PRO EVR 20

MEMORANDUM

TO: **Garth Redfield, District TOC Representative**

FROM: **Gary Goforth, Chief Consulting Engineer, ECP, ERD**

DATE: **January 5, 1999**

SUBJECT: **STA 1 West Interim Operations**

At the November 1998 TOC meeting, members asked for more information regarding the District's proposed operations of STA 1 West during the interim period before the Corps of Engineers completes STA 1 East. Attached is a briefing paper describing these proposed operations. I will be happy to make a presentation at a future TOC meeting to answer any remaining questions on this subject.

Attachment

STA-1W INTERIM OPERATIONS

1. Background.

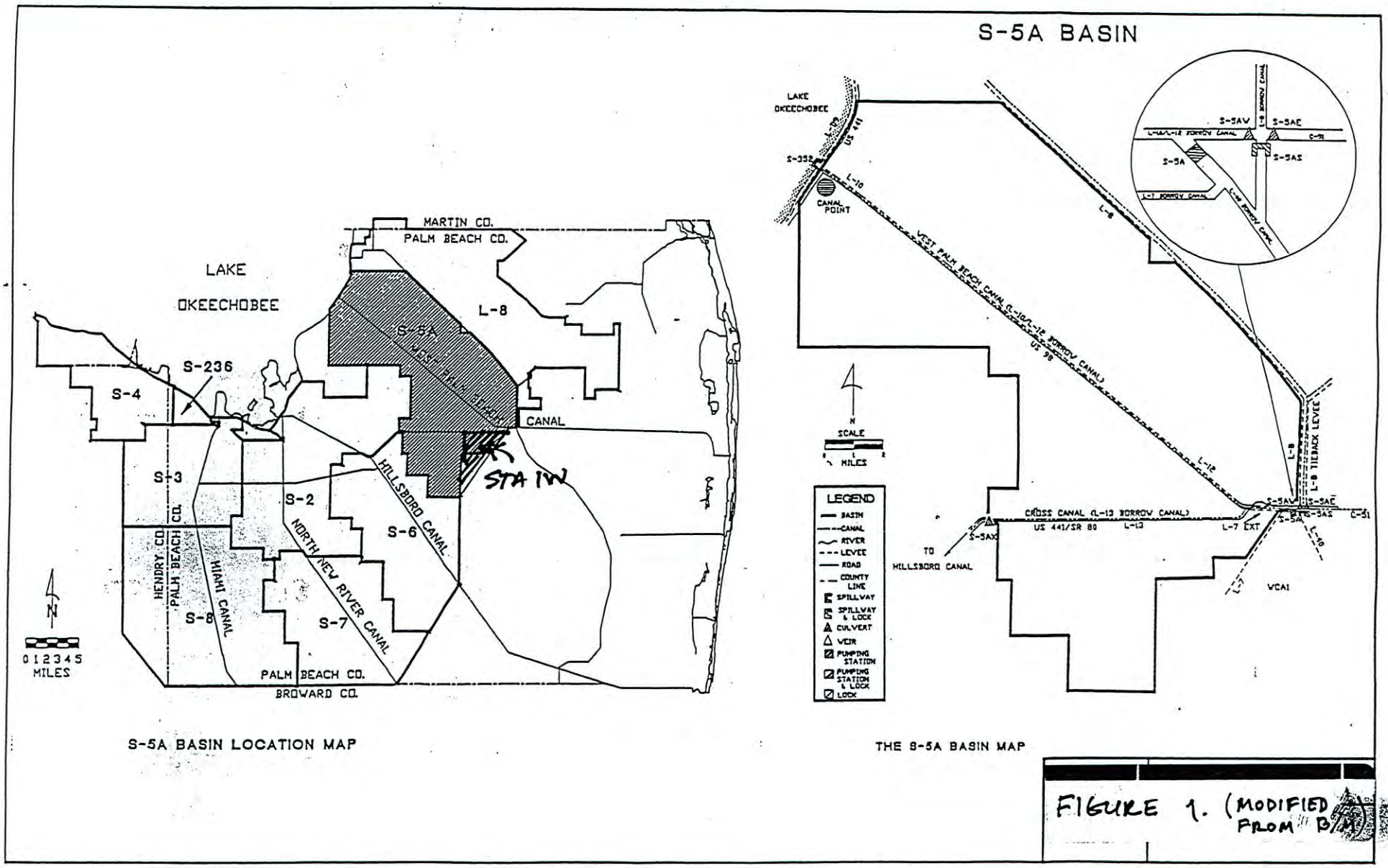
During the 1979-1988 base period, the Loxahatchee National Wildlife Refuge (Refuge) received discharges from the S-5A basin, the S-6 basin, the southern L-8 basin, the C-51 West basin and a small amount of Lake Okeechobee releases (see Figure 1).

