ANNEX F
PHOSPHORUS ASSESSMENT FOR WCA 3 AND ENP

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ANNEX F ASSESSMENT OF TOTAL PHOSPHORUS CHANGES IN WCA 3 AND ENP THAT RESULT FROM IMPLEMENTATION OF THE CEPP PACR (SFWMD 03.09.2018)

F.1 INTRODUCTION

This report presents a qualitative analysis of water quality improvements to the Water Conservation Area 3 (WCA 3) and Everglades National Park (ENP) as a result of implementing the Central Everglades Planning Project Post Authorization Change Report (CEPP PACR). This assessment focuses on construction of a 240,000 acre-foot (ac-ft) storage reservoir with Stormwater Treatment Area (STA), Alternative C240A, the Tentatively Selected Plan (TSP) (**Figure F-1**). Given the similarities between the TSP (C240A) and the other alternatives considered in this CEPP PACR the impact to water quality would be expected to be very similar. Also, since this is a qualitative analysis, the findings presented here are generally applicable to the other with-project alternatives. The CEPP will substantially alter the timing, quality, quantity, and distribution of water flows to WCAs 3A and 3B and Everglades National Park (ENP or Park). This CEPP PACR makes smaller scale changes in order to achieve the goals of the Central Everglades Restoration Project (CERP). The Future Without (FWO) project condition is CEPP. CEPP includes major features that improve flows through the WCA 3A and -3B such as an additional Flow-Equalization Basin (A-2 FEB) in the EAA, a partially backfilled Miami Canal in northern WCA 3A, degrade of the L-4 levee to distribute water in northwestern WCA 3A, and construction of structures to improve water deliveries into WCA 3A and WCA 3B including the construction of the Blue Shanty Flow-way in western WCA 3B. Additionally, the congressionally authorized CEPP features improved inflow at the northern boundary of ENP. Such features include a partial degrade of the L-29 levee allowing the Blue Shanty Flow-way to discharge into the Park, increasing S-333 and S-356 flow capacities, seepage management features, L-67 Extension Canal Backfill, and Old Tamiami Trail removal.

Figure F-1. Map of the Tentatively Selected Plan (TSP, Alternative C240A)

As required by the Everglades Forever Act (EFA), the State of Florida developed and implemented a total phosphorus (TP) water quality criterion or P Rule [Rule 62-302.540, Florida Administrative Code (F.A.C.)] for the Everglades Protection Area (EPA). The EPA includes the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge, also known as WCA 1), WCA 2, WCA 3, and ENP. One part of the four-part test for determining compliance with the P Rule, as it is applied to the WCAs, is expressed as a long-term geometric mean of 10 micrograms per liter (µg/L), or parts per billion (ppb) TP. A more complete explanation of the P Rule is provided in Section F.3.3. Compliance with the criterion for ENP is determined via the methods set forth in Appendix A of the 1991 Settlement Agreement (Case No. 88-1886-Civ-Moreno). This Annex focuses on WCA 3 and ENP, which are expected to have beneficial impacts on water quality with the project alternatives. Additionally, no analysis of water quality impacts to Taylor Slough inflows to ENP is presented as the with-project alternatives are expected to have minimal impacts to flow and water quality conditions within the C-111 basin.

F.2 EVERGLADES AGRICULTURAL AREA

Since EFA implementation, the State has established numeric criteria for TP throughout the EPA, required the implementation of agricultural Best Management Practices (BMPs) to reduce phosphorus levels in farm discharges and constructed, operated, and maintained massive manmade treatment wetlands known as the Everglades Stormwater Treatment Areas (STAs). Over the past two decades, the South Florida Water Management District (SFWMD or District) has operated STAs to substantially reduce TP concentrations in water being delivered to the WCAs. The effective treatment area of STAs has increased from approximately 4,000 acres in 1994 to 57,000 acres as of today. While the construction and operation of the STAs have substantially improved the quality of water discharged to the WCAs, both the Federal and State parties to the Settlement Agreement acknowledge that additional reductions are necessary.

In early 2010, the SFWMD, State of Florida, and United States Environmental Protection Agency (USEPA) began technical discussions to establish a Water Quality Based Effluent Limit (WQBEL) for TP discharges from the Everglades STAs that would achieve compliance with the state's numeric TP criterion in the EPA and to identify a suite of additional water quality projects to work in conjunction with existing STAs to meet the WQBEL. From these discussions, in 2012, the Florida Department of Environmental Protection (FDEP) issued a National Pollutant Discharge Elimination System (NPDES) Watershed Permit and an associated Consent Order and an EFA Watershed permit and associated Consent Order, establishing the WQBEL, the suite of water quality improvement projects to be constructed under the Restoration Strategies Program, and the compliance schedules for those projects.

These permits establish a WQBEL for TP in which STA discharges shall not exceed 13 ppb as an annual flow-weighted mean (FWM) in more than three out of five years on a rolling basis (Part 1), and shall not exceed 19 ppb as an annual FWM in any water year (Part 2). The State and USEPA agreed that achieving these limits would ensure that the STA discharges do not cause or contribute to exceedances of Florida's water quality standard for TP in the Everglades. The State and USEPA also agreed to a suite of additional projects which includes constructing 6,500 acres of STAs and 116,000 acre-feet of water storage, or Flow-Equalization Basins (FEBs). Additionally, the plan includes enhancements to existing conveyance features and STAs. **Figure F-2** shows the components of the Restoration Strategies Regional Water Quality Plan tagged with white labels; the existing STA facilities are shown in green. The Central Flow Path includes A-1 FEB, STA 3/4, and STA 2. Many of the Restoration Strategies projects are currently operational and the remaining projects are either currently in design or in construction. All project will be complete by 2025. Additional detail on the Restoration Strategies Regional Water Quality Plan is available at www.sfwmd.gov/restorationstrategies.

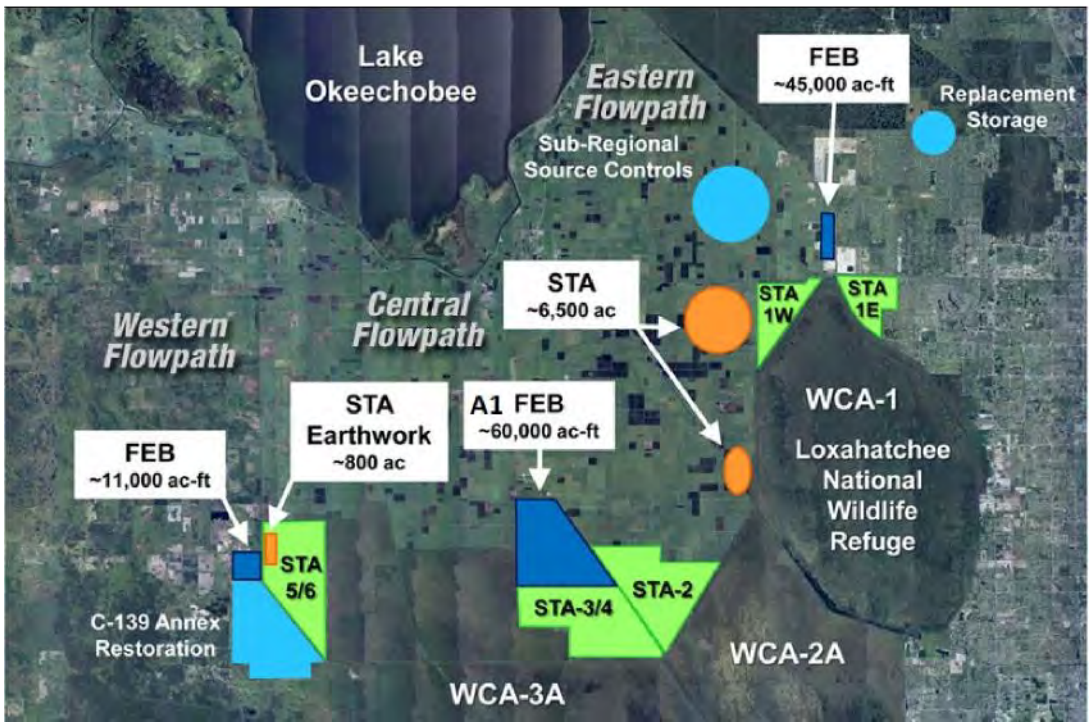


Figure F-2. Restoration Strategies (RS) Key Projects in Eastern, Central, and Western Flow Paths

In order to deliver the additional flows anticipated under the CEPP PACR, water would be delivered through the Central Flow Path down the Miami and North New River canals. These canals are the main north-south conduits connecting Lake Okeechobee and upstream basins to WCA 3A. These additional flows must be treated prior to entering WCA 3A to maintain compliance with water quality standards. Since the delivery of additional flows under the TSP proposes an additional STA along with the existing STAs and Restoration Strategies project features for water quality treatment, the TSP features that redistribute existing flows and/or deliver additional flows cannot proceed unless/until it is determined that construction and/or operation of the feature 1) will not cause or contribute to a violation of water quality standards; 2) will not cause or contribute to a violation of the permit(s) discharge limits or specific conditions; and, 3) reasonable assurances exist that demonstrate adverse impacts on flora and fauna in the area influenced by the project element will not occur. An additional 6,500 ac-ft A-2 STA, proposed as part of the TSP, would provide additional treatment to meet WQBEL compliance. Compliance with the WQBEL shall be determined based on the conditions contained within the NPDES permit (FL0778451), EFA permit (0311207), NPDES Consent Order (12-1148), and EFA Consent Order (12-1149).

The TSP proposes the A-2 FEB would be converted to an additional STA and an above-ground storage reservoir with an approximate capacity of 240,000 ac-ft to allow for additional inflows to the Central Flow Path. The TSP would also rely on several SFWMD-owned/operated facilities, such as the A-1 FEB for storage and STA 2 and STA 3/4 for treatment. The A-2 STA would be constructed to the west of the A-2 Reservoir. **Figure F-1** depicts the location of the A-2 Reservoir and A-2 STA. Flows from the A-1 FEB/A-2 Reservoir /A-2 STA can be delivered to the Miami and North New River canals and to STA 2 and STA 3/4 when capacity or operational desires exist. Additional details regarding the integrated operation of the TSP are presented in the Draft Project Operating Manual (DPOM), **Annex C** of this CEPP PACR.

DMSTA modeling predicted the TP removal performance of the integrated A-1 FEB/A-2 Reservoir, STA 2, STA 3/4, and additional A-2 STA facilities. The A-1 FEB and A-2 FEB (**Figure F-3**) were included in the FWO project conditions, and A-2 FEB will be replaced with A-2 Reservoir and an additional A-2 STA in the TSP. The DMSTA model assumed the phosphorus removal performance of the A-1 FEB was that of emergent aquatic vegetation (EAV). This assumption is based on the anticipated establishment of native marsh vegetation due to the hydrologic conditions expected at the site, coupled with proposed vegetation management activities.

