Preliminary Estimates of Loads to the Refuge After STA-1E is in Operation
DRAFT – May 12, 2005

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1.0 EXECUTIVE SUMMARY

Stormwater Treatment Area 1 East (STA-1E) is a critical component of an integrated set of treatment areas designed to work in unison to achieve the water quality and water quantity goals of Everglades restoration. It was added to the original matrix of STAs in the 1991 Settlement Agreement with a phosphorus discharge target of 50 ppb to achieve the hydropattern restoration and water quality improvement goals for the A. R. M. Loxahatchee National Wildlife Refuge (Refuge) and downstream Everglades, and has been built at an estimated cost approaching $300 million. Because STA-1W was designed to work in concert with STA-1E, it is critical that STA-1E is in operation to avoid additional phosphorus loads to the Refuge. The anticipated phosphorus loadings to the Refuge after STA-1E is in flow-through operation have received much discussion in federal court, at TOC meetings and at STA-1E permit meetings. Preliminary estimates of phosphorus loads to the Refuge after STA-1E is in flow-through operation, as well as a result of other improvements that are underway, were prepared to assist in a more quantitative discussion with stakeholders. Many assumptions were required to make an estimate of the phosphorus loading, and these assumptions will no doubt be subject to debate among the various stakeholders. However, this analysis suggests that by implementing a phased operations plan for STA-1E, phosphorus loads to the Refuge will be reduced compared to the existing conditions.

2.0 DISCUSSION

Phosphorus loadings to the A. R. M. Loxahatchee National Wildlife Refuge (Refuge) have been reduced over the last 10 years as a result of the implementation of EAA Best Management Practices and the initial projects of the Everglades Construction Project, including:

1. construction and operation of the 3,742-acre Everglades Nutrient Removal Project (flow-through operations began August 24, 1994);
2. construction and operation of the additional 2,885-acre treatment area to the ENR project in completion of STA-1W (flow-through operations began July 2000), and
3. diversion of inflows from S-6 to STA-2 (diversion began May 2001).

Phosphorus loads will continue to be reduced over the next few years as a result of several additional State and Federal actions, including:

1. commencement of flow-through operation of STA-1E;
2. completion of enhancements to STA-1W;
3. operation of the new divide structure (G-341) in the Ocean Canal;
4. diversion of Acme Basin B runoff, which presently discharges untreated into the Refuge, to STA-1E for treatment;
5. diversion of portion of the S-5A basin runoff to the expanded STA-2;
6. diversion of the L-8 basin runoff north to the CERP L-8 reservoir; and
7. potential revisions to the WCA-1 regulation schedule.

These various features will incrementally reduce the total phosphorus loads entering the Refuge as discussed below.

2.1 Commencement of flow-through operation of STA-1E

Stormwater Treatment Area 1 East (STA-1E) is a critical part of an integrated set of treatment areas designed to work in unison to achieve the water quality and water quantity goals of the Everglades Protection Area. It was added to the original matrix of STAs in the 1991 Settlement Agreement with a phosphorus discharge target of 50 ppb, in part to achieve the hydropattern restoration and water quality improvement goals for the Refuge and downstream Everglades, at an estimated cost approaching $300 million. Flow-through operation of STA-1E will increase the volume of water entering the Everglades, consistent with ecological goals as well as statutory and legal mandates, including:

1. Hydropattern restoration goals of Everglades Restoration programs
2. Everglades Settlement Agreement (see paragraph 9 and Appendix C),
3. Federal authorization of the STA-1E, including the design objectives of providing flood protection to the C-51 West Basin, water quality treatment, reduction of fresh water inflows to the Lake Worth Lagoon and increasing the volume of water delivered to the Refuge and Everglades ecosystem. (Of historical interest is that the original federal project for the C-51 West basin called for a 1600-acre flood control reservoir that was projected to discharge phosphorus at 191 ppb to the Refuge.); and
4. Florida authorization to increase flows to the Everglades by 28% through the Everglades Forever Act.

Evaluation of any individual STA cannot be performed in isolation, but must be considered in the larger context of the integrated set of STAs. This was envisioned in the goal of balancing flows and loads of Settlement Agreement (see for example page 4 of Appendix C) and the Long-Term Plan. It could be argued that an individual component of the integrated set of STAs should not be placed into operation because it potentially increases flows and/or phosphorus loads to a specific receiving water body, e.g., diversion of water from S-6 to STA-2, while reducing flows to the Refuge, at the same time increases flows to WCA-2A.

Nevertheless, calculations indicate the volume of water to the Refuge should not increase over the 1979-88 base period as a result of flow-through operation of STA-1E. The anticipated inflow volume diverted from the C-51 West Basin to the Refuge, approximately 112,513 acre feet per year, will be less than the volume of water diverted from the Refuge as a result of the S-6 diversion component of STA-2, approximately 133,230 acre feet per year (Burns and McDonnell 1994). During the 1979-88 base period, approximately 4,900 acre feet/year of runoff from the C-51W basin entered the Refuge through the S-5A structures.

There has been a significant increase in water supply deliveries from Lake Okeechobee to the Refuge, estimated to have increased by about 40,000 acre feet per year over water supply deliveries during the 1979-88 base period. This increase may be a result of an increase in water supply demand and possibly as a result of the change in the WCA-1 regulation

schedule. STA-1E will actually help in providing additional treatment area flexibility to treat this water prior to its discharge. An update to the 1994 estimates of flow and phosphorus anticipated to go to STA-1W and STA-1E is being updated as part of the EAA Regional Feasibility Study. In addition, the existing runoff from the L-8 basin to the Refuge (assumed in 1994 to be about 50,000 acre feet per year) is scheduled to be diverted north upon completion of the CERP North Palm Beach County Project (2010-2014).

