SOUTH FLORIDA WATER MANAGEMENT DISTRICT

OPERATION PLAN

VEGETATION MANAGEMENT PLAN

PERFORMANCE PLAN

NUBBIN SLOUGH / NEW PALM

STORMWATER TREATMENT AREA

FINAL - November 2005

Gary Goforth, Inc.

WETLAND CONSULTING SERVICES, INC.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

OPERATION PLAN

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November 2005 ***Gary Goforth, Inc.***

CERTIFICATION

I hereby certify, as a Professional Engineer in the State of Florida, that the information in this Operation Plan was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by the South Florida Water Management District or others without specific verification or adaptation by the Engineer. This certification is made in accordance with the provisions of the Laws and Rules of the Florida Board of Professional Engineers under Chapter 61G15-29, Florida Administrative Code.

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Gary F. Goforth, P.E. Florida P.E. # 35525

Date:________________________

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STRUCTURE REFERENCE

Structure Identification	Description	Normal Operations
S-385	5	20
S-386A & B	11	23
S-386C	9	22-23
S-387A-C	14	23
S-385 Diversion weir	5	N/A
S-385 Trash Rack	5	N/A
30-acre storage pond	7	N/A
Emergency overflow sections	15	N/A
Seepage control	17	N/A
Deep zone trenches	17	N/A
Levees	17	N/A
Airboat ramp and crossover	17	N/A

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PLEASE NOTE

During the preparation of this *Operation Plan*, a potential critical hydraulic issue was identified that needs attention to ensure that maximum phosphorus removal of the STA can be achieved.

Capacity of the S-386 and S-387 structures. After review of the hydraulic properties of the S-386A-C and S-387A-C structures, it appears that the hydraulic capacity of the structures is smaller than stated in the design documents, which was to pass the peak flow with a head loss of 1.0 ft or less. For the inlet structure S-386C, the head loss is estimated at 2.6 ft or more at the peak flow of 120 cfs; for the S-386A&B structures, the head loss is estimated at 2.5 ft or more at 60 cfs; for the S-387 structures the head loss is estimated at 1.5 ft or more at 40 cfs. This reduced capacity may increase the stage at peak flow through the STA, particularly in the 30-acre storage pond, which in turn may reduce the freeboard on the levees. It is recommended that the District pursue resolution of this issue with the Corps, perhaps through flow tests after the STA is constructed, to ensure that maximum phosphorus removal of the STA can be achieved. Until this issue is resolved, the Corps and District should consider an appropriate operational remedy such as limiting the number of pumps operating at one time to three, and revising the pump shut-off set point from 37.5 to 36.5 ft NGVD in the 30-acre storage pond.

Depending upon the resolution of this critical issue, this Operation Plan will need to be revised accordingly.

Summary of Start up phase operations

- Revise the STA High-high level set point that shuts off the pumps to 31.7 ft
- The target depth is between 0.5 ft and 1.0 ft
- With the gates at the S-387 structures closed, and the gates at the S-386 structures open fully, raise the water level in Cell 2 to an average of 29.5 ft (i.e., a depth of 1.0 ft), then partially close the S-386A&B gates to an elevation of 31.2 ft and raise the water level in Cell 1 to an average of 31.2 ft (i.e., a depth of 1.0 ft).
- Once flow-through operations begin, reset the STA High-high level set point to its normal setting.

Summary of Normal Operations:

- Wet season
  - The S-385 pumps will operate automatically to supply water to the STA based on the stage in Nubbin Slough
  - The gate at S-386C should remain fully open.
  - The gates at S-386A&B and S-387A-C should be fully open when pumps are on
  - Partially close the gates 1.75 ft when no pumps are running
    - S-386A&B gates closed to elevation 30.75 ft
    - S-387A-C gates closed to elevation 29.0 ft
- Dry season
  - The S-385 pumps will operate automatically to supply water to the STA based on stage in Nubbin Slough
  - The gate at S-386C should remain fully open.
  - The gates at S-386A&B and S-387A-C should be fully open when pumps are on
  - Partially close the gates when no pumps are running
    - S-386A&B gates closed to elevation 32.2 ft
    - S-387A-C gates closed to elevation 30.5 ft

Summary of Extreme Flow Operations:

- Prior to extreme events,
  - the trash rack should be checked to ensure it is clear and working properly, and
  - the gates at the S-386 and S-387 structures should be fully opened.
- As soon as safety permits after extreme events,
  - check the operating status of all the pumps and gates,
  - make repairs if needed, and clear debris if needed

Summary of Drought Operations:

- The S-387 gates should be closed to 30.5 ft and S-386 gates B&C opened as needed to allow water depths in both cells to rise up to 2-2.5 feet, if water is available.
- Maintain a minimum depth of 0.5 ft if water is available; this may necessitate a small portable pumping unit to hydrate Cell 2.
- Following a dry out, keep S-387 gates closed for a period following reflooding to a stage of 29.0 ft, depending on the severity of dry out and the status of the vegetation:
  - if the vegetation is robust, the recommended period of closure following reflooding is approximately two weeks, although site specific conditions may require more or less time for the outflow concentration to drop below the inflow;
  - if the vegetation is damaged, the period of closure will likely be greater, to be determined by field conditions and phosphorus levels.

1 PROJECT DESCRIPTION

1.1 BACKGROUND

The South Florida Water Management District (SFWMD), the U. S. Army Corps of Engineers (Corps), the Florida Department of Environmental Protection (FDEP), other agencies and private landowners are cooperating on efforts to improve water quality in the Lake Okeechobee watershed, and through the south Florida ecosystem. This cooperation includes studies and capital projects composing the Lake Okeechobee Protection Program, the Comprehensive Everglades Restoration Plan (CERP), and Critical Restoration Projects. The Lake Okeechobee Water Retention Phosphorus Removal Project consists of two shallow stormwater treatment areas – the Taylor Creek Stormwater Treatment Area (STA) and the Nubbin Slough STA – designed to remove phosphorus loads from the Nubbin Slough and Nubbin Slough watersheds. High phosphorus loads have been implicated in excessive eutrophication of Lake Okeechobee that have resulted in algal blooms, high oxygen demand, and loss of fisheries and recreational benefits provided by the lake.

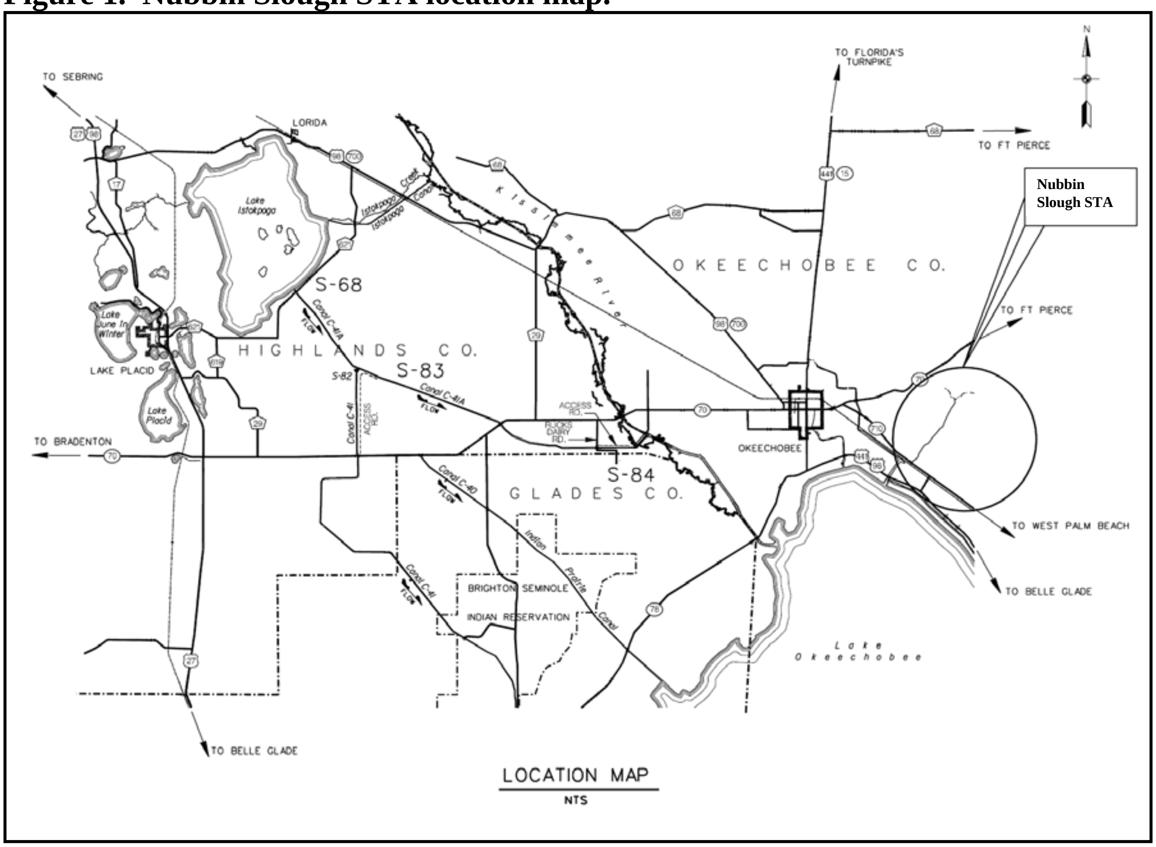
The Nubbin Slough / New Palm STA is one of the Critical Restoration Projects authorized by Congress through Section 528 of the Water Resources Development Act of 1996. The project was designed by Stanley Consultants, Inc. working under contract to the Corps, who was responsible for construction. Construction is presently underway with completion scheduled for early 2006. The SFWMD is the sponsor for the project and assisted in the funding of the capital works and will be responsible for operation and maintenance of the STA. The anticipated long-term average phosphorus reduction within the STA was estimated during the design phase to be greater than 90% (more than 5 tons per year), and greater than 85% of the phosphorus load of Nubbin Slough at the project location (Stanley Consultants, Inc. 2003).

The Nubbin Slough STA is approximately 6.5 miles southeast of the city of Okeechobee (Figure 1), adjacent to Nubbin Slough, immediately north of the State Road 710 and just east of the bridge that spans Nubbin Slough. The STA occupies approximately 809 acres of a 2,135-acre site purchased by the SFWMD. The southern end of this project is approximately 1.3 miles from the edge of Lake Okeechobee. The Nubbin Slough STA is located on a former dairy farm and remediation activities were completed during STA construction.

1.2 OPERATIONAL OBJECTIVES

The goal of the Nubbin Slough STA is to capture and reduce the mass of total phosphorus from the Nubbin Slough Basin prior to discharge back into Nubbin Slough and on to Lake Okeechobee. The phosphorus concentration in Nubbin Slough runoff exhibits considerable variability, with an average of approximately 515 parts per billion (ppb) (Stanley Consultants, Inc. 2003). This value greatly exceeds the phosphorus concentration of Lake Okeechobee, which averages just over 100 ppb. Emergent wetland vegetation (cattail, bulrush, *sagitaria*, *pontedaria*, etc.) should begin to colonize the treatment area after construction completion, and average depths of less than 2 feet should be conducive to sustaining these communities. The long-term phosphorus storage mechanism within the STA will be through accretion of new organic sediment, and for this reason it is important to operate the STA to avoid dry out, which could release nutrient through remineralization of these sediments. Estimates of the STA water budget developed during the project design indicate that average seepage and ET losses will be greater than average surface inflows from Nubbin Slough – hence dry out will likely occur on a regular basis. The anticipated long-term average phosphorus reduction within the STA was estimated during the design phase to be greater than 90% (more than 5 tons per year), and greater than 85% of the phosphorus load of Nubbin Slough at the project location. The FDEP Lake Okeechobee Protection Act (LOPA) permit issued to the Corps for the Nubbin Slough STA indicated the design objective is to reduce the discharge concentration toward a target of 40 ppb, and the Design Analysis Report indicates the design objective is to maximize load reductions (FDEP 2003; Stanley Consultants, Inc. 2003). In addition to the reduction of phosphorus loads and concentrations, the Nubbin Slough STA will provide additional water quality and quantity benefits to downstream waters, including the removal of suspended solids, nitrogen, metals, and pesticides that would otherwise flow into the lake.

Figure 1. Nubbin Slough STA location map.



The Nubbin Slough STA encompasses approximately 809 acres adjacent to Nubbin Slough, and has a rectangular geometry (shown in Figure 2). An inflow pump station lifts water from Nubbin Slough at the western edge of the STA and delivers it through a 48-inch diameter underground force main to a 30-acre storage pond located in the north central portion of the

STA. Treatment occurs through natural biogeochemical processes as the water slowly flows by gravity south and westerly through the 263-acre Cell 1 and subsequently through the 546-acre Cell 2 before being discharged back to Nubbin Slough. Water levels and flow rates through the treatment cells are controlled by gated structures located at the western boundaries of each cell. The predominant grade within the STA creates flow from the east to the west. Deep zone trenches at the inflow and outflow of each cell, and in the center of Cell 2, are designed to help distribute flow evenly throughout the cell. Discharge of treated water to Nubbin Slough will be through three uncontrolled concrete reinforced pipes, the most southerly of which is over 1,200-ft in length in order to avoid contact of the treated discharge with the phosphorus rich soils on site.

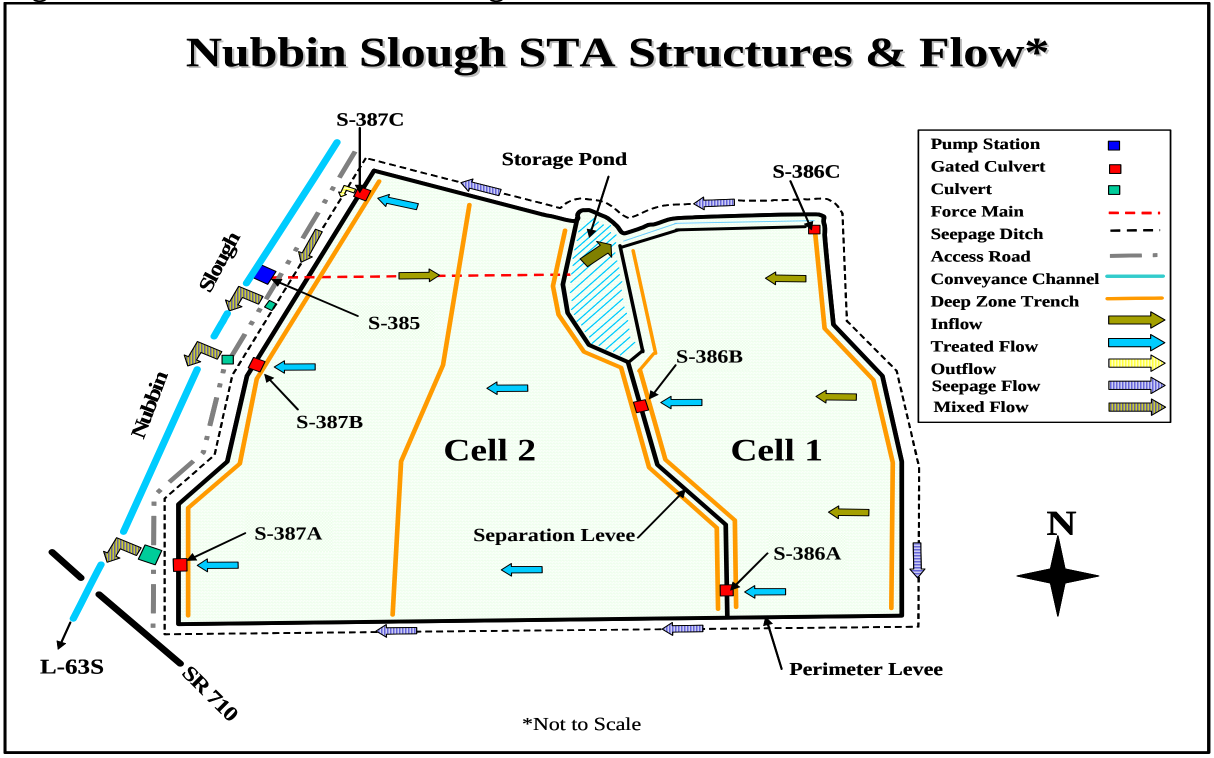
References. This *Operation Plan* for the Nubbin Slough STA was developed based upon the following documents:

1. Stanley Consultants, Inc., Lake Okeechobee Water Retention / Phosphorus Removal Project, Final Design Analysis Submittal, June 2003.

2. Stanley Consultants, Inc., Lake Okeechobee Water Retention / Phosphorus Removal Project, Final Design Document Report Submittal, June 2003.

3. U. S. Army Corps of Engineers, Draft Lake Okeechobee Water Retention / Phosphorus Removal Project – Nubbin Slough (New Palm) Stormwater Treatment Area (STA) Water Control Plan (June 2005).

Figure 2. Schematic of Nubbin Slough STA.



A summary of the key operational parameters is presented in Table 1.

Table 1. Summary of Nubbin Slough STA Operational Parameters

Design Parameter	Cell 1	Cell 2	Entire STA
Treatment Area			
Effective Treatment Area (acres)	251	522	773
Total Area (acres)	263	546	809
Average ground elevation (ft NGVD)	30.2 ±	28.5 ±	29.1 ±
Nominal Length (feet)	2,600	4,800	7,400
Nominal Width (feet)	4,210	4,735	4,550
Aspect Ratio (length:width)	0.6	1.0	1.6
Flow (excluding seepage and ET)			
Average inflow (cfs)	12.2	12.2	12.2
Average annual inflow (acre feet/yr)	8,838	8,838	8,838
Mean depth at design water surface (ft)	2 ±	2 ±	2 ±
Average hydraulic loading rate (ft/yr)	35.2	16.9	11.4
Average hydraulic loading rate (cm/d)	2.9	1.4	1.0
Volume at design water surface (AF)	503	1043	1546
Nominal hydraulic residence time (days)	21	43	64
Nominal linear velocity at average flow (ft/day)	125	111	116
Minimum depth (ft)	0.5	0.5	0.5
Minimum stage (ft NGVD)	30.7 ±	29.0 ±	
Nominal peak flow with 4 pumps (cfs)	120	120	120
Nominal peak flow with 3 pumps (cfs)	96	96	96
Modeled water surface elevation at 93.6 cfs (ft)	32.2	30.3	
Emergency Overflow Section			
Adjacent levee crest (ft NGVD)	36.0	34.5	
Emergency overflow crest (ft NGVD)	35.0	33.5	
Maximum depth at emergency overflow (ft)	4.8	5.0	
Length of emergency spillway (ft)	500	500	

Note: During the preparation of this *Operation Plan,* it was determined that the hydraulic capacity of the interior and outlet water control structures was smaller than stated in the design documents, which may require a reduction in the peak, and therefore the average, flows through the STA, with an associated adjustment to the values in this table.

All ground and water surface elevations are referenced to the 1929 NGVD.

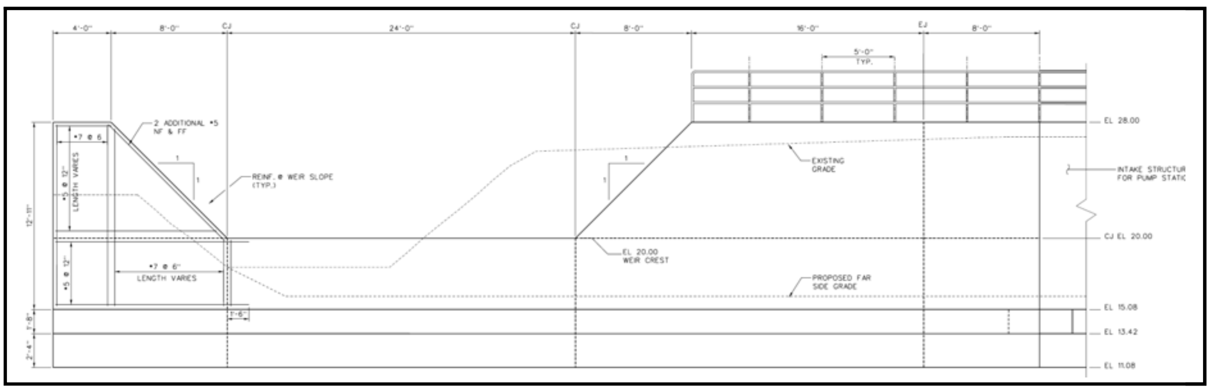
2 STRUCTURE AND CANAL DESCRIPTIONS

The following sections describe the associated project water control structures, canals and related features.