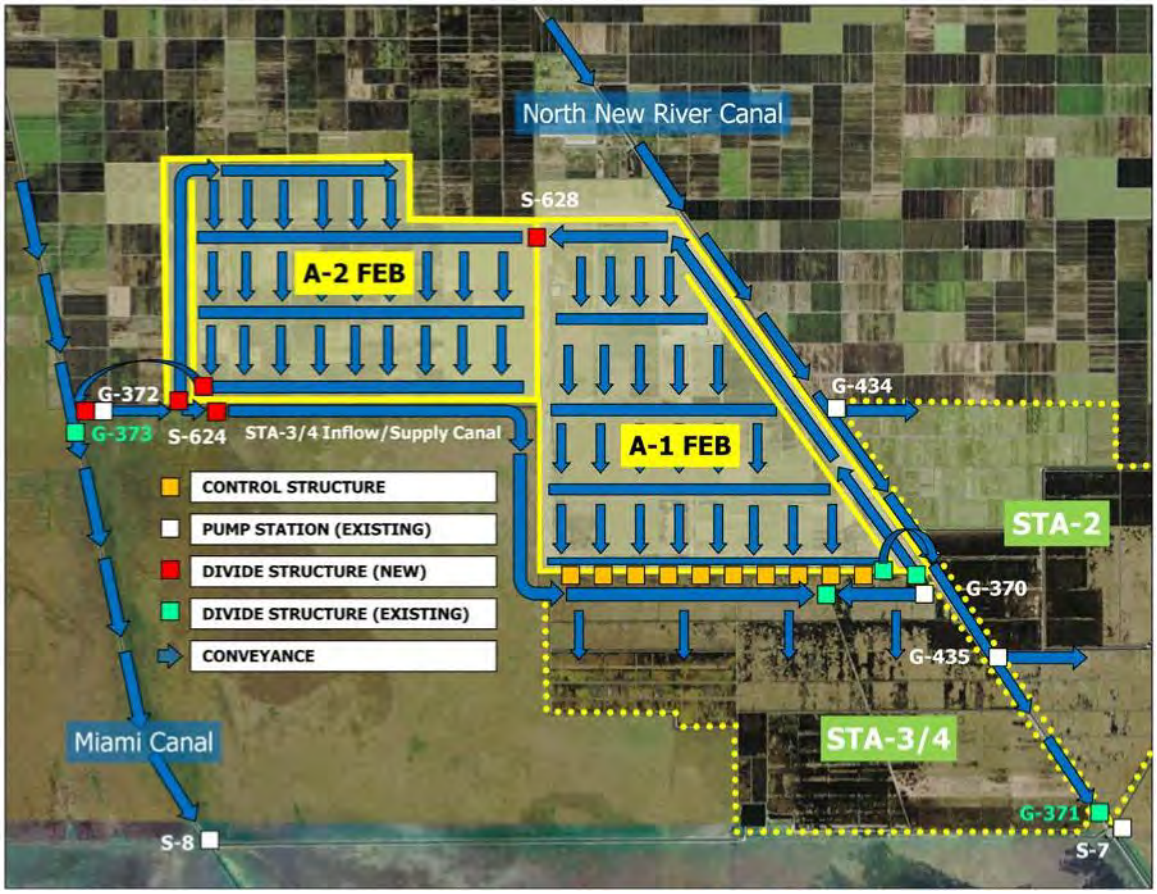


Figure F-3. Integrated A-1/A-2 FEB Component of the CEPP

The following assumptions were incorporated into the DMSTA model:

1. Lake Okeechobee TP concentrations were set to the 2000-2009 monthly average from the S-351 and S-354 structures at the Lake rather than at the lower concentrations observed at the STA 2 and STA 3/4 inflow structures.
2. The STA duty cycle factor used in DMSTA was set to 0.95, which effectively simulates each STA to be offline for 5 percent of the time.
3. The DMSTA modeling was done using the calibration dataset which does not reflect the future improvements in STA removal efficiency that are expected from Restoration Strategies operational refinements.
4. To allow for additional vegetation management flexibility within the STAs, a resting period of 45 days, scheduled every three years was incorporated into the DMSTA operational scheme for STA

3/4. STA resting periods are intended to simulate conditions during the dry season that allow vegetation rejuvenation and expansion, which will sustain vegetation health and maintain treatment performance.

5. Due to the uncertainty associated with DMSTA simulated low level TP concentrations, annual values less than 12 ppb were replaced with a value of 12 ppb.

DMSTA modeling results are provided below in **Figure F-4** and **Table F-1**. The difference in average monthly flows between the TSP and FWO project conditions is shown on **Figure F-4** and the seasonal distribution of those flows are shown in **Table F-1**. Note that the CEPP_FEB34 represents ALT4R with the integrated A-1/A-2 FEB for the FWO. **Figure F-4** shows that with the additional monthly TSP flows in the Central Flow Path, the TSP increases the percentage of annual flows occurring during the dry and wet season through the Central Flow Path, A-1 FEB/A-2 Reservoir, and is integrated with the STAs (**Table F-1**). TSP additional flows to the watershed are slightly higher during the wet season (93,000 ac-ft) as compared to the dry season (82,000 ac-ft). The addition of the upstream A-2 Reservoir and new A-2 STA provide an opportunity for improved distribution of flow and loads across restoration project features. In fact, the hydrologic regime predicted in the TSP for STA 2/B, STA 3/4 and the A-2 STA from the perspective of temporal inflow distribution and water depths is improved compared to the EARECB and EARFWO conditions. The TSP also provides additional capacity for storing and treating wet season runoff from the S8/S7 basins that would occur regardless of additional Lake Okeechobee releases. The TSP also reduces the runoff volume and load by reducing the watershed area (A-2 parcel and A-2 Expansion area).

Historical observations suggest that STA phosphorus removal efficiency may be lower during the dry season and this pattern is likely associated with multiple components of internal phosphorus cycling. Lower temperatures, fewer hours of daylight, STA dryout, reduced algal and plant growth, changes in microbial growth and decomposition, increased herbivory by avian species, and the overall decrease in biological activity that exist in the dry season may all impact an STA's ability to retain phosphorus. In addition to these contributing factors, stagnant or non-flowing conditions that can occur for several weeks during the dry season within the STAs and the resultant increase in upward flux of phosphorus are also hypothesized to affect STA outflow phosphorus concentrations. Accordingly, moderate STA inflows during the dry season may enhance an STA's ability to retain phosphorus from the sediment during the dry season. While uncertainty remains about the performance of STAs in the dry season, future implementation of storage features paired with appropriate STA resting periods and vegetation rejuvenation and management activities, should ultimately assist in reducing dryout and stagnant conditions and may result in improved dry season STA performance.

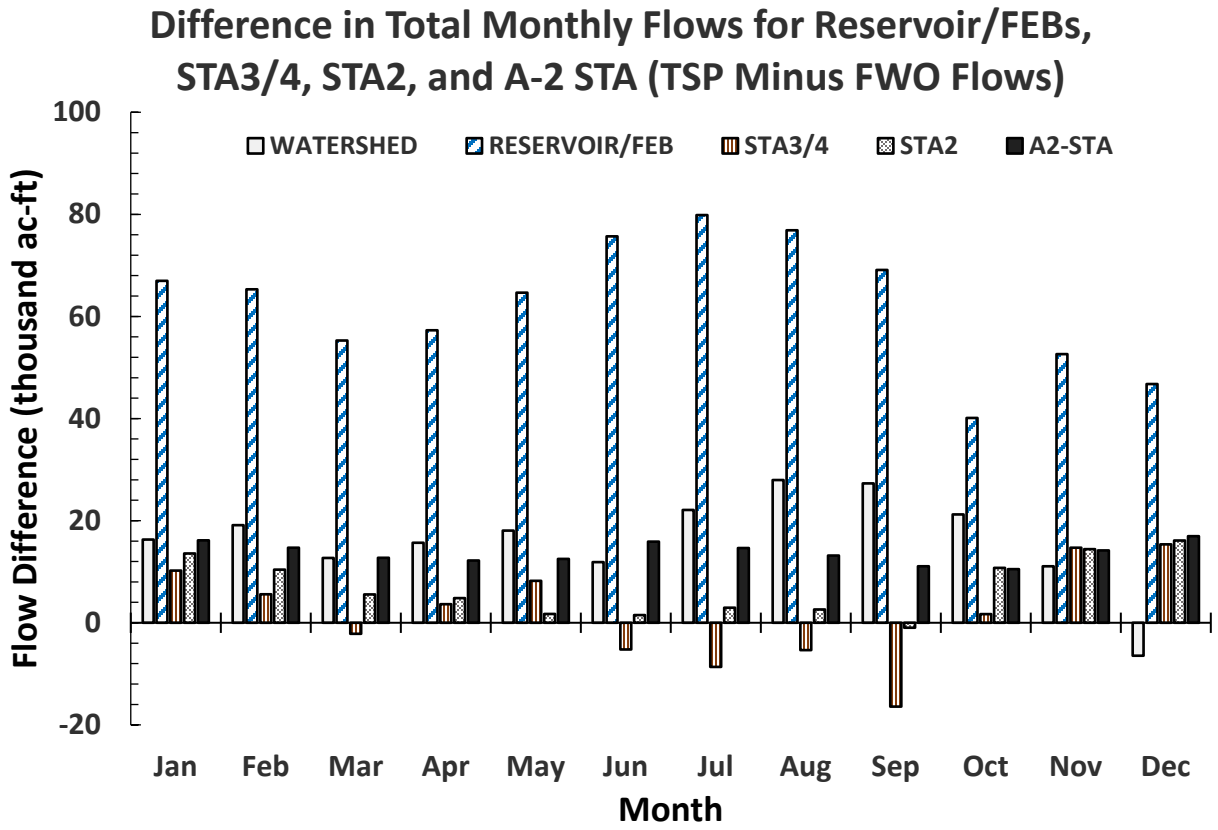


Figure F-4. Difference in Average Monthly Flows for Watershed, Reservoir/FEBs, STA 3/4, STA 2, and A-2 STA under the TSP and Future Without (FWO) Project Conditions over a 40-Year Simulation Period (1965-2005)

Table F-1. Annual and Seasonal Flows for A-2 Reservoir and FWO Project Conditions in the Central Flow Path Watershed, FWO_A-1/A-2 FEB vs. TSP_A-1 FEB/A-2 Reservoir, FWO_STA 3/4, and STA 2 vs. TSP_STA34-A-2, and STA 2

Period of Analysis	Average Annual Flow (May 1 to April 30)[1]	Dry Season Flow (Nov 1 through May 31)[1]	Wet Season Flow (June 1 through October 30)[1]	Dry Season Percent of Annual Flow	Wet Season Percent of Annual Flow
FWO_Watershed	1,058	505	553	48%	52%
TSP_Watershed	1,233	587	646	48%	52%
Watershed Difference	175	82	93	0%	0%
FWO_FEB A-1/A-2_FEB	641	355	285	55%	44%
TSP_A-1 FEB/A-2 Reservoir	1,378	761	617	55%	45%
Reservoir-FEB Difference	737	406	332	0%	0%
FWO_STA3/4	637	310	328	49%	51%
TSP_STA3/4-A-2	644	361	284	56%	44%
STA3/4 Difference	7	51	-44	7%	-7%
FWO_STA-2	415	163	252	39%	61%
TSP_STA-2	486	226	259	47%	53%
STA 2 Difference)	71	63	7	7%	-7%

Note: TSP_STA3/4-A-2 is the integrated STA3/4 and A-2 STA.
[1] Values in thousand acre-feet

Table F-2 shows the estimated performance of the A-1 FEB/A-2 Reservoir, STA 2, and STA 3/4/A-2 STA for the TSP and FWO based upon DMSTA modeling. The implementation of the TSP would maintain the predicted period of record FWM TP concentrations from STA 2 and STA 3/4/A-2 STA when compared to the FWO condition and also meet WQBEL planning level targets. **Table F-2** also shows that the TSP would increase the A-1 FEB/A-2 Reservoir annual inflow volumes and TP loads as compared to FWO in part by slightly increasing the flows that are sent directly to STA 3/4 and STA 2. There are significant increases in load removal in STA 3/4/A-2 STA. The TSP would also reduce the net annual diversion volumes and TP loads around STA 2 and STA 3/4 combined. The TSP would increase the unit area TP loading to the A-1 FEB/A-2 Reservoir by 147 percent, while increasing the unit area TP loading to STA 2 by 2 percent, and STA 3/4-A-2 by 42 percent over the FWO condition. Increased hydraulic and TP loading to the A-1 FEB/A-2 Reservoir, STA 2, and STA 3/4/A-2 STA is expected to increase the frequency in which these facilities will require maintenance to structures and the removal of accumulated sediments to maintain hydraulic capacity.

