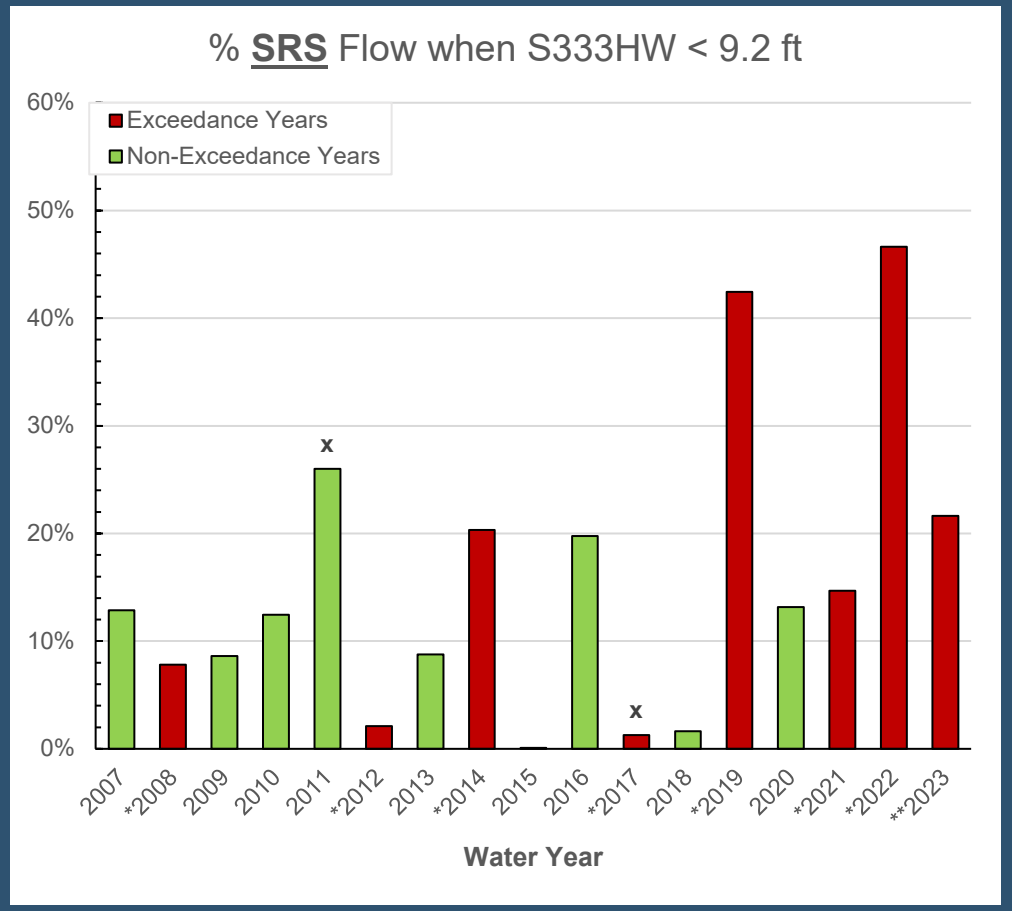
Stage	Kendall's τ	p-value	Sen's slope (µg/L/ft)
≥ 9.2 ft	-0.21	< 0.001	-1.3
< 9.2 ft	-0.36	< 0.001	-7.6

- Above 9.2 ft, TP concentration increases by 1.3 µg/L for each foot of recession.
- Below 9.2 ft, TP concentration increases by 7.6 µg/L for each foot of recession.