The performance of STA-1E is anticipated to be better than STA-1W. Vegetation enhancements are underway with Cells 4N, 6 and 4S being managed to encourage SAV instead of emergent vegetation. Net improvement of phosphorus has already been observed in the central and western flow-ways, with 4-week geometric means of grab samples averaging 32 ppb and 119 ppb, respectively. In addition, the Corps will construct a PSTA demonstration project in a portion of Cell 2 that should provide additional treatment enhancement. The Corps has been asked to ensure that PSTA project will be designed and operated to capture and treat the same hydraulic and nutrient loading as the remainder of the STA, thereby ensuring that the other cells of the STA are not overloaded as a result of the PSTA project.

Indirect Benefits to the Refuge. Because STA-1W was designed to work in concert with STA-1E, every year that STA-1E is not in operation has resulted in additional phosphorus loads to the Refuge as a result of:

1. reduced performance of STA-1W resulting from inflows above its design range; and
2. the discharge of untreated water to the Refuge resulting from inflows exceeding the hydraulic capacity of STA-1W.

Flow-through operation of STA-1E will decrease the flow and phosphorus loads to STA-1W, consistent with the intended synchronized operation of the two STAs. The 1994 Conceptual Design anticipated that 15.9% of the S-5A basin runoff would be sent to STA-1E for treatment. Similarly, the 1994 Conceptual Design anticipated that 10.9% of the C-51W basin runoff would be sent to STA-1W for treatment. This balancing of flows and phosphorus loads between STA-1W and STA-1E will enhance the performance of both STAs, resulting in lower phosphorus concentrations and loads discharging from STA-1W and STA-1E to the Refuge.

In addition, flow-through operation of STA-1E will also decrease the flow and phosphorus loads of untreated water discharged to the Refuge through the G-300 and G-301 diversion structures. Presently flows that exceed the capacity of STA-1W are diverted untreated through these structures. Once STA-1E is in flow-through operation, these flows will be able to pass through the new G-311 structure into STA-1E for treatment prior to discharging to the Refuge.

2.2 Completion of enhancements to STA-1W

Construction is also underway on structural and vegetation enhancements to STA-1W that will improve the performance of STA-1W, resulting in lower phosphorus concentrations and loads discharging from STA-1W to the Refuge.

2.3 Operation of the new divide structure (G-341) in the Ocean Canal

When completed later this year, G-341 will reduce the flows and phosphorus loads entering STA-1W by serving as a basin divide, with runoff entering the Ocean Canal to the west of the structure being diverted to STA-2 instead of STA-1W. The 1994 Conceptual Design anticipated that 20.3% of the S-5A basin runoff would be diverted west as a result of this structure and the already completed Ocean and Hillsboro Canal enlargements.

2.4 Diversion of Acme Basin B runoff to STA-1E for treatment

Presently, approximately 5 tons per year of phosphorus is sent untreated to the Refuge from Acme Basin B. Once STA-1E is in flow-through operation and the Acme Basin B diversion project is completed (prior to September 2007), this phosphorus and water will be treated in STA-1E, resulting in a further reduction of phosphorus loads to the Refuge.

2.5 Diversion of a portion of S-5A Basin runoff to the expanded STA-2

An expansion of STA-2 is presently underway, with approximately 2,000 acres scheduled for start-up by December 2006, and an additional 6,500 acres scheduled for startup near December 2008. A portion of the S-5A Basin runoff is anticipated to be diverted to that expanded treatment area. At the same time, the necessary increase in the conveyance capacities of the Ocean, Bolles, Cross and North New River Canals is being evaluated through an EAA Regional Feasibility Study.

2.6 Diversion of the L-8 basin runoff north to the CERP L-8 reservoir

Presently about 50,000 AF/yr of runoff from the L-8 Basin is being discharged to the Refuge, either after treatment in STA-1W (contributing to its overloading) or untreated through G-300/G-301. In addition, about 100,000 - 150,000 AF/yr is discharged to tide through the C-51 Canal. In the future (2010-2015), this runoff will be diverted north to the CERP L-8 reservoir, further reducing phosphorus loads to the Refuge. However, in the interim, when STA-1E begins flow-through operation, this runoff can be sent to STA-1E for treatment, which will improve the performance of STA-1W, thereby reducing the phosphorus loads entering the Refuge from STA-1W.

2.7 Potential Revision to the WCA-1 regulation schedule

Several aspects of the current regulation schedule are responsible for delivery of phosphorus loads to the Refuge under conditions that have unintended water quality impacts. The Refuge staff have indicated they are considering formal revision to the schedule and the

water quality impacts could be assessed during this review. In addition, Susan Sylvester of the Corps is leading a review of regional water management practices to evaluate their influence on the performance of the STAs and associated water quality impacts to the WCAs and Everglades National Park. The District recently requested a temporary deviation from the condition in the current schedule that requires preceding delivery of water supply at times when the stage is above the 14.5 ft level, a level commonly accepted as the stage which increases penetration of water and phosphorus into the interior marsh. Should this request be granted, the amount of phosphorus delivered to the Refuge would be reduced, and unintended adverse impacts averted.