2.1 INFLOW CONTROL FACILITY

Diversion Weir. A diversion weir is located in Nubbin Slough at the intake structure in order to maximize the volume of water available for treatment in the STA while minimizing frequent pump cycling (see Figure 3). It is expected that all but extreme flood flows will be pumped into the STA and treated (Stanley Consultants, Inc. 2003). The weir has a trapezoidal notch, with a 24-foot wide lower crest elevation of 20.0 ft NGVD and an upper crest elevation of 28.0 ft, which will allow high flows to pass the intake structure while passing high flows over a long sill to minimize backwater effects from high flows. There will be no minimum flows maintained over the diversion weir. Flood flows in excess of the pumping rate will overtop the weir and continue downstream via the original watercourse. Hydraulic modeling conducted during the detailed design process, was used in the design of the weir to prevent increased flooding during high flows (Stanley Consultants, Inc. 2003).

Figure 3. Cross section of diversion weir in Nubbin Slough at S-385 pump station.



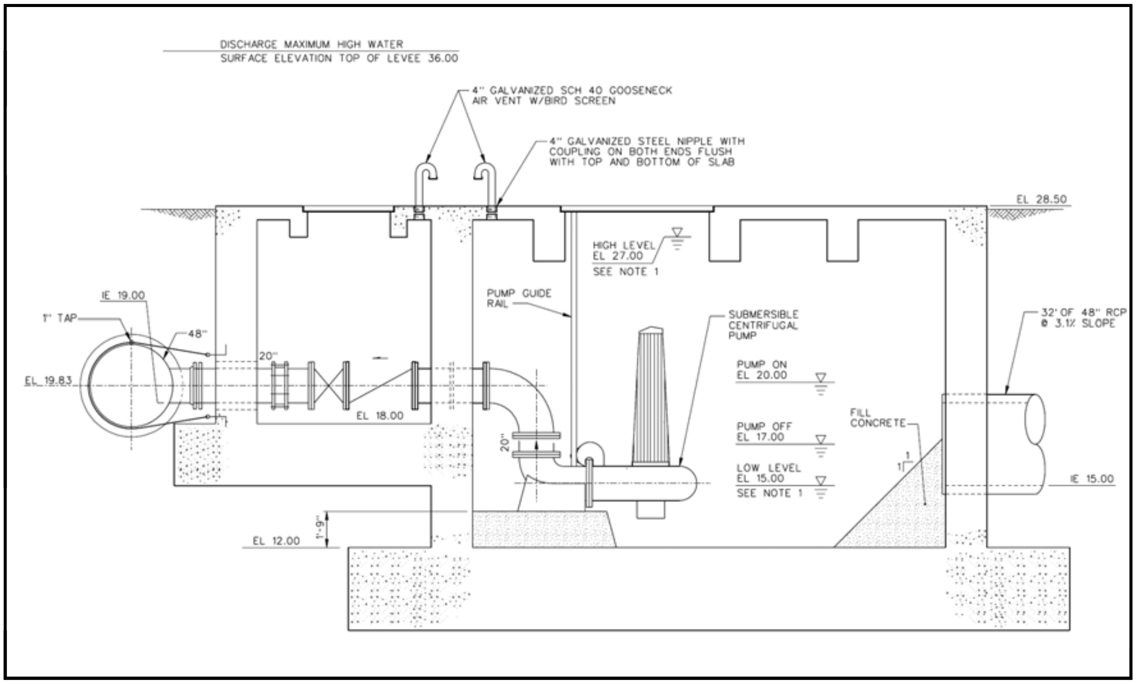
Pump Station. Structure S-385 is the inflow pump station for the Nubbin Slough STA and is located along the western boundary of the STA (see Figure 4). Twin 48-inch diameter by 32-ft long reinforced concrete pipes bring water from Nubbin Slough into the intake bay of the pump station. The pump station has four (4) submersible 20-inch diameter centrifugal pumps with 215-horsepower electric-powered motors. Each pump has a nominal discharge capacity of approximately 36 cfs pumping against a static head of 19 ft; however, friction and other energy losses within the piping system reduce the total pump station capacity, with a combined discharge of approximately 120 cfs (see Section 3 for operational details). A cross section of the pump station wet well is shown in Figure 5. The performance curves and additional manufacturer's information for these pumps are presented in Appendix A. There are no provisions to connect portable emergency power generators at Nubbin Slough, as the pumps are too large for most portable power units (Stanley Consultants, Inc. 2003). The four pumps' outlet pipes enter a common 48-inch diameter 3,340-ft long force main that conveys the intake water into the 30-acre storage pond.

Figure 4. Photograph of S-385 pump station during construction.

<u>Pump Station S-385 Information:</u>

Number of pumps:	4
Discharge capacity (each pump):	36 cfs at a static head of 19.0 ft
Design minimum headwater elevation:	17.0 ft NGVD
Design maximum tailwater elevation:	37.5 ft NGVD
Nominal pump operating speed:	595 rpm
Normal "on elevation":	When Nubbin Slough is 20.0 ft NGVD
Normal "off elevation":	When Nubbin Slough is 17.0 ft NGVD or when storage pond is 37.5 ft NGVD
Motor size:	215 horsepower
Centerline of 48-in discharge culvert:	19.83 ft (invert elevation 17.83 ft NGVD)
Pump station wet well floor elevation:	12.0 ft NGVD

Figure 5. Schematic of pump station S-385 wet well.



NOTE. High level elevation for float switch provides alarm to field office. Low level elevation for float switch provides pump shut-off.

Data Acquisition and Telemetry:
Presently the pumps are designed to work in automatic mode depending on local stage readings and set points. Telemetry control for remote operation and real-time status of each pump is planned for completion in early 2006. Headwater and tailwater sensors provide stage data to the pump operation controls, and eventually, to remote operator at the S-127 control center and at the West Palm Beach operations control center. Headwater and tailwater staff gages are available for manual/local operation.

Water Quality Sampling:
Flow proportional, automatic sampling equipment will be installed approximately 150 feet upstream of the pump station for the purpose of monitoring inflow water quality. Please refer to the Water Quality Monitoring Plan (SFWMD 2005) for updated details.

Trash Rack. The S-385 pump station is equipped with a self cleaning trash rack. The trash rack is driven by a chain that is activated by a preset pressure differential across the rack. Trash removed from the rack is deposited on a concrete pad for subsequent removal and disposal. Additional information is provided in Appendix A.

30-acre Storage Pond. The S-385 intake pump station conveys water from Nubbin Slough through a 48-inch diameter polyethylene pipe to a 30-acre storage pond located on the north central boundary of the STA (see Figure 6). Water from the storage pond flows along the inflow channel to structure S-386C and enters Cell 1 at the northeast corner of the STA (see Figure 7).

Data Acquisition and Telemetry:
A stage sensor will be located in the 30-acre pond approximately 150 feet south of the location that the force main enters the pond, and an “STA High-high alarm” sensor in the pump station will shut off the pumps if the stage exceeds 37.5 ft in the pond.

Figure 6. Storage pond looking south. Cell 1 is to the left and Cell 2 is to the right.

Figure 7. Water enters Cell 1 from the 30-ac storage pond via S-386C, located in the lower right hand corner of the photo. Lake Okeechobee is visible in the background.

2.2 INTERIOR CONTROL STRUCTURES

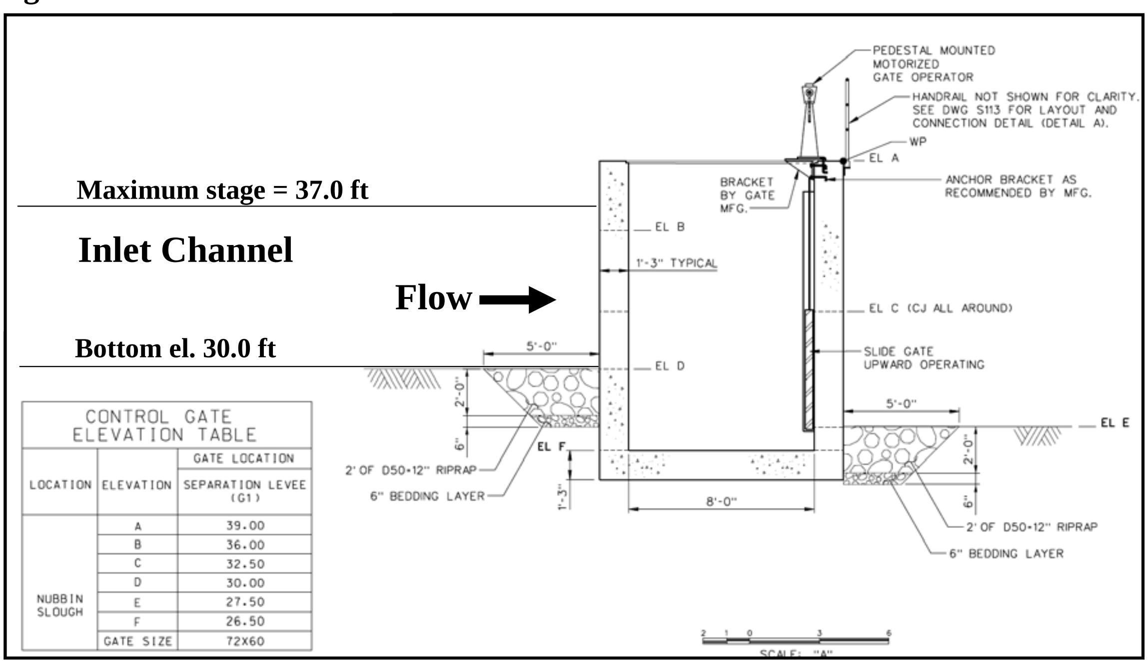
Structure S-386C controls flow from the 30-acre storage pond into Cell 1 from the inlet channel, which has a bottom elevation of approximately 30 ft. Structure S-386C conveys water to a distribution canal at the eastern (upstream) end of Cell 1 that has a bottom elevation of 27.5 ft. S-386C consists of a concrete box with a 6-ft wide by 6-ft high opening on the upstream side and a 6-ft wide by 5-ft high opening on the downstream side (see Figures 8 and 9). The inlet box has a 6-ft wide by 5-ft high upward opening slide gate on the downstream side to control water flow into Cell 1. The gate is operated by means of a pedestal mounted gate operator. Manufacturer's information on the gate and operator are presented in Appendix A. A series of rating curves for this structure is presented in Appendix A, including one chart for the upstream opening and a series of charts for various gate openings.

<u>Data Acquisition and Telemetry</u>

The stage sensor located in the 30-acre pond is the nearest real-time water level indicator to the headwater of S-386C. A gate position indicator sensor is available to monitor the status remotely. The District is planning to install a headwater staff gage and a tailwater staff gage at S-386C. In addition to providing operational information, these gages will assist flow calibration and estimation purposes, which are critical to establishing accurate water and nutrient mass balances for the treatment cells.

Figure 8. Structure S-386C prior to construction completion (August 2005).

Figure 9. Cross section of S-386C.



Water Quality Sampling

At the present time, there is no automatic sampling equipment installed at S-386C, however, the District is planning to either install such equipment or collect a weekly grab sample for total phosphorus at S-386C. This will enable a direct estimate of the phosphorus removal performance of the storage pond and Cell 1 of the STA, which will provide operational feedback to optimize removal performance. Please refer to the Water Quality Monitoring Plan (SFWMD 2005) for updated details.

Structures S-386A and B control flow from Cell 1 into Cell 2. These structures are located in the separation levee between Cells 1 and 2 and have a trash boom on the upstream side. A collection canal with bottom elevation of 27.5 ft is located upstream of these structures. The structures are combination structures consisting of an inlet box fitted to a 3 ft. diameter reinforced concrete pipe approximately 60-ft long (see Figures 10 through 13). Each inlet box has a 5-ft wide by 4.5-ft high downward opening slide gate on the headwater side for water control as shown in Figures 11 and 12. A distribution canal with bottom elevation of 25.5 ft is located downstream of these structures. Rating curves are presented in Appendix A for various gate openings and the 36-inch diameter culverts.

Figure 10. Photo of the headwater side of S-386A during construction.

Figure 11. Cross section of S-386A&B through the separation levee between Cells 1 & 2.

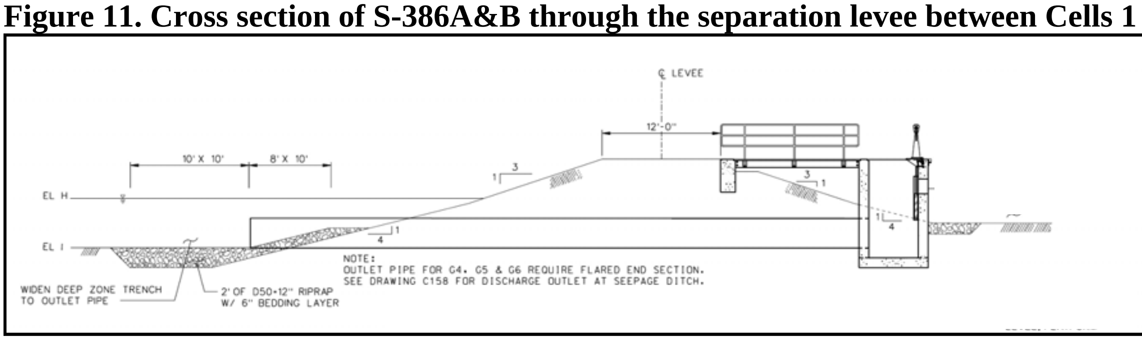
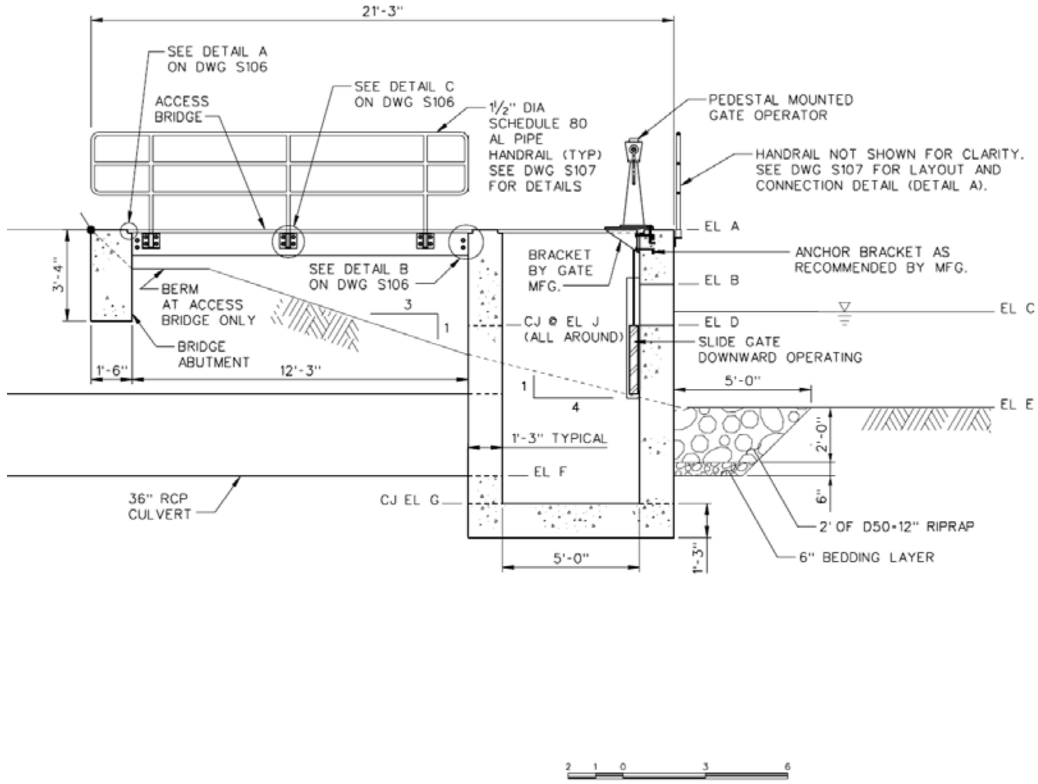


Figure 12. Cross section of water control structures.



CONTROL GATE ELEVATION TABLE					
		GATE LOCATION			
LOCATION	ELEVATION	SEPARATION LEVEE S-386A & B	**S-387C**	**S-387B**	**S-387A**
NUBBIN SLOUGH	A	35.50	33.75	33.75	33.75
	B	33.50	31.75	31.75	31.75
	C	32.00	30.25	30.25	30.25
	D	29.00	27.25	27.25	27.25
	E	27.50	25.50	25.50	25.50
	F	25.50	24.50	22.50	22.50
	G	24.25	21.50	21.50	21.50
	H	30.50	N/A	N/A	N/A
	I	25.50	24.50	22.10	21.30
	J	29.00	27.25	27.25	27.25
	GATE SIZE	60X54	60X54	60X54	60X54

Figure 13. Discharge pipe of S-386B within the distribution canal of Cell 2.

S-386 A&B structure information

Gate opening invert:	29.0 ft NGVD
Height of Gate:	4.5 ft
Width of gate:	5.0 ft
Invert of culvert:	25.5 ft NGVD
Diameter of culvert:	3.0 ft
Length of culvert:	~60 ft

Data Acquisition and Telemetry

A headwater stage sensor and staff gage will be located at the headwater of S-386B. A gate position indicator sensor is available on each structure to monitor the status remotely. The District is planning to install a headwater staff gage and a tailwater staff gage at each water control structure. In addition to providing operational information, these gages will assist flow calibration and estimation purposes, which are critical to establishing accurate water and nutrient mass balances for the treatment cells.

Water Quality Sampling

At the present time, there is no automatic sampling equipment installed at S-386A&B for the purpose of monitoring water quality. Please refer to the Water Quality Monitoring Plan (SFWMD 2005) for updated details. A weekly grab sample for total phosphorus at S-386B is collected to enable a direct estimate of the phosphorus removal performance of the individual treatment cells of the STA, which allow operational feedback to optimize removal performance.

2.3 OUTFLOW CONTROL STRUCTURES

Structures S-387A-C. Structures S-387A-C control flow from Cell 2 into Nubbin Slough. These structures are located in the perimeter levee along the western boundary of Cell 2. Treated water is collected upstream of the S-387 structures in a collection canal with a bottom elevation of 25.5 ft. The S-387 structures are combination structures consisting of an inlet box fitted to 3 ft. diameter reinforced concrete pipes, and have a trash boom on the upstream side (Figure 12). Each inlet box has a 5-ft wide by 4.5-ft high downward opening slide gate for water control. Rating curves are presented in Appendix A for various gate openings and the 36-inch diameter culverts. When the S-387 structures are open, the treated water will flow over the gate, through the inlet box and the culverts, and enter the seepage/discharge canal for return to Nubbin Slough via uncontrolled culverts.

a. The 36-inch culvert connecting S-387A to the seepage/discharge canal is approximately 80 ft long, and a 1,260-ft long 36-in diameter pipe carries the treated water from the seepage/discharge canal to Nubbin Slough.
b. The 36-inch culvert connecting S-387B to the seepage/discharge canal is approximately 80 ft long, and a 46.5-ft long 48-in diameter pipe (see Figure 14) carries the treated water from the seepage/discharge canal to Nubbin Slough via a swale.
c. The 36-inch diameter culvert connecting S-387C to the seepage/discharge canal is approximately 70 ft long; there is no connection between the seepage/discharge canal and Nubbin Slough at this location, as it is upstream of the intake pump. Instead, a 46-ft long 48-inch culvert connects the seepage/discharge canal to Nubbin Slough via a swale just south of the S-385 pump station.

The gates at the S-387 structures are operated by means of a pedestal mounted gate operator. Manufacturer's information on the gate and operator are presented in Appendix A.

Figure 14. Culvert downstream of Structure S-387B during construction.

Data Acquisition and Telemetry:
Headwater sensors and gate position indicator sensors are available to monitor the status remotely; headwater staff gages are available at each structure. A tailwater sensor is located 50 feet from the discharge point of G-387A in Nubbin Slough. The District is planning to install a tailwater staff gage at each outlet structure. In addition to providing operational information, these gages will assist flow calibration and estimation purposes, which are critical to establishing accurate water and nutrient mass balances for the treatment cells.

Water Quality Sampling:
Flow proportional, automatic sampling equipment is located at the three S-387 structures for the purpose of monitoring effluent water quality. Please refer to the Water Quality Monitoring Plan (SFWMD 2005) for updated details.

