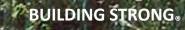




Loxahatchee River Watershed Restoration Project Constraints

Water Quality Water Supply Flood Impact May 9, 2018









- Evaluation tool approach:
 - ✓ Develop schematic diagram for ECB, FWO, and each alternative
 - Compile historical data (if available)* to estimate baseline flows, TP/TN concentrations, and TP/TN loads
 - ✓ Apply MODFLOW results to estimate flows, TP/TN concentrations, and TP/TN loads
 - ✓ Use conservative treatment assumptions for deep reservoirs, shallow impoundments, and natural storage features

*Data sources include SFWMD's DBHYDRO database, FDEP, Loxahatchee River District, Indian Trail Improvement District, and Mock Roos



Evaluation Tool – ECB Example



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5: LOX from Cypress Cr. 7: LOX from Kitching (TN 53 TP ppb \117171 6: LOX from Hobe Grove 1.363 75 TP ppb 10534 20886 ac-ft 20886 71 TP ppb 1.16968 10534 ac-ft 20 3759 ac-ft 1367 P load (k 3759 973 P load (kg) 18 330 P load (kg) 5 Loxahatchee LOX River Station 68 near Turnpike River NWF TN 49 1.17 con at TPK LOX River at TPK 101599 flow 101599 51 TP ppb 147 Load 6194 Average 7 (ppb) 49860 ac-ft 3137 P load (kg) 1: Flow over C-18 Weir TN 3: Flows over Lainhart Dam 2010 2012 2012 43 TP ppb 1.14627 41 TP ppb 1.037 Lainhart 44594 ac-ft 44594 66420 ac-ft 664 Water Year 3523 P load (k 917 P load (k 60928 Dam G92 Jupiter Farms 46 TP ppb 1.5 (14d) (14d)(FWM TN (mg/L) 26790 ac-ft 0.5 1505 P load (kg) 2011 210 G-92 4: S-46 to Tide Water Yea 41 TP ppb 0.946 45675 2: Flows over G92 45675 ac-ft 41 TP ppb 2326 P load (k 53291 39630 ac-ft Lox Slough 2018 P load (kg) S-46





- FWO WQ estimated to be similar to ECB WQ
 - Use MODFLOW outputs for FWO estimates
 - Calculate TP and TN concentrations for 3 flowways
 - Compare FWO with existing condition (ECB)
- FWO and ECB WQ used as starting point for alternatives evaluation
 - Use MODFLOW outputs of project features for all alternatives
 - Calculate TP and TN concentrations for 3 flowways
 - Compare concentrations with ECB, FWO and WQ standards.





- Total phosphorus treatment efficiencies conservatively estimated based on literature values, past Everglades performance, and best professional judgment:
 - Deep reservoirs assumed to have a concentration reduction of 15%
 - Shallow impoundments assumed to have a concentration reduction of 20%
 - Natural storage features assumed to have a 20% concentration reduction



Summary for TP Concentrations and Loads



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MODFLOW flow results used to calculate flow, loads, and TP

(Site	ECB TP (ppb)	ECB Loads (kg)	FWO TP (ppb)	FWO Loads (kg)	Alt 2 TP (ppb)	Alt 2 Loads (kg)	Alt 5 TP (ppb)	Alt 5 Loads (kg)	Alt 10 TP (ppb)	Alt 10 Loads (kg)	Alt 13 TP (ppb)	Alt 13 Loads (kg)
	CS3	92	6,428	92	6,430	92	<mark>6,494</mark>	76	6,415	35	1,764	92	<mark>6,502</mark>
	C-18W	41	2,226	41	2,294	34	2,276	28	2,279	31	<mark>2,621</mark>	25	1,742
	G-161	10	0	10	0	10	12	10	34	35	463	10	13
	G-92	41	3,502	41	3,517	24	2,636	21	2,265	22	2,521	19	1,885
	Lainhart	43	5,674	43	5,688	31	4,805	28	4,432	28	4,676	27	4,075
	S-46	41	2,326	41	2,326	24	1,093	21	1,006	22	1,017	19	858
	LR_NWF	50 *	12,695	50 *	12,709	41*	10,980	39*	10,607	39 *	11,080	39*	10,142
*	T <u>arget 54</u>	ppb											





MODFLOW flow results used to calculate flow, loads, and TN concentrations (ppb) for ECB, FWO and 4 Alternatives:

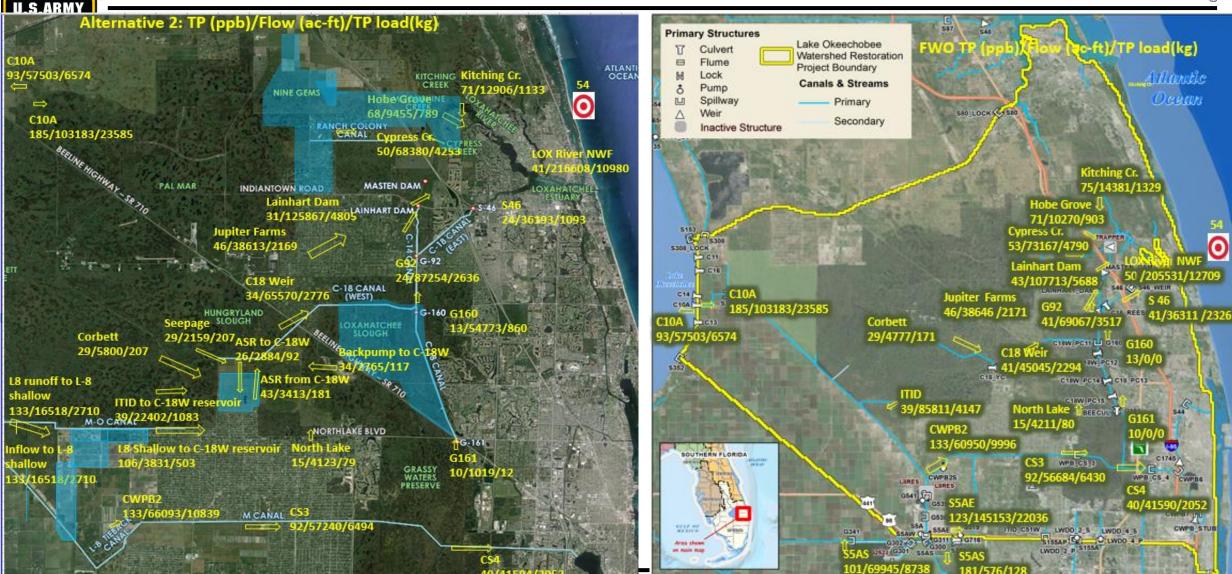
Site	ECB TN (mg/L)	ECB Loads (tons)	FWO TN (mg/L)	FWO Loads (tons)	Alt 2 TN (mg/L)	Alt 2 Loads (tons)	Alt 5 TN (mg/L)	Alt 5 Loads (tons)	Alt 10 TN (mg/L)	Alt 10 Loads (tons)	Alt 13 TN (mg/L)	Alt 13 Loads (tons)
G-92	0.92	78	0.92	78	0.87	94	0.87	96	0.87	102	0.87	88
S-46	0.95	53	0.95	53	0.90	40	0.90	44	0.90	42	0.90	41
LR_NWF	1.17*	297	1.17*	297	1.11*	297	1.11*	299	1.12*	<mark>314</mark>	1.12*	289