Table F-2. DMSTA Predicted Hydrologic and Water Quality Performance under FWO and TSP Conditions in the Central Flow Path

Performance Measures	Facilities	FWO (CEPP ALT4R2)	TSP A-1 FEB/A-2/ A-2 STA	Difference (TSP-FWO)	Percent Change
FWM Outflow TP Concentration (ppb) -Facility Outflow Only (No Diversions)	FEB/Reservoir	31.8	42.3	10.4	33%
	STA 2**	11.5	12.1	0.6	6%
	STA3/4 - A-2 STA**	10.9	11.5	0.6	5%
Average Annual Inflow Volumes (kac-ft/yr)	FEB/Reservoir	641	1378	737	115%
	STA 2	414	486	72	17%
	STA3/4 – A-2 STA	637	644	7	1%
	STA2 - STA3/4 – A-2 STA	1,051	1130	79	8%
Average Annual TP Load Reduction (mt/yr)	FEB/Reservoir	66.7	43.6	-23.1	-35%
	STA 2	48.7	48.6	-0.1	0%
	STA3/4 – A-2 STA	24.4	56.2	31.8	130%
	FEB+STAs	139.8	148.4	8.6	6%
Average Annual Untreated Diversion Volumes (kac-ft/yr)	STA 2	4.9	2.4	-2.5	-51%
	STA3/4 – A-2 STA	0.8	2.0	1.2	152%
Average Annual Untreated Diversion TP Load (mt/yr)	STA 2	0.7	0.3	-0.4	-51%
	STA3/4 – A-2 STA	0.1	0.2	0.1	126%
Unit Area TP Removal ($mg/m^2/yr$)	FEB/Reservoir	613.0	439.3	-174	-28%
	STA 2	871.0	774.2	-97	-11%
	STA3/4 – A-2 STA	393.0	608.7	216	55%
Unit Area TP Loading ($mg/m^2/yr$)	FEB/Reservoir	819.0	2,027	1,208	147%
	STA 2	871.0	890.4	19	2%
	STA3/4 – A-2 STA	497.0	705.6	209	42%

Note: All calculations followed the same procedure as used in the CEPP PIR (USACE 2014).
FWO_FEB34 is the integrated A-1/A-2 FEB.
kac-ft/yr – thousand acre-feet per year; FEB –Flow Equalization Basin; FWM – flow-weighted mean; mg/m^2 – milligrams per cubic meter; mt – metric tons; ppb – parts per billion; STA – Stormwater Treatment Area; TP – total phosphorus.
** Annual FWM TP concentrations for STA 2 and STA 3/4 were adjusted using minimum annual concentration of 12 ppb to maintain consistency with the CEPP PIR calculations.

F.3 WATER CONSERVATION AREA 3A (WCA 3A)

WCA 3A receives the majority of its surface water inflow from STA 3/4 and WCA 2. The CEPP authorized plan, FWO, diverted flows that had been historically routed to WCA 2 into WCA 3A. The FWO includes the removal of 2.9 miles of the L-4 levee to create an east-west distribution spreader for inflows along the northwestern boundary of WCA 3. This modification, together with the partial backfill of the Miami Canal from 1.5 miles south of the northern border of WCA 3A to Interstate 75 (I-75), will help introduce sheet flow into the northern WCA 3A marsh. At the southern end of WCA 3A/3B, the Blue Shanty Flow-way will be constructed to divert flows from the L-67A canal into the marsh before it flows across Tamiami Trail

into ENP. The TSP for this CEPP PACR includes all the elements of the FWO and provides additional flow to WCA 3A.

F.3.1 Flows and Loads into WCA 3A

The impact of the TSP on WCA 3A is described below in terms of additional flows and associated concentrations, changes to hydropattern, and TP concentrations within the marsh. **Table F-3** compares the flows and TP loads expected in the Existing Conditions Baseline (ECB), FWO, and TSP scenarios at the northern boundary of WCA 3A. These load estimates were developed using historic TP concentrations for ECB and DMSTA predicted TP concentrations for FWO (Alt4R) and TSP at WCA 3A inflow locations and hydrologic flow predictions from the RSMBN and RSMGL regional simulation models. The hydrologic predictions show that FWO flows will be slightly (11%) increased relative to ECB while the TSP flows would be greater than both the ECB (43%) and FWO (29%) condition. The TP concentration of the TSP would be the same as FWO and decreased by 5 percent compared with ECB. The FWM TP concentrations shown in **Table F-3** for the FWO and TSP are higher than the WQBEL of 13 ppb because 1) they were computed using flows and loads from all of the WCA 3A inflows, not just the northern WCA 3A inflows, 2) the lack of historic data prior to 1990 required the use of an average FWM TP concentration applied to the 41-year-long simulated flows at several of the structures (S9x, S190, S140 and S11x), and 3) future conditions will likely have lower concentrations at S9x, S190, and S140 than the historical data used here. Even with the likely over-estimated loads, the inflow concentrations into WCA 3A are expected to decrease by 5 percent relative to existing conditions for both the FWO and TSP condition.

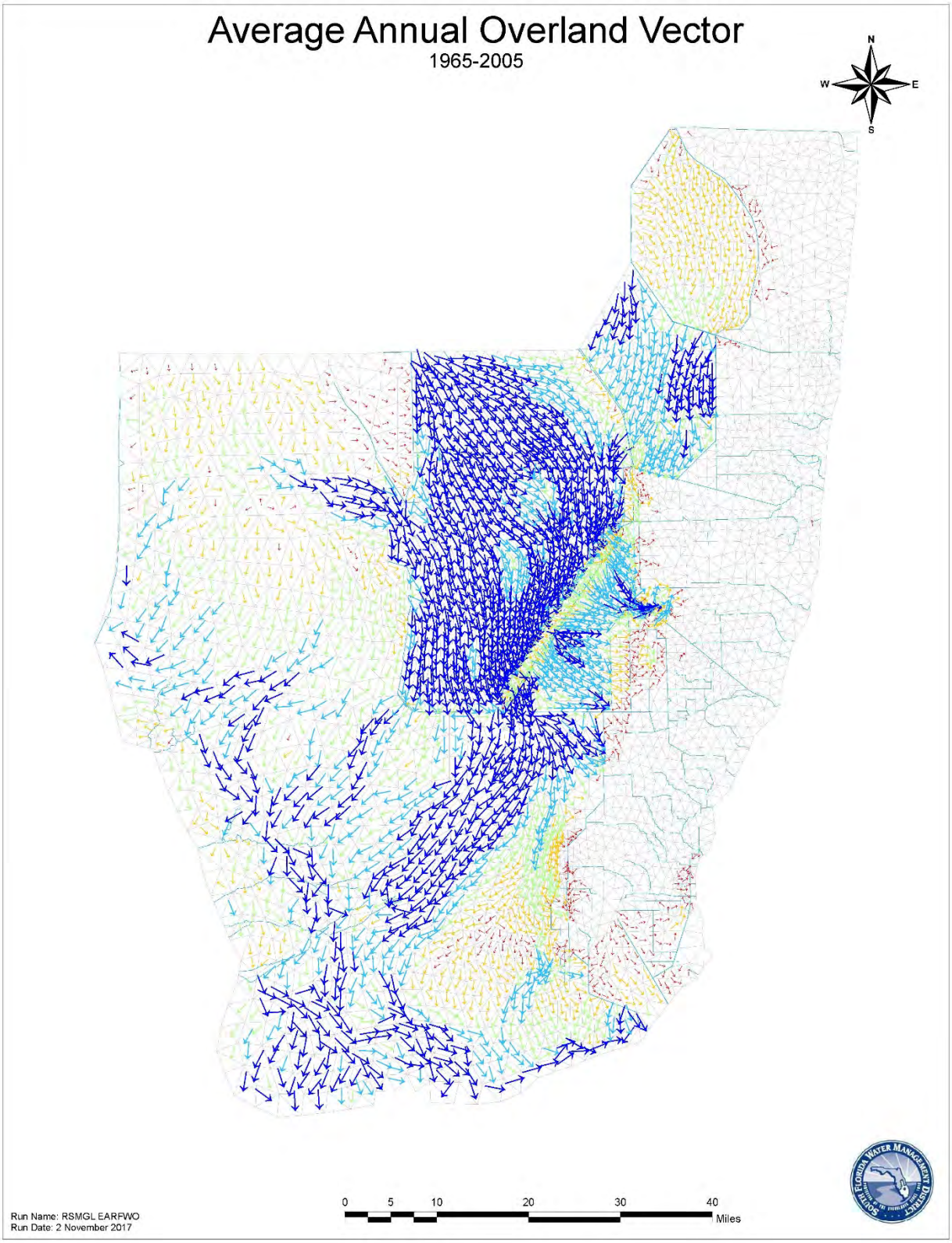
Table F-3. WCA 3A inflows and loads for ECB, FWO, and TSP

WCA 3A Average Annual Flow (thousand ac-ft/yr)			
	ECB	**FWO**	**TSP**
WCA 3A Inflows	1,470	1,637	2,105
Change from FWO	-10%	n/a	29%
Change from ECB	n/a	**11%**	**43%**
TP Load Discharged into Northern WCA 3A			
Total Load (mt/yr)	36	38	49
Change from FWO	-5%	n/a	30%
Change from ECB	n/a	**5%**	**36%**
TP Concentrations Discharged into Northern WCA 3A			
FWM TP Concentration (ppb)	20	19	19
Change from FWO	5%	n/a	0 %
Change from ECB	n/a	**-5%**	**-5%**

Notes:
1. Flow volumes are from Regional Simulation Model - Glades *LECSA* (*RSMGL*) model for 41 year simulation period.
2. ECB Average flow-weighted mean TP concentrations applied using available period of record grab sample data (Northern 3A 2006-2018), S11x (2006-2017), S9x (2003-2017), S140 (2008-2018), S190 (2008-2017) multiplied by daily simulated flows.
3. FWO, TSP (C240A) TP loads for Northern WCA 3A inflows calculated using DMSTA predictions adjusted to 12 ppb minimum annual outflow concentration. Estimated loads for the remaining structures were computed using historic period of record FWM TP concentrations applied to the 41-year simulated hydrology.
4. Loads based on flow-weighted mean calculations.