Structure information:

Gate opening invert:	27.25 ft NGVD
Height of Gate:	4.5 ft
Width of gate:	5.0 ft
Invert of culvert:	S-387A&B: 22.5 ft NGVD
	S-387C: 24.5 ft NGVD
Diameter of culvert:	3.0 ft
Length of culvert:	S-387A 70 ft; S-387B&C: 80 ft

2.4 EMERGENCY OVERFLOW

Each treatment cell contains a 500-ft long emergency overflow section, with the crest elevation 12 inches lower than the adjacent levee. The Cell 1 emergency overflow section is located just south of S-386B and has a crest elevation of 35.0 ft NGVD. When the water elevation increases above 35.0 ft along the western boundary of Cell 1, water will flow over the emergency overflow section to Cell 2. The Cell 2 emergency overflow section is located just south of S-387B and has a crest elevation of 33.5 ft NGVD. When the water level increases above 33.5 ft along the western boundary of Cell 2, water will flow over the emergency overflow section to the seepage collection/discharge canal and then to Nubbin Slough through the uncontrolled culverts. The transition between the adjacent levee and each emergency overflow section, from inside the treatment cell, over the levee, and across the downstream face of the levee, is armored with articulated concrete block overlaying geotextile (Figures 15 and 16).

Figure 15. Plan section of emergency overflow section.

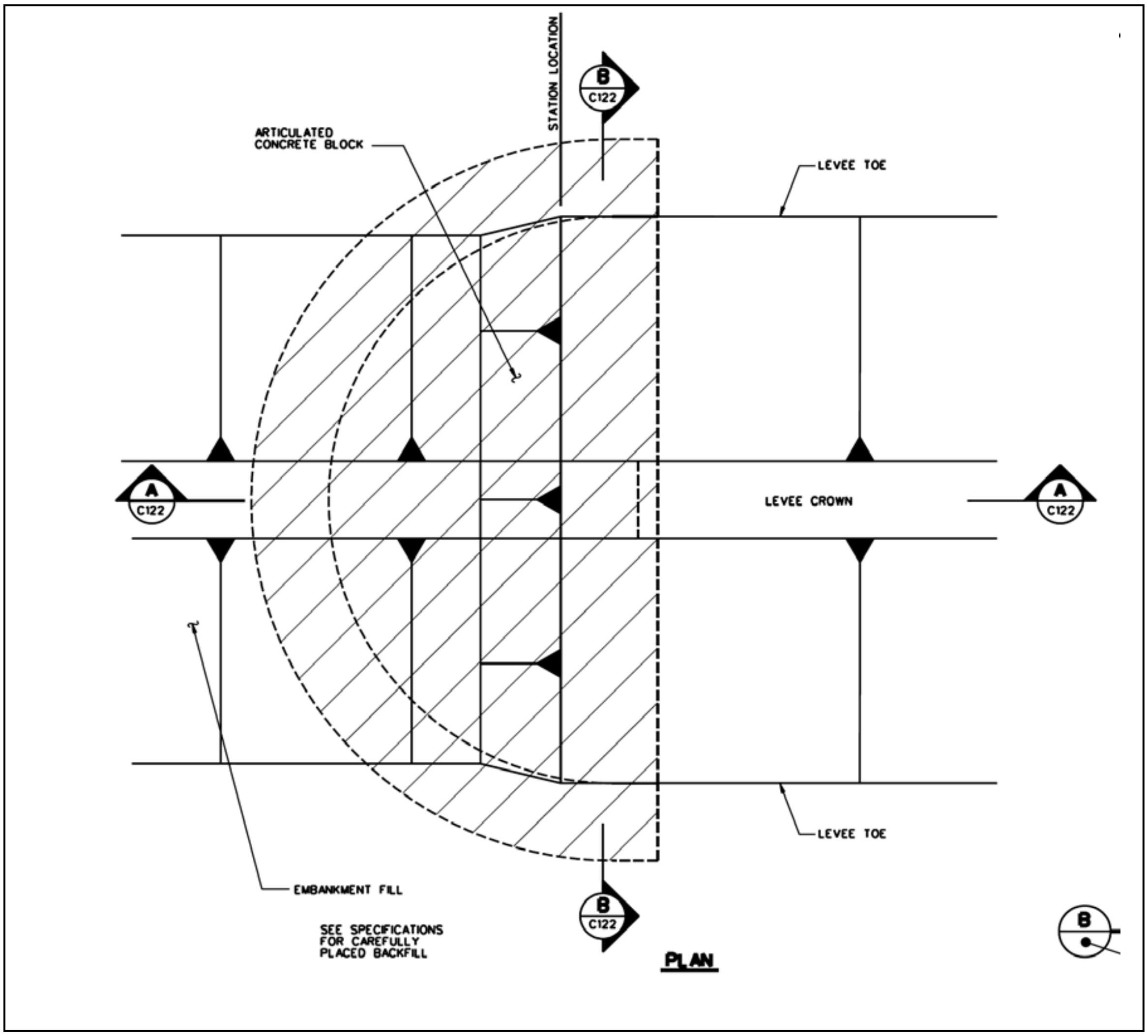
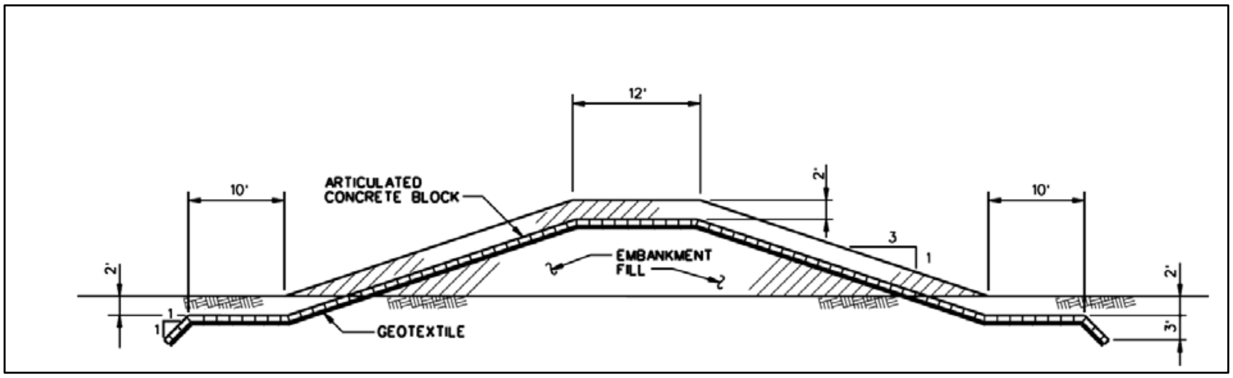


Figure 16. Cross section B-B through the transition to the emergency overflow section.



2.5 SEEPAGE CONTROL FACILITIES

A seepage collection / discharge canal rings the entire STA. This canal collects seepage and treated discharges from the STA, and runoff from the surrounding upstream areas, and conveys it to Nubbin Slough through three (3) uncontrolled culverts located south of the intake pump station. Along the western boundary of the STA, the seepage is co-mingled with treated water from the STA. Along the eastern boundary of the STA, the seepage is co-mingled with runoff from the upstream basin – the design documents indicated the canal should be able to convey runoff from storms with a magnitude of a 5-year return period event (Stanley Consultants, Inc. 2003). The bottom elevation of this seepage/discharge collection canal varies from elevation 21.2 ft at the southwest corner up to 28.92 ft at the northeast corner of the STA. The bottom width is 8 ft, and the side slopes are 3:1. A seepage analysis conducted during design of this project estimated an average seepage of approximately 9 cfs at the design water surface elevations. A 48-in diameter by 32-ft long reinforced concrete pipe is located beneath the access road crossing of the seepage collection canal at the northwest corner of the project.

2.6 RELATED FACILITIES

Deep Zone Trenches. Each treatment cell has deep zone trenches located immediately downstream of the inflow structures and immediately upstream of the outlet structures. The deep zone trench at the inflow of each cell is designed to distribute the inflow across the entire width of the cell. The deep zone trench at the outfall collects flow from across the entire width of the cell. In addition, Cell 2 has a deep zone trench approximately half-way across the treatment cell. The deep zone trenches were designed to have 10 ft. bottom widths and 4H to 1V side slopes. During construction, some of the deep zone trenches were widened based on the need for additional material. The Cell 1 deep zones have a bottom elevation of 27.5 ft, while the Cell 2 deep zones have a bottom elevation of 25.5 ft.

Levees. The STA is bounded on all sides by a perimeter levee with a separation levee across the mid section of the site between Cell 1 and 2. The levee crest elevation is set by the design water surface elevation within each cell plus a 3-ft freeboard allowance to accommodate the 10-year, 24-hour precipitation event, wind shear surge, and wave run-up. The 3-ft freeboard allowance consists of 6 inches for a 10-year 24-hour event, an estimated 4 inches surge, 1.5 ft for wave run-up and 8 inches for backwater effects (Stanley Consultants, Inc. 2003). The design water surface elevation for Cells 1 and 2 are 32.2 ft and 30.5 ft, respectively, and the levee crest elevations were set at 36.0 ft and 34.5 ft for Cell 1 and 2, respectively. Encircling the storage pond and the inlet channel up to the inlet to Cell 1 (S-386C), both the separation levee and the perimeter levee have a crest of 39.0 ft. The levee top width is 12 ft, and the side slopes are 3H to 1V. Each cell has an emergency overflow section on the western levee (as discussed in Section 2.4 above).

Airboat ramp and crossover. An airboat ramp is located on the northwest perimeter levee of Cell 2 just north of S-387C. An airboat crossover to facilitate airboat movement between the treatment cells is located at the southern terminus of the separation levee, just south of S-386A.

3 OPERATIONS

PLEASE NOTE

During the preparation of this *Operation Plan*, a potential critical hydraulic issue was identified that needs attention to ensure that maximum phosphorus removal of the STA can be achieved.

Capacity of the S-386 and S-387 structures. After review of the hydraulic properties of the S-386A-C and S-387A-C structures, it appears that the hydraulic capacity of the structures is smaller than stated in the design documents, which was to pass the peak flow with a head loss of 1.0 ft or less. For the inlet structure S-386C, the head loss is estimated at 2.6 ft or more at the peak flow of 120 cfs; for the S-386A&B structures, the head loss is estimated at 2.5 ft or more at 60 cfs; for the S-387 structures the head loss is estimated at 1.5 ft or more at 40 cfs. This reduced capacity may increase the stage at peak flow through the STA, particularly in the 30-acre storage pond, which in turn may reduce the freeboard on the levees. It is recommended that the District pursue resolution of this issue with the Corps, perhaps through flow tests after the STA is constructed, to ensure that maximum phosphorus removal of the STA can be achieved. Until this issue is resolved, the Corps and District should consider an appropriate operational remedy such as limiting the number of pumps operating at one time to three, and revising the pump shut-off set point from 37.5 to 36.5 ft NGVD in the 30-acre storage pond.

Depending upon the resolution of this critical issue, this Operation Plan will need to be revised accordingly.

Introduction. This section describes the general operations associated with the Nubbin Slough STA. Operations are classified in the following modes:

1. Start-up operations
2. Normal operations
3. Extreme flow operations
4. Drought operations, and
5. Operations to take one or more treatment cells out of service

The Initial Operational Testing and Monitoring Period of the construction phase of the project consists of two activities: Pre-Discharge and Flow-Through (Discharge) Activities. Because of the overlap in operations with those discussed below, no separate discussion of this Period is necessary.

3.1 START-UP OPERATIONS

General. The goal during STA startup is to provide hydrologic conditions conducive to wetland vegetation growth, while avoiding release of total phosphorus and mercury. The STA permits preclude flow-through operations until phosphorus and mercury concentrations demonstrate a net improvement compared to the source water in Nubbin Slough. In addition, the FDEP permit requires that pesticide samples be taken in the water column and sediment at the inflow and outflow structures before discharges are to occur from the STA. A complete description of the permit and performance conditions can be found in the associated *Performance Plan for the Nubbin Slough STA* (Gary Goforth, Inc. 2005).

Operations During Startup. The STA outlet structures, S-387A-C, should remain closed during the startup phase. The inflow pump station, S-385, should be operated to maintain approximately 1.0 ft water depth in Cells 1 and 2. **This will require revising the operating set points during the start-up phase from the values identified in the design documents, specifically the "High-high STA level" that shuts down the pumps needs to be set to 31.7 ft.** Since the ground elevation in Cell 2 is about 1.7 ft lower than in Cell 1, synchronized operation of S-385 and S-386B&C will be required to achieve these target depths. In general, structures S-386A-C should be open entirely during the start-up operations while Cell 2 is inundated to a stage of 29.5 ft (i.e., a depth of 1.0 ft). With two pumps operating, S-385 should be able to raise water elevations across the entire STA in just under a week at a rate of about 1 inch per day, assuming seepage and ET losses of about 1/2-inch per day; rainfall and additional pumps operating will accelerate the filling rate. When the average stage in Cell 2 (determined by the arithmetic average of the tailwater stage of S-386B and the headwater stage of S-387B) is approximately 29.5 ft (i.e., a depth of 1.0 ft), S-386A and B should be partially closed to an elevation of 31.2 ft, and water depths in Cell 1 should be allowed to rise until the average stage in Cell 1 (determined by the arithmetic average of the stage in the 30-acre storage pond and the headwater stage of S-386B) is approximately 31.2 ft (i.e., a depth of 1.0 ft). With two pumps at S-385 operating, Cell 1 should be close to the target depth roughly two days after setting the gates at S-386A and B to 31.2 ft. S-385 can be shut off when the average stage in Cell 1 is 31.2 ft (i.e., a depth of 1.0 ft). Periodic pumping of S-385 and opening S-386B may be necessary to maintain a desired depth of approximately 1.0 foot in the treatment cells. ***It is critical to keep depths between 0.5 and 1.0 ft during the start up phase to ensure proper growing conditions with minimal high-water damage to the young vegetation***.

Once net improvement for phosphorus and mercury removal is demonstrated, and the pesticide samples are collected, the S-387 slide gate can be opened to allow the treated water to flow into Nubbin Slough; the project structures can now be operated based on the normal operations in the following section. Once flow-through operations begin, the STA High-high level set point should be revised back to its normal setting.

Summary of Start up phase operations
- Revise the STA High-high level set point that shuts off the pumps to 31.7 ft
- The target depth is between 0.5 ft and 1.0 ft
- With the gates at the S-387 structures closed, and the gates at the S-386 structures open fully, raise the water level in Cell 2 to an average of 29.5 ft (i.e., a depth of 1.0 ft), then partially close the S-386A&B gates to an elevation of 31.2 ft and raise the water level in Cell 1 to an average of 31.2 ft (i.e., a depth of 1.0 ft).
- Once flow-through operations begin, reset the STA High-high level set point back to its normal setting.

3.2 NORMAL OPERATIONS

Normal operations are defined as flow-through operations for flows up to and including the design peak pumping rate of approximately 120 cfs. The operational goal is to capture and treat as much water through the STA as possible, subject to water availability in Nubbin Slough and maintaining appropriate water depths in the STA. Actual adjustment of the structures' gate heights will be a trial-and-error process until the actual head loss of the wetland vegetation is determined in each individual cell (Stanley Consultants, Inc. 2003). Analyses conducted during the design suggest an average inflow to the STA of approximately 12.2 cfs will result from the inflow pump operations (Stanley Consultants, Inc. 2003). Analyses conducted during design also indicated that average seepage and ET losses exceeded this average inflow rate, hence regular dry out of the STA is anticipated. ***Frequent gate operations will be required to minimize the frequency and duration of dry out, which otherwise could lead to excessive phosphorus releases from the STA.*** Water levels in the STA will be adjusted through operation of the inflow pumps and adjustment of the gates on the interior and outlet structures. Initial operating guidelines are provided below, however, as the STA vegetation matures the target water levels and gate openings will likely need to be refined based on actual operating experience.

3.2.1 S-385 Operations

During normal operations, the S-385 pumps will primarily operate based on a Nubbin Slough water level sensor located approximately 150 feet upstream of the pump station and the sensor located in the 30-acre storage pond. The pumps will begin sequencing on when the water level in the Nubbin Slough rises above 20.0 ft. If the stage in the 30-acre storage pond exceeds 37.5 ft, which is 1.5 ft below the crest of the perimeter levee and separation levees around the pond, the S-385 pumps will cease pumping until the stage drops below 36.0 ft. Stages within the 809-acre STA were simulated at a peak flow rate of 93.6 cfs using the 2-dimensional hydrodynamic model TABS 2D (Stanley Consulting, Inc. 2005). After review of the hydraulic properties of the S-386A-C and S-387A-C structures, it appears that the hydraulic capacity of the structures is smaller than stated in the design documents, which was to pass the peak flow with a head loss of 1.0 ft or less. For the inlet structure S-386C, the head loss is estimated at 2.6 ft or more at the peak flow of 120 cfs; for the S-386A&B structures, the head loss is estimated at 2.5 ft or more at 60 cfs; for the S-387 structures the head loss is estimated at 1.5 ft or more at 40 cfs. This reduced capacity may increase the stage at peak flow through the STA, particularly in the 30-acre storage pond, which in turn may reduce the freeboard on the levees. It is recommended that the District pursue resolution of this issue with the Corps, perhaps through flow tests after the STA is constructed, to ensure that maximum phosphorus removal of the STA can be achieved. Until this issue is resolved, the Corps and District should consider an appropriate operational remedy such as limiting the number of pumps operating at one time to three, and revising the pump shut-off set point from 37.5 to 36.5 ft NGVD in the 30-acre storage pond. ***It is recommended that controlled field tests be conducted to document stages in the storage pond and at the headwater and tailwater of each structure for flow regimes established by 1, 2, 3 and 4 pumps operating.***

Table 2 shows the percentage of time that the available flow in Nubbin Slough has historically exceeded the pump capacities of the STA. Analyses conducted during the design indicated that approximately 17% of the time, there is sufficient flow in Nubbin Slough to keep at least one pump running (Stanley Consultants, Inc. 2003).

Table 2. Flow availability in Nubbin Slough.

Number of pumps operating	Pumping capacity against 19 ft head (cfs)	Percentage of days flow is available in Nubbin Slough
1	35.7	17%
2	69.1	7%
3	95.8	5%
4	120	3%

During normal operations, the pumps are set to run in automatic mode based on the operating set points identified in Table 3 below. A lag of 10 minutes is set between subsequent pump starts. The pumps will be electronically rotated in an attempt to equalize the total running time among the pumps. Pump operating set points were established during the design of the STA with the intent to operate S-385 as often as possible. Therefore, minimal intervention should be required. Local operation of this pump station is also possible, and remote operation and monitoring is scheduled to be made available in the future by the District.

Table 3. Pump operating set points for S-385.

Pump operating points	Water Level	Reset elevation	Purpose for operating point	Purpose for reset point
Nubbin Slough Stage, measured 150 ft upstream of S-385 intake				
Low level	Drops <17.0	Rises >17.5	Pumps start sequencing off	Pumps stop sequencing off
High level	Rises >20.0	Drops <19.5	Pumps start sequencing on	Pumps stop sequencing on
High-high level alarm	Rises >26.0	N/A	Sends an alarm to field office	N/A
S-385 Pump Station, measured at wet well				
Low-low level	Drops <15.0	Rises >15.5	All pumps stop	Restart pump sequencing
High-high level alarm	Rises >27.0	N/A	Sends an alarm to field office	N/A
STA, measured at the 30-ac storage pond				
High-high level	Rises >37.5	Drops <36.0	All pumps stop	Restart pump sequencing

Note: due to higher head losses than anticipated during design at the interior and outlet structures, it is recommended to lower the STA High-high level set point to 36.5 ft until flow tests can be conducted to document actual stages in the STA with 3 and 4 pumps operating simultaneously.

3.2.2 Wet Season Operation

Initial operating guidance for wet season operations is provided below; this guidance should be revisited periodically and revised based on field observations and STA performance.

Structure S-386C. According to the design documents, the peak inflow to the STA is anticipated to be approximately 120 cfs, and the average inflow to the STA is anticipated to be approximately 12.2 cfs. The recommended operation for S-386C during normal operations in the wet season is to keep the gate fully open to allow maximum flow into the treatment area with minimal head loss. Rating curves presented in Appendix A were developed by Stanley Consulting, Inc. and suggest that 120 cfs can pass through S-386C at a headwater of 35.1 ft NGVD with 2.6 ft head loss, yielding a tailwater of approximately 32.5 ft NGVD. This tailwater is consistent with the 2-dimensional modeling results, however, excessive head losses at the interior and outlet structures at 120 cfs suggest that the inflow should be limited to approximately 96 cfs to stay within the design stages, achievable with 3 pumps operating. At a flow of 96 cfs, the rating curves suggest a headwater of approximately 34.4 ft with a head loss of 1.9 ft will produce a tailwater of 32.5 ft.