2.8 Estimated Phosphorus Loads to the Refuge

Disclaimer: This information is presented for discussion purposes only and is not intended to supplant the process underway as part of the technical discussions of the Settlement Agreement.

The net effect of the features described above will be a reduction in the amount of water and phosphorus sent to the Refuge. The key factors influencing the loads to the Refuge are:

1. the performance of STA-1W and STA-1E after the on-going enhancements;
2. the portion of the S-5A Basin runoff that is diverted to STA-2 upon completion of the G-341 divide structure;
3. the subsequent 2,000-acre expansion of STA-2;
4. the diversion of Acme Basin B to STA-1E for treatment, and
5. the diversion of L-8 Basin runoff north to the proposed CERP project works.

Many assumptions are required to make an estimate of the phosphorus loading impacts, and these assumptions will no doubt be subject to debate among the various stakeholders. A sensitivity analysis was performed to determine the influence of lower and higher values of these key parameters on the loads to the Refuge. For the purpose of these estimates, the performance of STA-1W was assumed to be similar to the performance over the last 12 months, with an effective settling rate of approximately 18 m/yr; this is likely a conservative assumption in light of the management activities underway to enhance performance of STA-1W. For the purpose of these estimates, the performance of STA-1E was assumed to be between the performance of STA-1W over the last 12 months and the anticipated performance of STA-2, STA-3/4 and STA-6, with an effective settling rate of approximately 23 m/yr (i.e., halfway between 18 m/yr and 28 m/yr). Using the assumptions listed in Table 1, which excludes any impact of possible WCA-1 schedule revisions, estimates of flow and phosphorus loads to the Refuge were prepared, and these are presented in Tables 2-4 for various scenarios:

Existing condition – WY2001-2004 (excluded regulatory releases from Lake Okeechobee during WY2003).

Scenario 1. Flow-through operation of STA-1E, without Acme Basin B diversion.

Scenario 2. Flow-through operation of STA-1E, with Acme Basin B diversion.

Scenario 3. Flow through operation of STA-1E, with Acme Basin B diversion, and a portion of C-51W diverted to tide.

Scenario 4. Flow through operation of STA-1E, with Acme Basin B diversion, and L-8 runoff diverted north to the proposed CERP rock-pit reservoir.

Scenario 5. Flow through operation of STA-1E, without Acme Basin B diversion, and entirety of L-8 runoff diverted to STA-1E.

Table 1. Summary of the Key Assumptions Used in Estimating Loads to the Refuge

1	S-5A basin runoff diversion to STA-1E matches 1994 Conceptual design assumption of	15.90%
2	S-5A basin runoff diversion to STA-2 matches 1994 Conceptual design assumption of	20.30%
3	C-51W basin runoff diversion to STA-1W matches 1994 Conceptual Design assumption of	10.90%
4	Flows and loads in the future can be represented by flows and loads in past	
5	STA-1W performance can be represented by the long-term settling rate of 18 m/yr	18
6	STA-1E performance can be represented by the long-term settling rate of 23 m/yr	23
7	S-155A will be operated to pass an equivalent volume of Indian Trails WCD runoff to tide	
8	S-155A will be operated to pass an equivalent volume of L-8 Basin runoff that currently goes to tide	
9	PSTA demonstration project will be operated at same hydraulic/nutrient loading rate as STA-1E	
10	PSTA demonstration project will produce TP at levels equal to remainder of STA-1E	
11	C-51 W basin runoff volume calculated from 1997-2001 flows, adj. for lands in STA-1E (1000 AF/yr)	112.513
12	C-51 W basin runoff load calculated from 1997-2001 data (metric tons/yr)	20.958
13	Existing flows to STA-1W are represented by WY2001-WY2004 values (1000 AF/yr)	314.303
14	Existing loads to STA-1W are represented by WY2001-WY2004 values (metric tons/yr)	57.946
15	Base Period (1979-1988) loads from Acme Basin B	1.855
16	Acme Basin B flows are represented by WY1995 - WY2004 values (1000 AF/yr)	33.724
17	Acme Basin B loads are represented by WY1995 - WY2004 values (metric tons/yr)	4.937
18	Portion of Lake Okeechobee water supply deliveries that go to STA-1E	0%
19	Volume of untreated water that went to Refuge through G-300 & G-301 (WY2001-2004) (kAF/yr)	25.744
20	P load in untreated water that went to Refuge through G-300 & G-301 (WY2001-2004) (MT/yr)	4.750
21	P concentration for C-51W equal to flow weighted mean of 1997-2001	151

Using the assumptions listed in Table 1, each of the Scenarios except Scenario 5 results in lower phosphorus loads entering the Refuge as a result of the combination of features to be completed in the next few years. Scenario 5 highlights the need to take into account L-8 runoff during the interim period prior to its diversion north to the proposed CERP rock-pit reservoir. By implementing a phased operations plan for STA-1E, phosphorus loads to the Refuge should be reduced compared to the existing conditions, achieving the goal of improving the Everglades hydropattern without adversely impacting water quality.

A summary of these initial calculations, along with a sensitivity analysis of the key assumptions, is provided below.