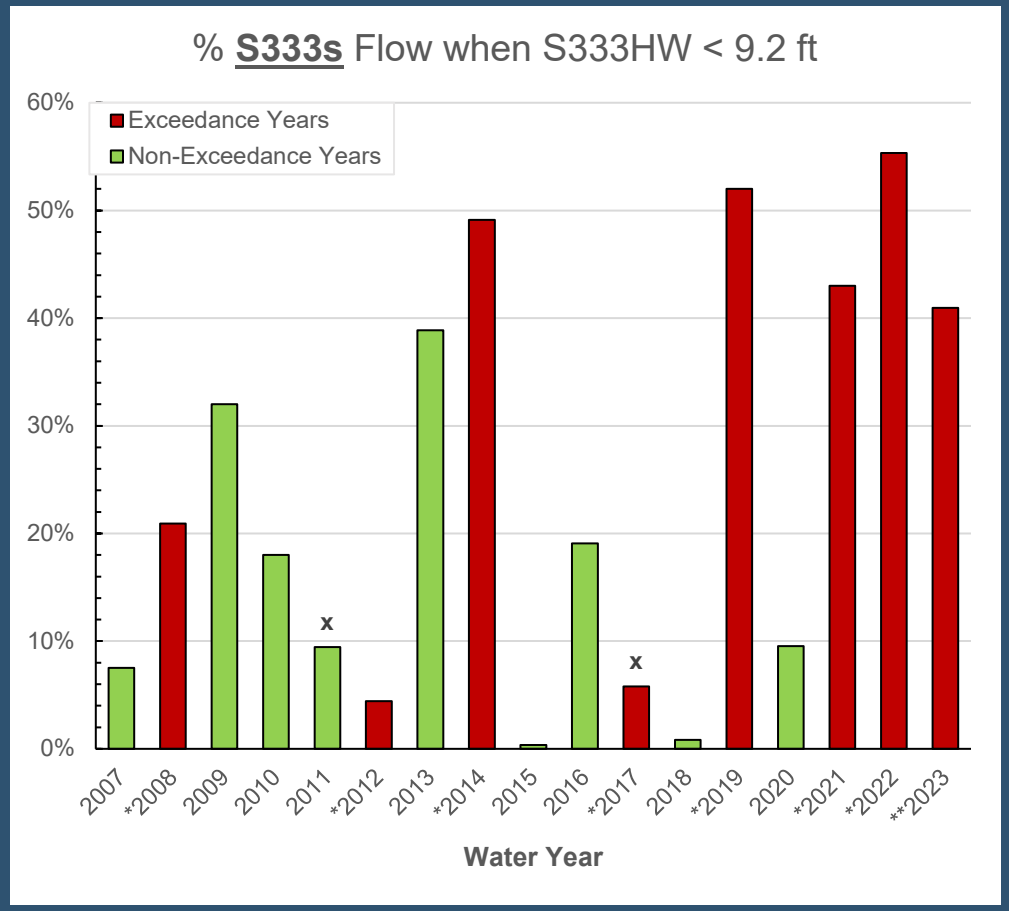
The rate of TP concentration increase compounds six-fold under 9.2 ft

Note: Weekly TP grab data taken from SFWMD SRS TP spreadsheet (Updated 9/30/2023); WY2023 data is provisional; Kendall's tau and Sen's slope calculated in R.

Exceedance Years Appear to Have Higher Proportion of Flows when S333HW < 9.2 ft.



** Exceedance year; ** Provisional data; x – Exceptional circumstances (2011 – S333 flows routed around SRS; 2017 – drought year)*



Note: S333s = S333 + S333N – S334

Conclusions

Dec. 2023 TOC

Water Quality Analysis – Conclusions

History of Recent Exceedances	• LTL has trended down, SRS FWMC has no trend • Frequency & magnitude of exceedances have increased • More water is being delivered, especially during dry conditions
Hydrodynamics of WCA-3A	• Marsh data doesn't support S190, S140, S150, & S11A-C TP loads reaching SRS outflows • Miami Canal water entering L-67A has been highly influenced by marsh interaction • S9 TP loads appear to be inversely correlated with S333 TP FWMCs – marsh interaction along L-67A influences TP concentrations
Local Drivers	• TP concentration rate of increase is six times higher when S333HW stage recedes under 9.2 ft • Higher annual proportions of low-stage SRS deliveries are strongly associated with exceedance years

Future Influences on WCA-3A Hydrodynamics

Central Everglades Planning Project (CEPP)

- **CEPP North**
  - Removal of L-4 & Miami canal sections will promote hydration in NW WCA-3A
- **CEPP South**
  - Blue Shanty Levee will be constructed in WCA-3B to create a new flow-way from the L-67A into NE SRS
  - L-67C, L-67 Ext., & L-29 will be partially or wholly backfilled to remove barriers to flow