Table 1. Base Period (10/1979-9/1988) Average Flows into the Refuge

Source	Annual Volume Ac-ft/yr	Annual Phosphorus Load (metric tons/yr)	Average Phosphorus Concentration (ppb)
S-5A basin	256,802	71.2	225
S-6 basin	154,847	29.1	152
L-8 basin	50,740	3.5	56
C-51 West basin	4,897	0.9	149
Lake Okeechobee	5,212	0.9	134
Totals	**472,498**	**105.6**	**181**

Stormwater Treatment Area 1 West (STA-1W) and STA 2 are two of six wetland treatment systems being constructed to treat waters flowing into the Refuge and the Everglades Protection Area (EPA). When fully operational, STA 2 will divert the entirety of the S-6 basin discharges and associated phosphorus loads, **away from the Refuge**. In addition, approximately 39,600 ac-ft of the S-5A basin flows and associated phosphorus loads will be diverted away from the Refuge (and to the Hillsboro Canal). The effort is required by the Everglades Forever Act (EFA), §373.4592, Fla. Statutes, which was passed by the Florida Legislature in 1994. The EFA expanded the number and effective acreage of the treatment areas contained in the 1991 Settlement Agreement with the United States of America. Based upon the timelines in the 1994 EFA and the 1995 Proposed Modified Settlement Agreement, the STAs will be constructed and begin operation in accordance with a phased schedule. The U.S. Army Corps of Engineers will construct STA 1 East, presently projected to begin start-up operation by July 1, 2002 and to begin full flow through operation in July 2003. STA 1 West and STA 2 are anticipated to begin initial flow-through operations between May and October 1999 and begin full flow-through operations simultaneously in July 2000 upon completion of the new outflow pump stations. STA 3/4 is presently projected to begin operation by October 1, 2003. Neither the 1994 Conceptual Design for the STAs, the 1994 EFA nor the 1995 Proposed Modified Settlement Agreement specified what operational steps the District should take during the interim period when some, but not all, of the STAs were functional.

The District proposes flexibility in operations during this interim period, with the goal of minimizing the total phosphorus loads to the Refuge. This document describes the basis for these flexible operations, and provides planning-level estimates of potential resulting flows and phosphorus loads. Actual flows and loads will of course depend on actual rainfall, runoff and STA performance conditions.



S-5A BASIN LOCATION MAP

THE S-5A BASIN MAP

FIGURE 1. (MODIFIED FROM B/M)

2. Annual Variability in Flow

The average annual inflow volume envisioned in the design assumptions for STA-1W operation contained in the February 15, 1994, *Conceptual Design* for the Everglades Construction Project and the STA-1W Design Reports dated June 5, 1996, October 30, 1996, and January 1997 is 142,859 ac-ft (ac-ft). During normal operations, annual inflow volumes and associated TP loads into STA-1W are expected to fluctuate in response to variations in upstream rainfall and runoff. For example, during the Base Period of record, 1979-1988, the annual average discharge to the Refuge was 472,498 ac-ft, while the minimum and maximum annual discharge volumes for this period of record were 221,869 ac-ft and 639,758 ac-ft, respectively. These minimum and maximum values are 47% to 135% of the average annual value. Base Period discharges to the Refuge included flows from the S-5A basin, the S-6 basin, Lake Okeechobee regulatory releases, East Beach Water Control District, the C-51 West basin and the L-8 basin. A summary of the variability observed in these flows during the Base Period is presented in Table 2.