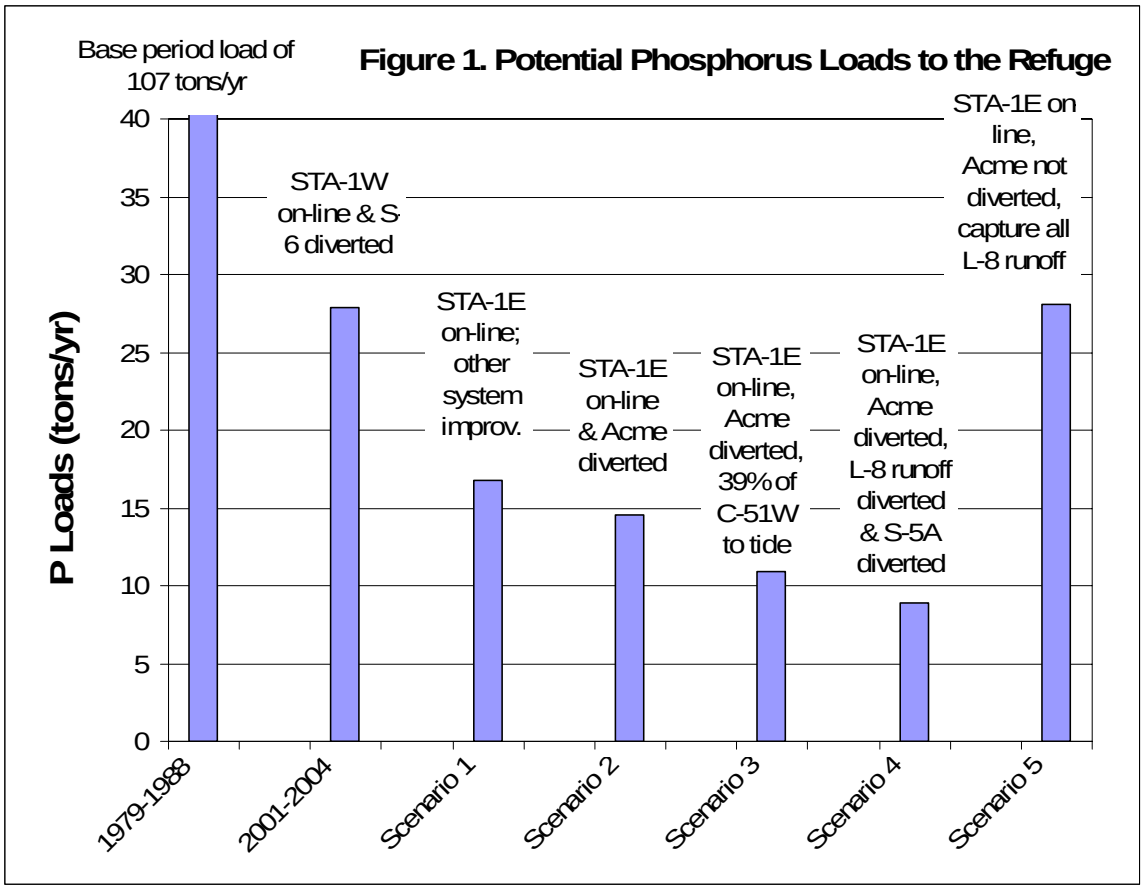

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Table 5. Summary of Phosphorus Load Reductions

Scenario	Load to Refuge tons/year	Improvement Over Base Period tons/year	Improvement Over Existing Condition tons/year
1979-1988	106.855 See Note 1		
2001-2004	27.838 See Note 2	79.017	
Scenario 1	16.785	90.070	11.054
Scenario 2	14.538	92.317	13.300
Scenario 3	10.864	95.991	16.974
Scenario 4	8.877	97.978	18.962
Scenario 5	28.126	78.729	-0.287

Note 1. Base Period load includes Acme Basin B (1.86 tons/yr)
Note 2. Excludes Lake Okeechobee regulatory releases during WY2003

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Table 6. Sensitivity Analysis for Key Assumptions

Factor	Scenario 4 Value	Change in Scenario 4 loads with a reduction in initial value (tons/year)	Change in Scenario 4 loads with an increase in initial value (tons/year)
Performance of STA-1W after the on-going enhancements	18 m/yr settling rate	3.007 (75%)	-1.779 (125%)
Performance of STA-1E after the on-going enhancements	23 m/yr settling rate	2.012 (75%)	-1.101 (125%)
Portion of the S-5A Basin runoff that is diverted to STA-2 upon completion of the G-341 divide structure, and the subsequent 2,000-acre expansion of STA-2	36%	3.669 (20% diversion)	-2.397 (50% diversion)
Diversion of Acme Basin B to STA-1E for treatment	100%	3.358 (0% diversion)	
Diversion of L-8 Basin runoff currently entering STA-1 Inflow Basin north to the proposed CERP project works	100%	2.180 (for 0% diversion)	

Based on a status report provided by Susan Sylvester at a January 19, 2005, Refuge Quarterly Coordination meeting, the Corps is proposing to enhance the L-40 borrow canal and bank as follows:

1. Increase the conveyance capacity of the Refuge canal downstream of STA-1E, including
    a. 3,000 feet of widening the canal from 150 to 300 feet, and
    b. 8,200 feet of dredging the L-40 canal to the original cross section.

2. In addition, the Corps is proposing to install of 1,000 feet of berm on the west bank of the L-40 canal. This should reduce the hydraulic penetration of STA-1E discharges into the interior marsh of the Refuge. The anticipated contract award date is 10/05.