Summary for TN Concentrations and Loads

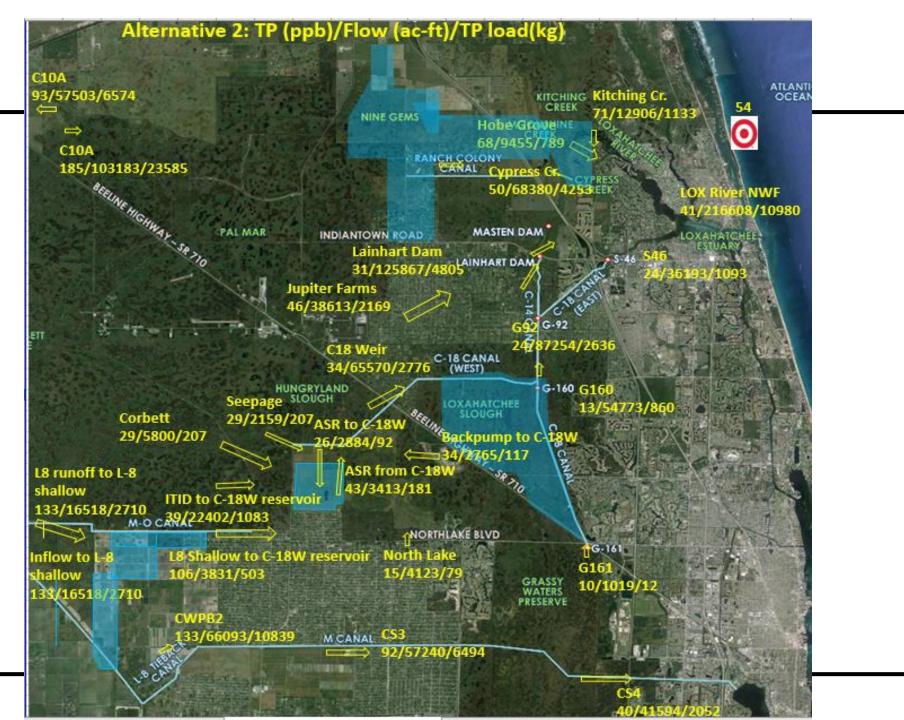
*Target 1.20 mg/L

Alternative 2







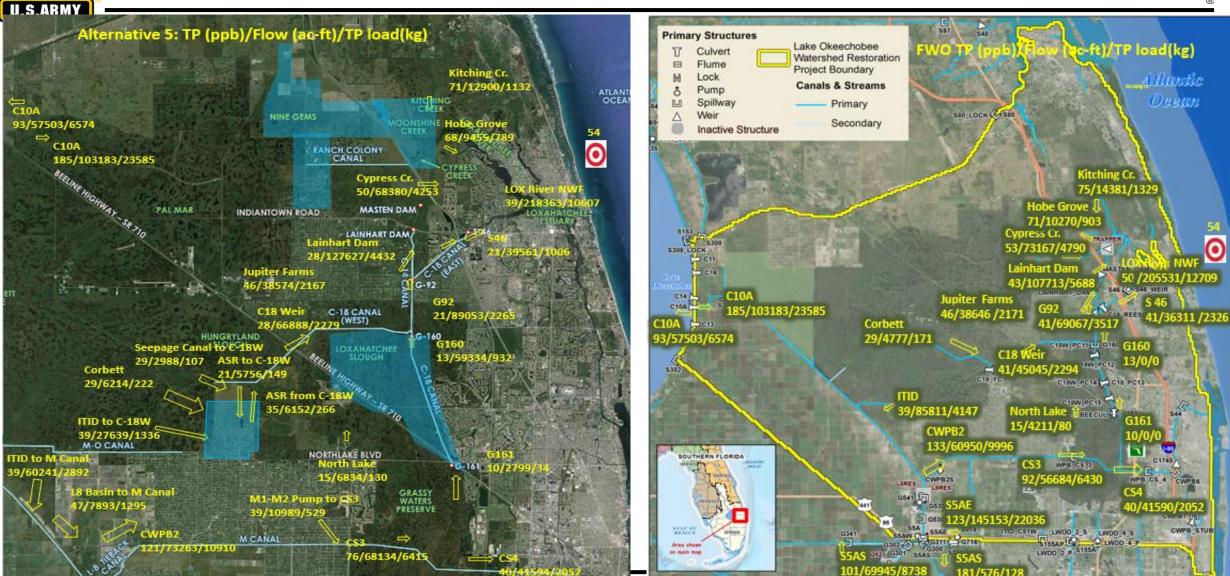






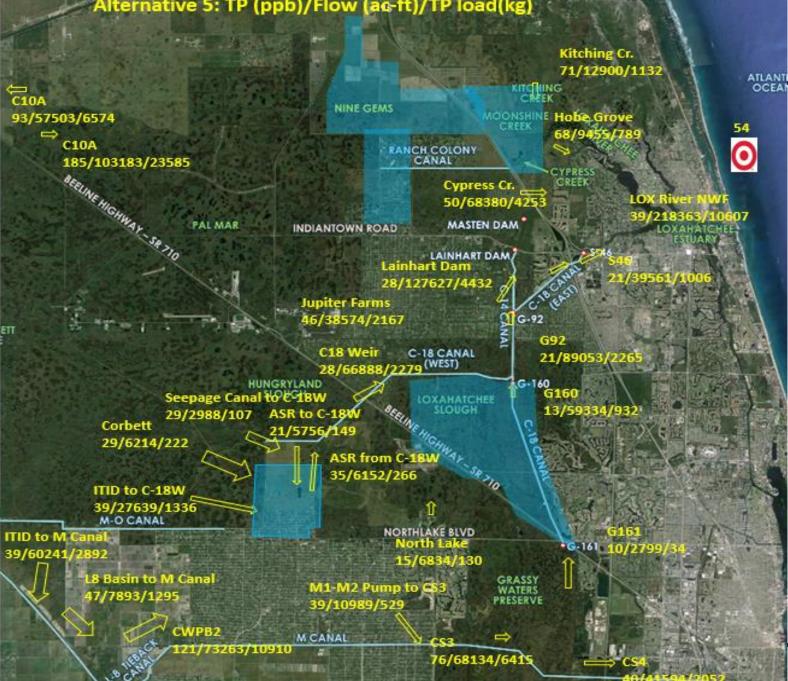
Alternative 5







Alternative 5: TP (ppb)/Flow (ac-ft)/TP load(kg)