Table 2. Annual Variability Observed in Base Period Flows into the Refuge

Source	Average Annual Volume Ac-ft/yr	Minimum Annual Volume Ac-ft/yr	Maximum Annual Volume Ac-ft/yr
S-5A basin	256,802	130,441	339,989
S-6 basin	154,847	79,444	252,460
L-8 basin	50,740	4,907	125,199
C-51 West basin	4,897	0	23,375
Lake Okeechobee	5,212	482	29,066
Totals	**472,498**	**221,869**	**639,758**
Compared to Average	**100%**	**47%**	**135%**

3. Treatment Objectives of the Everglades Construction Project.

The EFA and Proposed Modified Settlement Agreement both have a common objective: to reduce discharges of phosphorus into the Everglades Protection Area. Operation of all six STAs will reduce phosphorus concentrations and total phosphorus loads reaching the Everglades, when compared with a historic baseline period of 1979-1988. The STAs are expected to remove approximately 70 percent of the influent phosphorus loads (Settlement Agreement, C-2), and in conjunction with EAA best management practices, discharges from the STAs are expected to reduce long-term average annual phosphorus concentrations to levels at or below 50 parts per billion (ppb) (February 15, 1994 Conceptual Design, IV-2, Settlement Agreement, C-3). The BMP regulatory component of the control program is expected to reduce long-term average phosphorus loads to the EPA from EAA runoff by at least 25%. After construction is completed and phosphorus stabilization is achieved at all the STAs, implementation of these two components of the control program together – BMPs and STAs – is expected to reduce the overall long-term average phosphorus loading from the EAA to the EPA and the Refuge by approximately 80% and 85%, respectively.

4. Operations and Sources of Water During the Interim Period.

Achieving the long-term objectives, however, depends upon completion of all the components of the ECP. In the interim, there will be several phases of operation that will influence the flows and phosphorus loads discharged to the Everglades Protection Area. Specifically for STA 1 West, five phases are contemplated:

1. **Current operations** – ENR project and S-5A pump station.
   a. **Timeframe** (approximate): through 3/19/99 (completion of STA 1 West interior works)
   b. **Inflow**: No change in S-5A pumping capacity (nominal 4,800 cfs) is anticipated; the inflow to ENR is limited during dry season.
   c. **Discharge**: The ENR discharge will be limited to the capacity of the outflow pump station, G-251 (nominal 450 cfs). The discharge from ENR should be similar to what has occurred during the first four years of operation.

2. **Start-up of Cell 5** – ENR project and S-5A pump station.
   a. **Timeframe** (approximate): 3/19/99 – 6/19/99
   b. **Inflow**: Inflow to Cell 5 will be limited to maintain Cell 5 depths between 6 inches and 2 feet to encourage vegetation development. Inflow to the ENR will be limited to the capacity of the historic inflow pump (nominal 600 cfs) and will be reduced if stages at the tailwater of the new inflow structure (G-303) is 4.5 feet for more than 10 consecutive days. Inflow volumes to the ENR should be similar to what has occurred during the first four years of operation.
   c. **Discharge**: Based on the draft operating permit, it is anticipated that no discharge from Cell 5 will occur until the interior phosphorus levels are lower than the phosphorus at the inflow. During this time, the ENR will operate independently of Cell 5. The ENR discharge will be limited to the capacity of the outflow pump station, G-251 (nominal 450 cfs). The discharge through ENR should be similar to what has occurred during the first four years of operation.

3. **Pre-G-310** - S-5A pump station, ENR project, and Cell 5 discharges
   a. **Timeframe** (approximate) 6/19/99 – 7/23/00
   d. **Inflow**: Inflow to the ENR will be limited to the capacity of the historic inflow pump (nominal 600 cfs) and will be reduced if stages at the tailwater of the new inflow structure (G-303) is 4.5 feet for more than 10 consecutive days. Inflow volumes to the ENR should be similar to what has occurred during the first four years of operation.
   b. **Discharge**: Discharge will occur through ENR pump station G-251 (450 cfs) and/or G-310 seepage pumps (200 cfs) and/or through temporary pumps (200 cfs) at G-310 location. The maximum discharge is anticipated to be 450-650 cfs.