The potential hydraulic impact of the S-362 on the Refuge marsh is presently unknown, but may be significant in the near-field without improvements to the adjacent L-40 borrow canal and western bank. The Corps of Engineers performed steady state modeling in association with the initial pump tests for S-362, however, those simulations probably overestimated the potential hydraulic impacts to the Refuge. This is because:

i. The durations simulated may greatly exceed the anticipated durations anticipated at the flows modeled – particularly the higher flows;
ii. The anticipated discharge hydrographs are highly transient in nature;
iii. The model may not have accurately simulated the ~3 ft north-to-south slope of the Refuge or the L-40 borrow canal;
iv. The model may not have accurately simulated the dense vegetation on the west bank of the L-40 borrow canal; and
v. The initial conditions of the Refuge (e.g., 17.0 ft at the highest discharge rate) represent the worst case scenario – movement of water to the interior marsh will likely be much less at lower Refuge stages.

In light of the uncertainty surrounding the expected performance of the proposed L-40 canal/bank improvements to minimize movement of STA-1E discharges into the unimpacted areas of the Refuge, it is suggested that transient hydrodynamic modeling be conducted to properly evaluate the near-field and far-field effects of STA-1E discharges, both before and after the L-40 enhancements are complete.

3.0 PHASED OPERATION PLAN FOR STA-1E

Given the inter-relationship between phosphorus loading to the Refuge and the various regional activities planned over the next few years, it is critical that the operation of STA-1E be phased accordingly. It is suggested that the STA-1E operation strategy be integrated with STA-1W and other regional operations, including STA-1W operations, flood control operations for the C-51 West, C-51 East and L-8 Basins, and water supply deliveries in order to reduce the potential water quality impacts to the unimpacted areas of the Refuge. It is suggested that the STA-1E operation strategy contain the following key provisions:

1. Discharge of untreated water into the Refuge through the G-300 & G-301 structures should be terminated to the maximum extent practical by diverting the flow through the G-311 structure for treatment in STA-1E prior to discharge to the Refuge, or for discharge to the C-51W canal by gravity through the S-319 pump station and discharge to tide or meet downstream water supply demand.

2. Presently about 50,000 AF/yr of L-8 Basin is being discharged to the Refuge, either after treatment or untreated. In addition, about 150,000 AF/yr is discharged to tide through the C-51 Canal. Until the L-8 basin runoff is diverted north into the proposed CERP project, the S-155A divide structure should be operated to pass at least the same volume of stormwater to tide as L-8 presently discharges to C-51. This will be a mixture of L-8 and C-51W basin runoff.

3. STA-1E and STA-1W should be operated in an attempt to keep their inflows within the range anticipated in the design of enhancements, with an expected mean inflow of ~ 165,000 AF/yr for STA-1E and ~180,000 AF/yr STA-1W. This will require synchronized operation of the S-319 inflow pump to STA-1E and the S-155A divide

structure. ***Until L-8 is fully diverted, flows to STA-1E and STA-1W will likely exceed their design range.***

4. Construction and operation of a PSTA demonstration project in Cell 2 must not hinder the STA-1E operation, i.e., the PSTA project must be designed and operated to treat the same hydraulic and nutrient unit loading that STA-1E was designed for.

5. Until the L-40 improvements are completed *and shown to be effective*, and except under upstream flooding conditions, discharges from STA-1E should be limited to reduce impacts to presently unimpacted area. Technical staff have not reached consensus on the magnitude of this limit. There are two fundamental approaches to this:
   a. Limit the discharge to a fixed rate. Department Of Interior staff have calculated that 550 cfs will likely avoid impacts.
   b. Another approach is to create discharge rate limits using conceptual TP and stage relationships. One possible flow limitation relationship is presented in Figure 2. To understand the magnitude of the volume associated with the discharge rates in Figure 2, a probability plot for the simulated STA-1E discharges is shown in Figure 3 below. The potential impact to the STA treatment cells of limiting the outflow rates shown in Figure 2 can best be assessed by using a hydraulic model of STA-1E and varying the outflow limits to determine the effect on water depths within the STA and limitations on inflow pumping. Lacking the time for such a series of simulations, the existing simulated outflow rates developed for the Basin Specific Feasibility Study were analyzed. A frequency analysis was performed on the 31-yr period of simulated outflows which identified the percentages of time and total volume that the simulated outflow exceeded specific capacities. The results are shown in Figure 3 and accompanying Table 5. These indicate that only 0.5% of the time is the simulated outflow in excess of 2500 cfs. Similarly, only 8.6% of the total volume was simulated as occurring at flows above 2500 cfs. Although this analysis cannot accurately estimate the complete effect on treatment cell depths and potential inflow pumping rates, it does give a coarse view of these potential impacts.

6. In order to better understand potential water quality impacts associated with the intrusion of treated water into the interior marsh of the Refuge, collection and analysis of hydrological and certain water quality data will be conducted by the Department of the Interior before and during the initial operation of STA-1E. The STA-1E operation plan should be reviewed and revised periodically based on the results of the downstream monitoring and upstream flood control and water supply levels of service.