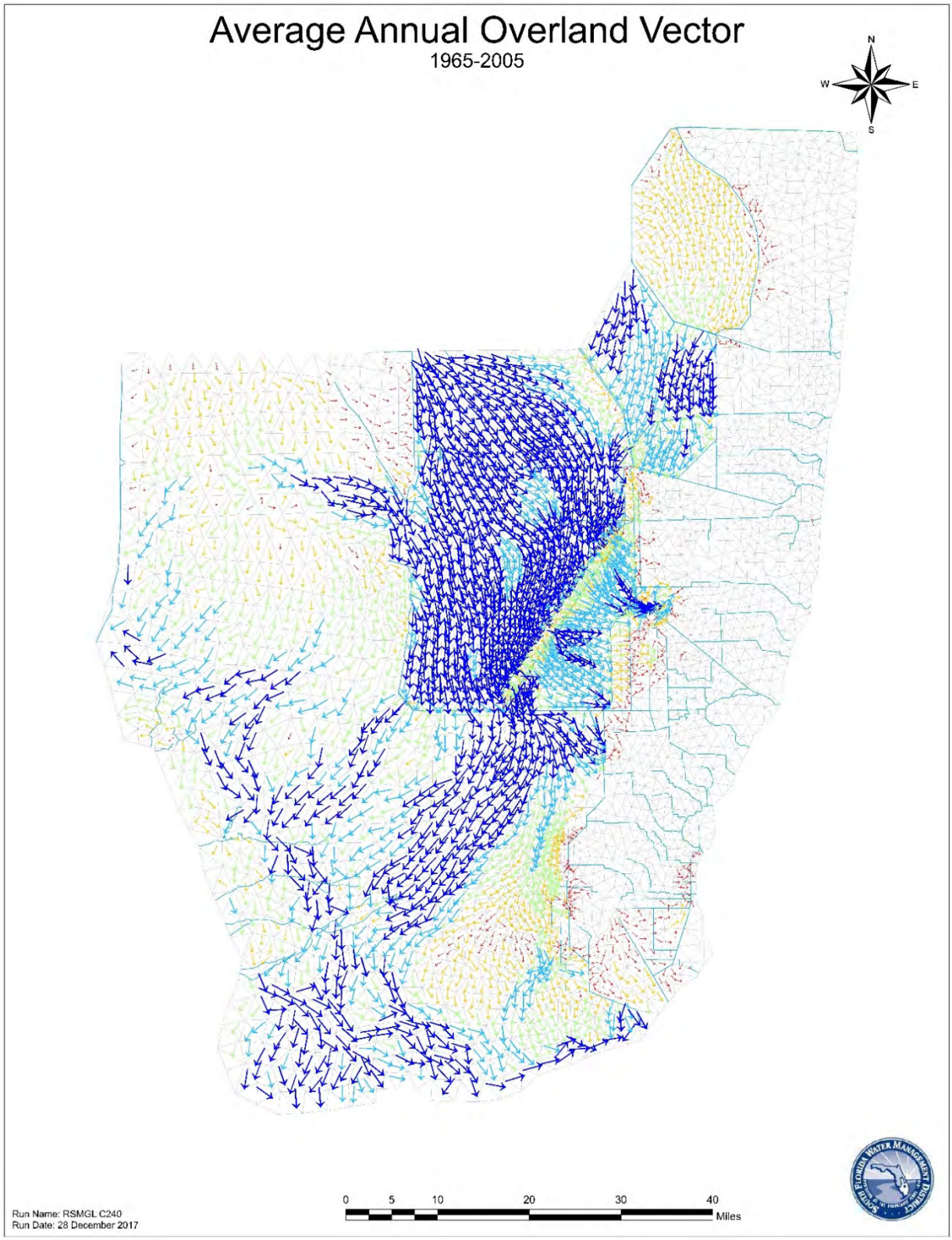
F.3.2 Hydrologic Flow Patterns in WCA 3A

The TSP would improve the sheetflow distribution and hydroperiod as compared to the FWO conditions as shown in **Figure F-5** and **Figure F-6**, respectively. The flow and hydroperiod patterns for FWO are similar to the TSP except in the northeastern corner of WCA 3A where more sheetflow would be expected. Increased sheetflow coupled with a longer hydroperiod would likely decrease soil oxidation and flux of TP over time within the northern WCA 3A marsh and decrease TP transport to the southern WCA 3A and ENP. Once the marsh and impacted areas have had time to stabilize from both past hydroperiod alterations and project construction, the risk of downstream TP spikes caused by dry out and rewetting should be reduced.



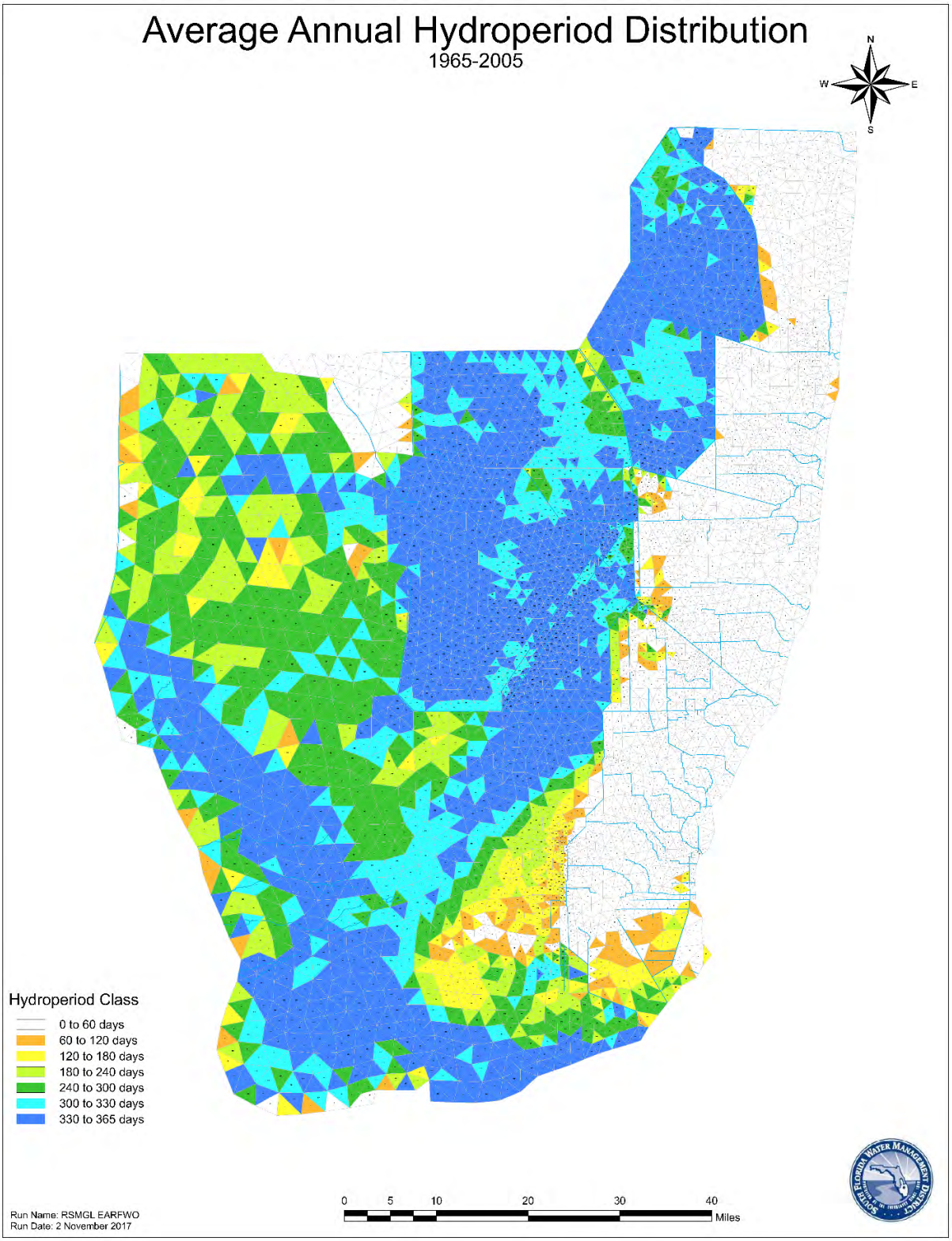
(Source *Regional Simulation Model Glades-LECSA* (*RSMGL*) EAA Reservoir Model Output, Dec. 2017, SFWMD)

Figure F-5a. Average Flow Pattern Conditions for FWO in WCA 3



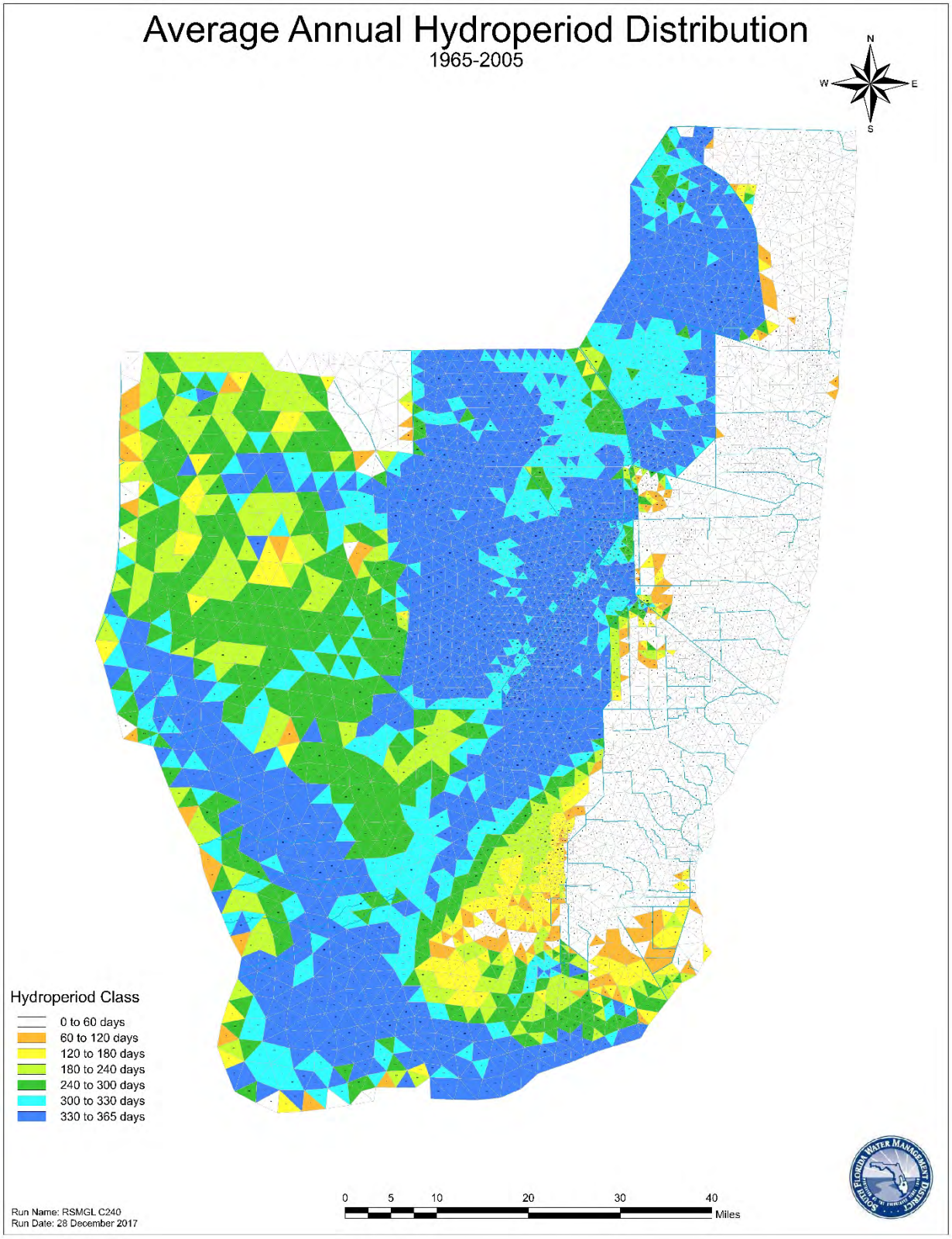
(Source: *Regional Simulation Model Glades-LECSA* (*RSMGL*) EAA Reservoir Model Output, Dec. 2017, SFWMD)

Figure F-5b. Average Flow Pattern Conditions for TSP in WCA 3



(Source: *RSMGL EAA Reservoir Model Output,* Dec. 2017, SFMWD)