Structures S-386A&B. The recommended operation for S-386A&B during normal operations in the wet season is to keep the gates wide open to allow maximum flow through the treatment area during days when the pumps are on. To minimize dry out, it is recommended to partially close the gates 1.75 ft (to an elevation of 30.75 ft) during the wet season when no pumps are running; this setting is equivalent to an average depth of 0.55 ft in Cell 1.

Structures S-387A-C. The recommended operation for S-387A-C during normal operations in the wet season is to keep the gates wide open to allow maximum flow through the treatment area during days when the pumps are on. To minimize dry out, it is recommended to partially close the gates 1.75 ft (to an elevation of 29.0 ft) during the wet season when no pumps are running; this setting is equivalent to an average depth of 0.5 ft in Cell 2.

3.2.3 Dry Season Operation

Initial operating guidance for dry season operations is provided below; this guidance should be revisited periodically and revised based on field observations and STA performance.

An important aspect of the STA operation is avoiding treatment cell dry out, as dry out typically results in a release of phosphorus. To minimize the duration and frequency of dry out, the gates in S-386B&C and S-387A-C will need to be partially closed as the number of pumps in operation decrease. However, gate closure reduces the flow capacity of the treatment area at design peak flow, and since the gates are not operated remotely, more frequent manual gate changes will be required during the dry season. S-386C should remain fully open throughout the dry season. The ideal minimum water depth is 0.5 ft in both cells. However, to conserve water and compensate for evapotranspiration and seepage losses, it is recommended to close the S-386A & B gates to an elevation of 32.2 ft and the S-387A-C gates to 30.5 ft, which should establish a water depth of 2.0 ft during the dry season. During pumping events, gates should be opened if possible to allow maximum flow through the treatment area during days when the pumps are on.

Subject to water supply conditions in the Nubbin Slough basin, there may be times when S-385 should be operated outside the normal operating set points described in Table 3, specifically, turning on the pumps when the Nubbin Slough stage is below 20 ft in order to prevent the STA from drying out.

Should the STA dry out, please refer to section 3.4.1 for operations following dry out.

Summary of Normal Operations:

- Wet season
  - The S-385 pumps will operate automatically to supply water to the STA based on the stage in Nubbin Slough
  - The gate at S-386C should remain fully open.
  - The gates at S-386A&B and S-387A-C should be fully open when pumps are on
  - Partially close the gates 1.75 ft when no pumps are running
    - S-386A&B gates closed to elevation 30.75 ft
    - S-387A-C gates closed to elevation 29.0 ft
- Dry season
  - The S-385 pumps will operate automatically to supply water to the STA based on stage in Nubbin Slough
  - The gate at S-386C should remain fully open.
  - The gates at S-386A&B and S-387A-C should be fully open when pumps are on
  - Partially close the gates when no pumps are running
    - S-386A&B gates closed to elevation 32.2 ft
    - S-387A-C gates closed to elevation 30.5 ft

3.3 EXTREME FLOW OPERATIONS

Discretion in the operation of the STA structures is reserved by the District Operations staff to account for excess precipitation and upstream and downstream conditions. The Nubbin Slough STA has been designed to accommodate peak stages associated with the estimated rainfall resulting from the 10-yr 24-hr storm; depending on the wind and wave effects and the slope of the backwater profile, the stage in the cells may exceed the crest of the emergency overflow section and flow may occur to Nubbin Slough over these sections. Flows and stages resulting from precipitation events smaller than this event should fall under "Normal Operating Conditions" for the STA.

To minimize the occurrence of emergency overflow resulting from extreme rainfall events, the inflow pumps at S-385 are set to shut off should the water level rise to an elevation of 37.5 ft in the 30-ac storage pond at the upstream end of Cell 1 (equal to 1.5 ft below the crest elevation of the separation levee and perimeter levee surrounding the pond). Should water levels in Cell 2 continue to rise due to extreme rainfall, discharges will occur over the emergency overflow section that has a crest elevation of 33.5 ft. ***It is recommended that controlled field tests be conducted for flow regimes established by 1, 2, 3 and 4 pumps operating to determine the corresponding stages within the STA.***

Summary of Extreme Flow Operations:

- Prior to extreme events,
  - the trash rack should be checked to ensure it is clear and working properly, and
  - the gates at the S-386 and S-387 structures should be fully opened.
- As soon as safety permits after extreme events,
  - the operating status of all the pumps and gates should be checked,
  - repairs made if needed, and
  - debris cleared if needed

3.4 DROUGHT OPERATIONS

Subject to water availability, operations of the STA should maintain water depths at a minimum of 0.5 feet above the average ground elevation in the treatment cells to minimize potential negative effects of dry out on project performance. The ability to maintain this minimum water elevation is determined primarily by the availability of water from the upstream watershed and on local rainfall. In the extreme case that there is no water available from the upstream watershed and/or from rain, the treatment cells may dry out. The severity and duration of the dry conditions that may lead to reduced project performance is currently unknown, as is the magnitude and duration of the potential depression of project performance. Analysis of the monthly compliance monitoring data collected at the project outflow monitoring station will be useful in making these determinations.

To minimize dry out, the gates in S-386 and S-387 will need to be closed down as the number of pumps in operation decreases. The ideal minimum water depth is 0.5 ft in both cells, However, to compensate for evapotranspiration and seepage losses, it is recommended to close the gates to an elevation of 32.2 ft and 30.5 ft, which should establish a water depth of 2.0 ft during the dry season if sufficient water supply is available in Nubbin Slough. During pumping events, gates should be opened if possible to allow maximum flow through the treatment area during days when the pumps are on. This initial guidance should be revisited periodically and revised base on field observations.

Once it is suspected a drought is imminent, to the extent possible, water should be conserved within the treatment cells at higher than normal depths in anticipation of a decrease in future flows. The S-387 gates should be closed to 30.5 ft, and S-386 B & C opened as needed to allow water depths in both cells to rise up to 2-2.5 feet if water is available. The “pump-on” stage for S-385 may need to be lowered during drought conditions in order to prevent the cells from drying out. Should drought conditions persist and prevent the inundation of Cell 2 using S-385, the use of a small temporary pump (e.g., an 8-inch diameter unit) may be considered for maintaining a minimum depth of 0.5 feet in Cell 2, in conjunction with using S-385 to hydrate Cell 1. A temporary pump could be placed outside of the west perimeter levee and draw water from Nubbin Slough to hydrate the vegetation in Cell 2.

3.4.1 Operations Following STA Dry Out

There will be times when there are insufficient flows and/or stages in Nubbin Slough to operate the S-385 inflow pump for long enough duration to keep the treatment cells from drying out. Following reflooding after a dry out, treatment wetlands typically exhibit a spike in outflow concentrations, a result of phosphorus remineralization processes that occur with exposed sediment. To minimize the magnitude of this flux leaving the Nubbin Slough STA, it is recommended to keep the S-387A-C gates closed for approximately two weeks after dry out and following reflooding to a stage of 29.0 ft measured at the S-387B headwater, although site specific conditions may require more or less time for the outflow concentration to drop below the inflow. This recommendation should be revisited periodically to ensure it is achieving water quality goal of annual net improvement. The severity and duration of the dry conditions that may lead to reduced project performance is currently unknown, as is the magnitude and duration of the potential depression of project performance. Analysis of the weekly grab sample data collected at the S-387 structures will be useful in making these determinations.

Management activities following a dry out will vary depending on the severity of the drought and the attendant loss of vegetation. For mild to moderate loss of vegetation, the inundation regime described in Section 3.1 above can be followed (i.e., slowly raising depths to 1.0 ft). For severe loss of vegetation, it may be necessary to limit the initial depth to 0.5 ft to promote re-establishment desirable emergent vegetation. The length of time to retain water in the STA before initiating flow-through should be based on achieving a net reduction in the weekly phosphorus concentrations. This recommendation should be revisited periodically to ensure it is achieving water quality goal of annual net improvement. Table 4 provides an estimate of time required for reflooding the cells.

Table 4. Estimated time required to raise water levels following dry out.

Pumps Operating	Flow (cfs)	Rise per day (ft)	Days to Raise Water 0.5 ft	Days to Raise Water 1 ft
1	35.7	0.05	10.9	21.8
2	69.1	0.13	3.9	7.8
3	95.8	0.19	2.6	5.2
4	120	0.25	2.0	4.0

Assumes 1/2 inch ET and seepage loss per day

Summary of Drought Operations:

- The S-387 gates should be closed to 30.5 ft and S-386 gates B&C opened as needed to allow water depths in both cells to rise up to 2-2.5 feet, if water is available.
- Maintain a minimum depth of 0.5 ft if water is available; this may necessitate lowering the "pump-on" set point for S-385 and using a small portable pumping unit to hydrate Cell 2, if needed.
- Following a dry out, keep S-387 gates closed for a period following reflooding to a stage of 29.0 ft, depending on the severity of dry out and the status of the vegetation:
  - if the vegetation is robust, the recommended period of closure following reflooding is approximately two weeks, although site specific conditions may require more or less time for the outflow concentration to drop below the inflow;
  - if the vegetation is damaged, the period of closure will likely be greater, to be determined by field conditions and phosphorus levels

3.5 TREATMENT CELLS OUT OF SERVICE

After flow-through operations begin, the STA may be taken off-line for vegetation management or other activities in order to improve the phosphorus removal performance. Pumping at S-385 may be reduced or stopped during activities for performance enhancement, and S-386 may be adjusted to reduce or stop flow to Cell 2 depending on the management activities underway (please refer to the associated *Nubbin Slough / New Palm STA Vegetation Management Plan* for additional details). Depending on the severity of the management operations, the reflooding operations may or may not require similar actions as in the start-up phase, i.e., demonstrating a 4-week net improvement in phosphorus.

3.6 DEVIATIONS FROM THE OPERATION PLAN

This initial Operation Plan for the Nubbin Slough STA is meant to be updated regularly based on field observations of stage-flow relationships, structure flow calibrations, STA performance and other factors. Discretion in the operation of the STA structures is reserved by the District Operations staff to deviate from these guidelines to account for flood protection, excess precipitation and upstream and downstream conditions. It is anticipated that after the first year of flow-through operation, and annually thereafter, this Operation Plan will be reviewed to identify any needed revisions.

3.6.1 Deviations from the Water Control Plan

The Corps of Engineers developed a Water Control Plan for the Nubbin Slough STA and this Operation Plan will be added to the Water Control Plan as an appendix. Deviations from that Plan may require advanced notification and approval from the Corps, as discussed below.

3.6.2 Deviation from Normal Operation.

The United States Army Corps of Engineers (USACE), Jacksonville District Engineer is occasionally requested to deviate from the normal regulation of the project. Prior approval for a deviation is to be obtained from the Jacksonville District Office (SAJ) except as noted below. The Jacksonville District Office will in turn obtain the necessary approvals from the South Atlantic Division (SAD) except as noted below. Deviation requests usually fall into the following categories:

3.6.3.1 **EMERGENCIES.** Some emergencies that can be expected include drowning and other accidents, failure of project facilities, and flushing of pollutants. Antecedent conditions, as well as forecasted storm events, may result in SFWMD declaring an Emergency Authorization Order which would result in an Emergency Deviation. Necessary action under emergency conditions is taken immediately, unless such action would create an equal or worse condition. The Jacksonville District Office should be informed as soon as practicable. Written confirmation should be furnished after the incident. SAJ will report these deviations to SAD.

3.6.3.2 **UNPLANNED MINOR DEVIATIONS.** There are unplanned instances where there is a temporary need for a minor deviation from normal regulation, although they are not considered emergencies. A change in releases is sometimes necessary for construction, maintenance, or inspection. These requested deviations are usually for duration of a few hours to a few days. Each request is analyzed on its own merits. Consideration is given to upstream watershed conditions, potential flood threat, conditions of lakes, and possible alternative measures. In the interest of maintaining good public relations, the request is complied with, providing there are no adverse effects on the overall project regulation for authorized project purposes. Approval for minor deviations will normally be obtained from the Jacksonville District by telephone. A written confirmation will be furnished after the deviation is completed. SAJ will report these deviations to SAD.

3.6.3.3 **PLANNED DEVIATIONS.** Each condition should be analyzed on its own merits. Sufficient data on flood potential, lake and watershed conditions, possible alternative measures, benefits to be expected, and probable effects on other authorized and useful purposes will be presented to the Jacksonville District along with recommendations for review and approval. SAJ will report these deviations to SAD and obtain approval.

In light of the uncertainty in specifying operating criteria necessary to optimize phosphorus removal in the Nubbin Slough STA, the SFWMD has the authority to refine the operations described in this plan without seeking Corps approval, as long as those operations are within the overall range of water depths and flows anticipated in the project design documents.

4 OPERATIONAL PERMITS

4.1 LAKE OKEECHOBEE PROTECTION ACT PERMITS

On September 15, 2003, the Florida Department of Environmental Protection (FDEP) issued Lake Okeechobee Protection Act (LOPA) permit 0194483-001-GL to the Corps for the construction of the Nubbin Slough STA. Presently the FDEP and the SFWMD are negotiating the operations, maintenance and monitoring permit for the project (0194483-002-GL). Accordingly, the STA Operation Plan must be consistent with the requirements of those permits. Additional information on the permits is found in the *Performance Plan for the Nubbin Slough / New Palm STA* (Gary Goforth, Inc. 2005).

4.2 MONITORING

Data are collected to monitor flow rates and phosphorus removal rates within the STA, as well to gather other water quality information. Inflow volumes to the system are determined by the manufacturer's pump curves and system head determined from water levels transmitted from sensors upstream of the pump station and at the 30-ac storage pond. An autosampler is located approximately 150 feet upstream of the intake pump station to characterize the inflow water quality. Grab samples will be collected at the S-386C structure to characterize the water quality entering the treatment cells. In addition, the District is planning to collect a grab sample for total phosphorus at the S-386B structure to enable direct estimates of phosphorus removal performance in the storage pond and each treatment cell, which allow operational feedback to optimize removal performance. At S-386B, a gate level sensor, monitored in conjunction with the headwater level sensor provides discharge information from Cell 1 to Cell 2, however, due to the anticipated submerged flow conditions, tailwater levels are necessary for accurate flow measurements. A similar arrangement of water and gate level sensors at the outfall of Cell 2 provides total effluent discharge. The District is planning to install a headwater staff gage and a tailwater staff gage at each water control structure. In addition to providing operational information, these staff gages will assist flow calibration and estimation purposes, which are critical to establishing accurate water and nutrient mass balances for the treatment cells. The three flow measurements, one at the inflow, one at the separation levee, and one at the discharge end of the STA, in conjunction with local rainfall measurements, enable the estimation of quantity of water treated and combined losses from seepage and evapotranspiration. Stage readings across the STA are also helpful in assessing static and dynamic surface water profiles, allowing verification of estimates developed during design. An autosampler is located at each of the outlet structures to characterize the inflow water quality. A schematic of the hydraulic and water quality monitoring network is shown in Figure 17. A schematic of the sampling arrangement for S-387A-C is shown in Figure 18. A detailed water quality monitoring plan has been developed for the Nubbin Slough STA (SFWMD 2005). Additional information on the project evaluation and reporting can be found in the associated *Performance Plan for the Nubbin Slough / New Palm STA* (Gary Goforth, Inc. 2005). Additional information on vegetation monitoring can be found in the associated

Vegetation Management Plan for the Nubbin Slough / New Palm STA (Wetland Consulting Services, Inc. 2005).

Figure 17. Schematic of Nubbin Slough STA monitoring network.

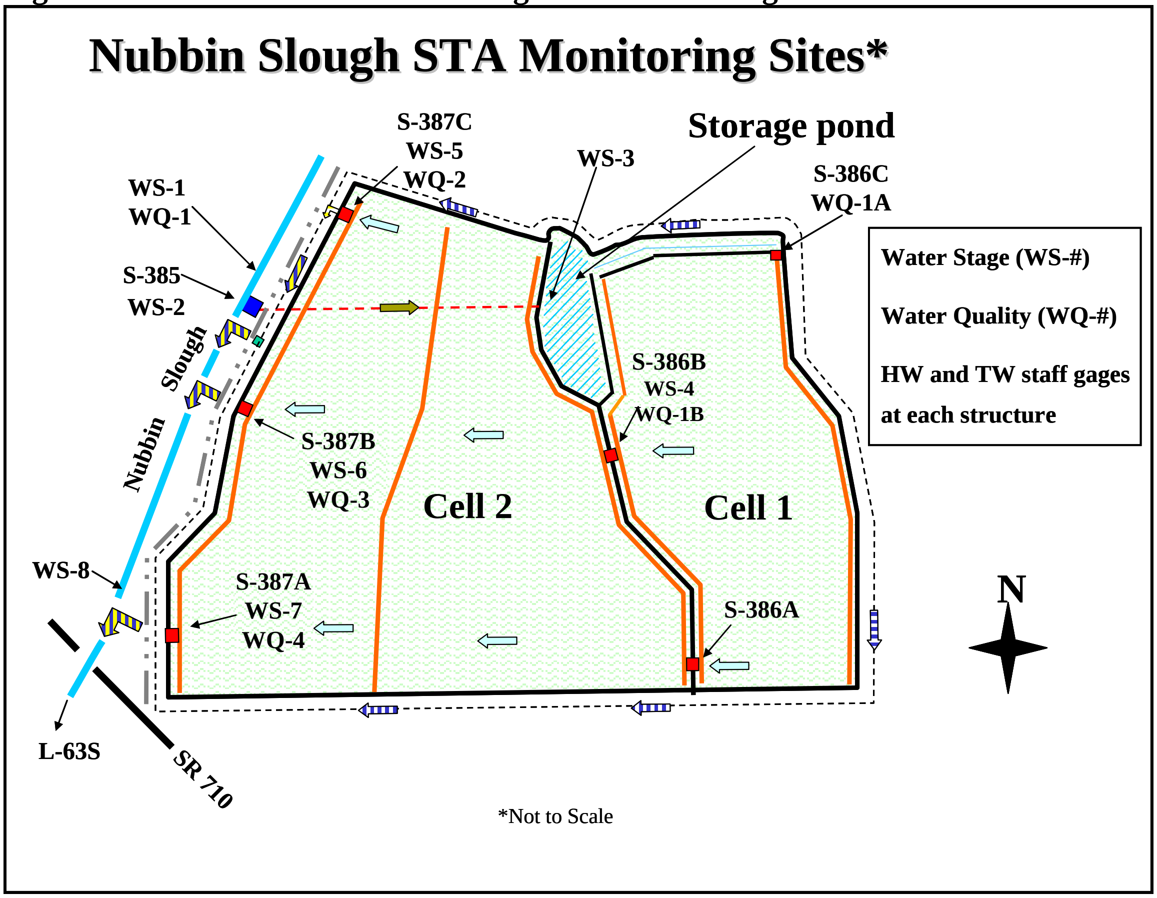
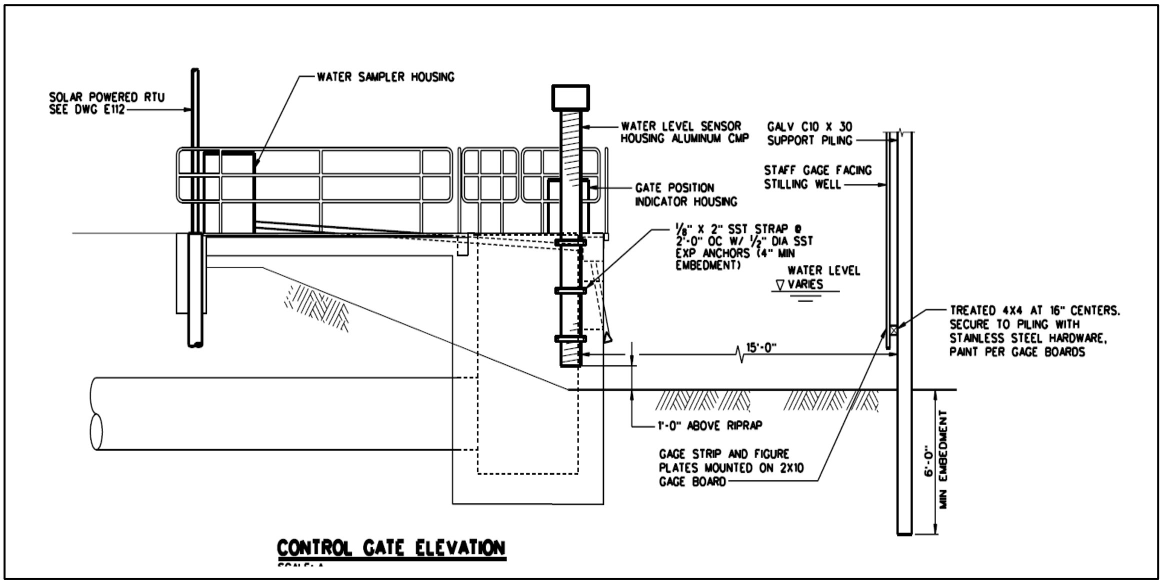


Figure 18. Stage and water quality sampling at the S-387 structures.



