DRAFT – Preliminary Assessment of WY2015 Lake Releases to the STAs – 8/12/2015

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SUMMARY

During Water Year 2015 (WY2015), approximately 580,000 acre feet of Lake Okeechobee releases were sent to four of the five STAs (STA-1E, STA-1W, STA-2 and STA-3/4). This magnitude was the largest volume of Lake releases in the history of STA operations. During this period, Lake releases made up approximately 45 percent of the total inflows to these STAs, with stormwater runoff from adjacent basins making up the balance. Despite the large movement of Lake water through the EAA and L-8 Canal basins, there was no reduction in the level of flood protection provided to those areas. The performance of these four STAs as a whole improved compared to the prior year, with an overall reduction of 4 parts per billion (ppb) down to 16 ppb - the lowest cumulative outflow phosphorus concentration in the history of these four STAs. Other benefits of sending these Lake releases to the STAs included

- supplying approximately 580,000 acre feet of treated water to the Everglades Water Conservation Areas (WCAs),
- supplying additional treated water to the Palm Beach, Broward and Miami-Dade County wellfields,
- supplying supplemental water to the STAs during the dry season, thereby preventing dryout and its associated adverse impacts to STA performance, and
- reducing the destructive releases of polluted Lake water to the coastal estuaries by approximately 450,000 acre feet.

By contrast, STA-5/6 did not receive any Lake water during WY2015 despite a pressing need for water to prevent dryout of its treatment cells. STA-5/6 performance decreased compared to the previous year, with a 9 ppb increase in outflow phosphorus concentration. Note that these findings are preliminary and reflect an analysis of short-term effects of WY2015 Lake releases on STA performance; it is entirely possible that we may see other effects in the future.

Early WY2016 results demonstrate a continuation of the exceptional STA performance observed in WY2015.

Suggestions for future operations include continuing the slow and steady year-round Lake releases to the STAs (particularly during the dry season), improving the capability to send Lake water to STA-5/6, integrating the operation of the new 16,000-acre EAA flow equalization basin, and investigating operations to balance the hydraulic and nutrient load among the STAs and among the flow-ways within each STA.

WATER YEAR 2015 OPERATIONS

For the period May 1, 2014 through April 2015 (Water Year 2015, or "WY2015"), the U.S. Army Corps of Engineers (USACE) and the South Florida Water Management District (SFWMD) sent a combined flow of approximately 1.9 million acre feet (AF) of Lake Okeechobee releases south (to the EAA, other basins, and the Lake Worth Lagoon), east (to the C-44 Basin and St. Lucie River and Estuary) and west to the Caloosahatchee River and Estuaries (**Figure 1** and **Appendix 1**). During this period, SFWMD sent approximately 1.3 million AF of combined stormwater runoff and Lake Okeechobee releases to four STAs: STA-1E, STA-1W, STA-2, and STA-3/4 (**Figure 2** and **Table 1**). No Lake water was sent to STA-5/6, despite the pressing need for water in that STA. For the four STAs that received Lake releases, basin runoff contributed approximately 55 percent of the inflow volume, the remaining 45 percent (580,000 AF) was Lake releases. The Lake releases were the largest magnitude of Lake releases ever sent to the STAs (**Figure 3**), and were distributed to the STAs throughout the year (**Figure 4**). STA-2 and STA-3/4 received the largest Lake releases in absolute magnitude and hydraulic loading rate (i.e., volume of water per acre of STA; **Figure 5**). Due to the locations of lake discharge points, these STAs received Lake water with lower phosphorus levels than did STA-1E and STA-1W, which influenced the resulting phosphorus loading rates (i.e., the mass of phosphorus per acre of STA; **Figure 6**). Water managers have the ability to distribute STA inflow into various interior treatment cells and flow-ways by operating pumps, gates and other water control structures. Comparison of the loading rates within the STAs demonstrates a significant imbalance of loads among the flow-ways in STA-1E, STA-2 and STA-3/4 (**Figure 7**).

District simulations indicated that sending this magnitude of lake releases to the STAs resulted in approximately 264,000 AF less Lake discharges to the St. Lucie River and Estuary, and approximately 192,000 AF less Lake discharges to the Caloosahatchee Estuary (Kivett 2015a, Kivett 2105b). However, in spite of the large magnitude of Lake releases to the south, Lake releases were sent to the coastal estuaries during WY2015:

- approximately 80,000 AF of <u>untreated</u> Lake discharges were sent to the St. Lucie River and Estuary, conveying more than 34,000 pounds of phosphorus, 320,000 pounds of nitrogen and 3 million pounds of sediment;
- approximately 490,000 AF of <u>untreated</u> Lake discharges were sent to the Caloosahatchee Estuary, conveying more than 121,000 pounds of phosphorus, 1.7 million pounds of nitrogen and 5.5 million pounds of sediment.

The original 40,000 acres of STAs were designed to treat an annual average of more than 250,000 AF of Lake releases (Burns and McDonnell 1994; **Appendix 2**). This design objective

was echoed in the 1994 Everglades Forever Act (EFA, Ch. 373.4592, Florida Statutes; **Appendix 2**) which formed the basis for the 2001 amendment of the Everglades Consent Decree. Since the 1994 design, the cumulative area of the STAs has increased by almost 20,000 acres, and a new 16,000-acre flow equalization basin has recently been added to the network. Even including the large releases in WY2015, the average annual volume of Lake releases sent to the STAs for the last ten years has been 103,400 AF, well below the original design objectives and EFA direction.

PRELIMINARY EFFECTS OF LAKE RELEASES ON STA PERFORMANCE

It is difficult to determine with certainty the effects of the WY2015 Lake releases on STA performance due to many reasons, including the following.

- Lake releases made up only 45 percent of the STA inflows, and the other inflows influenced STA performance. It is practically impossible to tease out the performance effects of individual inflow sources.
- STAs are biological systems, and their performance is influenced by many biological and other factors that we're still learning about.
- Management activities conducted in WY2015 and prior years undoubtedly influenced STA performance in WY2015, and it is practically impossible to tease out the performance effects of individual factors.
- There may be longer-term impacts associated with the Lake releases that are not yet manifested.

Nevertheless, preliminary analysis of high-level STA performance can be conducted. The following findings are preliminary and reflect an analysis of the short-term effects of WY2015 Lake releases; it is entirely possible that additional effects may manifest in the future.