Figure F-6a. Average Hydroperiod Conditions for FWO in WCA 3



(Source: *RSMGL EAA Reservoir Model Output*, Dec. 2017, SFMWD)

Figure F-6b. Average Hydroperiod Conditions for TSP in WCA 3

F.3.3 Marsh TP Concentrations in WCA 3A

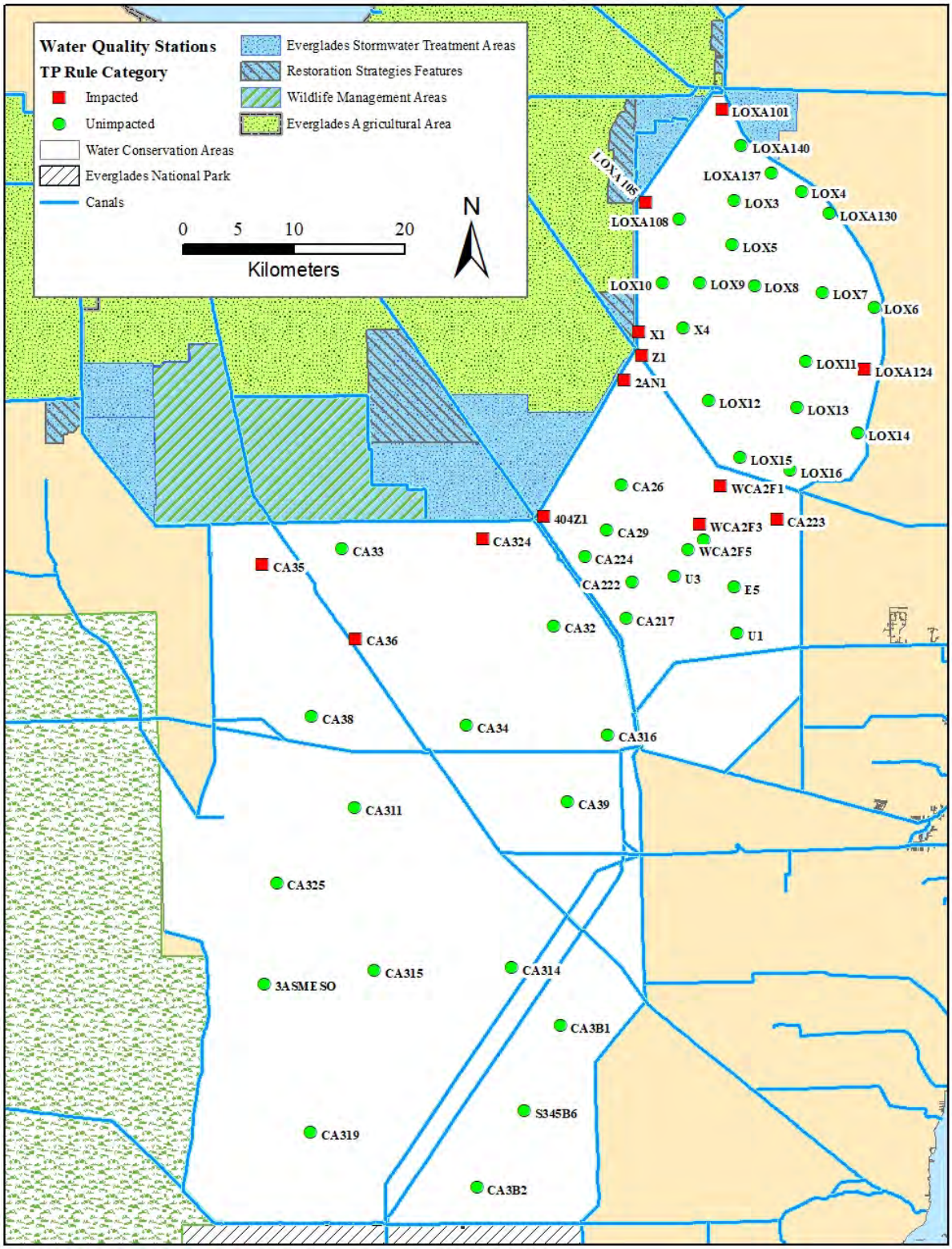
The state's Phosphorus Rule (Rule 62-302.540, F.A.C) requires the SFWMD to maintain a network of marsh monitoring stations to track changes in soil and water column TP concentrations within the EPA (WCAs and ENP). **Figure F-7** shows the network of monitoring stations within the WCAs. In WCA 3A, five marsh stations were originally identified as impacted based upon elevated soil phosphorus and water column TP concentrations; of these, three of the marsh stations (CA324, CA35, and CA36) remain impacted.

Achievement of the criterion for the ambient monitoring network is evaluated and determined annually for each WCA based on data collected monthly from a network of ambient monitoring stations in both impacted and unimpacted areas (reported each year in the annual South Florida Environmental Report). To achieve the criterion, the following four provisions must be met:

1. The five-year geometric mean averaged across all stations is less than or equal to 10 µg/L.
2. The annual geometric mean averaged across all stations is less than or equal to 10 µg/L for three of five water years.
3. The annual geometric mean averaged across all stations is less than or equal to 11 µg/L; and
4. The annual geometric mean at all individual stations is less than or equal to 15 µg/L.

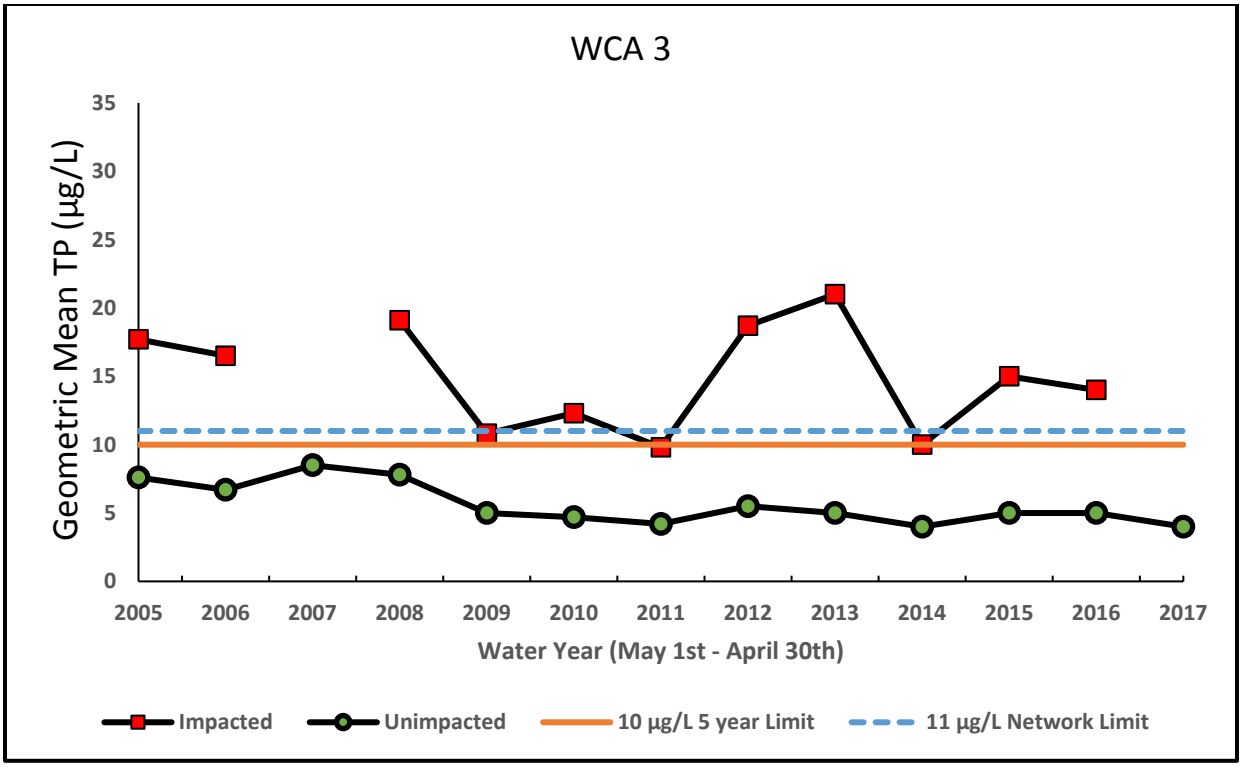
This section presents the compliance calculation period from Water Years 2013–2017 (WY2013–WY2017) (May 1, 2012–April 30, 2017) for WCA 3 only. While the geometric mean TP fluctuated for the impacted network, the unimpacted network had a slight decreasing trend in the average geometric mean TP concentrations from WY2005 to 2017 (**Figure F-8**), the unimpacted portion of the marsh did not exceed the limits of 10 µg/L (long-term, five-year limit) and 11 µg/L (network limit). Furthermore, all stations within the WCA 3 unimpacted network did not exceed the 15 µg/L annual limit, and only one station (CA36) within the impacted network exceeded the 15 µg/L annual limit (**Figure F-9** and **Table F-4**). The highest TP concentration was observed at an impacted network station, CA36, which is located in northern WCA 3A near the Miami Canal and the S-339 divide structure. The S-339 structure is usually closed, forcing S-8 discharge water into the marsh at this location. The highest geometric mean TP concentration within the unimpacted network was experienced at station CA33 (10 µg/L). During WY2017, all three impacted stations were below the 15 µg/L annual limit.

The results of the WY2013–WY2017 TP criterion assessment (**Table F-4**) indicate that, even with the data limitations, the unimpacted portions of the WCAs passed all four parts of the compliance test (as expected) and are therefore in compliance with the 10 µg/L TP criterion. Occasionally, individual sites within the unimpacted portions of the WCAs exhibited an annual site geometric mean TP concentration above 10 µg/L, as expected, but in no case did the values for the individual unimpacted sites result in an exceedance of the annual or long-term network limits.



Note: All sites were used in the Water Years 2013–2017 (WY2008–WY2017; May 1, 2007–April 30, 2017) evaluation.

Figure F-7. Total Phosphorus (TP) Criterion Assessment Network Stations within the Everglades Protection Area (EPA)



Note: Adapted from Julian 2018.