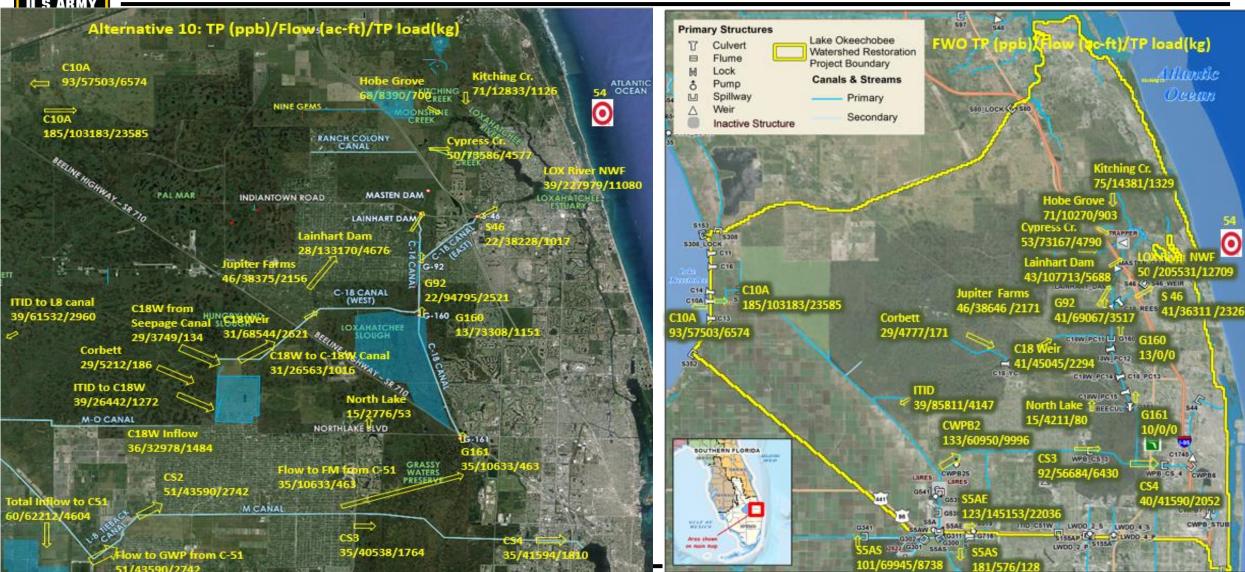






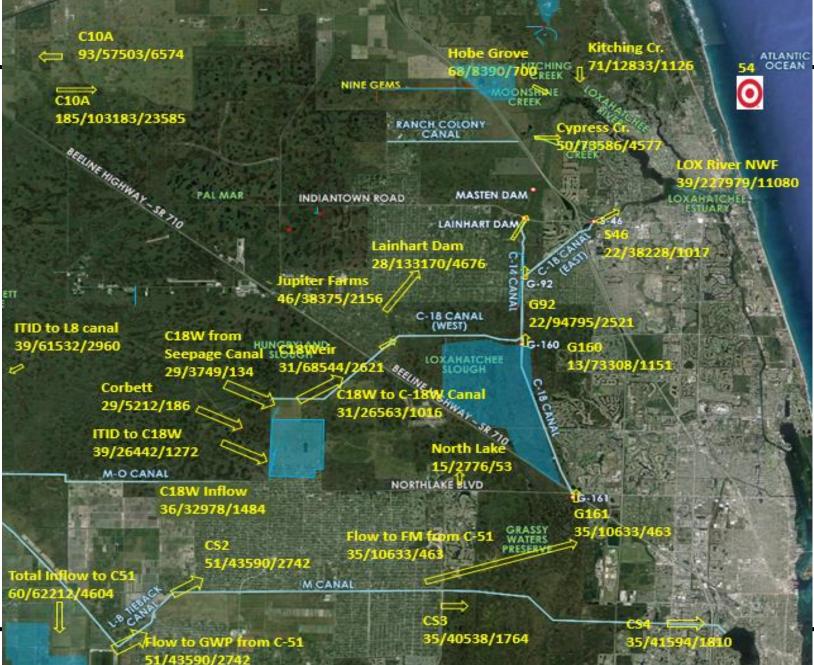
Alternative 10







Alternative 10: TP (ppb)/Flows(ac-ft)/TP load(kg)

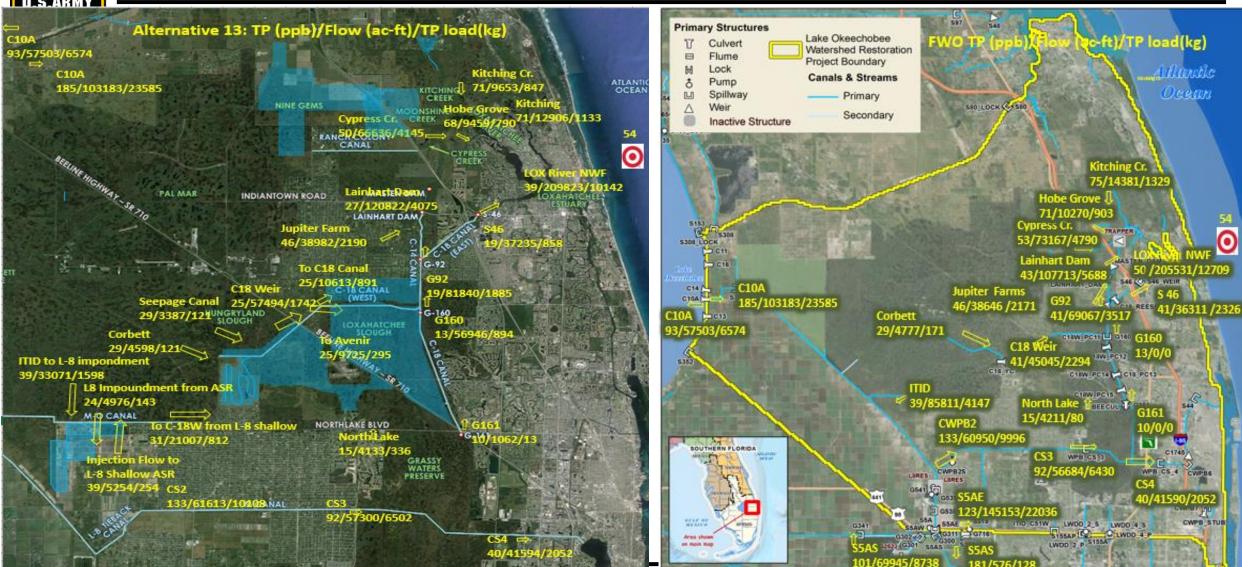






Alternative 13







Alternative 13: TP (ppb)/Flow (ac-ft)/TP load(kg) C10A 93/57503/6574 • • las C10A Kitching Cr. KITCHING 71/9653/847 ATLANTI 185/103183/23585 OCEAN NINE GEMS Kitching Cypress Cr. CREEK 68/9459/79071/12906/1133 RAN SPLESS 5/4145 54 0 BEEINE HIGHWAY-SE 710 CYPRESS CREEK NF PALMAR 10142 LainhasteDown INDIANTOWN ROAD 27/120822/4075 LAINHART DAM **Jupiter Farm** 46/38982/2190 G-92 To C18 Canal 25/10613/891 **G92** C18 Weir 19/81840/1885 Seepage Canal 25/57494/1742 (WEST) 29/3387/121UNGRYLAND SLOUGH G-160 G160 LOXAHATCHEE SLOUGH Corbett 13/5694 29/4598/121 25/9725/295 **ITID to L-8 impondment** 39/33071/1598 L8 Impoundment from ASR 24/4976/143 MIQ CANAL NORTHLAKE BLVD To C-18W from L-8 shallow NorthLake -31/21007/812 15/4133/336 **Injection Flow to** GRASSY WATERS PRESERVE L-8 Shallow ASR 39/5254/254 CS2 133/61613/10208 NAL CS3 92/57300/6502