5 COORDINATION

As with most large water resource projects, effective coordination within the agency and among the various agencies will be critical to ensure the STA operational objectives are achieved. The nature of this coordination will change as the project goes through the initial operational and testing period, and is then transferred to the District by the Corps.

5.1 Initial Operational Testing and Monitoring Period

In accordance with the Project Cooperation Agreement executed between the Corps and the District, prior to turnover of the project to the District, the Corps will conduct an **initial operational testing and monitoring period**. During this period, data will be collected to demonstrate that the project achieves the designated benefits. This period is further divided into two phases – a start-up phase (no discharge) and a flow-through phase once discharge commences. Prior to initiating flow-through (discharge) activities, phosphorus and mercury will be monitored to demonstrate that the STA is achieving a net improvement in both constituents. In addition, pesticide sampling will occur as a condition for moving into the flow-through phase. Once the District Engineer determines that the project is performing as designed, the Corps will transfer the project to the District for subsequent operations, maintenance, repair, replacement and rehabilitation, commencing the **operations phase.**

5.1.1 On-going data review and operational feedback

In accordance with the project PCA, the operation of the STA during start-up will be a joint effort of the Corps and the District. A **Project Coordination Team** consisting of Corps and District staff was established in accordance with the Project Cooperation Agreement, and this team will establish a protocol for communicating the start up operations between the agencies prior to the initiation of start up. Key aspects are to identify who will be the respective tactical contact points, and the appropriate type and frequency of start up communication. The frequency of telephone conferences and meetings will likely be weekly at first as issues surrounding structure operations may arise; experience in other new systems suggests that the frequency will likely decrease to approximately once per month by the end of the start-up phase.

Once flow-through operations begin, the weekly/monthly communications will include operational feedback (pump operations, gate openings, flow rates and water levels) in addition to the performance discussion. By that time, the criteria for project transfer from the Corps to the District should be finalized.

5.1.2 Interagency coordination

In addition to the day-to-day project coordination, by virtue of the fact that the Nubbin Slough STA is a feature of an integrative set of water quality protection projects, project staff will necessarily be communicating and coordinating with other District staff (e.g., Lake Okeechobee Division), the Corps (CERP and related activities), FDEP (for permitting and other wetland protection purposes), and the Florida Department of Agriculture and Consumer Services (DACS, e.g., for implementation of watershed BMPs).

An initial list of potential contact persons from these agencies is presented below.

STA Project Manager: Lisa Kreiger, Staff Environmental Scientist, (863) 462-5280 x 3026 lkreiger@sfwmd.gov; South Florida Water Management District, Okeechobee Service Center, 205 N Parrott Ave, Suite 201, Okeechobee, FL 34972.

Program Manager: Dave Unsell, Lead Project Manager, (561) 686-8800 x 6888; dunsell@sfwmd.gov; South Florida Water Management District; 3301 Gun Club Road; West Palm Beach, FL 33406

Okeechobee Field Station: Terry Peters, Interim Director, 863-462-5280 x 3102; rpeters@sfwmd.gov; and Bruce Chesser, Interim Director of Field Operations, x 3114; bchesser@sfwmd.gov; Okeechobee Field Station, Okeechobee, FL

Operations Department: Tom Kosier, Environmental Operations Section (561) 682-6533; tkosier@sfwmd.gov; South Florida Water Management District; 3301 Gun Club Road; West Palm Beach, FL 33406

Water quality monitoring: W. Patrick Davis **Field Project Manager** (863) 462-5280 x 3171; wpdavis@sfwmd.gov; Okeechobee Water Quality Field Section, 1000 NE 40 Avenue, Okeechobee, FL 34972.

U. S. Army Corps of Engineers: Stephanie Jenkins; Hydraulic Engineer (904) 232-1612; Stephanie.L.Jenkins@saj02.usace.army.mil; US Army Corps of Engineers, Jacksonville District, ENHW, 701 San Marco Blvd, Jacksonville, Florida 32207 and Chuck Wilburn, Civil Engineer (863) 471-1741; Charles.R.Wilburn@usace.army.mil; Sebring Project Office, 6406 U.S. Hwy 27 S, Sebring, Florida 33876

Florida Department of Environmental Protection: Kim Shugar, Program Administrator, (561) 681-6706; kimberly.shugar@dep.state.fl.us; FDEP-Southeast District, 400 N. Congress Avenue, Suite 200, West Palm Beach, Florida 33401

Florida Department of Agricultural and Consumer Services: Bo Griffin, Environmental Manager, (863) 462-5883; griffid@doacs.state.fl.us; 305 E.N. Park Street, Suite C, Okeechobee, Florida 34972.

5.2 Operations Phase

Once the Corps transfers the project over to the District, the **Operations Phase** commences. Most, if not all, of the same degree of communication and coordination that began in the **initial operational testing and monitoring period** will continue.

5.2.1 On-going data review and operational feedback

The frequency and type of the weekly/monthly meetings during the Operations Phase may not differ from the earlier phases, depending on the status of the STA and whether or not there are significant refinements to the operations based on previous experience or permit requirements. During the summer, the performance evaluation for the previous water year should be drafted for including in the draft of the annual South Florida Environmental Report.

5.2.2 Interagency coordination

Depending on the Corps continued role and responsibilities after the project is turned over to the District, their involvement in the weekly/monthly coordination conferences may change in the Operations Phase. There may or may not be a shift in the other agency contacts shown in section 5.1.2 above, depending on the status of the STA and other needs.

5.3 COORDINATION WITH OTHER PLANS

The South Florida Water Management District (SFWMD), the U. S. Army Corps of Engineers (Corps), the Florida Department of Environmental Protection (FDEP), other agencies and private landowners are cooperating on efforts to improve water quality in the Lake Okeechobee watershed, and throughout the south Florida ecosystem. This cooperation includes studies and capital projects composing the Lake Okeechobee Protection Program, the Comprehensive Everglades Restoration Plan (CERP), and Critical Restoration Projects. The operations, monitoring and reporting associated with the Nubbin Slough STA will be coordinated with several other plans, including:

1. The Lake Okeechobee Protection Plan
2. Draft Lake Okeechobee Water Retention / Phosphorus Removal Project – Nubbin Slough (New Palm) Stormwater Treatment Area (STA) Water Control Plan
3. Operations, Maintenance, Repair, Replacement, and Rehabilitation Manual (USACE), as required by the Project Cooperation Agreement between the Corps and SFMWD
4. Vegetation Management Plan for the Nubbin Slough / New Palm STA (Wetland Consulting Services, Inc. 2005)
5. Performance Plan for the Nubbin Slough / New Palm STA (Gary Goforth, Inc. 2005)
6. South Florida Water Management District, WQ Monitoring Plan For Nubbin Slough Storm Water Treatment Area (STA), Draft August 2005.

6 REFERENCES

Gary Goforth, Inc., Performance Plan for the Nubbin Slough / New Palm STA, November 2005.

Stanley Consultants, Inc., Lake Okeechobee Water Retention / Phosphorus Removal Project, Final Design Analysis Submittal, June 2003.

Stanley Consultants, Inc., Lake Okeechobee Water Retention / Phosphorus Removal Project, Final Design Document Report Submittal, June 2003.

Stanley Consultants, Inc., additional hydraulic information (2-D modeling results and rating curves) from Dan Miller and Mark Werner, October 2003.

South Florida Water Management District, Draft WQ Monitoring Plan For Nubbin Slough Storm Water Treatment Area (STA), August 2005.

U. S. Army Corps of Engineers, Draft Lake Okeechobee Water Retention / Phosphorus Removal Project – Nubbin Slough (New Palm) Stormwater Treatment Area (STA) Water Control Plan (June 2005).

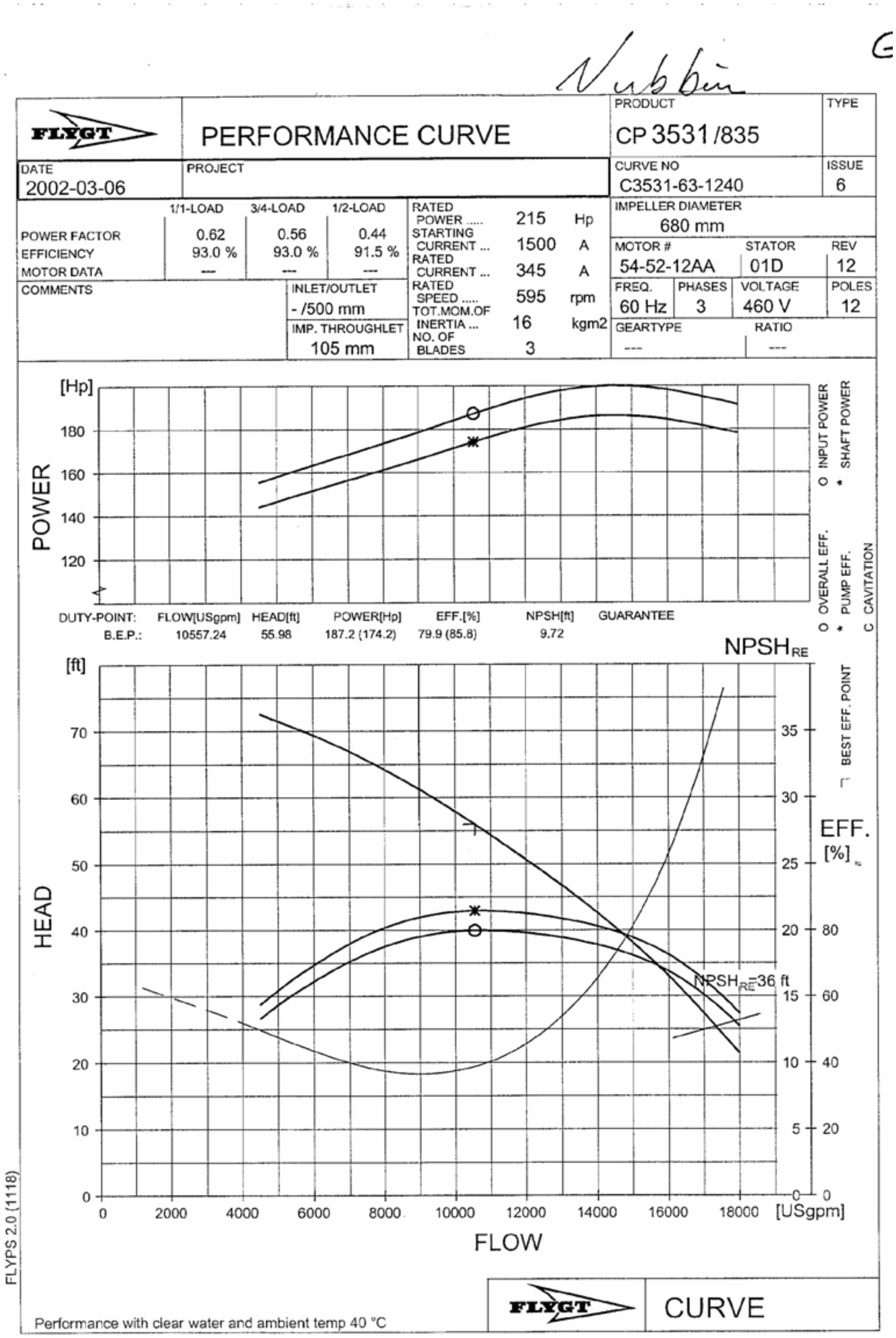
U. S. Army Corps of Engineers, Critical Project Letter Report, February 1998, approved May 6, 1998.

U. S. Army Corps of Engineers, Project Cooperation Agreement between the Department of the Army and South Florida Water Management District for Construction of Lake Okeechobee Water Retention / Phosphorus Removal Critical Restoration Project, January 7, 2000.

Wetland Consulting Services, Inc., Vegetation Management Plan for the Nubbin Slough / New Palm STA, November 2005.

APPENDIX A – ADDITIONAL WATER CONTROL STRUCTURE INFORMATION

PUMP PERFORMANCE CURVES



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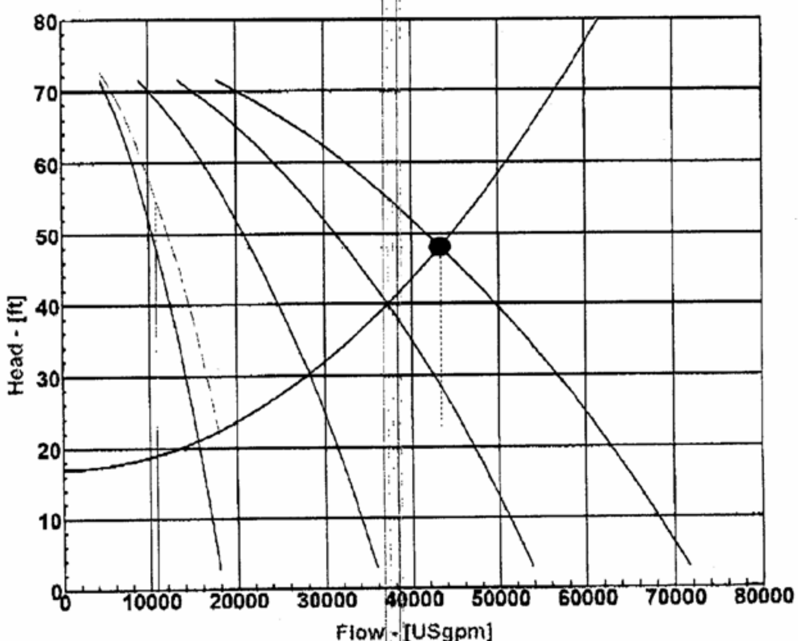
FLYGT

Duty Analysis - Duty conditions

Project: Nubbin Slough
Created by:: Thomas Miller

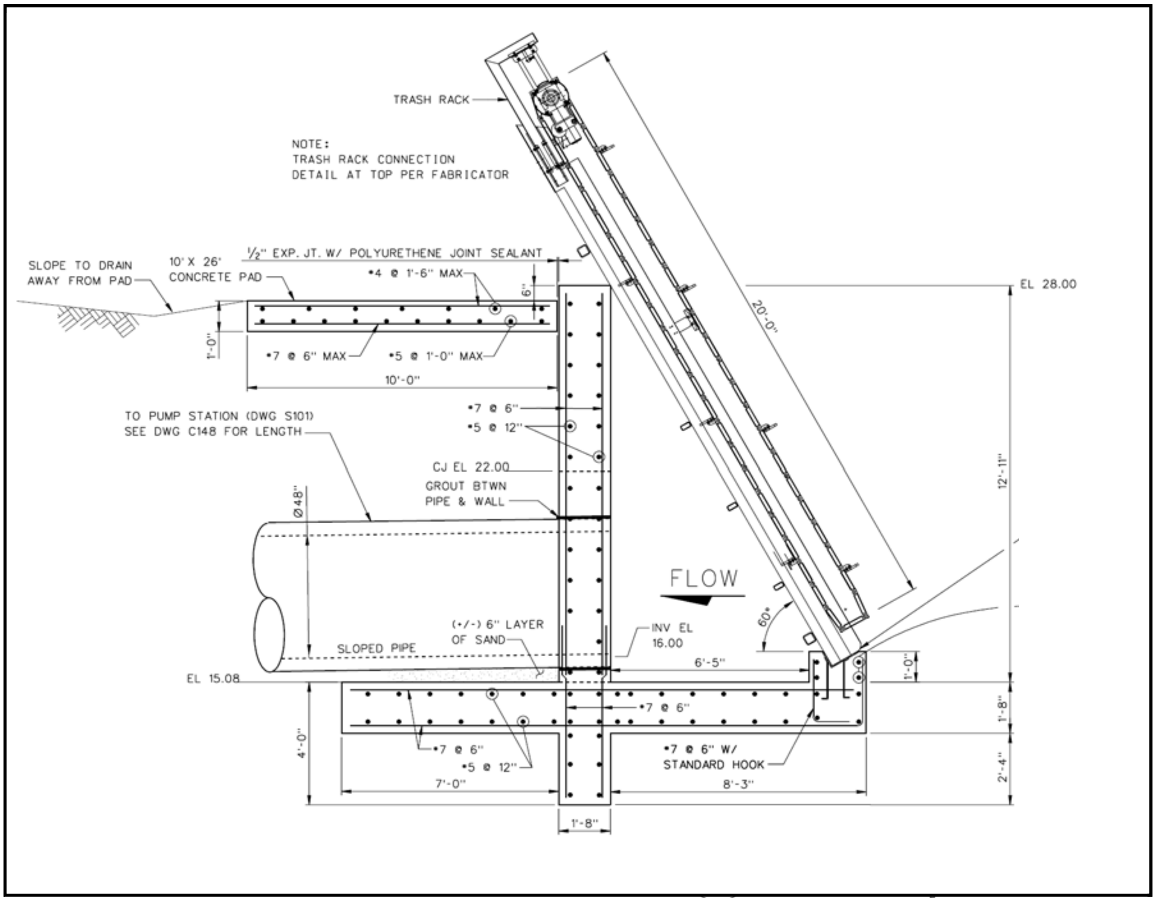


Reduced curve
Pump curve

4 CP 3531 C3531-63-1240
PRODUCT DATA
Rtd. pwr.: 215 hp
Imp. diam.: 680 mm
Vanes: 3
Throughlet: 4 inch

DUTY CONDITIONS
No of pumps: 4
Flow: 43317.0 USgpm
Head: 55.0 ft
Reduced head: 48.0 ft
Shaft power: 702.2 hp
Pump efficiency: 85.8 %
Specifc energy: 216.0 kWh/mg

Schematic of the trash rack at S-385.



S-385 System Pumping Characteristics

Calculate Pump Head;
Nubbins Slough

Static Head

WS.El In [ft]	WS. El. Out [ft]	Hs [ft]
17	34	17

Note: Due to a reduction in the length of the force main, the friction loss (Hf) is only 41% of that reported here.