Figure F-8. Network (Impacted and Unimpacted) Trends for WCA 3 from WY2005–WY2017 relative to the TP 10 µg/L Long-Term (five-year) and 11 µg/L Network Limits

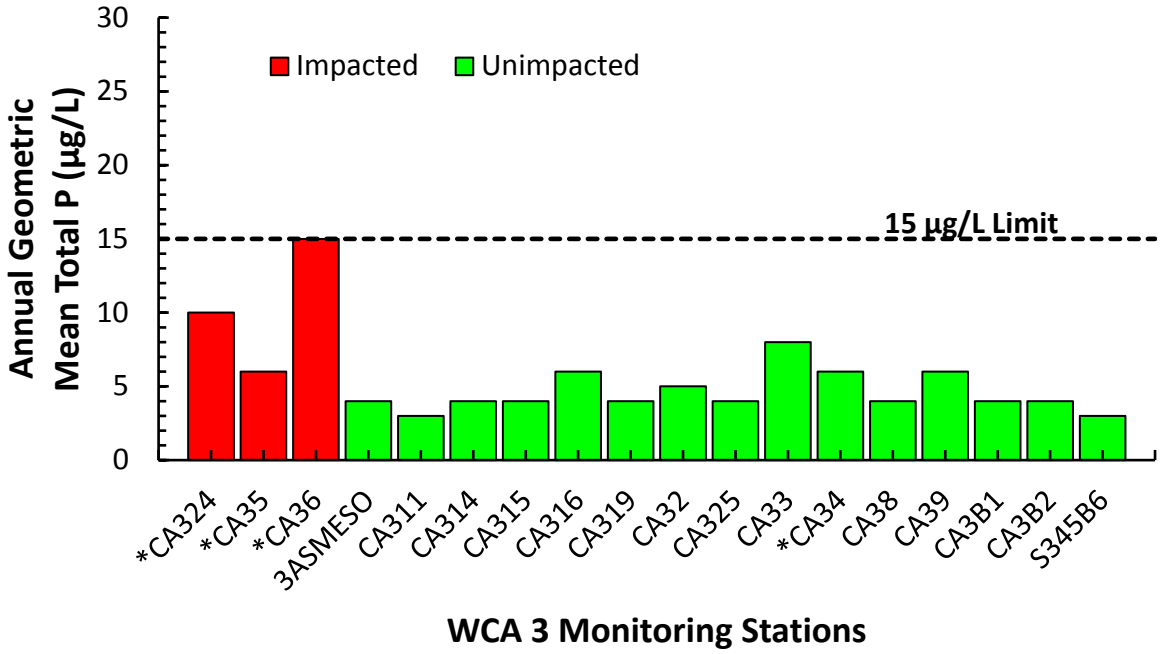


Figure F-9. Annual geometric mean total P concentrations during WY2017 (May-April) at WCA 3 stations relative to the 15 µg/L annual limit. Stations not meeting the minimum requirements for compliance assessment are identified with an asterisk (*) (Adapted from Julian et al. 2018)

Table F-4. Annual TP Criteria Compliance Assessment in WCA 3 for the Five-Year Period from WY2013–WY20017 (Adapted from Julian et al. 2018)

Network	WY	Station	Sample Size (N)	Annual Site Geometric Mean (µg/L)	≤15 µg/L Pass / Fail	Network Annual Average Geometric Mean (µg/L)	≤11 µg/L Pass/Fail	Network Five-Year Average Geometric Mean (µg/L)	≤10 µg/L Pass / Fail	3 of 5 Year Network Average ≤10 µg/L
Impacted	2013	CA324	6	10	Pass	21	Fail	15	Fail	N/A
		CA35	2	N/A (6)	N/A					
		CA36	8	32	Fail					
	2014	CA324	5	N/A(8)	N/A	10	*Pass*			
		CA35	6	6	Pass					
		CA36	7	13	Pass					
	2015	CA324	4	N/A(14)	N/A	15	Fail			
		CA35	8	6	Pass					
		CA36	7	23	Fail					
	2016	CA36	7	24	Fail	14	Fail			
		CA324	7	13	Pass					
		CA35	7	7	Pass					
	2017	CA324	6	N/A(10)	N/A	NA	NA			
		CA35	4	N/A (6)	N/A					
		CA36	5	N/A (15)	N/A					
Unimpacted	2013	CA311	12	4	Pass	5	*Pass*	5	*Pass*	*Pass*
		CA3B2	11	6	Pass					
		CA316	12	6	Pass					
		CA39	12	5	Pass					
		CA33	8	9	Pass					
		CA314	12	4	Pass					
		S345B6	12	5	Pass					
		CA319	12	5	Pass					
		3ASMESO	12	4	Pass					
		CA34	10	7	Pass					
		CA315	12	4	Pass					
		CA38	10	4	Pass					
		CA32	9	5	Pass					
		CA325	9	5	Pass					
		CA3B1	12	3	Pass					

Table F-4. Annual TP Criteria Compliance Assessment in WCA 3 for the Five-Year Period from WY2013–WY20017 (continued)

Network	WY	Station	Sample Size (N)	Annual Site Geometric Mean (µg/L)	≤15 µg/L Pass/Fail	Network Annual Average Geometric Mean (µg/L)	≤11 µg/L Pass/ Fail	Network Five-Year Average Geometric Mean (µg/L)	≤10 µg/L Pass/Fail	3 of 5 Year Network Average ≤10 µg/L
Unimpacted	2014	CA32	8	5	Pass	4	*Pass*	5	*Pass*	*Pass*
		CA316	12	6	Pass					
		CA39	10	5	Pass					
		CA311	12	4	Pass					
		CA3B2	11	3	Pass					
		S345B6	11	3	Pass					
		CA319	11	4	Pass					
		3ASMESO	11	3	Pass					
		CA314	11	3	Pass					
		CA315	12	3	Pass					
		CA38	10	4	Pass					
		CA33	7	7	Pass					
		CA325	8	3	Pass					
		CA3B1	11	2	Pass					
	2015	CA34	7	6	Pass	5	*Pass*			
		CA38	9	4	Pass					
		CA316	9	6	Pass					
		CA32	6	7	Pass					
		CA3B2	10	4	Pass					
		S345B6	11	4	Pass					
		CA319	10	4	Pass					
		CA311	7	4	Pass					
		CA314	12	4	Pass					
		CA315	11	4	Pass					
		CA3B1	9	4	Pass					
		CA39	10	5	Pass					
		CA33	7	10	Pass					
		CA325	8	4	Pass					
		3ASMESO	10	4	Pass					
		CA34	8	5	Pass					

Table F-4. Annual TP Criteria Compliance Assessment in WCA 3 for the Five-Year Period from WY2013–WY20017 (continued)

Network	WY	Station	Sample Size (N)	Annual Site Geometric Mean (µg/L)	≤15 µg/L Pass/Fail	Network Annual Average Geometric Mean (µg/L)	≤11 µg/L Pass/ Fail	Network Five-Year Average Geometric Mean (µg/L)	≤10 µg/L Pass / Fail	3 of 5 Year Network Average ≤10 µg/L
Unimpacted	2016	CA315	11	4	Pass	5	Pass	5	*Pass*	*Pass*
		CA38	8	4	Pass					
		CA3B2	9	5	Pass					
		S345B6	10	4	Pass					
		CA32	7	6	Pass					
		CA311	10	4	Pass					
		CA314	12	5	Pass					
		CA3B1	9	5	Pass					
		CA316	8	7	Pass					
		CA39	9	7	Pass					
		CA33	8	9	Pass					
		CA325	9	5	Pass					
		CA319	11	5	Pass					
		3ASMESO	12	5	Pass					
		CA34	8	7	Pass					
	2017	CA315	9	4	Pass	4	*Pass*			
		CA314	12	4	Pass					
		CA38	6	4	Pass					
		CA32	8	5	Pass					
		CA311	8	3	Pass					
		CA34	5	N/A (6)	N/A					
		CA3B1	11	4	Pass					
		CA316	10	6	Pass					
		CA39	12	6	Pass					
		CA33	6	8	Pass					
		CA3B2	11	4	Pass					
		S345B6	11	3	Pass					
		CA319	11	4	Pass					
		3ASMESO	11	4	Pass					
		CA325	7	4	Pass					

Note;

N/A Not applicable because the minimum number of samples for compliance assessment were not met, number of samples ≥6 with at least on sample during the dry season.

(Value) Represents the annual geometric mean calculated for stations denoted with an N/A.

A trend analysis was performed using annual compliance TP data for TP Rule monitoring stations in WCA 3 for the period from Florida Water Years 2005 through 2017. The results of this trend analysis are presented in **Table F-5** and **Figure F-10**. The annual compliance TP data were taken from published South Florida Environmental Reports (SFWMD 2010 through 2018). The Kendall's tau-b (τ_b) test was used to assess trends of these annual data sets for each monitoring station. Unlike parametric tests, like a linear regression, the Kendall's τ_b, which is a non-parametric test, makes no assumption regarding the distribution of the residuals. Given the sparse quantity of data for each monitoring station ($n \leq 8$), it is highly improbable that the residuals from these data follow a normal distribution. Additionally, Kendall's τ_b provides a more robust probability value for small data sets ($3 < n \leq 8$). The numeric results from the trend analysis are presented in **Table F-5** for these marsh monitoring stations in WCA 3. A graphic presentation of trend assessments for the TP compliance network in WCA 3, including impacted and unimpacted marsh stations, is presented in **Figure F-10**. Due to data density and screening protocol requirements for the TP Rule, some water years were removed from the trend analyses. Because of these constrains, one marsh station (CA324) had insufficient data to assess a trend.

Of the 17 monitoring stations analyzed that could be assessed (**Figure F-10**), 13 stations exhibited a decreasing trend based on Kendall's τ_b (**Table F-5**) with 7 of these stations exhibiting a statistically significant decrease in annual TP concentrations. Two marsh station (3ASMESO and CA39) exhibited slight increasing trends (Kendall's τ_b = 0.02 and 0.16, respectively; **Table F-5**) over the period of interest. These trends were found to be highly insignificant (p-value = 1.00 and 0.60, respectively; **Table F-5**). Future changes in historical TP concentrations would likely be more noticeable for marsh stations located adjacent to the major project features such as the Miami Canal backfill, the L-4 levee degrade/spreader, WCA 3B inflows and the Blue Shanty Flow-way. A review of the long-term phosphorus data presented in the 2018 South Florida Environmental Report (SFWMD 2018) suggests the likelihood of more marsh stations and some of the inflow/outflow structures exhibiting significant decreasing trends if a Kendall's τb trend analysis were to be performed using monthly TP data over a period longer than the Florida Water Year 2005 to 2017 period presented herein.

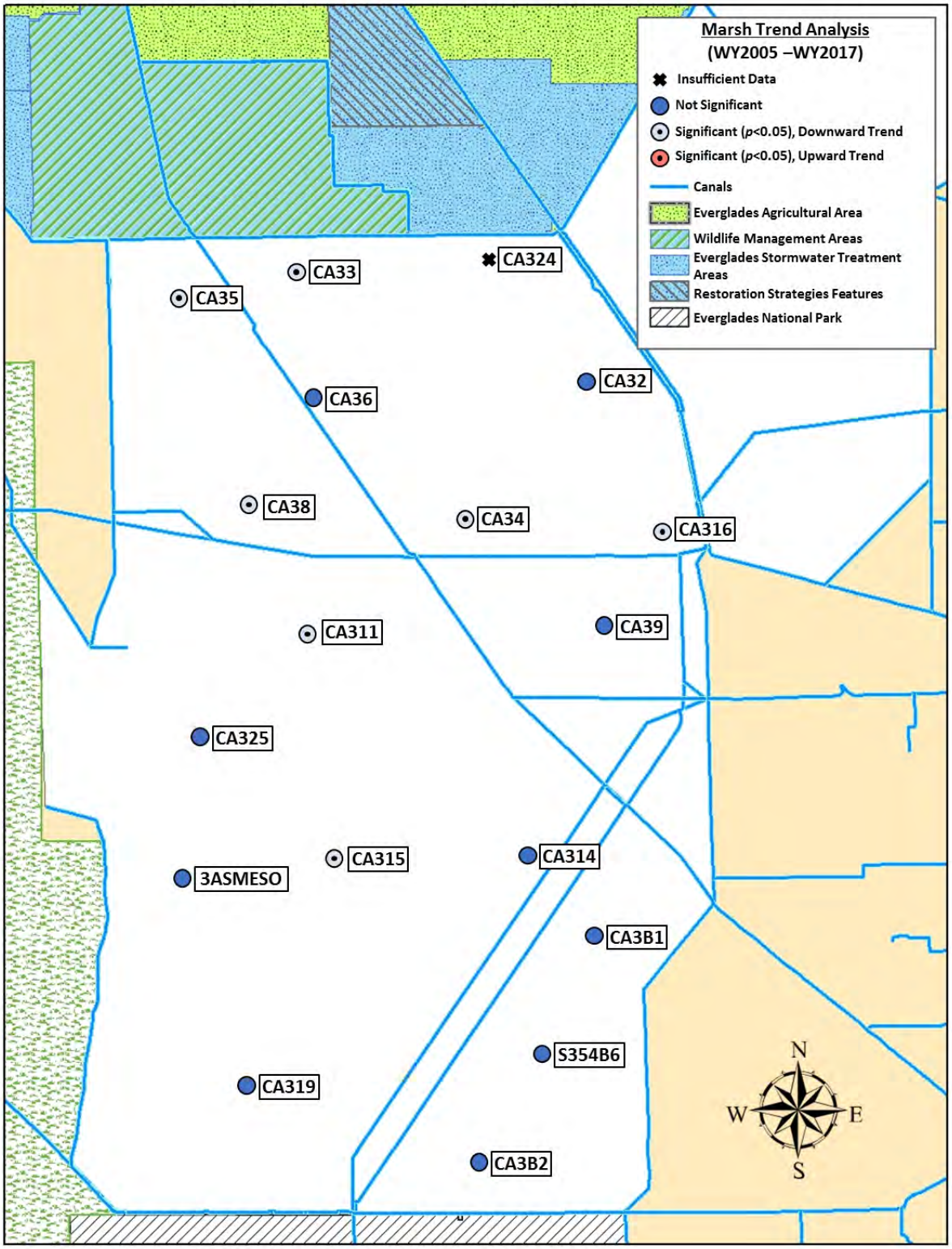


Figure F-10. Trend Analysis Determined Using Annual Compliance Geometric Mean TP Concentrations for Impacted and Unimpacted Marsh Stations in WCA 3 for the Period from Florida Water Year 2005 through 2017