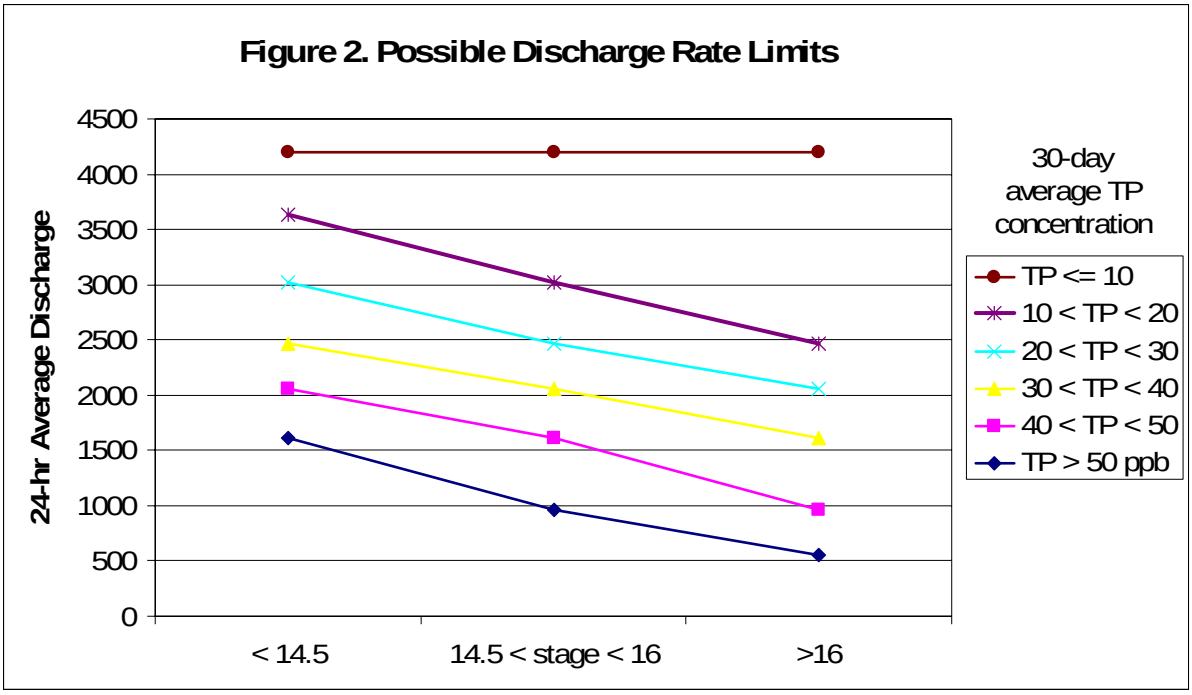

Figure 3. Probability Plot For S-362, the STA-1E Outflow Pump

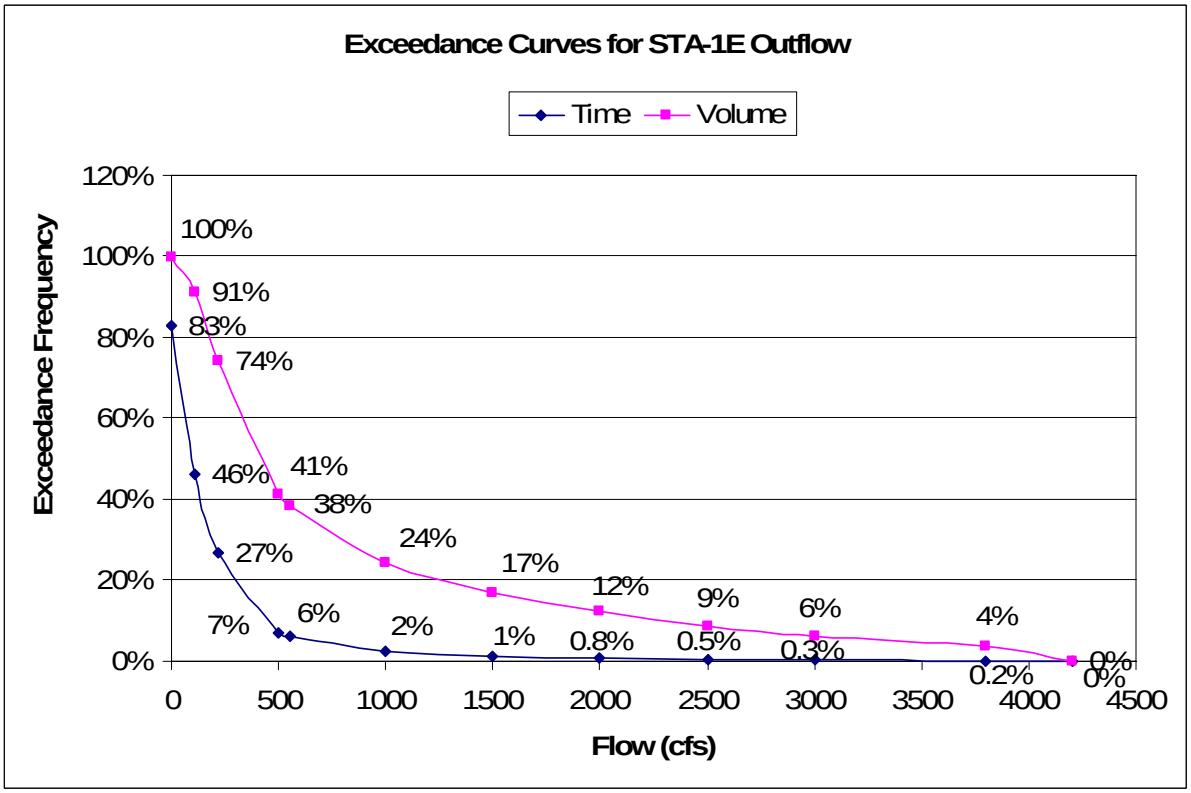

Table 5. Exceedance Relationship for Simulated Flows From S-362.