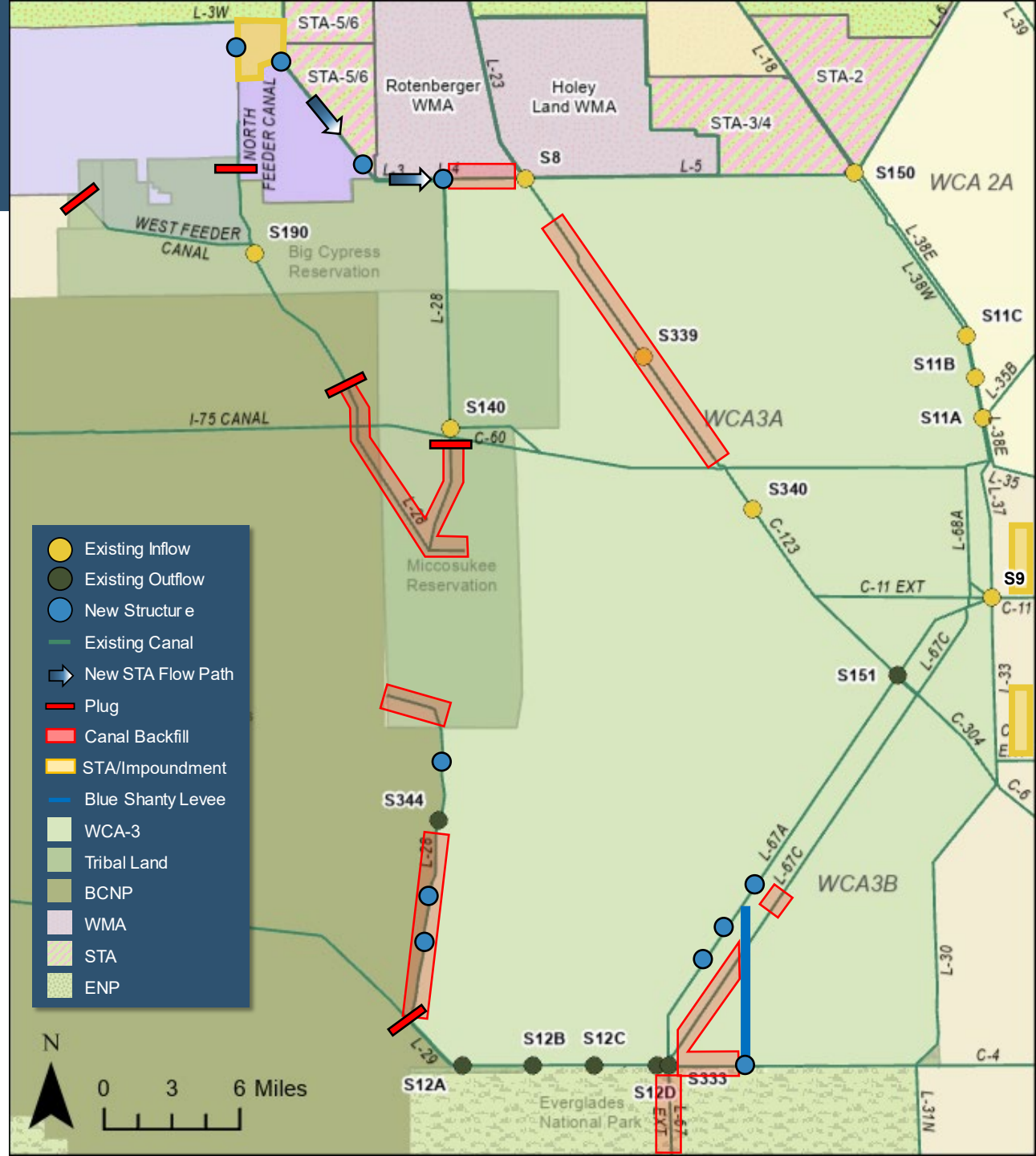
Western Everglades Planning Project (WERP)

Note: Scheduled for WRDA 2024 authorization

- **L-28 Canal Backfill/Levee Degrade**
  - Removal & plugging of L-28N, L-28 Int., L-28 Tieback, & L-28S canal sections will separate S190 from WCA-3A & restore hydrology
- **North Feeder STA**
  - New water treatment in feeder canal basin will improve Western WCA-3A inflow WQ from L-3 canal

Broward County Water Preserve Areas (BCWPA)

- Impoundments to capture untreated runoff from the C-11 and C-9 basins instead of discharging directly into WCA 3A




FLORIDA DEPARTMENT OF
ENVIRONMENTAL PROTECTION

Terminology

SRS: Shark River Slough
WCA: Water Conservation Area
LTL: Long-Term Limit for Total Phosphorus
FWMC, FWM: Flow-Weighted Mean [Concentration]
TPC, TP: Total Phosphorus [Concentration]
µg/L: Micrograms per liter – equivalent to parts per billion (ppb)
S333HW: S333 Headwater Stage Elevation
WY: Federal Water Year (Oct 1 – Sep 30)
COP: Combined Operations Plan
Low-Stage: S333HW < 9.2 ft