The overall STA performance improved for the four STAs that received Lake water (STA-1E, STA-1W, STA-2, and STA-3/4) during WY2015, recording a drop in cumulative outflow phosphorus concentration from 21 ppb in WY2014 to 16 ppb (**Figure 8**). This represents the lowest cumulative outflow phosphorus concentration in the history of these four STAs. In addition, the STAs that received Lake releases experienced a improvement in cumulative load reduction, from 80 percent in WY2014 to 83 percent in WY2015 (**Figure 9**). While it is not possible to say with certainty that these historically low concentrations and improved load reductions are directly attributable to the historically large Lake releases, it is highly unlikely that the Lake discharges were adverse affected to the exceptional performance.

Individual flow-way performance improved. Within these four STAs, there are fourteen individual flow-ways. During WY2015, phosphorus concentrations dropped, or remained the same, from WY2014 levels in thirteen of these fourteen flow-ways (**Figure 10**).

STA-2 performance improved by 3 ppb despite the high annual phosphorus loading rate to STA-2 Cell 1, as the outflow phosphorus concentration for the STA dropped from 19 ppb in WY2014 to 16 ppb in WY2015. As shown in **Figure 7**, the phosphorus loading rate among the eastern flow-ways in STA-2 was significantly out of balance, with Cell 1 receiving more than twice the loading rate of Cell 3. Despite this, the annual flow-weighted mean outflow concentration for Cell 1 remained at 8 ppb, the same level as observed in WY2014. District staff have demonstrated that there is not a clear linear relationship between the phosphorus loading rate and the outflow concentration, particularly at concentrations below 15 ppb (Chen et al. in press). However, there may be performance benefits to distributing the loading more uniformly among the flow-ways of STA-2 by opening and closing cell inflow structures.

STA-5/6 performance declined. The only STA not demonstrating an improvement in outflow concentration and load reduction was STA-5/6, which did not receive any Lake releases during WY2015. STA-5/6 continued to suffer from a lack of water, with a hydraulic loading rate of just 0.5 ft/month, and a commensurate increase in outflow concentration since WY2014 of 9 ppb, from 23 ppb to 32 ppb. The hydraulic loading rate received by STA-5/6 is less than 25 percent of the 2.3 ft per month average rate of the four STAs that received Lake releases. The upper treatment cells in STA-5/6 routinely dry out due to lack of water, and this has been linked to adverse impacts to STA performance. A new project in the C-139 Basin – the Alico Dispersed Water Management Project – is under construction and will likely reduce the inflow to STA-5/6 as basin water is re-routed to the west. Approximately 19,000 acres (55 percent) of the Alico project is located in the C-139 Basin – not in the Caloosahatchee River Basin – and this project may result in the capture and/or diversion of approximately 20,000 AF/yr that would have otherwise gone to STA-5/6. The District has not identified any plans to replenish this diverted water or otherwise increase the flow of water to STA-5/6.

Early WY2016 results demonstrate a continuation of the exceptional STA performance. Through mid-July 2015, the 12-month flow-weighted mean outflow phosphorus concentrations have remained stable for STA-1E, and have decreased for STA-1W (from 19 ppb to 17 ppb), decreased for STA-2 (from 16 to 15 ppb), and decreased for STA-3/4 (from 15 ppb to 14 ppb). The cumulative outflow concentration for these four STAs that received Lake water during WY2015 has dropped from 16.2 ppb to 15.6 ppb.

SUGGESTIONS FOR FUTURE OPERATIONS

The SFWMD deserve recognition for sending historically large volumes of Lake water to the STAs in WY2015. The following suggestions are offered to continue this momentum.

- continue the slow and steady year-round Lake releases to the STAs in accordance with LORS2008, with a target of more than 250,000 acre feet during the dry season,
- improve the capability to send Lake water to STA-5/6 to achieve target stages in the upstream emergent vegetation cells,
- develop plans to replenish water diverted away from STA-5/6 as part of the Alico Dispersed Water Management Project,
- investigate operations to balance the hydraulic and nutrient loading rates among the STAs and among the flow-ways within individual STAs in an attempt to improve STA performance, and
- operate the new EAA flow equalization basin to continue the slow and steady year round releases from Lake Okeechobee, to enhance the performance of the STAs, and to supply additional treated water to the Everglades and the wellfields of the Lower East Coast.

Other suggestions were provided earlier and will not be repeated here.

REFERENCES

Burns and McDonnell 1994. Everglades Protection Project Palm Beach County, Florida Conceptual Design. February 15, 1994.

Chen, H., D. Ivanoff and K. Pietro, in press. Long-term phosphorus removal in the everglades stormwater treatment areas of the South Florida in the United States. Ecological Engineering, in press.

Kivett 2015a. Water Conditions Report to Governing Board. March 2015.

Kivett 2015b. Water Conditions Report to Governing Board. May 2015.

SFWMD 2015. South Florida Environmental Report Chapter 5b. STA Performance. March 1, 2015.

Figure 1 – WY2015 Lake Releases.

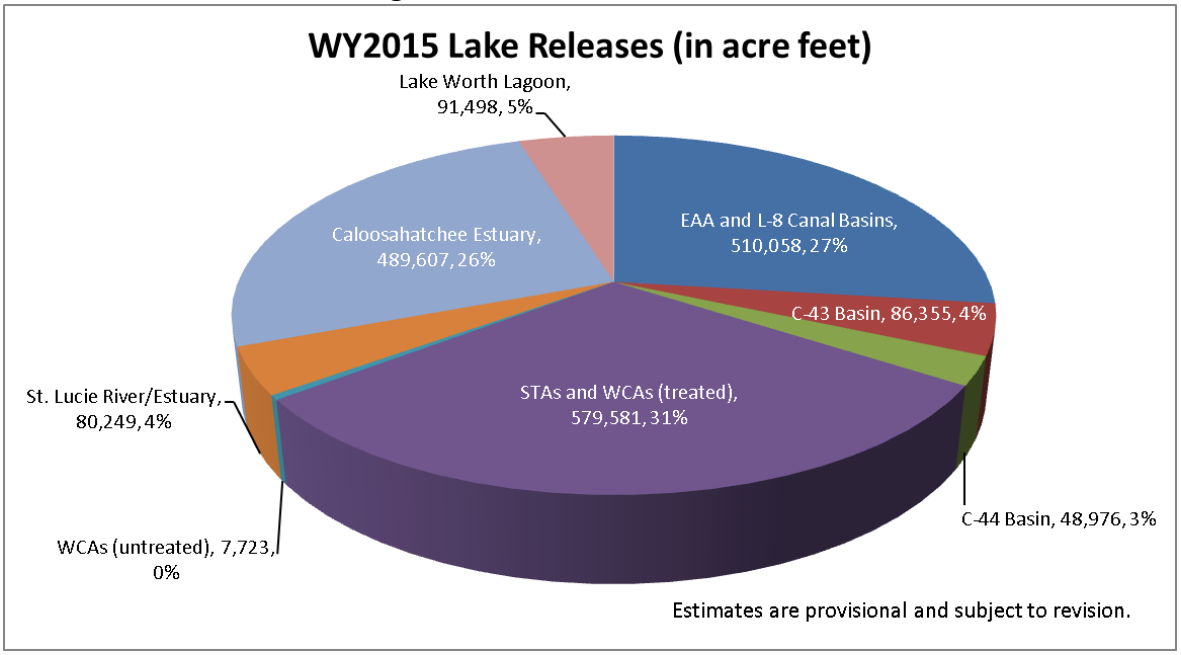


Figure 2 – Location of the Everglades Stormwater Treatment Areas (from SFWMD 2015).