Pump Curve: 3531-63-1240 with 680mm Impellor

Friction Head: Force Main Length [ft]	Diameter [ft]	Area [sf]	FM - Q [gpm]	cfs	FM - V [fps]	HW Coefficient	Hf [ft]	Pump Stataion: No. of Pumps	Dia. Dischge	Area [sf]	Vel [fps]	HfPS [ft]	FM Ftngs: HfFM [ft]	Static: Hs [ft]	Htotal [ft]	Pump Curve: 1 Pump [ft]	eff.	2pmps	3pmps	4pmps
8100	4	12.57	9000	20.1	1.60	140	1.23	1	20	2.18	9.19	4.59	0.04	17	22.86	61.2				
8100	4	12.57	10000	22.3	1.77	140	1.50	1	20	2.18	10.21	5.67	0.05	17	24.22	57.9				
8100	4	12.57	11000	24.5	1.95	140	1.79	1	20	2.18	11.23	6.86	0.06	17	25.71	54.4				
8100	4	12.57	12000	26.7	2.13	140	2.10	1	20	2.18	12.26	8.16	0.07	17	27.33	50.7				
8100	4	12.57	13000	29.0	2.31	140	2.44	1	20	2.18	13.28	9.58	0.08	17	29.10	46.8				
8100	4	12.57	14000	31.2	2.48	140	2.79	1	20	2.18	14.30	11.11	0.10	17	31.00	42.6				
8100	4	12.57	15000	33.4	2.66	140	3.17	1	20	2.18	15.32	12.76	0.11	17	33.04	38.1				
8100	4	12.57	16000	35.7	2.84	140	3.58	1	20	2.18	16.34	14.51	0.12	17	35.21	33.0				
8100	4	12.57	17000	37.9	3.01	140	4.00	1	20	2.18	17.36	16.38	0.14	17	37.52	27.4				
8100	4	12.57	18000	40.1	3.19	140	4.45	1	20	2.18	18.38	18.37	0.16	17	39.97	21.4		61.2		
8100	4	12.57	19000	42.3	3.37	140	4.91	1	20.	2.18	19.40	20.46	0.18	17	42.55	15.0		59.55		
8100	4	12.57	20000	44.6	3.55	140	5.40	2	20	2.18	10.21	5.67	0.20	17	28.27			57.9		
8100	4	12.57	21000	46.8	3.72	140	5.91	2	20	2.18	10.72	6.25	0.22	17	29.38			56.15		
8100	4	12.57	22000	49.0	3.90	140	6.44	2	20	2.18	11.23	6.86	0.24	17	30.54			54.4		
8100	4	12.57	23000	51.2	4.08	140	7.00	2	20	2.18	11.75	7.50	0.26	17	31.75			52.6		
8100	4	12.57	24000	53.5	4.26	140	7.57	2	20	2.18	12.26	8.16	0.28	17	33.01			50.7		
8100	4	12.57	25000	55.7	4.43	140	8.16	2	20	2.18	12.77	8.86	0.31	17	34.33			48.8		
8100	4	12.57	26000	57.9	4.61	140	8.78	2	20	2.18	13.28	9.58	0.33	17	35.69			46.8		
8100	4	12.57	27000	60.2	4.79	140	9.41	2	20	2.18	13.79	10.33	0.36	17	37.10			44.7	61.2	
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8100	4	12.57	29000	64.6	5.14	140	10.74	2	20	2.18	14.81	11.92	0.41	17	40.07			40.4	59.0	
8100	4	12.57	30000	66.8	5.32	140	11.44	2	20	2.18	15.32	12.76	0.44	17	41.63			38.1	57.9	
8100	4	12.57	31000	69.1	5.50	140	12.15	2	20	2.18	15.83	13.62	0.47	17	43.24			35.6	56.7	
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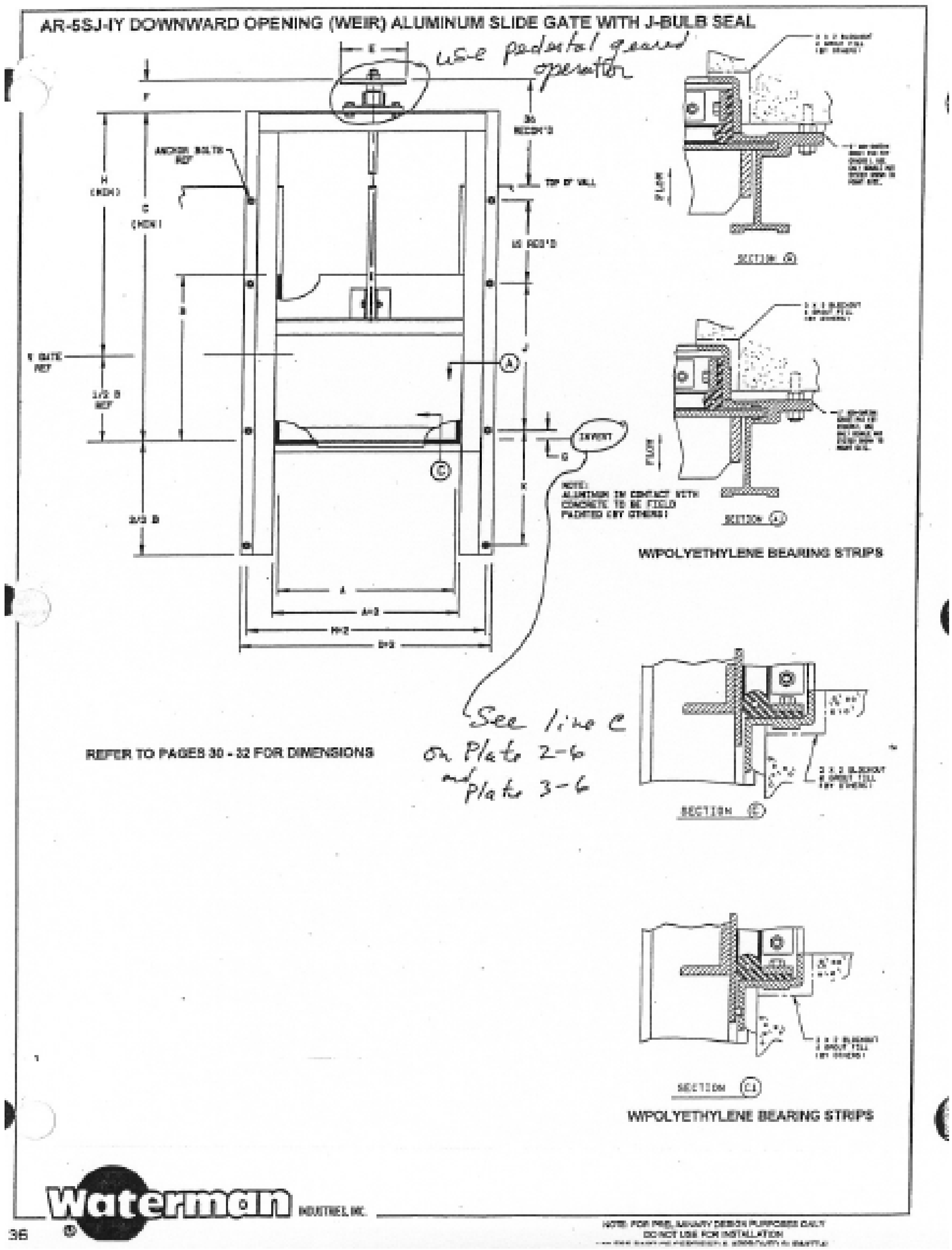
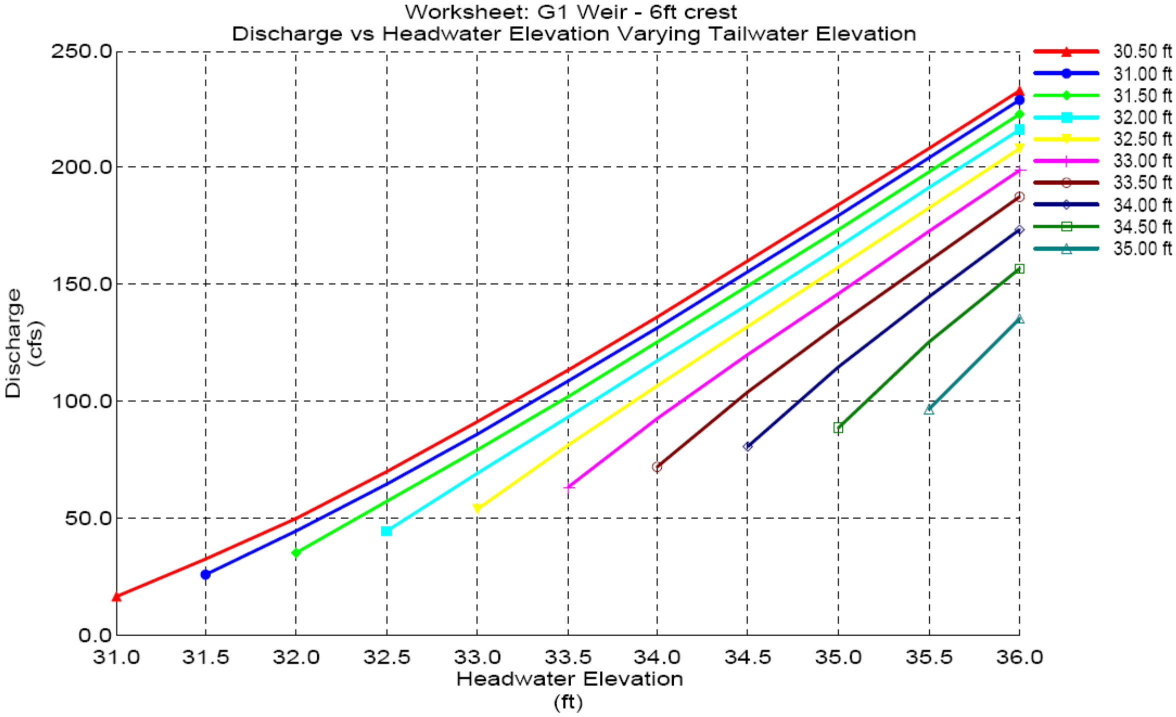
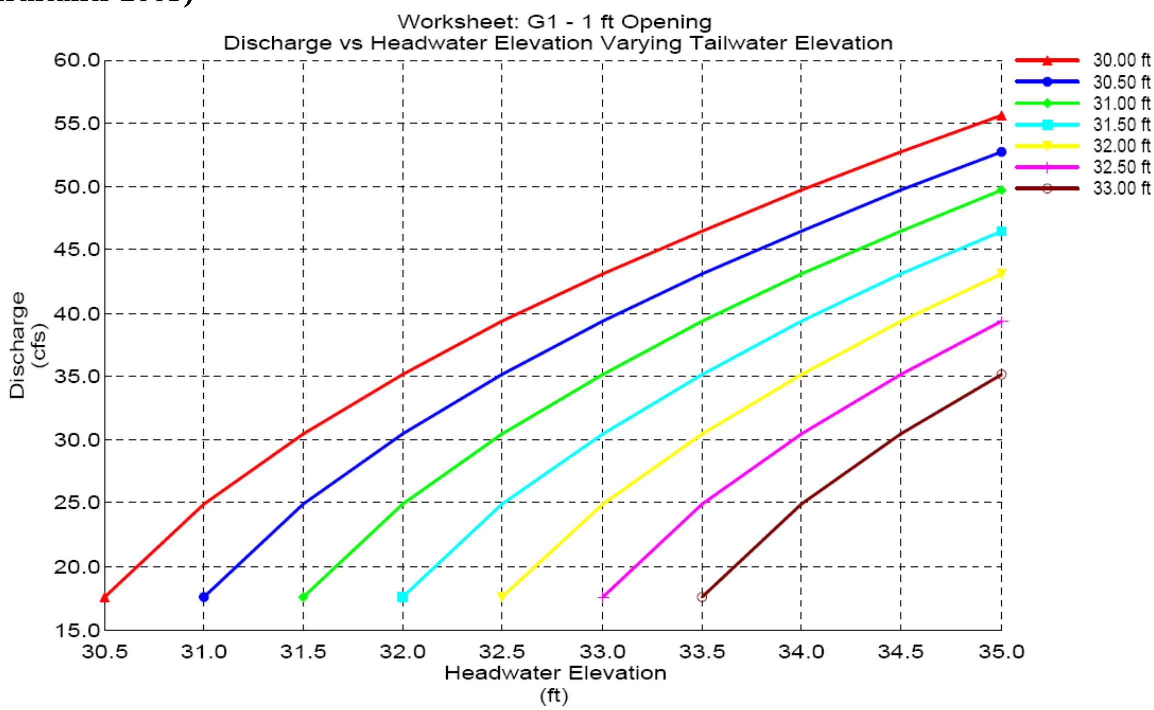
8100	4	12.57	34000	75.8	6.03	140	14.42	3	20	2.18	11.57	7.28	0.56	17	39.27			27.4	53.2	
8100	4	12.57	35000	78.0	6.21	140	15.21	3	20	2.18	11.92	7.72	0.60	17	40.53			24.4	51.9	
8100	4	12.57	36000	80.2	6.38	140	16.03	3	20	2.18	12.26	8.16	0.63	17	41.82			21.4	50.7	61.2
8100	4	12.57	37000	82.4	6.56	140	16.86	3	20	2.18	12.60	8.62	0.67	17	43.15			18.2	49.4	60.4
8100	4	12.57	38000	84.7	6.74	140	17.71	3	20	2.18	12.94	9.10	0.70	17	44.51			15.0	48.1	59.55
8100	4	12.57	39000	86.9	6.92	140	18.59	3	20	2.18	13.28	9.58	0.74	17	45.91				46.8	58.7
8100	4	12.57	40000	89.1	7.09	140	19.48	3	20	2.18	13.62	10.08	0.78	17	47.34				45.4	57.9
8100	4	12.57	41000	91.4	7.27	140	20.39	3	20	2.18	13.96	10.59	0.82	17	48.80				44.0	57.0
8100	4	12.57	42000	93.6	7.45	140	21.32	3	20	2.18	14.30	11.11	0.86	17	50.29				42.6	56.15
8100	4	12.57	43000	95.8	7.62	140	22.27	4	20	2.18	10.98	6.55	0.90	17	46.72				41.1	55.3
8100	4	12.57	44000	98.0	7.80	140	23.23	4	20	2.18	11.23	6.86	0.95	17	48.04				39.6	54.4
8100	4	12.57	45000	100.3	7.98	140	24.22	4	20	2.18	11.49	7.17	0.99	17	49.38				38.1	53.5
8100	4	12.57	46000	102.5	8.16	140	25.22	4	20	2.18	11.75	7.50	1.03	17	50.75				36.4	52.55
8100	4	12.57	47000	104.7	8.33	140	26.25	4	20	2.18	12.00	7.83	1.08	17	52.15				34.7	51.6
8100	4	12.57	48000	107.0	8.51	140	27.29	4	20	2.18	12.26	8.16	1.12	17	53.58				33.0	50.7
8100	4	12.57	49000	109.2	8.69	140	28.35	4	20	2.18	12.51	8.51	1.17	17	55.03				31.1	49.7
8100	4	12.57	50000	111.4	8.87	140	29.43	4	20	2.18	12.77	8.86	1.22	17	56.51				29.3	48.75
8100	4	12.57	51000	113.6	9.04	140	30.53	4	20	2.18	13.02	9.22	1.27	17	58.01				27.4	47.8
8100	4	12.57	52000	115.9	9.22	140	31.65	4	20	2.18	13.28	9.58	1.32	17	59.55				25.4	46.8
8100	4	12.57	53000	118.1	9.40	140	32.78	4	20	2.18	13.53	9.95	1.37	17	61.11				23.4	45.8
8100	4	12.57	54000	120.3	9.57	140	33.93	4	20	2.18	13.79	10.33	1.42	17	62.69				21.4	44.7
8100	4	12.57	55000	122.5	9.75	140	35.11	4	20	2.18	14.04	10.72	1.48	17	64.30				19.3	43.7
8100	4	12.57	56000	124.8	9.93	140	36.30	4	20	2.18	14.30	11.11	1.53	17	65.94				17.1	42.6
8100	4	12.57	57000	127.0	10.11	140	37.50	4	20	2.18	14.55	11.51	1.59	17	67.60				15.0	41.5
8100	4	12.57	58000	129.2	10.28	140	38.73	4	20	2.18	14.81	11.92	1.64	17	69.29					40.35
										Avg		10.18								


AR-5SJ-IY DOWNWARD OPENING (WEIR) ALUMINUM SLIDE GATE WITH J-BULB SEAL
use pedestal geared operator
ANCHOR BOLTS REF
TOP OF WALL
INVERT
NOTE: ALUMINUM IN CONTACT WITH CONCRETE TO BE FIELD PAINTED (BY OTHERS)
SECTION A
W/POLYETHYLENE BEARING STRIPS
See line C on Plate 2-6 and Plate 3-6
REFER TO PAGES 30 - 32 FOR DIMENSIONS
SECTION C
SECTION C1
W/POLYETHYLENE BEARING STRIPS
Waterman INDUSTRIES, INC.
36
NOTE: FOR PRELIMINARY DESIGN PURPOSES ONLY
DO NOT USE FOR INSTALLATION

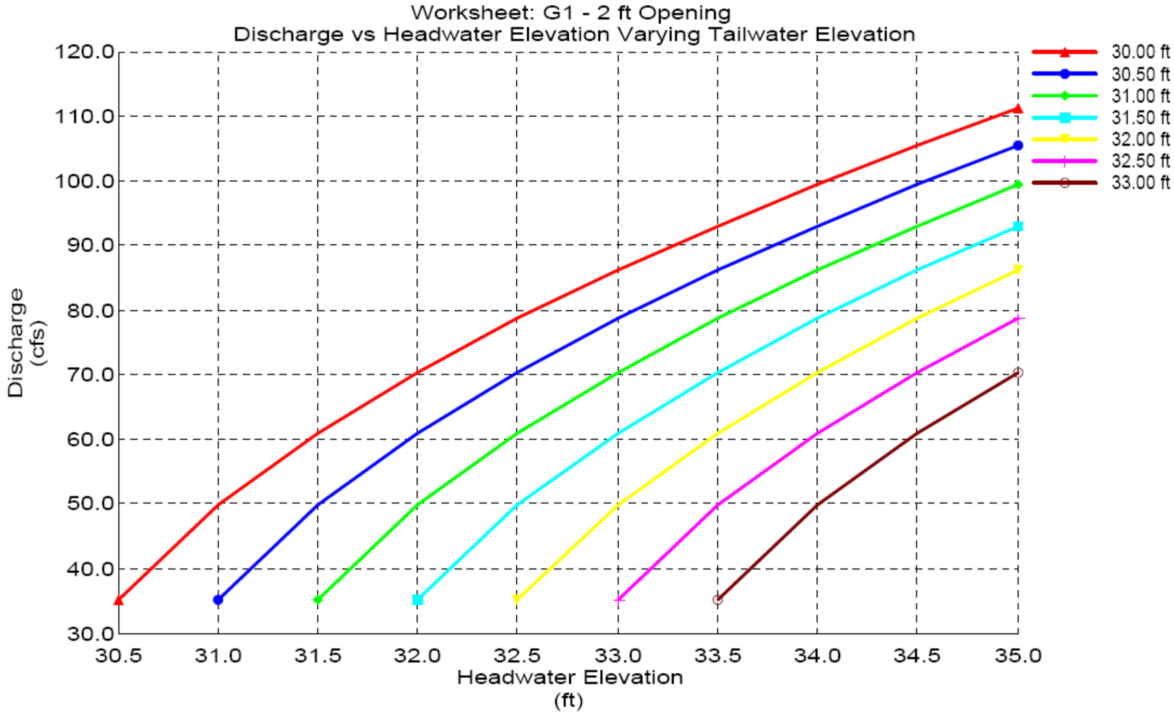
Rating Curves for S386C – Upstream Opening (Stanley Consultants 2005)



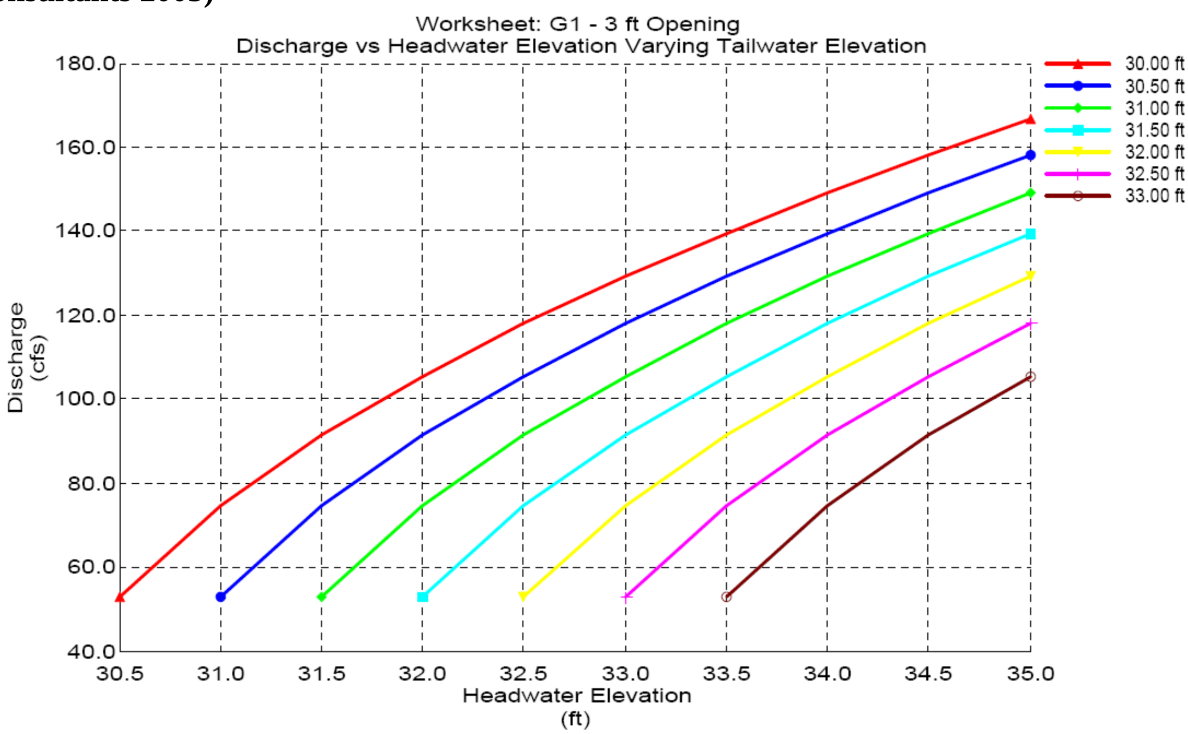
Rating Curve for S-386C - Downstream Opening with Gate Open 1 Foot (Stanley Consultants 2005)