Flow cfs	Portion of Time the Flow is Exceeded	Portion of Volume Ocurring When the Flow is Exceeded
0	83.0%	100.0%
110	46.2%	90.9%
220	26.7%	74.1%
500	7.1%	41.2%
550	6.1%	38.5%
1000	2.5%	24.4%
1500	1.3%	16.7%
2000	0.8%	12.5%
2500	0.5%	8.6%
3000	0.3%	6.0%
3800	0.2%	3.5%
4200	0.0%	0%

Table 2.

Refuge loading scenarios		**Existing Conditions** WY2001-WY2004		**Scenario 1** **STA-1E on-line; before Acme diversion**	
Base Period (1979-1988) load to Refuge (incl. Acme) tons/yr =	106.855	S-5A basin diversion % to STA-1E	0%	S-5A basin diversion % to STA-1E	16%
		S-5A basin diversion % to STA-2	0%	S-5A basin diversion % to STA-2	20%
		% of Lake O water supply to STA-1E	0%	% of Lake O water supply to STA-1E	0%
		L-8 diversion to STA-1E	0%	L-8 diversion to STA-1E	100%
		Acme Basin B diversion to STA-1E	0%	Acme Basin B diversion to STA-1E	0%
		Balance of untreated to STA-1E	0%	Balance of untreated to STA-1E	100%
		C-51W basin to STA-1W	7%	C-51W basin to STA-1W	11%
		C-51W basin to STA-1E	0	C-51W basin to STA-1E	89%
		C-51W basin to tide	93%	C-51W basin to tide	0%
		STA-1W k (m/yr)	17.5	STA-1W k (m/yr)	18.0
		STA-1W discharge (ppb)	47	STA-1W discharge (ppb)	24
		STA-1E k (m/yr)	N/A	STA-1E k (m/yr)	23.0
		STA-1E discharge (ppb)	N/A	STA-1E discharge (ppb)	25
		Improvement over existing condition	**0.000**	**Improvement over existing condition**	**11.054**
		Improvement over Base Period	**79.017**	**Improvement over Base Period**	**90.070**

	kAF/y	**ppb**	**MT/yr**	**kAF/y**	**ppb**	**MT/yr**
to STA-1W						
S-5A	256.343	158	49.812	163.547	158	31.780
Lake Okee for water supply	10.896	221	2.971	10.896	221	2.971
C-51W	7.950	84	0.824	12.264	151	2.284
L-8 Canal (L-8 & Lake)	39.108	73	3.515	0.000	73	0.000
total to STA-1W	314.297	147	57.122	186.707	161	37.036
to Refuge from STA-1W	314.297	**47**	18.151	186.707	**24**	5.484
to STA-1E						
S-5A	0.000	158	0	40.758	158	7.920
Lake Okee for water supply	0.000		0	0.000	#DIV/0!	0
C-51W	0.000	151	0	100.249	151	18.674
L-8	0.000	73	0	39.114	73	3.516
Acme Basin B	0.000	119	0	0.000	119	0
untreated to STA-1E	0.000	150	0	25.744	150	4.750
total to STA-1E	0.000		0	205.865	137	34.860
to Refuge from STA-1E	0.000		0	205.865	**25**	6.364
untreated to Refuge						
mixture of S-5A, L-8, Lake O & C-51W	25.744	150	4.750	0.000	150	0.000
Acme Basin B	33.724	119	4.937	33.724	119	4.937
Total untreated to Refuge	59.468	132	9.687	33.724	119	4.937
total to Refuge	**373.765**	**60**	**27.838**	**426.296**	**32**	**16.785**
C-51W to tide	104.563	151	19.477	0.000	151	0
L-8 to tide	150.331	71	13.167	150.325	71	13.166
total	628.659	**78**	60.482	576.621	**42**	29.951
to STA-2	0.000	158	0.000	52.038	158	10.112
to CERP L-8 project	0.000		0.000	0.000		0.000
Total	628.659			628.659		

Table 3.

Refuge loading scenarios	**Scenario 2**			**Scenario 3**		
	STA-1E online with Acme diversion			**STA-1E on-line; Acme diversion; C-51W to tide**		
Base Period (1979-1988) load to Refuge (incl. Acme) tons/yr = 106.855	S-5A basin diversion % to STA-1E	16%		S-5A basin diversion % to STA-1E	16%	
	S-5A basin diversion % to STA-2	20%		S-5A basin diversion % to STA-2	20%	
	% of Lake O water supply to STA-1E	0%		% of Lake O water supply to STA-1E	0%	
	L-8 diversion to STA-1E	100%		L-8 diversion to STA-1E	100%	
	Acme Basin B diversion to STA-1E	100%		Acme Basin B diversion to STA-1E	100%	
	Balance of untreated to STA-1E	100%		Balance of untreated to STA-1E	100%	
	C-51W basin to STA-1W	11%		C-51W basin to STA-1W	11%	
	C-51W basin to STA-1E	89%		C-51W basin to STA-1E	50%	
	C-51W basin to tide	0%		C-51W basin to tide	**39%**	
	STA-1W k (m/yr)	18.0		STA-1W k (m/yr)	18.0	
	STA-1W discharge (ppb)	24		STA-1W discharge (ppb)	24	
	STA-1E k (m/yr)	23.0		STA-1E k (m/yr)	23.0	
	STA-1E discharge (ppb)	31		STA-1E discharge (ppb)	22	
	Improvement over existing condition	**13.300**		**Improvement over existing condition**	**16.974**	
	Improvement over Base Period	**92.317**		**Improvement over Base Period**	**95.991**	