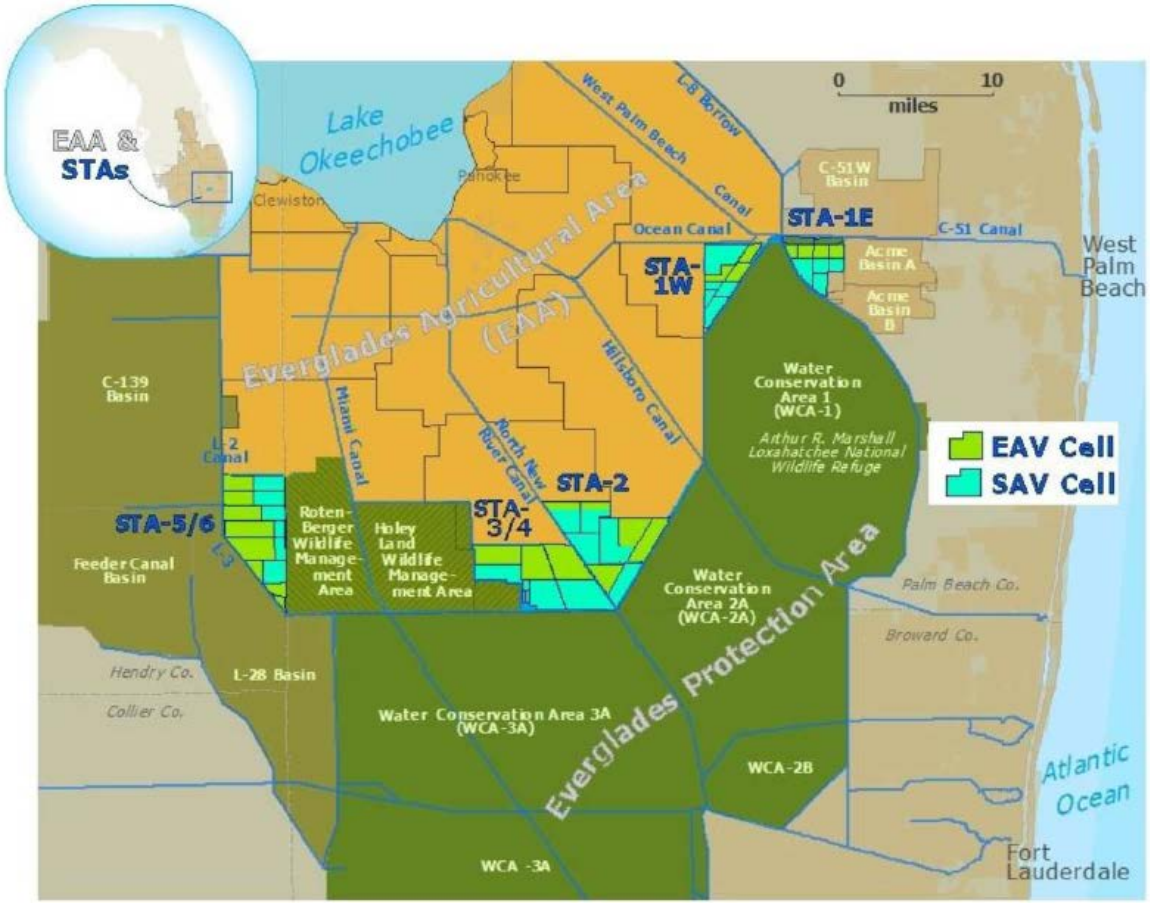


Figure 3. Annual Lake Releases to the STAs.