4. **Transition – After STA 1 W is fully operational, but before STA 1 E is fully operational**
   a. **Timeframe** (approximate): 7/23/00 – 7/2003
   b. **Inflow**: STA 1 West inflow limited to the capacity of G-302 (nominal 3250 cfs) and will be reduced if stages at the tailwater of the new inflow structure (G-303) is 4.5 feet for more than 10 consecutive days.

c. **Discharge**: Maximum discharge limited to combined capacity of the outflow pumps, G-310 (nominal 2840 cfs plus 200 cfs seepage pumps) and G-251 (nominal 450 cfs).

5. **Normal flows**

a. **Timeframe** (approximate): After 7/2003

d. **Inflow**: STA 1 East is operating, so STA 1 West will be operating at target flows, limited to the capacity of G-302 (nominal 3250 cfs) and will be reduced if stages at the tailwater of the inflow structure (G-303) is 4.5 feet for more than 10 consecutive days.

e. **Discharge**: STA 1West will be operating at target flows, with a maximum discharge limited to combined capacity of the outflow pumps, G-310 (nominal 2840 cfs plus 200 cfs seepage pumps) and G-251 (nominal 450 cfs).

Planning-level Flow Estimates During the 3-yr Transition Period. Although STA-1W will begin operation in 1999, STA-1 East (STA-1E), which is to be constructed by the U.S. Army Corps of Engineers, and which will also treat waters flowing to the A. R. Marshall Loxahatchee National Wildlife Refuge (Refuge), will not begin Start-up operations until 2002. STA 1 East will not be ready for full flow-through operations until 2003, with completely stabilized discharge expected to occur later. **[Please note that the following estimates of flows and loads are planning-level estimates based on 1979-88 conditions – actual flows and loads will vary depending in rainfall, runoff and STA performance.]** Until STA 1E is operating at full flow-through capacity, it is anticipated that a long-term average of 31,000 ac-ft per year of S-5A basin runoff (scheduled eventually to go to STA 1E) will continue to go through the S-5A pump station. Offsetting this volume is a reduction in the design runoff from the C-51W basin of 11,500 ac-ft per year, contemplated to be diverted to STA 1W once STA 1E is fully operational. It is assumed that the 1979-88 base period average of 4,900 ac-ft per year from C-51 W will continue to go to the Refuge. The net is an interim increase of 24,400 ac-ft in the long-term average annual flow assumed to go to the STA 1 Inflow and Distribution Works. Prior to completion of STA-1E, these waters will continue to flow to the Refuge, either as treated discharge from STA 1W or as untreated discharge through the STA 1 Inflow and Distribution Works. After G-310 is complete and before STA 1East is operating, we will be faced with the operating decision of whether to treat flows that will eventually be diverted or bypass untreated these additional flows.

Consistent with the Settlement Agreement and the EFA, the District is also required to offset flow reductions in EAA runoff due to BMPs. For the S-5A basin, some of this BMP replacement water is also contemplated to be diverted to STA 1E. Consistent with the intended operations guidelines in the 1994 Conceptual Design, the BMP replacement water will be delivered to the STAs only if available treatment capacity exists. The District's BMP Replacement Water rule contains the flexibility to reduce delivery to the STAs "when the delivery is likely to cause hydraulic bypass around the STA or otherwise hinder its performance." It is anticipated that BMP replacement water deliveries will be made during the Interim Period only when sufficient treatment capacity is available in the STA.

During the 1979-1988 base period, approximately 50,700 ac-ft (with an associated 3.5 metric tons of phosphorus) from the southern L-8 basin was discharged into the Refuge. District planning efforts underway include construction of diversion works that send waters from the

southern L-8 basin to Lake Okeechobee and other areas, instead of the Refuge where the runoff goes today. In accordance with the load reduction targets of the proposed modified settlement agreement and conceptual design, the southern L-8 basin water will be diverted, with a current schedule of 2003. Prior to completion of STA-1E and the diversion works, these waters may continue to flow to the Refuge, either as treated discharge from STA 1W or as untreated discharge through the STA 1 Inflow and Distribution Works.