Rating Curve for S-386C - Downstream Opening with Gate Open 2 Feet (Stanley Consultants 2005)



Rating Curve for S-386C - Downstream Opening with Gate Open 3 Feet (Stanley Consultants 2005)



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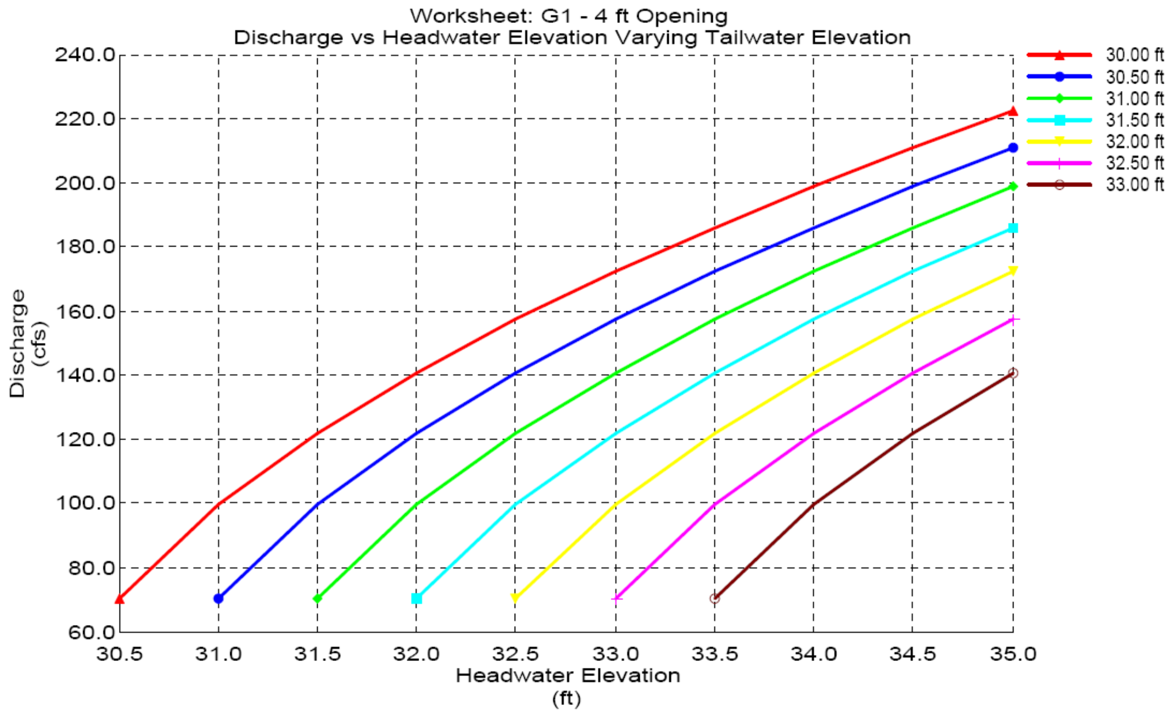
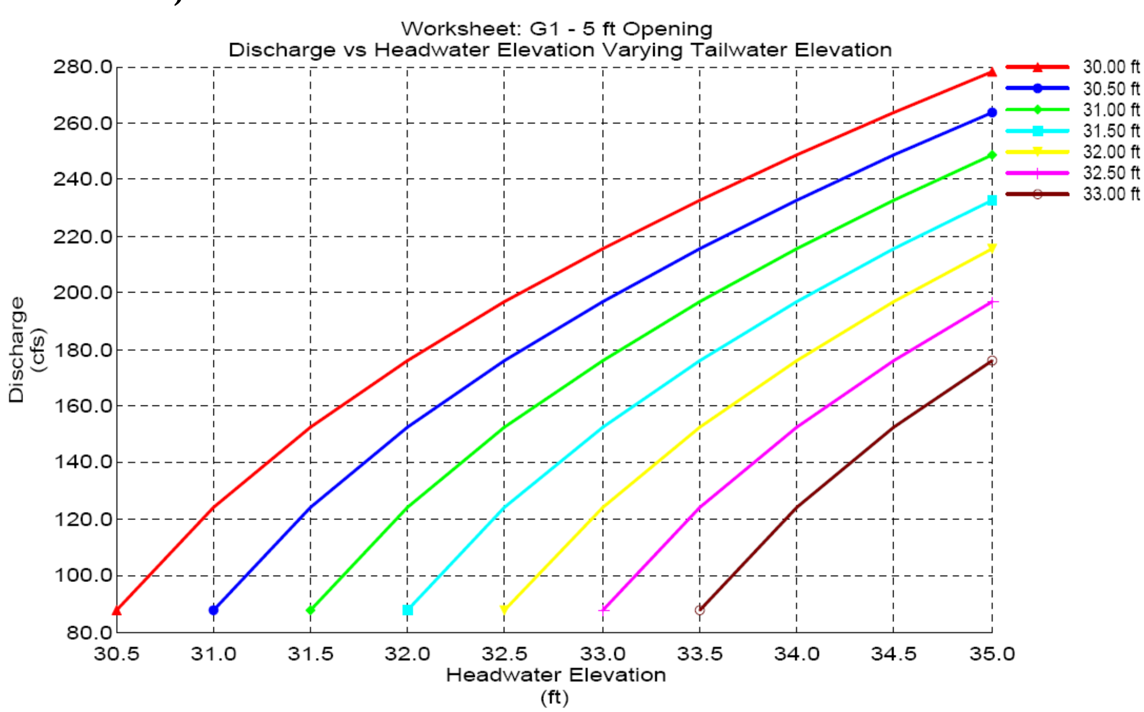
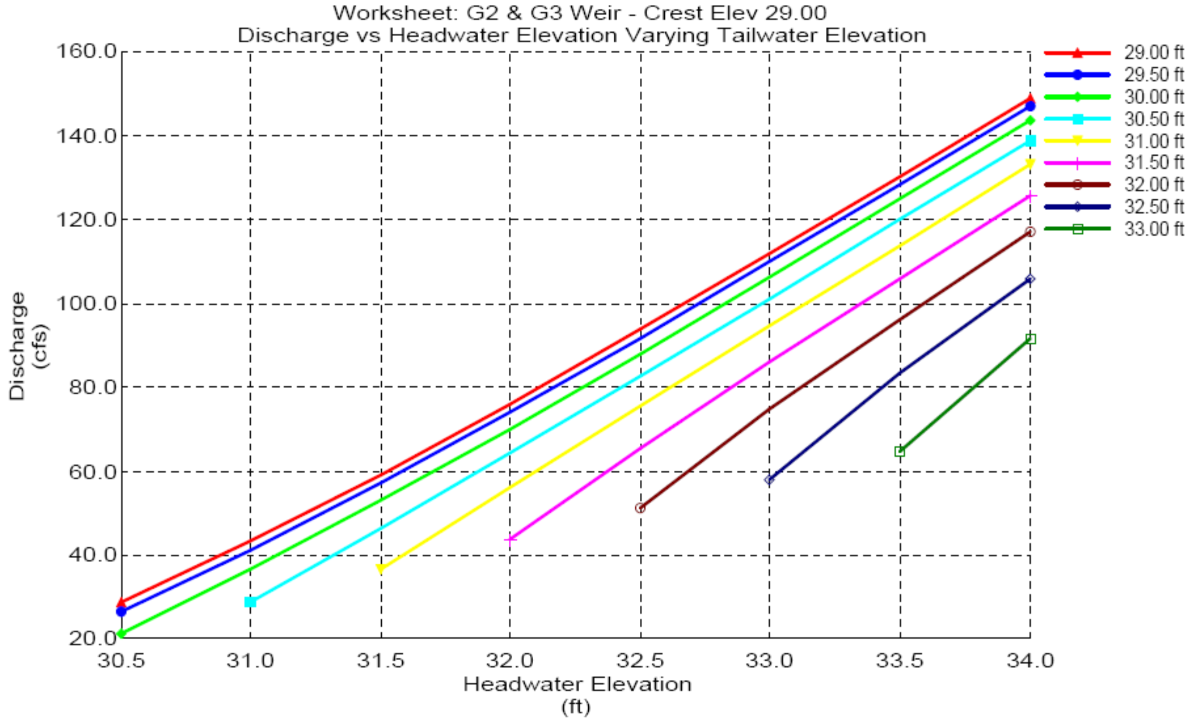


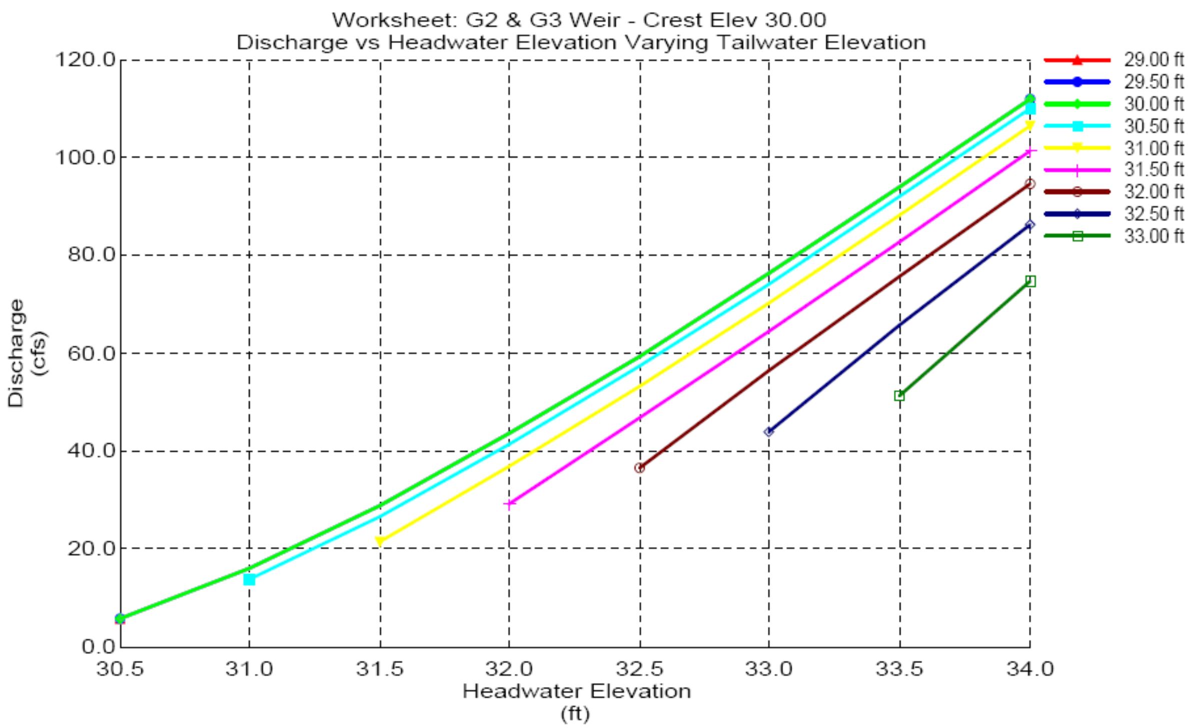
Rating Curve for S-386C - Downstream Opening with Gate Open 5 Feet (Stanley Consultants 2005)



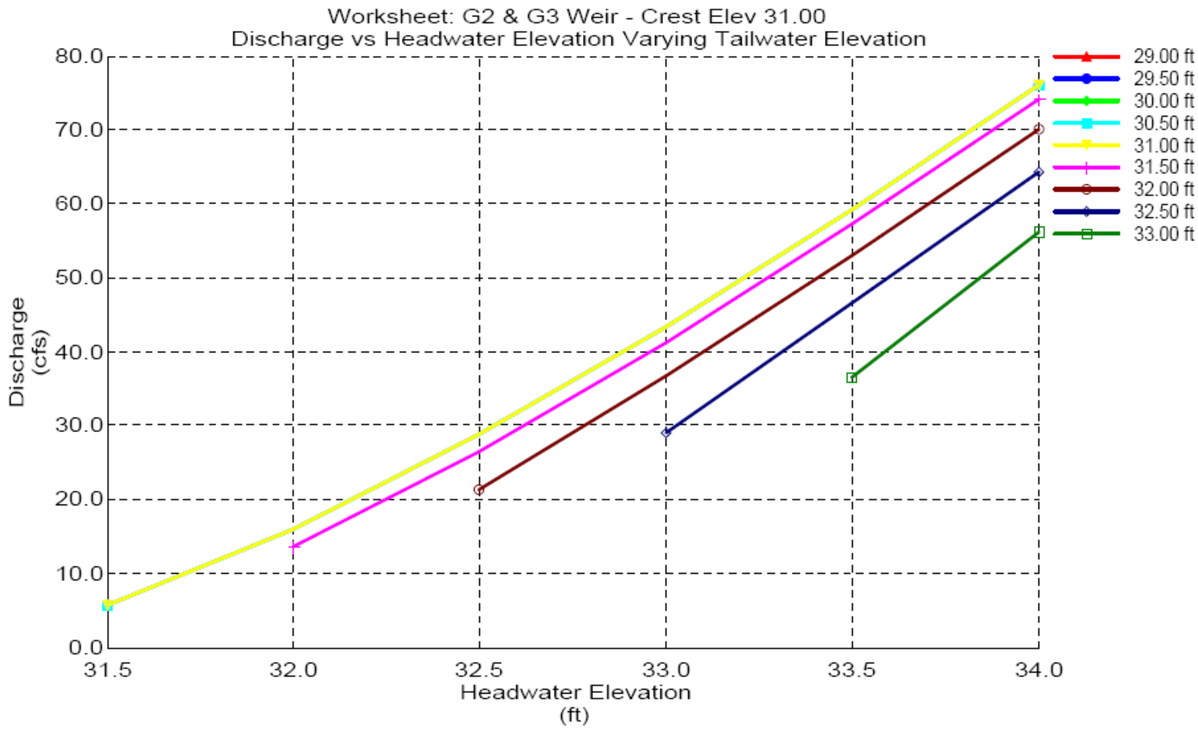
Rating Curve for S-386A&B - with Gate Fully Open (Stanley Consultants 2005)



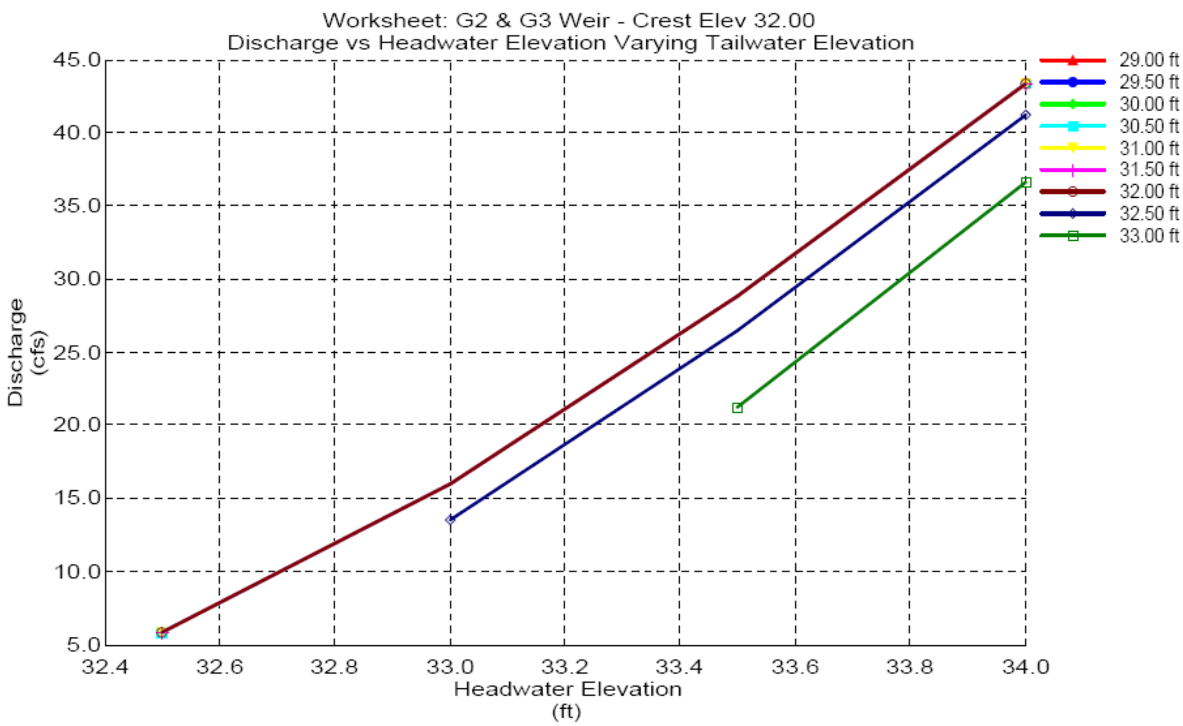
Rating Curve for S-386A&B - with Gate Open 3.5 Feet (Stanley Consultants 2005)



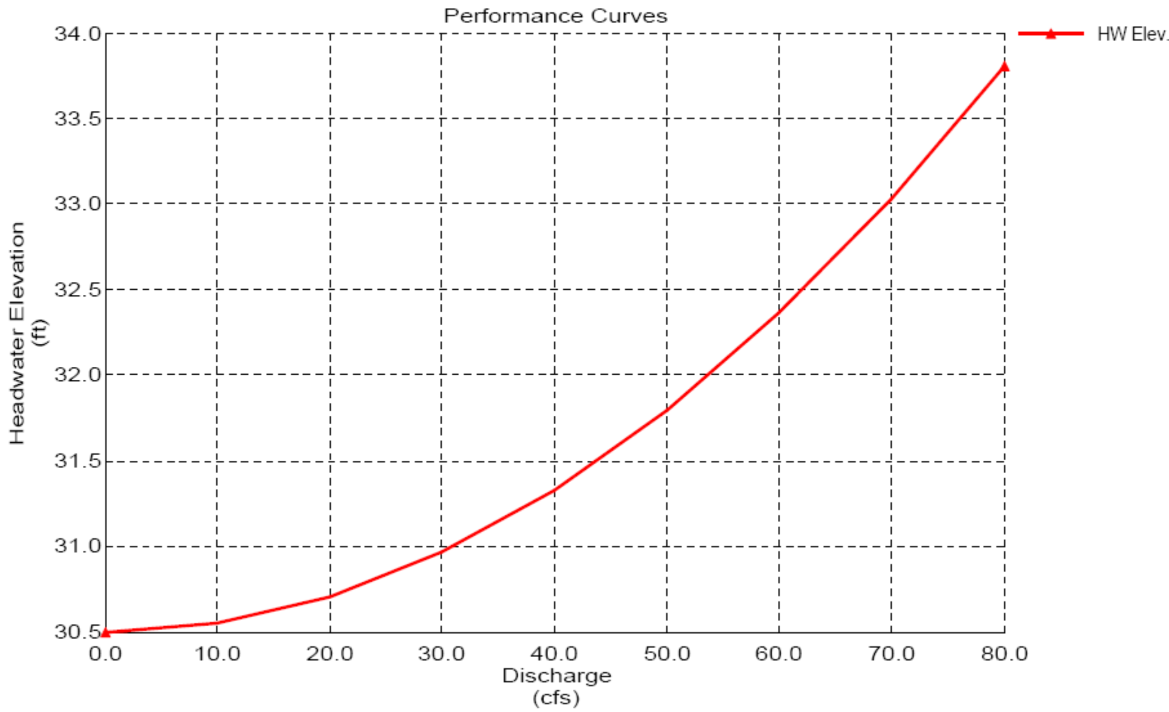
Rating Curve for S-386A&B - with Gate Open 2.5 Feet (Stanley Consultants 2005)



Rating Curve for S-386A&B - with Gate Open 1.5 Feet (Stanley Consultants 2005)



Rating Curve for Culvert S-386A&B – Tailwater Elevation = 30.5 ft (Stanley Consultants 2005)



Performance Report for Culvert S-386A&B – Tailwater Elevation = 30.5 ft (Stanley Consultants 2005)

Culvert Summary					
Allowable HW Elevation	32.40	ft	Headwater Depth/Height	2.30	
Computed Headwater Eleva	32.40	ft	Discharge	60.62	cfs
Inlet Control HW Elev.	30.50	ft	Tailwater Elevation	30.50	ft
Outlet Control HW Elev.	32.40	ft	Control Type	Outlet Control	

Grades					
Upstream Invert	25.50	ft	Downstream Invert	25.50	ft
Length	64.00	ft	Constructed Slope	0.000000	ft/ft