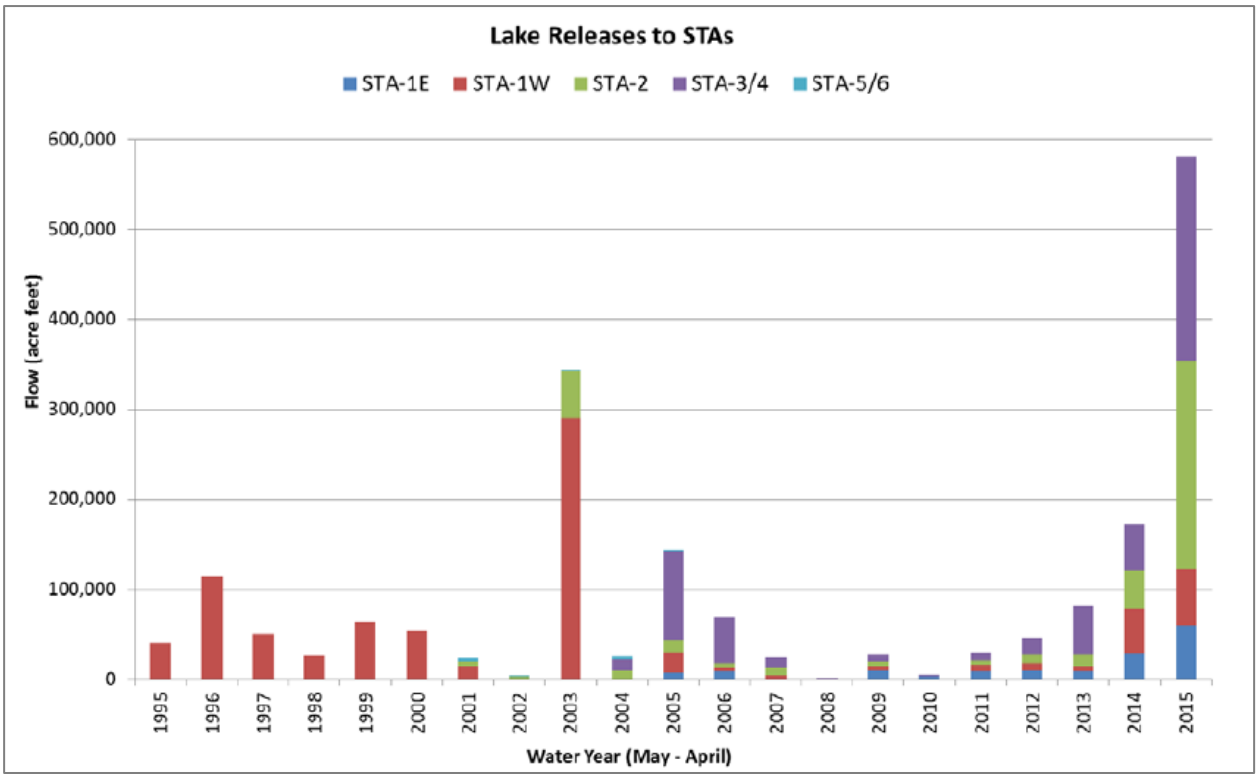


Figure 4. Monthly Lake Releases to the STAs During WY2015.

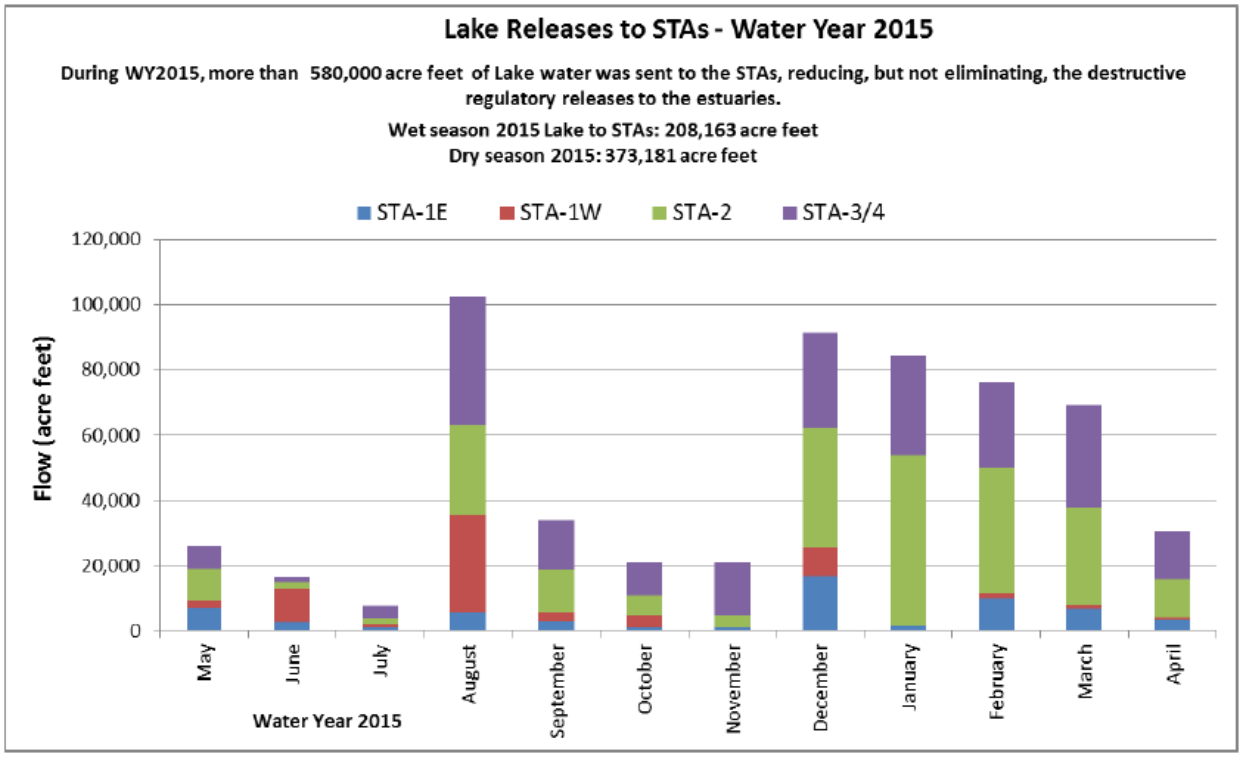


Figure 5 – Hydraulic Loading Rates to the STAs for WY2015.

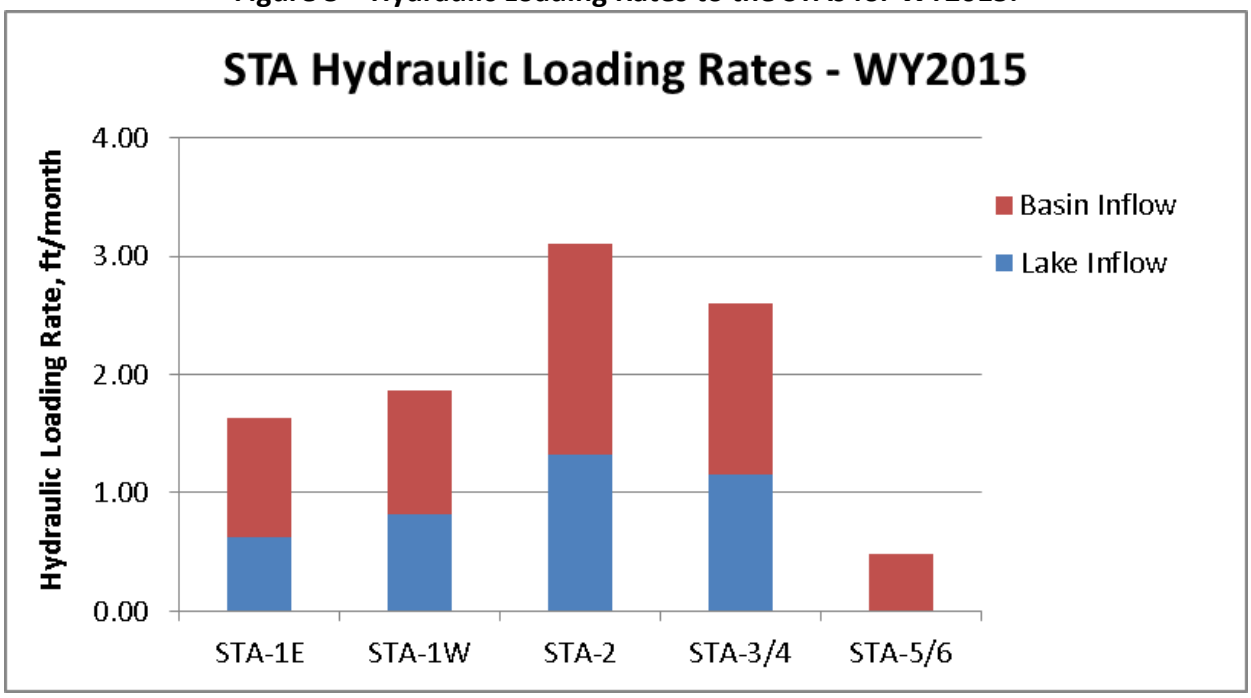


Figure 6 – Phosphorus Loading Rates to the STAs for WY2015.