ENR operational experience. The STA 1 West project will encapsulate the existing 3,800-acre Everglades Nutrient Removal Project (ENR). Over the first four years of operation, the annual inflow to the ENR project has averaged 126,642 ac-ft per year, with an average depth of 1.88 feet, an average outflow phosphorus concentration of 22 ppb and an average phosphorus load removal of 82%. The minimum annual inflow to the project was 95,779 ac-ft during the year ending July 1998. The maximum annual inflow to the project was 197,921 ac-ft during the year ending July 1996. It should be noted that the majority of the inflows during 1996 resulted from constant addition of around 200 cfs, rather than during large storm events. During the first four years, the average effective settling rate has been 18.5 m/yr, compared to the STA 1 West design assumption of 10.2 m/yr.

ENR Performance as a Function of Depth. From experience with the ENR Project, it is difficult to maintain a monoculture cattail marsh if water depths are maintained at or above 3 ft accompanied by strong winds for periods of time, in that the cattail start to float and are blown around. We have no data to determine how long is too long before the cattail start to float. When cattail float in the ENR Project they are generally replaced by submerged aquatic vegetation. Based on past performance of the ENR and results from the SAV/Limerock study, submerged aquatic vegetation appears to be more efficient than cattail stands at removing phosphorus from the water column. So even if the water depths are too deep for cattails, ENR experience suggests that nutrient removal performance may not suffer.

It should be noted that the while the maximum operational depth for all STA treatment cells has been established at 4.5 ft above average ground elevation, the historical maximum depth at the ENR inflow is 3.5 ft (13.68 ft NGVD) which occurred on 8/23/96. For this same location the longest period of stages in excess of 13.0 ft NGVD occurred from 9/4/94 to 9/21/94. This occurred over a period of approximately 18 days with an associated minimum and maximum depth of about 3.0 to 3.5 ft deep.

Dr. Bill Walker found a positive relationship between depth and phosphorus uptake for a depth range of ~ 2 to 2.8 ft. However, we cannot automatically extrapolate this relationship, or any of the other relationships discussed above, to depths outside of this range to predict performance at higher depths.

Estimates of Loads to the Refuge During 3-yr Transition Period. Planning-level estimates of phosphorus loads to the Refuge were calculated for both operational scenarios during the **3-yr transition period**, i.e., after STA 1 West is fully operational and STA 1 East is not yet operational (July 2000 – July 2003):

1. Bypass of the "additional" water during the interim period, and
2. Treat all flows in STA 1 West.

Table 3. STA-1W INTERIM OPERATING PLAN OPTIONS
Prior to STA-1E on line and L-8 Basin Project complete
Settling Rate = 10.2 m/yr

A. "BYPASS" OPTION: **STA-1E partial diversion and L-8 Basin Runoff bypassed to Refuge untreated**

	Flow Qin (KAF/yr)	TP Conc Cin (ppb)	TP Load In (MT/yr)	
STA-1W Inflow Sources				
S-5A Basin Gross Inflow	206.293	210	53.454	
Land Conversion Reduction	-10.951	209	-2.823	
Hillsboro Canal/STA-2 Diversion	-39.600	209	-10.200	
STA-1E partial divers. to Refuge	-24.400	209	-6.291	
C-51W Basin	4.900	149	0.900	
Lake Okeechobee Releases	2.311	200	0.570	
EBWCD Diversion	4.306	396	2.096	
Total Average Annual Inflow:	142.859	214	37.706	
Outflow Phosphorus Conc.:	49.5 ppb			
STA-1W rainfall	26.975			
STA-1W evapotranspiration	-25.154			
Total Average Annual Outflow:	144.680			
Refuge Inflow Sources				
STA-1W	144.680	49.5	8.829	
Future STA-1E S-5A div	24.400	209	6.291	
L-8 Basin Runoff	50.700	56	3.502	
Total Phosphorus Load to Refuge:			18.622	MT/yr