Table F-5. Trend Analysis of Annual Compliance Geometric Mean TP Concentrations for Impacted and Unimpacted Marsh Stations in WCA 3 for the Period from Florida Water Year 2005 through 2017

Network	Station	No. of Water Years	Kendall's τ_b	Sen's Slope Estimate	p value	Trend Status
Impacted	CA324	Insufficient data to perform analysis (n = 3)				
	CA35	***7***	***-0.71***	***-0.3***	***<0.05***	***Significant Decline***
	CA36	*11*	*-0.20*	*-0.7*	*0.45*	*No significant trend*
Unimpacted	3ASMESO	10	0.02	0.0	1.00	No significant trend
	CA311	***13***	***-0.62***	***-0.2***	***<0.05***	***Significant Decline***
	CA314	*10*	*-0.29*	*-0.1*	*0.29*	*No significant trend*
	CA315	***13***	***-0.67***	***-0.4***	***<0.05***	***Significant Decline***
	CA316	***13***	***-0.54***	***-0.2***	***<0.05***	***Significant Decline***
	CA319	*10*	*-0.42*	*-0.1*	*0.11*	*No significant trend*
	CA32	*13*	*-0.39*	*-0.2*	*0.08*	*No significant trend*
	CA325	*9*	*-0.17*	*0.0*	*0.61*	*No significant trend*
	CA33	***12***	***-0.49***	***-0.5***	***<0.05***	***Significant Decline***
	CA34	***12***	***-0.52***	***-0.3***	***<0.05***	***Significant Decline***
	CA38	***13***	***-0.46***	***-0.2***	***<0.05***	***Significant Decline***
	CA39	10	0.16	0.1	0.60	No significant trend
	CA3B1	*10*	*-0.20*	*-0.2*	*0.48*	*No significant trend*
	CA3B2	*10*	*-0.20*	*-0.2*	*0.48*	*No significant trend*
	S345B6	*10*	*-0.02*	*0.0*	*1.00*	*No significant trend*

Kendall's τ_b is analogous to a correlation coefficient; Sen's Slope provides a non-parametric approach at estimating the slope or inclination of a trend; p-value defines the statistical probability of the analysis. Trends were determined using a non-parametric (Kendall's τ_b) method at an assigned statistical significance level (α) of 0.05. *Italicized* rows identify marsh stations with decreasing trends. **Bolded and shaded** rows identify statistically significant trends. The data and statistical summary used for these analyses were taken South Florida Environmental Reports (SFWMD 2010-2018). Kendall's τ_b analysis was performed using the Base stats R package and Sen's slope estimate was determined using the zyp R package.

F.4 WATER CONSERVATION AREA 3B (WCA 3B)

Nutrient uptake within the proposed STAs would likely lower the concentration of TP in water delivered through the Blue Shanty Flow-way to ENP. **Table F-4** shows the annual and five-year geometric mean TP concentrations for the three TP Rule marsh stations in WCA 3B. Though the state calculates compliance with the TP rule for WCA 3 (3A and 3B) as a whole, these data show that all stations in WCA 3B currently meet the annual test provisions of the TP Rule. While operations under the TSP are expected to improve hydroperiods within WCA 3B, the system is primarily rainfall driven. Changes in the operations of this area may or may not affect compliance with the annual tests provisions of the TP Rule for these stations until the system can adapt to the conditions imposed through the implementation of the CEPP PACR.

Impacts to marsh TP concentrations during construction of the A-2 Reservoir and A-2 STA are expected to be minimal given the distance between the feature and the marsh monitoring stations. While uncertainty exists, it is unlikely that discharges into WCA 3B would cause or contribute to violations of the TP Rule, particularly the annual test provisions of the TP Rule. Over the long term, the risk of exceedances of the TP Rule in WCA 3B and WCA 3A is expected to decrease as upstream concentrations adjust.

F.5 EVERGLADES NATIONAL PARK (ENP)

Compliance with TP water quality criteria for water entering ENP is specified in Chapter 62-302.540, F.A.C. The rule states that:

> "Achievement of the phosphorus criterion in the Park shall be based on the methods as set forth in Appendix A of the Settlement Agreement unless the Settlement Agreement is rescinded or terminated the Department shall review data from inflows into the Park at locations established pursuant to Appendix A of the Settlement Agreement and shall determine that compliance is achieved if the Department concludes that phosphorus concentration limits for inflows into the Park do not result in a exceedance of the limits established in Appendix A."

Construction of the TSP and FWO project features such as the Blue Shanty Flow-way, L-29 levee degrade, L-67 Extension canal backfilling, and flow capacity increases at the S-333 and S-356 structures would alter the quality, quantity, timing, and distribution of flows entering Shark River Slough (SRS) in northern ENP. Non-CEPP features, such as the Tamiami Trail 1-mile bridge that was constructed and the future Tamiami Trail 2.6-mile Bridge Project that is under construction and is expected to be completed in early 2020, also alter flow patterns into SRS.

F.5.1 Impact of Future Loads into ENP

The TSP would increase flows to the ENP and therefore impact how water is delivered to the ENP. The existing STA 2 and STA 3/4 and proposed A-2 STA would be expected to treat any additional flow from the A-2 Reservoir. Improved sheetflow in the northern and southern ENP would be expected to improve water quality. After the system stabilizes or responds consistently with lower concentrations as a result of restored hydroperiods, concentrations are expected to be lower than the ECB condition and lower than the FWO condition. Increased sheetflow coupled with a longer hydroperiod would likely decrease soil oxidation and flux of TP over time within WCA 3 relative to ECB and FWO, and decrease TP transport to SRS and ENP.

F.5.2 Appendix A Compliance at Shark River Slough

The implementation of the TSP in conjunction with other projects and operational schemes would alter the flow and locations at which these flows enter SRS. These changes would have an effect on SRS compliance with the requirements of state law and Appendix A from the 1991 Settlement Agreement. Similar to the FWO, the three most important aspects of Appendix A compliance assessment for the TSP in this CEPP PACR are as follows: (1) CEPP-related increases in flow would generally reduce the annual Long-Term Limit (LTL) for TP and greatly increase the frequency of needing to comply with the minimum LTL of 7.6 ppb; (2) although long-term TP concentrations entering northeast SRS are expected to decrease, there would likely be short-term effects of CEPP-related project implementation sequence on TP concentrations and loads; and (3) CEPP-related structural changes would alter existing SRS inflow points. All of these would have some effect on Appendix A compliance or the sufficiency of the compliance methodology and are currently undergoing review by a subteam assigned by the Everglades Technical Oversight Committee.

F.5.2.1 Impact of Additional A-2 Reservoir Flows on SRS Compliance Limit

Appendix A compliance is currently assessed by comparing the LTL against the 12-month FWM TP concentration in parts-per-billion, calculated using the measured flows from the S-12A, S-12B, S-12C, S-12D, and S-333 structures that distribute flows from WCA 3A into SRS. The LTL, as defined in Appendix A of the 1991 Settlement Agreement, has an inverse relationship with flow; as flow into SRS increases, the LTL is reduced. Data from **Table F-6** show that while the LTL concentration decreases as flow increases, the measured FWM concentration (1991-2016) has a similar historical trend of decreasing as flow increases. Other factors, such as water stages in the marsh and also the canals, were evidenced to have influence on TP concentrations. In addition, under the TSP, concentrations are expected to decrease from historical levels. Nonetheless, given that the measured FWM TP concentration at SRS has been very close or equal to the LTL since 2007 (shown in **Figure F-11** and **Table F-6)**, there is concern that the addition of flows could alter the frequency of compliance with the limit. Proposed A-2 Reservoir annual flows are slightly greater with the TSP than for the FWO and much greater than ECB as shown in **Figure F-12**. Based on the current Appendix A compliance methodology, this increased flow volume results in a decrease of the LTL by about 2.1 ppb 53% of the time and by 1.4 ppb TP about 10% of the time, depending upon the annual inflow. The TSP has a similar increase in flow at SRS as the FWO. Furthermore, using the current Appendix A compliance methodology with the TSP, the minimum LTL compliance concentration of 7.6 ppb would be applicable about 20% more frequently. It is possible that exceedances of the LTL would occur due to the increased flow volume; however, the additional flow would be treated to the WQBEL and then routed through the northern WCA 3A marsh, which should lower TP concentrations relative to present conditions.