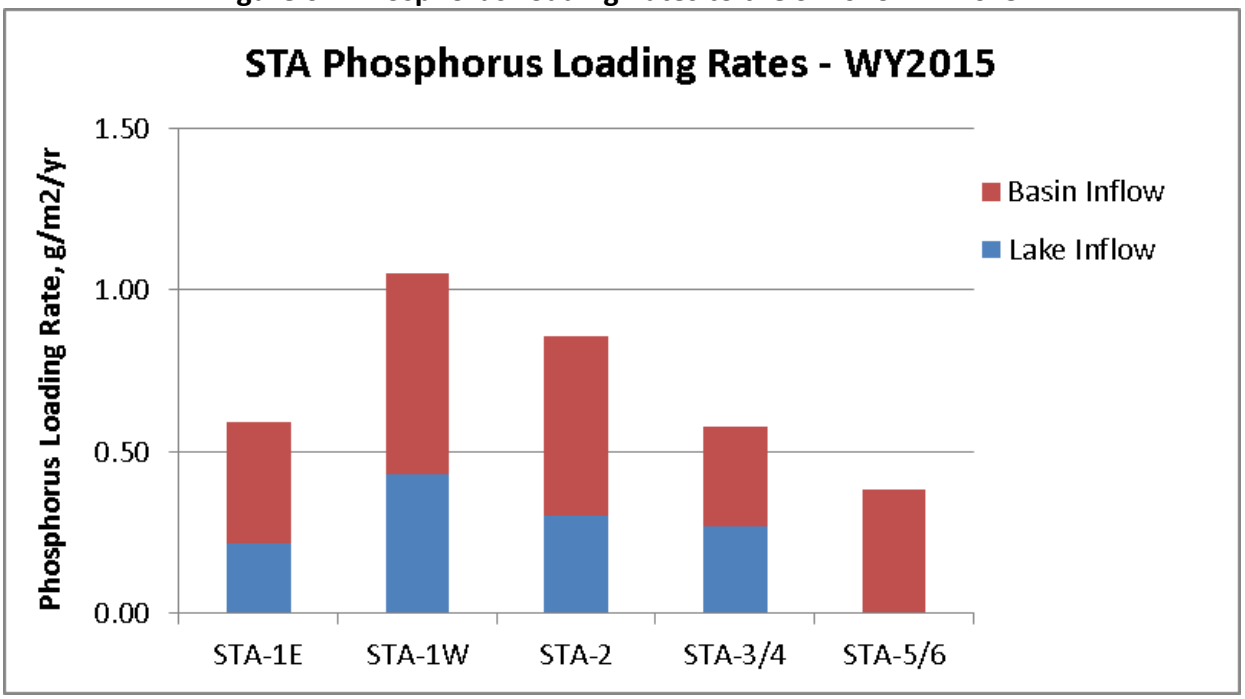
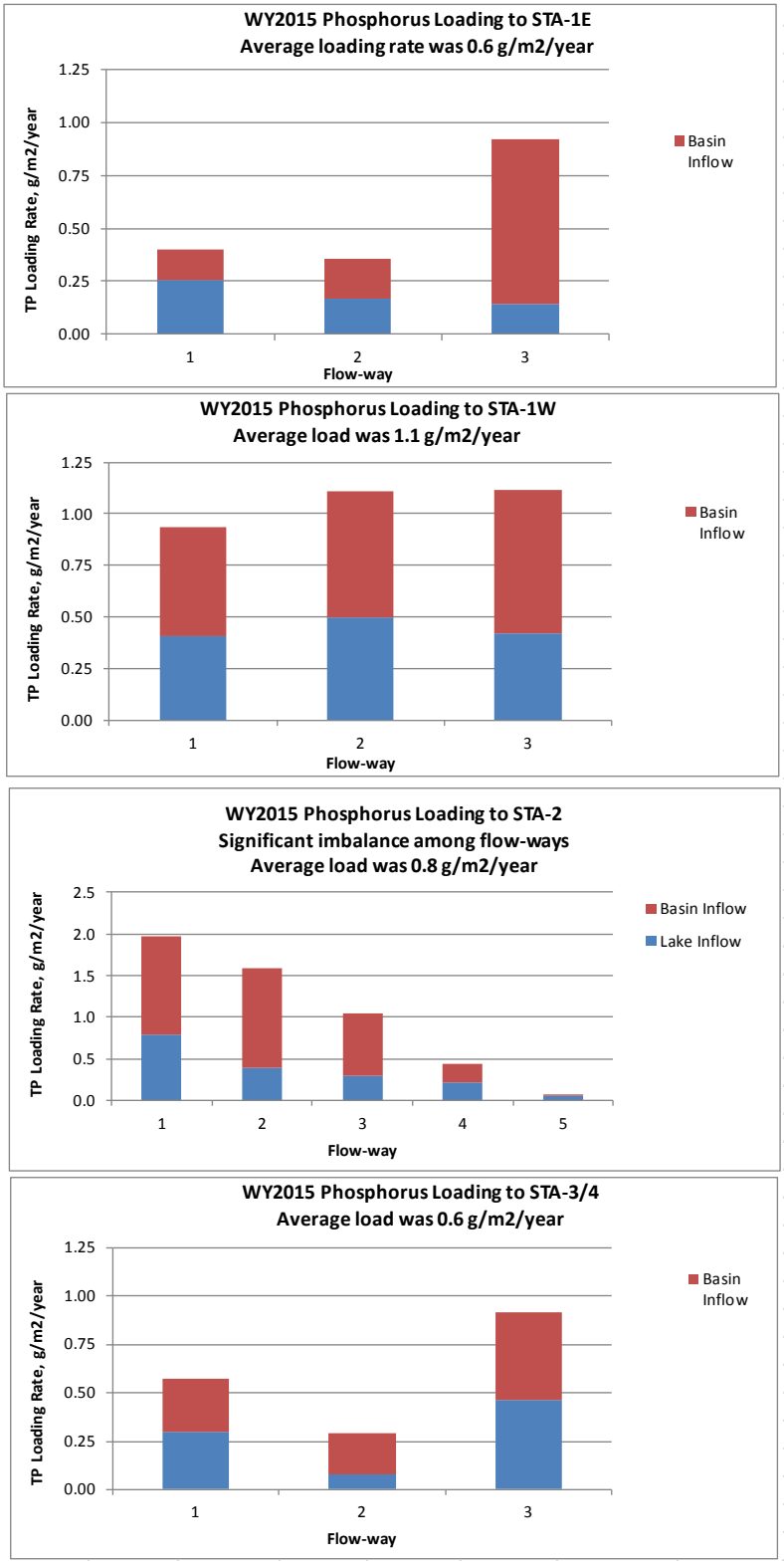


Figure 7. Distribution Of Phosphorus Loading Rates Among The Cells Within The STAs.