Specific Conductance Analysis for Alt 10



ARMY			
	Alt 10 Max	Alt 10 Expected	ECB
C-51 Area (acres)	1	1,600	-
C-51 Volume (ac-ft)	4.	4,000	-
C-51 Depth (ft)		27.5	-
Seepage rate (in/day)	0.33 ¹	0.25 ²	
Annual seepage Qseep (ac-ft)	16,060	12,034	-
% of Seepage (Qseep/Qtotal)	26%	19%	-
Seepage Specific Conductance (µS/cm)	3,220 ³	3,220	-
Specific Conductance of C-51 Reservoir (µS/cm)	1,053	936	-
Specific Conductance of C-51 Reservoir at CS2 (µS/cm)	758 ⁴	709	548
Seepage Specific Conductance (μ S/cm) for 800 (μ S/cm) target at CS2	3,700	4,565	-

*Note: 1 - data in the dry season period of 4/28-6/17/2011 in L-8 reservoir extended to 365 day for maximum; 2 - extended 182 days of dry season and 183 days for half of the seepage rate for wet season; 3 - observation of L-8 FEB in 2016-2018. 4 – assumes mixing in L8 Canal











Historic Conditions Table



	· · · · · · · · · · · · · · · · · · ·						
			Inflow			Outflow	
Flowway	Basin/natural area	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Volume (ac-ft)	TP (mg/L)	TN (mg/L)
3	PalMar	Not measured	Not measured	Not measured	Not measured	Not measured	Not measured
3	Cypress Creek	Not measured	0.079	1.11	20,886	0.053	<1.54
3	Hobe-St.lucie	Not measured	0.110	1.26	3,759	0.071	<1.54
3	Kitching Creek	Not measured	0.079	1.32	10,534	0.075	1.363
2	C-18 Basin	27804	0.029	1.00	44594	0.017	0.98
2	C-18 Basin	16790	0.017	1.225	44594	0.029	1.037
2	Lox Slough	20639	0.015	1.011	34081	0.029	0.81
1	Lake Okeechobee C10A	103183	0.185	2.45			
1	L-8+Lake to C51	117925	0.143	2.3	117925	0.123	1.636
1	ITID	27804	0.039	1.352	27804	0.039	1.352
1	GWP	13442	0.01	0.839	2977 *	0.01	0.839
1	GWP	13442	0.01	0.839	17660 **	0.013	1.011
River	Loxahatchee River NWF Middle Estuary	101599	0.049	1.17			
River	(Southwest Fork)	45675	0.041	0.946			
NM = N	ot measured						







U.S.ARMT		r		Outflow				
			Inflow			Outflow		
Flowway	Basin/natural area	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	
3	PalMar	Not measured	Not measured	Not measured	Not measured	Not measured	Not measured	
	Cypress Creek	Not measured	0.079	1.11	73,167	0.053	<1.54	
3	Cypress Creek	Not measured	0.079	1.11	/3,10/	0.055	×1.54	
3	Hobe-St.lucie	Not measured	0.110	1.26	10,270	0.071	<1.54	
3	Kitching Creek	Not measured	0.079	1.32	10,534	0.075	1.363	
2	C-18 Basin	4777	0.017	1	45045	0.017	0.98	
2	C-18 Basin	40268	0.043	1.104	45045	0.029	1.037	
2	Lox Slough	4211	0.015	1.011	0	0.029	0.81	
	Lake Okeechobee							
1	C10A	103183	0.185	2.45				
	L-8+Lake	101003	0.122	2.3	-85811	0.000	0.000	
1	L-8+Lake	101003	0.123	2.3	-83811	0.000	0.000	
1	ITID	85811	0.039	1.352	85811	0.039	1.352	
1	GWP	56684	0.01	0.839	2977 *	0.01	0.839	
1	GWP	56684	0.01	0.839	17660 **	0.013	1.011	
	Loxahatchee River							
River	NWF	205531	0.050	1.17				
	Middle Estuary							
River	(Southwest Fork)	36311	0.041	0.946				