B. "TREAT ALL" OPTION: **STA-1W treating STA-1E diversion and L-8 Basin Runoff**

	Flow Qin (KAF/yr)	TP Conc Cin (ppb)	TP Load In (MT/yr)	
STA-1W Inflow Sources				
S-5A Basin Gross Inflow	206.293	210	53.454	
Land Conversion Reduction	-10.951	209	-2.823	
Hillsboro Canal/STA-2 Diversion	-39.600	209	-10.200	
C-51W Basin	4.900	149	0.900	
Lake Okeechobee Releases	2.311	200	0.570	
EBWCD Diversion	4.306	396	2.096	
L-8 Basin Runoff	50.700	56	3.502	
Total Average Annual Inflow:	217.959	177	47.499	
Outflow Phosphorus Conc.:	67.0 ppb			
STA-1W rainfall	26.975			
STA-1W evapotranspiration	-25.154			
Total Average Annual Outflow:	219.780			
Refuge Inflow Sources				
STA-1W,S-5A divers.,L-8	219.780	67	18.175	
Total Phosphorus Load to Refuge:			18.175	MT/yr

SUMMARY - INTERIM OPERATING PLAN OPTIONS	
Option	Total Phosphorus Load to Refuge
"BYPASS"	18.622 MT/yr
"TREAT ALL"	18.175 MT/yr

Table 4. STA-1W INTERIM OPERATING PLAN OPTIONS
Prior to STA-1E on line and L-8 Basin Project complete
Settling Rate = 18.5 m/yr

A. "BYPASS" OPTION: **STA-1E partial diversion and L-8 Basin Runoff bypassed to Refuge untreated**

	Flow Qin (KAF/yr)	TP Conc Cin (ppb)	TP Load In (MT/yr)	
STA-1W Inflow Sources				
S-5A Basin Gross Inflow	206.293	210	53.454	
Land Conversion Reduction	-10.951	209	-2.823	
Hillsboro Canal/STA-2 Diversion	-39.600	209	-10.200	
STA-1E partial divers. to Refuge	-24.400	209	-6.291	
C-51W Basin	4.900	149	0.900	
Lake Okeechobee Releases	2.311	200	0.570	
EBWCD Diversion	4.306	396	2.096	
Total Average Annual Inflow:	142.859	214	37.706	
Outflow Phosphorus Conc.:	15.8 ppb			
STA-1W rainfall	26.975			
STA-1W evapotranspiration	-25.154			
Total Average Annual Outflow:	144.680			
Refuge Inflow Sources				
STA-1W	144.680	16	2.814	
Future STA-1E S-5A div	24.400	209	6.291	
L-8 Basin Runoff	50.700	56	3.502	
Total Phosphorus Load to Refuge:			12.607	MT/yr

B. "TREAT ALL" OPTION: **STA-1W treating STA-1E diversion and L-8 Basin Runoff**

	Flow Qin (KAF/yr)	TP Conc Cin (ppb)	TP Load In (MT/yr)	
STA-1W Inflow Sources				
S-5A Basin Gross Inflow	206.293	210	53.454	
Land Conversion Reduction	-10.951	209	-2.823	
Hillsboro Canal/STA-2 Diversion	-39.600	209	-10.200	
C-51W Basin	4.900	149	0.900	
Lake Okeechobee Releases	2.311	200	0.570	
EBWCD Diversion	4.306	396	2.096	
L-8 Basin Runoff	50.700	56	3.502	
Total Average Annual Inflow:	217.959	177	47.499	
Outflow Phosphorus Conc.:	30.4 ppb			
STA-1W rainfall	26.975			
STA-1W evapotranspiration	-25.154			
Total Average Annual Outflow:	219.780			
Refuge Inflow Sources				
STA-1W,S-5A divers.,L-8	219.780	30	8.230	
Total Phosphorus Load to Refuge:			8.230	MT/yr