STA-1E: Flow-way 1 = Eastern Flow-way; Flow-way 2 = Central Flow-way; Flow-way 3 = Western Flow-way
STA-1W: Flow-way 1 = Eastern Flow-way; Flow-way 2 = Western Flow-way; Flow-way 3 = Northern Flow-way
STA-3/4: Flow-way 1 = Eastern Flow-way; Flow-way 2 = Central Flow-way; Flow-way 3 = Western Flow-way

Figure 8. Improvement in Historical STA Performance.

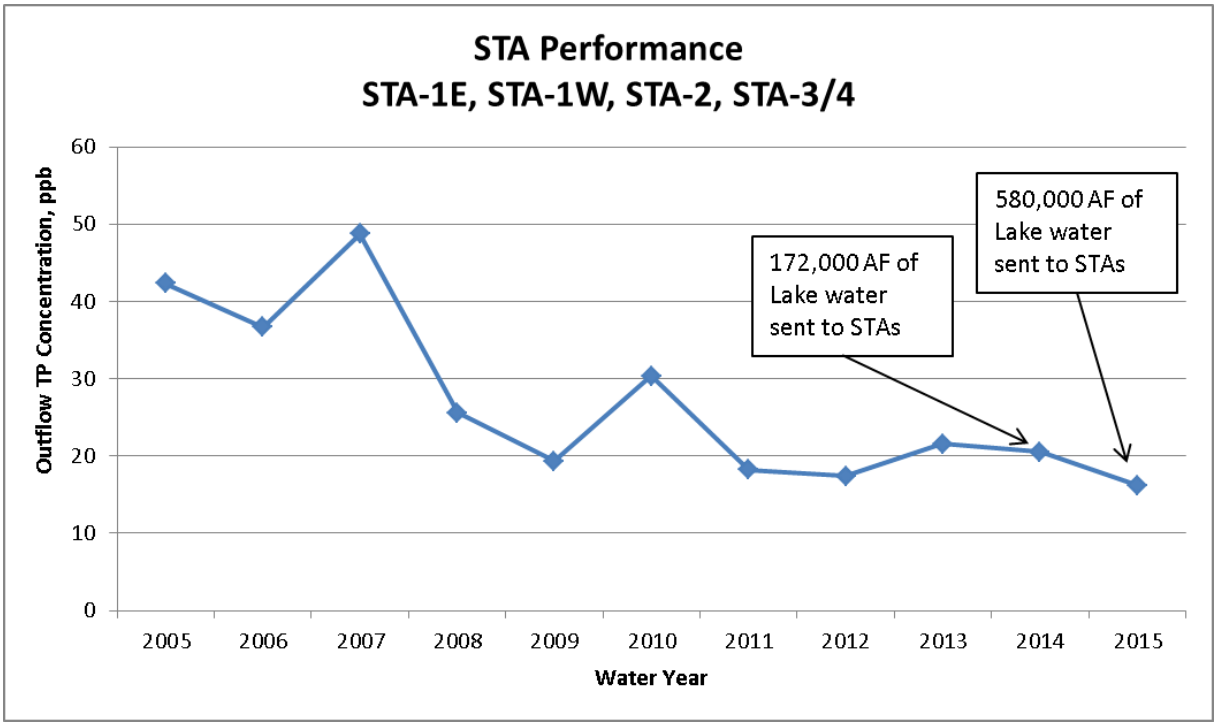


Figure 9. Improvement in STA Phosphorus Load Reduction. The only STA not demonstrating an improvement in load reduction was STA-5/6 – which did not receive Lake releases.