Alternative 2 Table



		Inflow					
Basin/natural area	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Data Sources
PalMar	Not measured	Not measured	Not measured	Not measured	Not measured	Not measured	Not applicable
- anvia	Hot measured	Not measured	Hot medsared	Hot medsared	tot incusared	in the inclusion co	Not applicable
Cypress Creek	Not measured	0.079	1.11	68,380	0.050	<1.54	LRD 2016
Hobe-St lucie	Not measured	0.110	1 26	9.455	0.071	<1 54	LRD 2016
Hobe othere	Hot medbared	0.110	1.20	5,400	0.071	1.04	2010
Kitching Creek	Not measured	0.079	1.32	12,906	0.068	1.363	LRD 2016
C-18 Basin	5800	0.017	1	44594	0.034	0.985	LRD 2016
C-18 Basin	16790	0.017	1.225	65570	0.034	0.985	SFWMD, DBHYDRO, 2017
Lox Slough	13814	0.011	1.011	54773	0.013	0.81	Mock Roos 2017
Lake Okeechobee							
C10A	0	0.000	2.45				
L-8+Lake	129211	0.185	2.3	129211	0.123	1.636	Julian 2016
							IDIT personal
							communication,
ITID	16510	0.020	1 252	16510	0.020	1 252	and SFWMD,
IIID	10518	0.039	1.352	10518	0.039	1.352	DBHYDRO, 2017 SFWMD,
GWP	57240	0.01	0.839	2977 *	0.01	0.839	DBHYDRO, 2017
							SFWMD,
GWP	57240	0.01	0.839	17660 **	0.013	1.011	DBHYDRO, 2017
Loxahatchee River							
	216608	0.041	1.11				Julian 2016
(Southwest Fork)	36193	0.024	0.899				LRD 2016
	PalMar Cypress Creek Hobe-St.lucie Kitching Creek C-18 Basin C-18 Basin C-18 Basin C-18 Basin Lox Slough Lox Slough Lake Okeechobee C10A L-8+Lake L-8+Lake ITID GWP Loxahatchee River NWF Middle Estuary	PalMarNot measuredCypress CreekNot measuredHobe-St.lucieNot measuredKitching CreekNot measuredC-18 Basin5800C-18 Basin16790Lox Slough13814Lake Okeechobee C10A0L-8+Lake129211ITID16518GWP57240Loxahatchee River NWF216608Middle Estuary1160	Basin/natural areaVolume (ac-ft)TP (mg/L)PalMarNot measuredNot measuredCypress CreekNot measured0.079Hobe-St.lucieNot measured0.110Kitching CreekNot measured0.079C-18 Basin58000.017C-18 Basin167900.017Lox Slough138140.011Lake Okeechobee C10A00.000L-8+Lake1292110.185ITID165180.039GWP572400.01Loxahatchee River NWF2166080.041	Basin/natural areaVolume (ac-ft)TP (mg/L)TN (mg/L)PalMarNot measuredNot measuredNot measuredCypress CreekNot measured0.0791.11Hobe-St.lucieNot measured0.1101.26Kitching CreekNot measured0.0791.32C-18 Basin58000.0171C-18 Basin167900.0171.225Lox Slough138140.0111.011Lake Okeechobee00.0002.45L-8+Lake1292110.1852.3ITID165180.0391.352GWP572400.010.839Loxahatchee River NWF2166080.0411.11	Basin/natural areaVolume (ac-ft)TP (mg/L)TN (mg/L)Volume (ac-ft)PalMarNot measuredNot measuredNot measuredNot measuredNot measuredCypress CreekNot measured0.0791.1168,380Hobe-St.lucieNot measured0.1101.269,455Kitching CreekNot measured0.0791.3212,906C-18 Basin58000.017144594C-18 Basin167900.0171.22565570Lox Slough138140.0111.01154773Lake Okeechobee C10A00.0002.45129211ITID165180.0391.35216518GWP572400.010.8392977 *Loxahatchee River NWF2166080.0411.11Middle Estuary0.0411.111.11	Basin/natural area Volume (ac-ft) TP (mg/L) TN (mg/L) Volume (ac-ft) TP (mg/L) PalMar Not measured 0.050 Hobe-St.lucie Not measured 0.110 1.26 9,455 0.071 Kitching Creek Not measured 0.079 1.32 12,906 0.068 C-18 Basin 5800 0.017 1 44594 0.034 C-18 Basin 16790 0.017 1.225 65570 0.034 Lox Slough 13814 0.011 1.011 54773 0.013 Lake Okeechobee 0 0.0000 2.45	Basin/natural area Volume (ac-ft) TP (mg/L) TN (mg/L) Volume (ac-ft) TP (mg/L) TN (mg/L) PalMar Not measured No