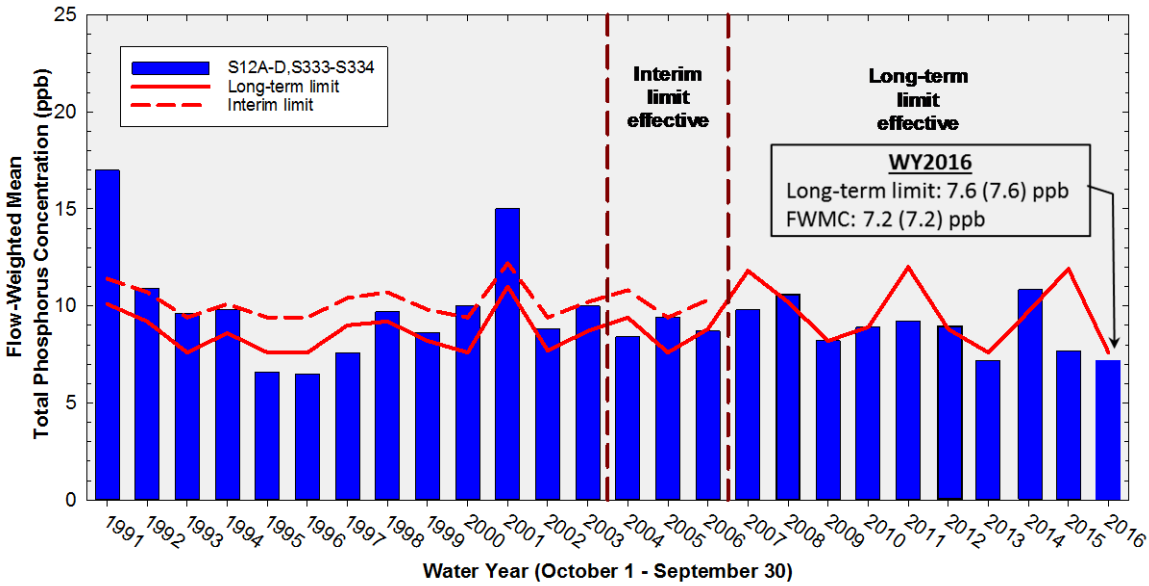


Figure F-11. SRS Compliance History (from Settlement Agreement Report, SFWMD 2017)

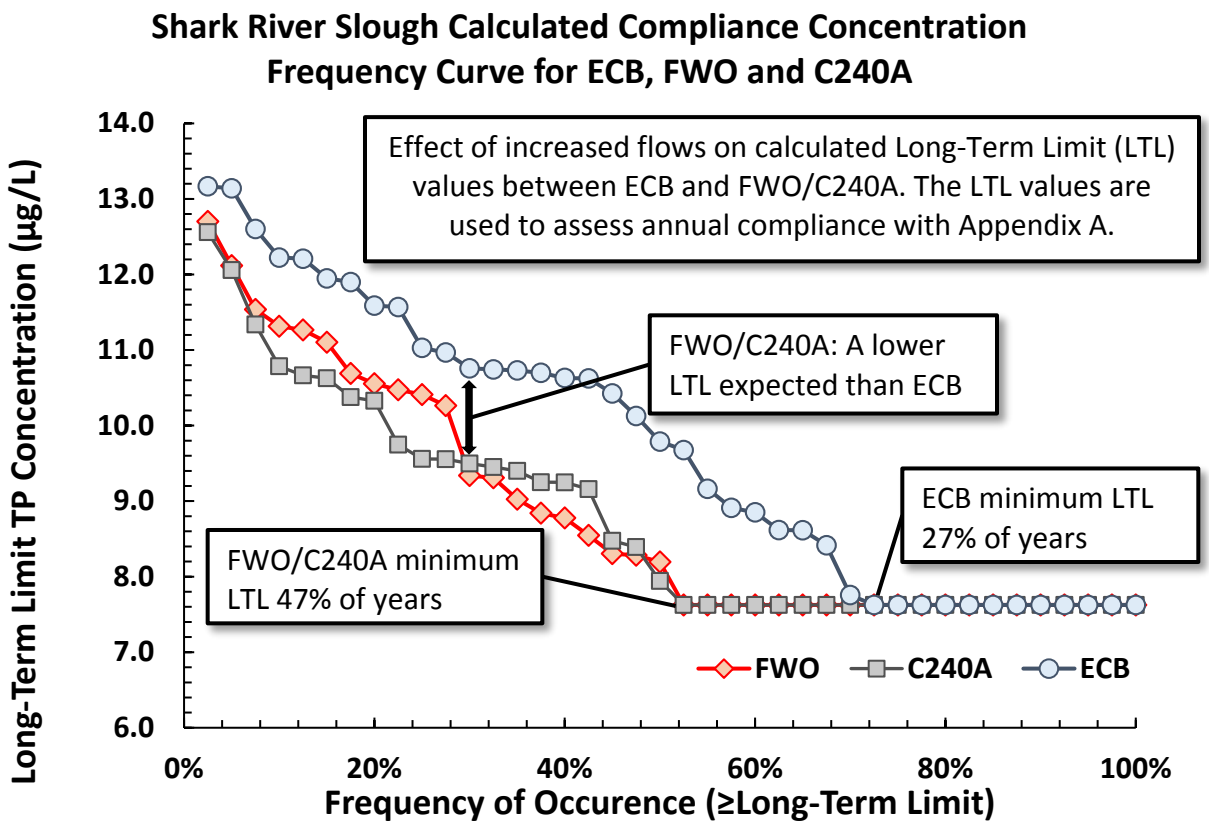


Figure F-12. Impact of Increased A-2 Reservoir Flows on Appendix A Compliance Criteria

Table F-6. SRS Compliance History (data from quarterly Settlement Agreement Reports prepared by the SFWMD)

Water Year (Oct 1 to Sep 30)	Total Flow (S-12s+S-333) (1,000 ac-ft)	Interim Limit (µg/L)	Long-Term Limit[1] (µg/L)	Flow-Weighted Mean (S-12s+S-333-S-334) (µg/L)
WY1991	581.1	11.4	10.1	17.0
WY1992	738.7	10.7	9.2	10.9
WY1993	1529.6	9.4	7.6	9.6
WY1994	856.1	10.1	8.6	9.8
WY1995	2491.9	9.4	7.6	6.6
WY1996	1478.5	9.4	7.6	6.5
WY1997	786.5	10.4	9.0	7.6
WY1998	737.6	10.7	9.2	9.7
WY1999	939.8	9.8	8.2	8.6
WY2000	1145.3	9.4	7.6	10.0
WY2001	420.5	12.2	11.0	15.0
WY2002	1048.1	9.4	7.7	8.8
WY2003	850.1	10.2	8.7	10.0
WY2004	704.4	10.8	9.4	8.4
WY2005	1345.9	9.4	7.6	9.4
WY2006	814.1	10.3	8.8	8.7
WY2007	289.7	n/a	11.8	9.8
WY2008	562.0	n/a	10.2	10.6
WY2009	945.3	n/a	8.2	8.2
WY2010	809.9	n/a	8.9	8.9
WY2011	247.0	n/a	12.0	9.2
WY2012	818.3	n/a	8.8	8.9
WY2013	1159.2	n/a	7.6	7.2
WY2014	649.0	n/a	9.7	10.8
WY2015	267.0	n/a	11.9	7.7
WY2016	1444.5	n/a	7.6	7.2

[1] Long-Term Limit (LTL) was effective in WY2007. LTL reported prior to WY2007 (shown in gray) are for reference only.

F.5.2.2 Effect of the Implementation Sequence on SRS TP Concentrations and Loads

It is recognized that the implementation sequence outlined in the CEPP PIR and CEPP PACR would be necessary to realize the full benefits of each component. These project features include Restoration Strategies and the Broward County Water Preserve Area C-11 Impoundment among others (see **Section 6.0 Table 6-15 – Project Dependencies** of the CEPP PACR) and must be integrated into the sequencing of CEPP and this CEPP PACR to avoid unintended adverse water quality consequences. Several basic principles were considered in development of an implementation plan which include the following:

1. All features of the State's Restoration Strategies must be completed and meet State water quality standards prior to initiating operations of the CEPP PACR project features;
2. Construction of CEPP or CEPP PACR project features cannot proceed until it is determined that construction and operation of the feature:

   a. Will not cause or contribute to a violation of State water quality standards; and
   b. Will not cause or contribute to a violation of any applicable water quality permit discharge limits or specific permit conditions; and
   c. Reasonable assurances exist that demonstrate adverse impacts on flora and fauna in the area influenced by the CEPP or CEPP PACR project features will not occur.
3. Appendix A water quality compliance must be addressed for new water entering ENP
4. Additional CEPP and CEPP PACR water quality treatment features, including operational and structural modifications, may need to be constructed if State water quality standards are not met upon operation of CEPP or CEPP PACR project features
5. Sequencing for the earliest opportunity to realize benefits, including the features that can provide benefits that utilize existing water meeting State water quality standards.

The project implementation plan for the FWO calls for a construction period of 15 to 20 years post-authorization. The proposed construction and sequencing of the various project features can have a substantial effect on the projects ability to comply with water quality standards. The implementation and construction sequencing plan is presented in **Figure 6-9** in **Section 6.7.2** of the CEPP PACR and was developed to maximize benefits while considering important constraints such as water quality and flood protection.

F.5.2.3 Effect of Altered Inflows and New Inflows on Appendix A Compliance Determination

At present, the quantification of flows and loads for Appendix A compliance includes measurement of inflows and TP concentration at the S-12A-D, S-333, and S-334 structures. The FWO includes new features such as the Blue Shanty Flow-way that would affect the location of inflows to SRS at Tamiami Trail. In addition to the CEPP and CEPP PACR changes to hydrology, the Tamiami Trail Bridge projects would provide new SRS inflows through sheetflow under these bridges.

It is uncertain how changes in flow distributions proposed under CEPP and this CEPP PACR would impact compliance with Appendix A of the 1991 Settlement Agreement. Over the long term, distributing the flow over the northern WCA 3A marsh, reducing short-circuiting down the canals to ENP, adding more flow from the lake that is treated to the WQBEL, and distributing these flows over the marsh should result in improvements by lowering the flow weighted mean total phosphorus concentration entering the ENP. In the short-term, to address the uncertainty in compliance with Appendix A, the Technical Oversight Committee (TOC) is reviewing applicability of the current Appendix A compliance methodology for a restored ecosystem.

F.6 CONCLUSION

This Annex provides evidence that implementation of the CEPP PACR is likely to improve water column TP concentrations within most areas of WCA 3 primarily due to the use of state owned water quality treatment facilities and increased upstream storage capacity provided by the A-2 Reservoir and A-2 STA redistributing flows into the northeastern corner of WCA 3A, which should allow for decreased soil oxidation and flux of TP over time. Over the long term, it is likely that the project would beneficially affect WCA 3. However, there may be temporally and spatially limited impacts to TP concentrations within the marsh until more stabilized water level conditions are established. Increasing flow from the A-2 Reservoir and A-2 STA would reduce the SRS LTL, but increasing flow would also increase marsh and canal stage

levels that could stabilize the TP concentration in the inflows to SRS. It has been observed that the TP concentrations are increased when stage level is low (as previously presented at Everglades TOC meetings). However, while water quality is expected to improve, compliance with Appendix A cannot be quantified given the high level of uncertainty from changes in flow distributions proposed under the TSP.

Similar to CEPP, it is important to note that this CEPP PACR only includes a qualitative rather than quantitative assessment of Appendix A compliance at SRS. Although water quality is expected to improve with respect to P concentrations because of both CEPP and CEPP PACR, the impact of the project on Settlement Agreement compliance is uncertain because of the qualitative nature of the analysis A quantitative prediction of future SRS TP concentrations was not done because the uncertainties were considered to be unacceptably high. The limitation of predictive tools, uncertainties in the systems response and the lack of historical data that reflects the substantially altered flow and loading patterns contribute to these uncertainties. Also, with future Appendix A compliance methodology currently under review by the TOC, these quantitative predictions may be premature at this time.

CEPP PACR project features cannot proceed unless/until it is determined through the Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) permitting process that construction and/or operation of the feature 1) will not cause or contribute to a violation of water quality standards; 2) will not cause or contribute to a violation of the permit(s) discharge limits or specific conditions; and, 3) reasonable assurances exist that demonstrate adverse impacts on flora and fauna in the area influenced by the project element will not occur. The tentative feature implementation sequence is designed to minimize the potential for temporary increases in TP during project construction, commissioning, and long-term operations. Given the magnitude of the hydrologic changes proposed in CEPP and the CEPP PACR, this project presents some risk of future non-compliance with water quality criteria particularly in the SRS.

As the CEPP proceeds and data from individual projects are gathered, these data are expected to feed back into the CEPP PACR adaptive management plan. Each individual component of the CEPP and CEPP PACR will require a CERPRA permit from the FDEP. Integration of adaptive management/operations/monitoring into the CEPP PACR will help provide reasonable assurance associated with water quality issues and uncertainties. Ideally, adaptive management will be applied iteratively throughout the phasing to address issues early and allow for lessons learned to be applied for future phases. Commitment to adaptive management is key to moving this restoration project forward given the uncertainties associated with water quality.

F.7 REFERENCES

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