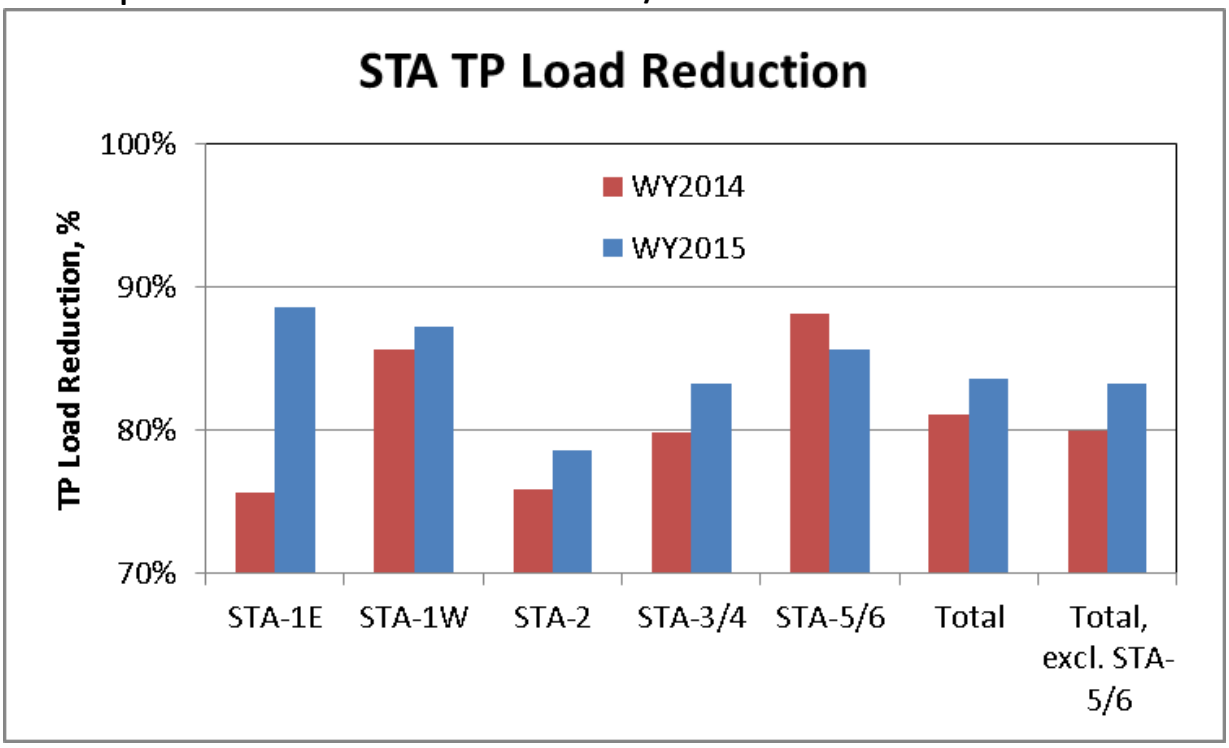
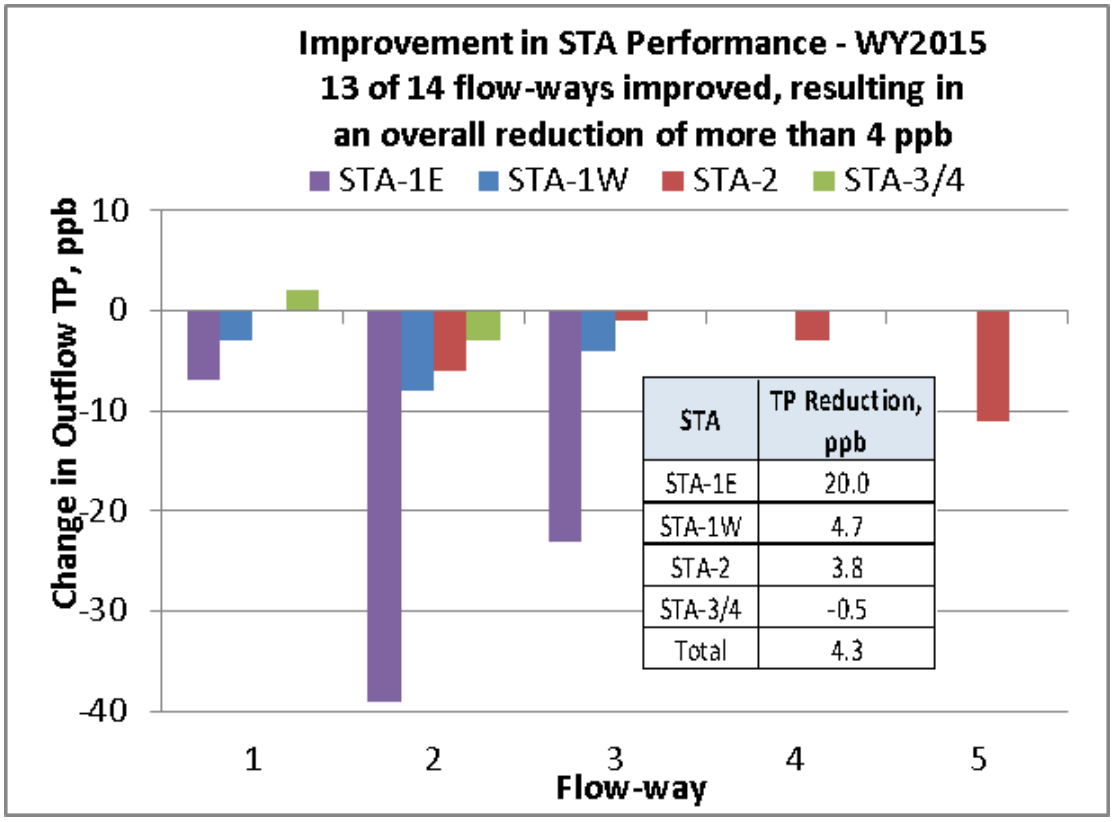


Figure 10. WY2015 Improvement in Flow-way Performance



STA-1E: Flow-way 1 = Eastern Flow-way; Flow-way 2 = Central Flow-way; Flow-way 3 = Western Flow-way
STA-1W: Flow-way 1 = Eastern Flow-way; Flow-way 2 = Western Flow-way; Flow-way 3 = Northern Flow-way
STA-3/4: Flow-way 1 = Eastern Flow-way; Flow-way 2 = Central Flow-way; Flow-way 3 = Western Flow-way

Table 1. Preliminary Estimates of WY2015 STA Performance

STA	WY2015 STA Inflow			WY2015 STA Outflow			WY2014	Improvement
	Flow, AF	TP Load, kg	TP Conc, ppb	Flow, AF	TP Load, kg	TP Conc, ppb	TP Conc, ppb	TP Conc, ppb
STA-1E								
Basin Runoff	61,750	11,883	156					
Lake Releases	58,421	10,695	148					
Total	*120,171*	*22,577*	*152*	*98,798*	*2,579*	*21.2*	41.2	20.0
Lake % of inflow	49%	47%		*Reduction:*	*89%*	*86%*		
STA-1W								
Basin Runoff	78,284	16,048	166					
Lake Releases	61,855	11,067	145					
Total	*140,139*	*27,116*	*157*	*148,056*	*3,450*	*18.9*	23.5	4.7
Lake % of inflow	44%	41%		*Reduction:*	*87%*	*88%*		
STA-2								
Basin Runoff	304,008	29,713	79					
Lake Releases	232,448	18,102	63					
Total	*536,456*	*47,815*	*72*	*532,384*	*10,246*	*15.6*	19.4	3.8
Lake % of inflow	43%	38%		*Reduction:*	*79%*	*78%*		
STA-3/4								
Basin Runoff	274,077	26,310	78					
Lake Releases	226,857	22,718	81					
Total	*500,934*	*49,028*	*79*	*447,028*	*8,209*	*14.9*	14.3	-0.5
Lake % of inflow	45%	46%		*Reduction:*	*83%*	*81%*		
Total, Excluding STA-5/6								
Basin Runoff	718,119	83,953	95					
Lake Releases	579,581	62,583	88					
Total	*1,297,700*	*146,536*	*92*	*1,226,267*	*24,484*	*16.2*	20.5	4.3
Lake % of inflow	45%	43%		*Reduction:*	*83%*	*82%*		
STA-5/6								
Basin Runoff	83,197	23,616	230					
Lake Releases	0	0						
Total	*83,197*	*23,616*	*230*	*85,942*	*3,383*	*31.9*	22.8	-9.1
Lake % of inflow	0%	0%		*Reduction:*	*86%*	*86%*		
Total, Incl. STA-5/6								
Basin Runoff	801,317	107,569	109					
Lake Releases	579,581	62,583	88					
Total	*1,380,898*	*170,152*	*100*	*1,312,209*	*27,866*	*17.2*	20.7	3.5
Lake % of inflow	42%	37%		*Reduction:*	*84%*	*83%*		