Alternative 5 Table



U.S.AKMY			Inflow		Outflow			
Flowway	Basin/natural area	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	
3	PalMar	Not measured	Not measured	Not measured	Not measured	Not measured	Not measured	
3	Cypress Creek	Not measured	0.050	1.11	68,380	0.050	<1.54	
3	Hobe-St.lucie	Not measured	0.110	1.26	9,455	0.068	<1.54	
3	Kitching Creek	Not measured	0.079	1.32	12,900	0.071	1.363	
2	C-18 Basin	6214	0.029	1	66888	0.028	0.985	
2	C-18 Basin	2988	0.029	1.225	66888	0.028	0.985	
2	Lox Slough	9634	0.014	1.011	59334	0.013	0.81	
1	Lake Okeechobee C10A	103183	0.185	2.45				
1	L-8+Lake	203864	0.133	2.3	203864	0.123	1.636	
1	ITID	27639	0.039	1.352	27639	0.039	1.352	
1	GWP	68134	0.01	0.839	9872	0.01	0.839	
1	GWP	68134	0.01	0.839	6834	0.02	1.011	
River	Loxahatchee River NWF	218363	0.039	1.110				
River	Middle Estuary (Southwest Fork)	39561	0.021	0.899				



Alternative 10 Table



U.S.AKMY	_		Inflow			Outflow			
Flowway	Basin/natural area	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Volume (ac-ft)	TP (mg/L)	TN (mg/L)		
з	PalMar	Not measured	Not measured	Not measured	Not measured	Not measured	Not measured		
з	Cypress Creek	Not measured	0.079	1.11	73,586	0.050	<1.54		
з	Hobe-St.lucie	Not measured	0.110	1.26	8,390	0.068	<1.54	ļ	
з	Kitching Creek	Not measured	0.079	1.32	12,833	0.071	1.363		
2	C-18 Basin	5212	0.017	1	68544	0.031	0.985		
2	C-18 Basin	0	0.000	1.225	68544	0.031	0.985		
2	Lox Slough	13409	0.031	1.011	73308	0.013	0.81	•	
1	Lake Okeechobee C10A	103183	0.185	2.45					
1	L-8+Lake	0	0.000	2.3	43590	0.123	1.636		
								ŀ	
1	ITID	87974	0.039	1.352	87974	0.039	1.352	₽	
1	GWP	40538	0.01	0.839	10633	0.01	0.839	⊥	
1	GWP	40538	0.01	0.839	2776	0.0154385	1.011		
River	Loxahatchee River NWF	227979	0.039	1.12					
River	Middle Estuary (Southwest Fork)	38228	0.022	0.899					



Alternative 13 Table



							BUILDING STRONG
			Inflow			Outflow	
Flowway	Basin/natural area	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Volume (ac-ft)	TP (mg/L)	TN (mg/L)
з	PalMar	Not measured	Not measured	Not measured	Not measured	Not measured	Not measured
з	Cypress Creek	Not measured	0.079	1.11	66,636	0.050	<1.54
3	Hobe-St.lucie	Not measured	0.110	1.26	9,459	0.071	<1.54
з	Kitching Creek	Not measured	0.079	1.32	12,906	0.071	1.363
2	C-18 Basin	4598	0.029	1	57494	0.025	0.985
2	C-18 Basin	0	0.000	1.225	10613	0.025	0.985
2	Lox Slough	10787	0.023	1.011	56946	0.013	0.81
1	Lake Okeechobee	0	0.000	2.45			
1	L-8+Lake	0	0.000	2.3	61613	0.031	1.636
1	ITID	33071	0.039	1.352	33071	0.039	1.352
1	GWP	57300	0.01	0.839	9862	0.010	0.839
1	GWP	57300	0.01	0.839	4133	0.015	1.011
River	Loxahatchee River NWF	209823	0.039	1.116			
River	Middle Estuary (Southwest Fork)	37235	0.019	0.8987			