	kAF/y	**ppb**	**MT/yr**	**kAF/y**	**ppb**	**MT/yr**
to STA-1W						
S-5A	163.547	158	31.780	163.547	158	31.780
Lake Okee for water supply	10.896	221	2.971	10.896	221	2.971
C-51W	12.264	151	2.284	12.264	151	2.284
L-8 Canal (L-8 & Lake)	0.000	73	0.000	0.000	73	0.000
total to STA-1W	186.707	161	37.036	186.707	161	37.036
to Refuge from STA-1W	186.707	**24**	5.484	186.707	**24**	5.484
to STA-1E						
S-5A	40.758	158	7.920	40.758	158	7.920
Lake Okee for water supply	0.000	#DIV/0!	0	0.000	#DIV/0!	0
C-51W	100.249	151	18.674	56.257	151	10.479
L-8	39.114	73	3.516	39.114	73	3.516
Acme Basin B	33.724	119	4.937	33.724	119	4.937
untreated to STA-1E	25.744	150	4.750	25.744	150	4.750
total to STA-1E	239.589	135	39.797	195.597	131	31.602
to Refuge from STA-1E	239.589	**31**	9.055	195.597	**22**	5.381
untreated to Refuge						
mixture of S-5A, L-8, Lake O & C-51W	0.000	150	0.000	0.000	150	0.000
Acme Basin B	0.000	119	0.000	0.000	119	0.000
Total untreated to Refuge	0.000		0.000	0.000		0.000
total to Refuge	**426.296**	**28**	**14.538**	**382.303**	**23**	**10.864**
C-51W to tide	0.000	151	0	43.993	151	8.195
L-8 to tide	150.325	71	13.166	150.325	71	13.166
total	576.621	**39**	27.704	576.621	**45**	32.225
to STA-2	52.038	158	10.112	52.038	158	10.112
to CERP L-8 project	0.000		0.000	0.000		0.000
Total	628.659			628.659		

Table 4.

Refuge loading scenarios		**Scenario 4** **STA-1E on line; L-8 diverted north; S-5A diverted west**		**Scenario 5** **STA-1E on line; all L-8 captured by STA-1E**	
Base Period (1979-1988) load to Refuge (incl. Acme) tons/yr =	106.855	S-5A basin diversion % to STA-1E	0%	S-5A basin diversion % to STA-1E	16%
		S-5A basin diversion % to STA-2	36%	S-5A basin diversion % to STA-2	20%
		% of Lake O water supply to STA-1E	0%	% of Lake O water supply to STA-1E	0%
		L-8 diversion to STA-1E	0%	L-8 diversion to STA-1E	484%
		Acme Basin B diversion to STA-1E	100%	Acme Basin B diversion to STA-1E	0%
		Balance of untreated to STA-1E	100%	Balance of untreated to STA-1E	100%
		C-51W basin to STA-1W	11%	C-51W basin to STA-1W	11%
		C-51W basin to STA-1E	89%	C-51W basin to STA-1E	89%
		C-51W basin to tide	0%	C-51W basin to tide	0%
		STA-1W k (m/yr)	18.0	STA-1W k (m/yr)	18.0
		STA-1W discharge (ppb)	24	STA-1W discharge (ppb)	24
		STA-1E k (m/yr)	23.0	STA-1E k (m/yr)	23.0
		STA-1E discharge (ppb)	17	STA-1E discharge (ppb)	40
		Improvement over existing condition	**18.962**	**Improvement over existing condition**	**-0.287**
		Improvement over Base Period	**97.978**	**Improvement over Base Period**	**78.729**

	kAF/y	**ppb**	**MT/yr**	**kAF/y**	**ppb**	**MT/yr**
to STA-1W						
S-5A	163.547	158	31.780	163.547	158	31.780
Lake Okee for water supply	10.896	221	2.971	10.896	221	2.971
C-51W	12.264	151	2.284	12.264	151	2.284
L-8 Canal (L-8 & Lake)	0.000	73	0.000	0.000	73	0.000
total to STA-1W	186.707	161	37.036	186.707	161	37.036
to Refuge from STA-1W	186.707	**24**	5.484	186.707	**24**	5.484
to STA-1E						
S-5A	0.000	158	0.000	40.758	158	7.920
Lake Okee for water supply	0.000	#DIV/0!	0	0.000	#DIV/0!	0
C-51W	100.249	151	18.674	100.249	151	18.674
L-8	0.000	73	0.000	189.438	73	17.028
Acme Basin B	33.724	119	4.937	0.000	119	0.000
untreated to STA-1E	25.744	150	4.750	25.744	150	4.750
total to STA-1E	159.717	144	28.361	356.190	110	48.372
to Refuge from STA-1E	159.717	**17**	3.393	356.190	**40**	17.705
untreated to Refuge						
mixture of S-5A, L-8, Lake O & C-51W	0.000	150	0.000	0.000	150	0.000
Acme Basin B	0.000	119	0.000	33.724	119	4.937
Total untreated to Refuge	0.000		0.000	33.724		4.937
total to Refuge	**346.424**	**21**	**8.877**	**576.621**	**40**	**28.126**
C-51W to tide	0.000	151	0.000	0.000	151	0.000
L-8 to tide	150.325	71	13.166	0.000	71	0.000
total	496.749	**36**	22.043	576.621	**40**	28.126
to STA-2	92.796	158	18.032	52.038	158	10.112
to CERP L-8 project	39.114	90	4.339	0.000	0	0.000
Total	628.659			628.659		