SUMMARY - INTERIM OPERATING PLAN OPTIONS	
Option	Total Phosphorus Load to Refuge
"BYPASS"	12.607 MT/yr
"TREAT ALL"	8.230 MT/yr

The calculations used the equation for **long-term** phosphorus concentrations developed by Dr. Bill Walker and used in the sizing of the STAs. In light of the fact that the performance of the STA 1 West during this interim period will not be representative of long-term performance, the estimates can only be considered as planning level. Actual inflows, phosphorus loads, and STA performance will undoubtedly vary from the assumptions used, however, these calculations are reasonable to compare among the different scenarios. In recognition of the exceptional performance of the ENR project during the first four years of operation, the calculations used effective settling rates of both k=10.2 m/yr (design assumption) and k=18.5 m/yr (observed at the ENR project). Details of the calculation are presented in Tables 3 and 4, and summarized in Table 5.

Table 5. Comparison of 3-Year Phosphorus Loads To the Refuge (Planning-level estimates)

Scenario	Estimated STA 1W Annual Inflow Ac-ft/yr	3-Year Phosphorus Load (Metric Tons) Settling Rate = 10.2 m/yr	3-Year Phosphorus Loads (Metric Tons) Settling Rate = 18.7 m/yr
Bypass	142,859	55.866	37.602
Full Treatment	217,959	54.525	24.231
Difference	**75,100**	**-1.341**	**-13.371**

Regardless of the effective settling rate, the greatest reduction of phosphorus loads to the Refuge occurs when all the additional flows are treated in STA 1 West. This net benefit to the Refuge increases with the effective settling rate, and experience with the ENR suggests that the settling rate will be higher in the first few years of the project's operation. While the annual volume treated during the Full Treatment scenario exceeded the maximum annual inflow to the ENR project, the larger treatment area of STA 1 West (additional 2980 acres) more than compensates for the additional volume. The average hydraulic loading rate for the Full Treatment scenario is 2.73 cm/day, while the hydraulic loading rate for the ENR during the maximum inflow year was 4.32 cm/day.

5. Comparison of Interim Operation to Historic Flows

It is important to note that all of these waters historically flowed to the Refuge. STA-1E will treat waters from the S-5A Basin and the C-51 West Basin, which historically flowed to the Refuge. BMP replacement waters come from Lake Okeechobee to compensate for the reduction in volume of waters reaching the Refuge because of the implementation of Best Management Practices. Finally, waters which will eventually be diverted to Lake Okeechobee or other points through the L-8 Diversion Projects have historically reached the Refuge. Thus, no new discharges of waters are flowing to the Everglades or the Refuge.

6. Proposed Operations During the Interim Period.

In order to maximize reductions in phosphorus to the Refuge and the EPA during the interim period prior to the complete implementation and stabilization of the control program – when some but not all of the STAs and diversion works are operating at their design conditions – the District shall, to the extent consistent with its responsibilities as the local sponsor of the C&SF Project:

(1) reduce phosphorus loading to the Refuge and the EPA compared to 1979-1988 base period;

(2) optimize the quantity of waters sent through the STAs, subject to their hydraulic, structural and biologic design limitations (with respect to STA-1W, waters flowing into STA-1W cannot exceed the inflow capacity of 3,250 cfs and water depths cannot exceed 4.5 feet, unless during extreme rainfall events, for more than 10 days).

7. Conclusions.

Regardless of the effective settling rate, the greatest reduction of phosphorus loads to the Refuge occurs when all the additional flows are treated in STA 1 West. This net benefit to the Refuge increases with the effective settling rate, and experience with the ENR suggests that the settling rate will be higher in the first few years of the project's operation. It is essential to understand that this proposal does not increase the total volume of waters flowing to the Refuge, and since those waters will be treated, the total phosphorus loads are decreasing compared to the historic data. The District is committed to achieving the load reductions of the Settlement Agreement and the design objectives of the ECP, and ultimately, the restoration of the Everglades. During the interim period prior to completion of all components of the ECP, including the STAs, the District is further committed to maximizing the treatment of phosphorus in the watershed. The above proposal reflects the District's best efforts to achieve those interim objectives.