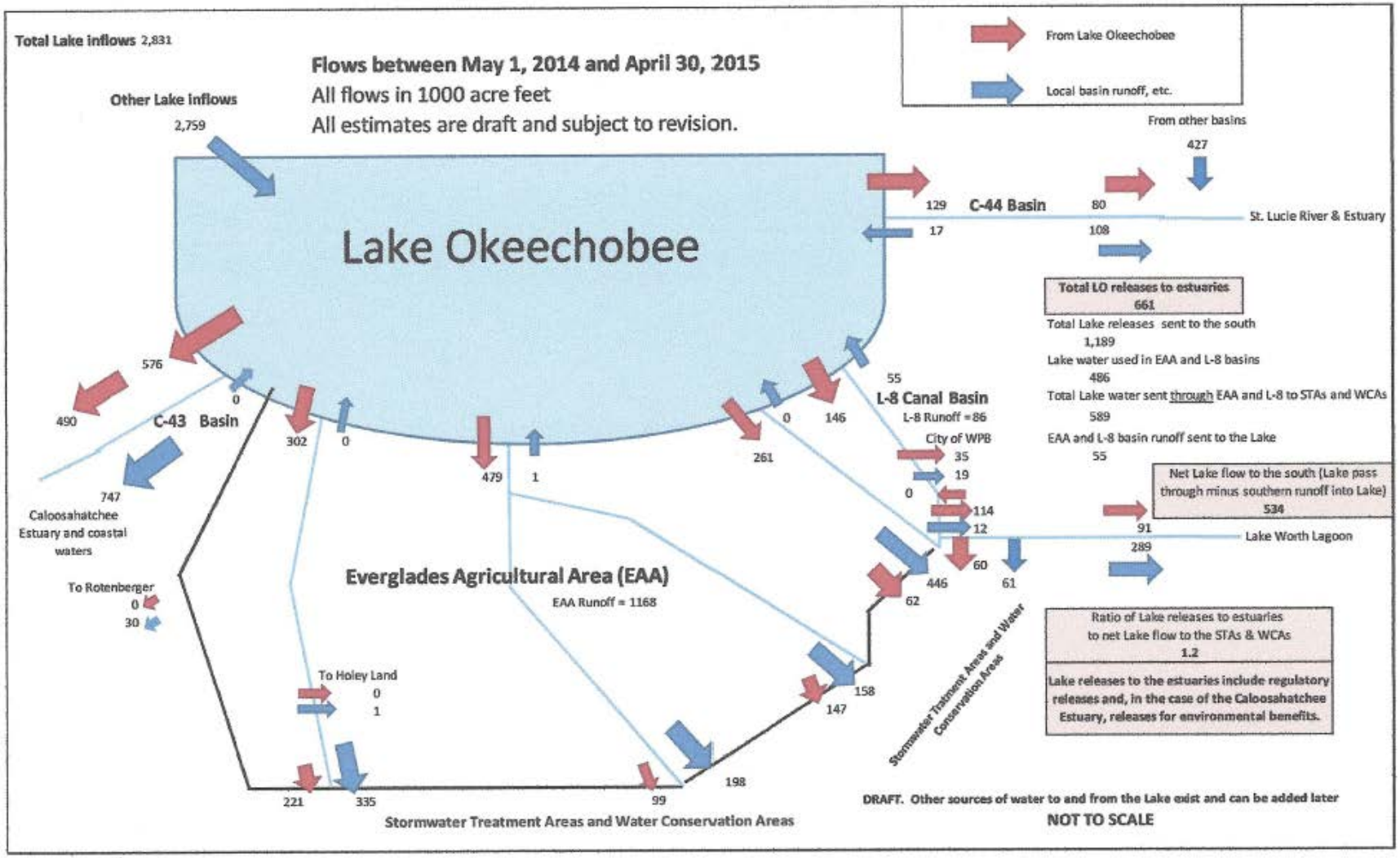
Notes:

All estimates are provisional and subject to revision

AF = acre feet; TP = total phosphorus; kg = kilogram = 2.2046 pounds; Conc = concentration; ppb = parts per billion

TP loads and concentrations do not reflect load adjustments described in Rule 40E-63.

Appendix 1. Preliminary Flow Diagram for Water Year 2015.



Appendix 2. The STAs Were Designed to Treat Lake Releases

Excerpt from 1994 Conceptual Design of the STAs (Burns and McDonnell 1994), page IV-68:

STA-3/4 DESIGN INFLOWS

Source	Average Annual Inflow		
	Volume (ac-ft)	TP Load (Kg)	TP Conc. (gm/m^3)
S-7/S-2 Basin			
- Gross Inflow	184,460	23,484	0.103
- Reduction for lands used in STA-3/4	(20,866)	(3,104)	0.121
- Reduction for lands used in STA-2	(2,315)	(344)	0.121
- Net Inflow	161,279	20,036	0.101
S-8/S-3 Basin			
- Gross Inflow	195,680	49,397	0.205
- Reduction for lands used in STA-5	(7,865)	(1,913)	0.197
- Reduction for lands diverted to STA-6	(19,444)	(4,731)	0.197
- Net Inflow	168,371	42,753	0.205
C-139 Basin (@ G-136)	10,605	693	0.053
SFCD (67%)	9,380	1,574	0.136
SSDD (67%)	2,787	344	0.100
Subtotal, all private sources	352,422	65,400	0.150
Historic Lake Okeechobee Reg. Releases	15,956	1,390	0.071
Additional Lake Okeechobee Release	236,375	20,410	0.070
TOTAL INFLOW	604,753	87,200	0.120

Other STAs were also designed to capture and treat Lake releases, with a cumulative annual average of more than 250,000 AF/yr.

Excerpt from Everglades Forever Act (Ch. 373.4592(4)(b)2):

The district shall operate the Everglades Construction Project as specified in the February 15, 1994, conceptual design document, to provide additional inflows to the Everglades Protection Area. The increased flow from the project shall be directed to the Everglades Protection Area as needed to achieve an average annual increase of 28 percent compared to the baseline years of 1979 to 1988. Consistent with the design of the Everglades Construction Project and without demonstratively reducing water quality benefits, the regulatory releases will be timed and distributed to the Everglades Protection Area to maximize environmental benefits.