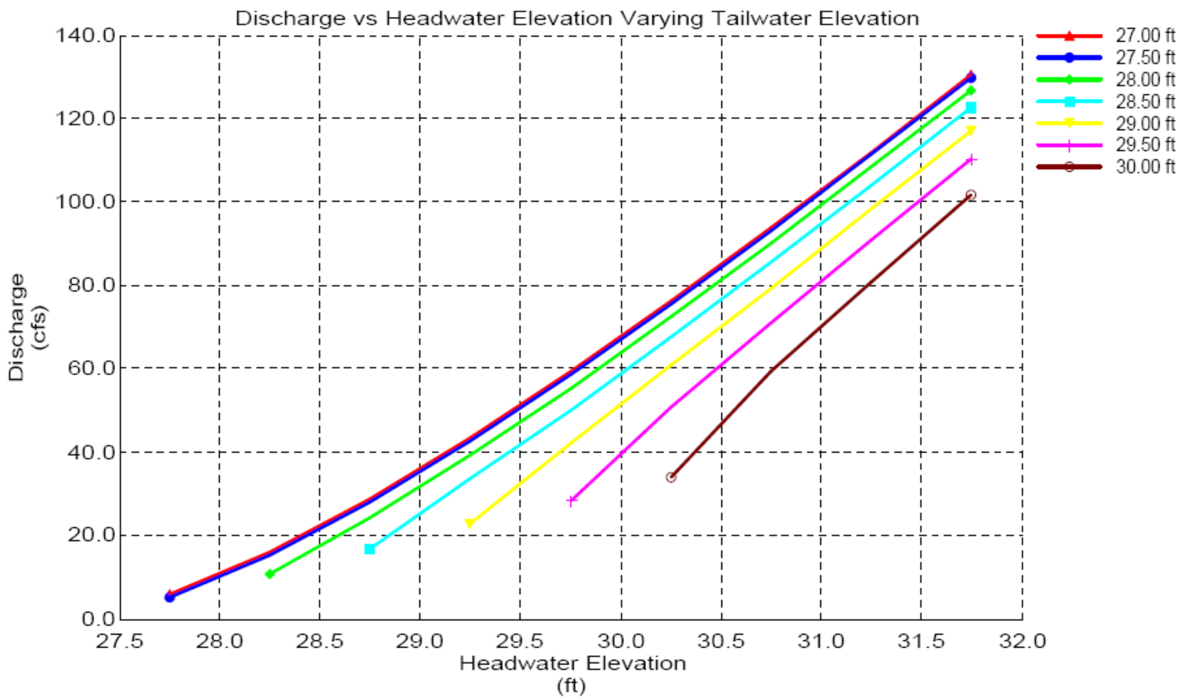
Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	5.00	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	2.51	ft
Velocity Downstream	8.58	ft/s	Critical Slope	0.007960	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	3.00	ft
Section Size	36 inch		Rise	3.00	ft
Number Sections	1				

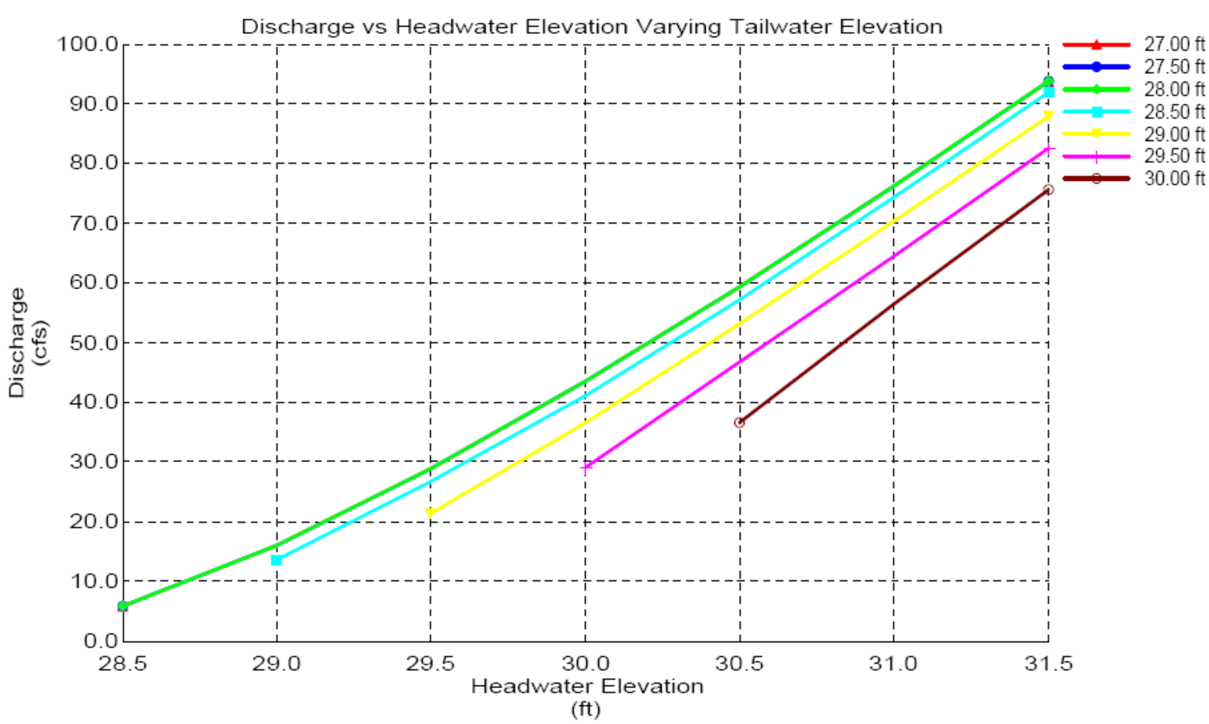
Outlet Control Properties					
Outlet Control HW Elev.	32.40	ft	Upstream Velocity Head	1.14	ft
Ke	0.20		Entrance Loss	0.23	ft

Inlet Control Properties					
Inlet Control HW Elev.	30.50	ft	Flow Control	Submerged	
Inlet Type	Groove end w/headwall		Area Full	7.1	ft²
K	0.00180		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	2	
C	0.02920		Equation Form	1	
Y	0.74000				

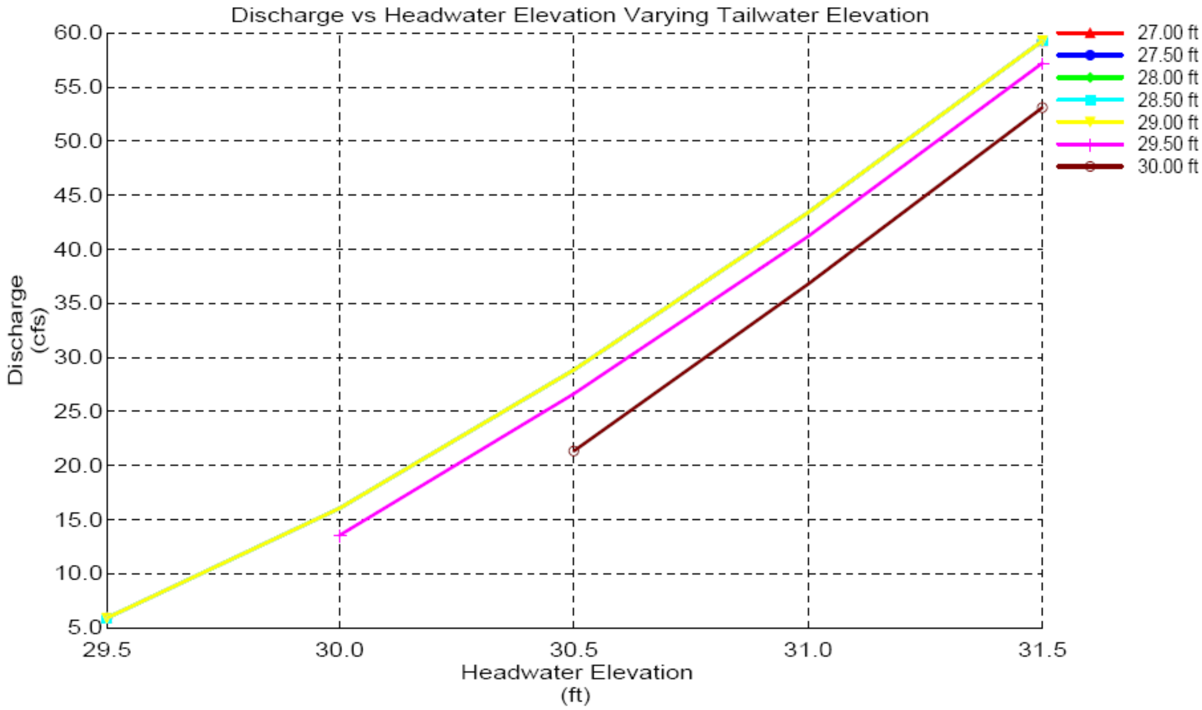
Rating Curve for S-387A-C - with Gate Fully Open: Crest Elevation 27.25 ft (from Stanley Consultants 2005)



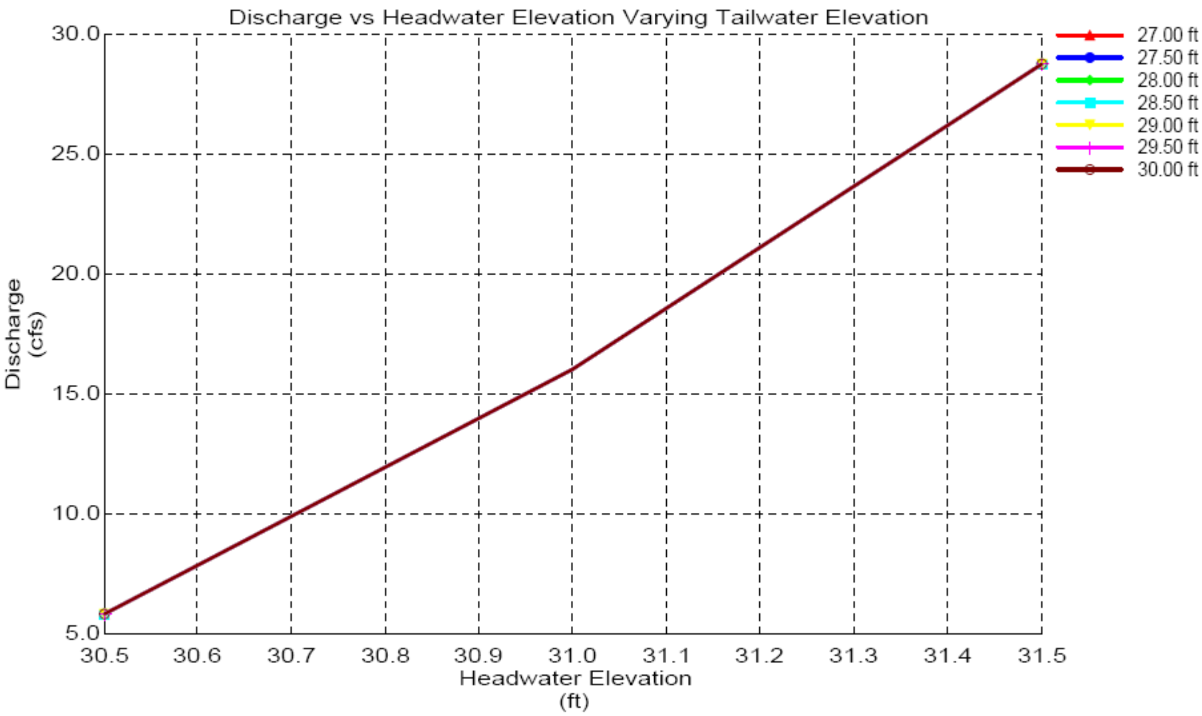
Rating Curve for S-387A-C - with Gate Open 3.75 Feet: Crest Elevation 28.0 ft (from Stanley Consultants 2005)



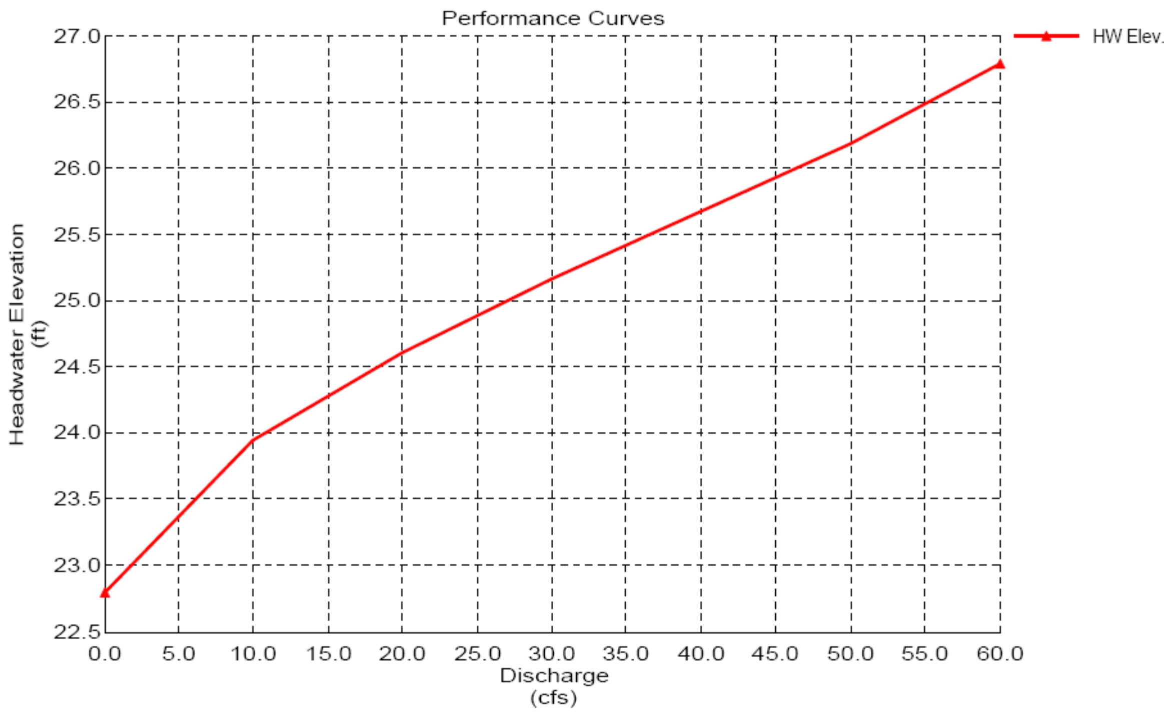
Rating Curve for S-387A-C - with Gate Open 2.75 Feet: Crest Elevation 29.0 ft (from Stanley Consultants 2005)



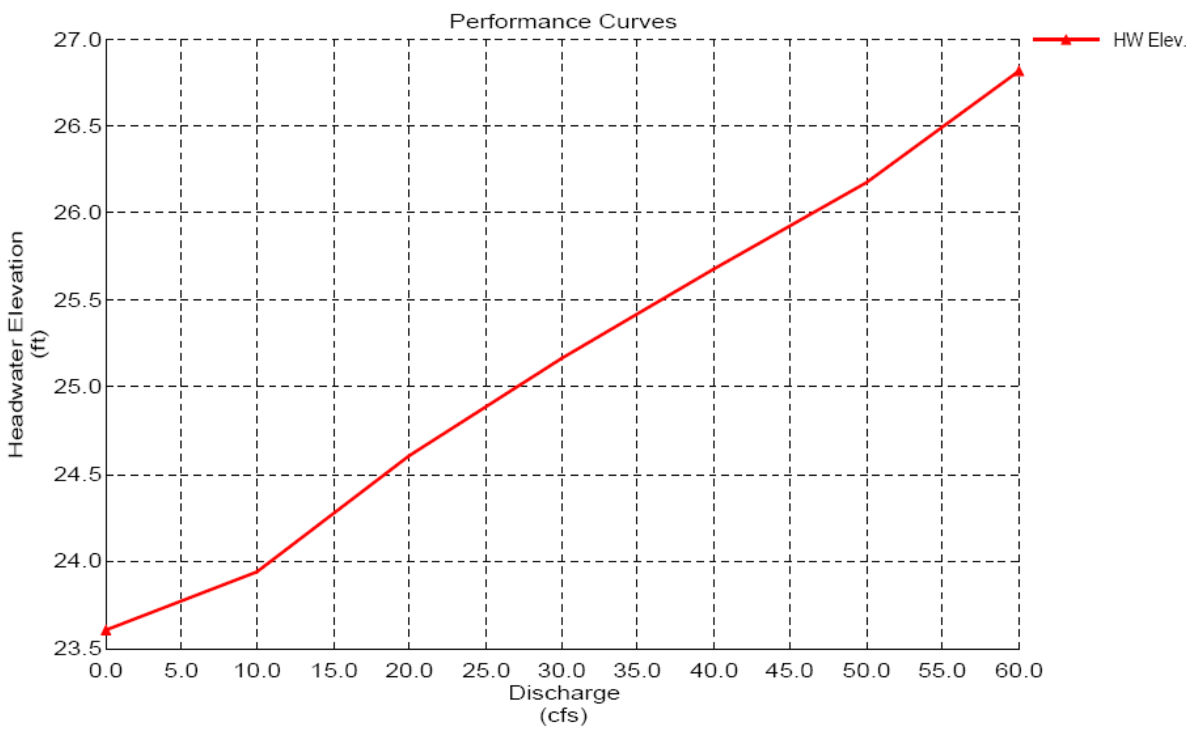
Rating Curve for S-387A-C - with Gate Open 1.75 Feet: Crest Elevation 30.0 ft (from Stanley Consultants 2005)



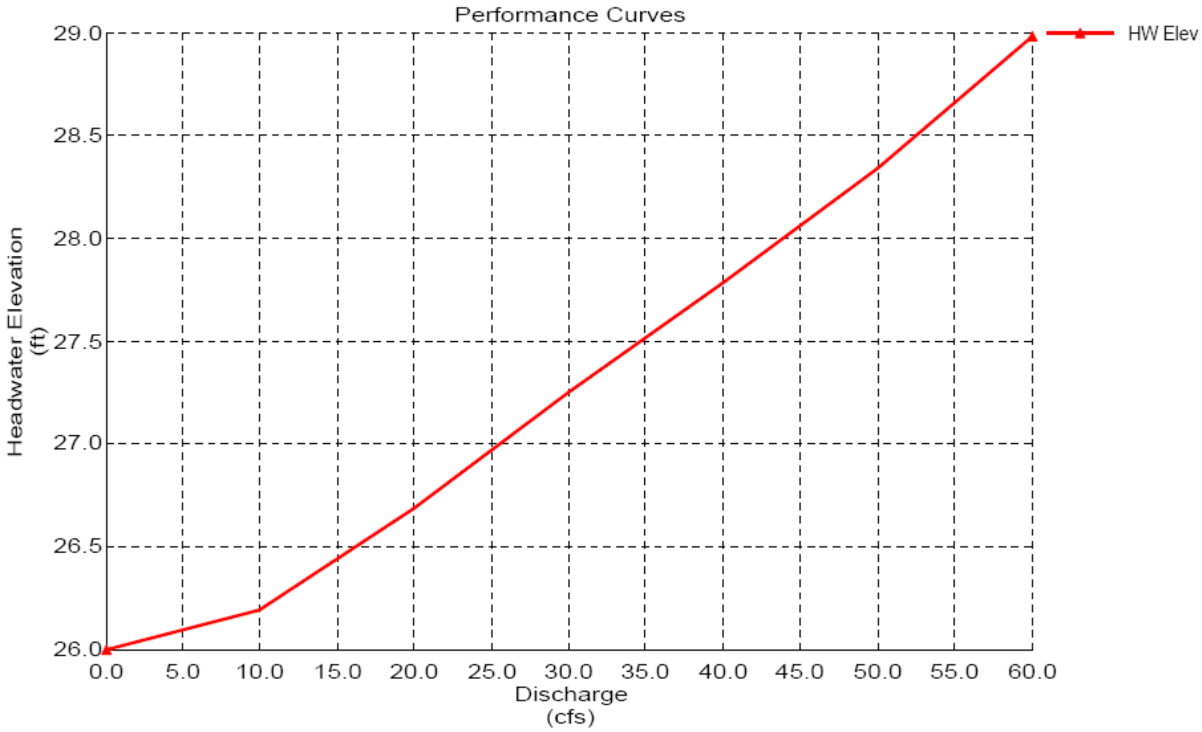
Rating Curve for Culvert S-386A: Tailwater Elevation 22.8 (from Stanley Consultants 2005)



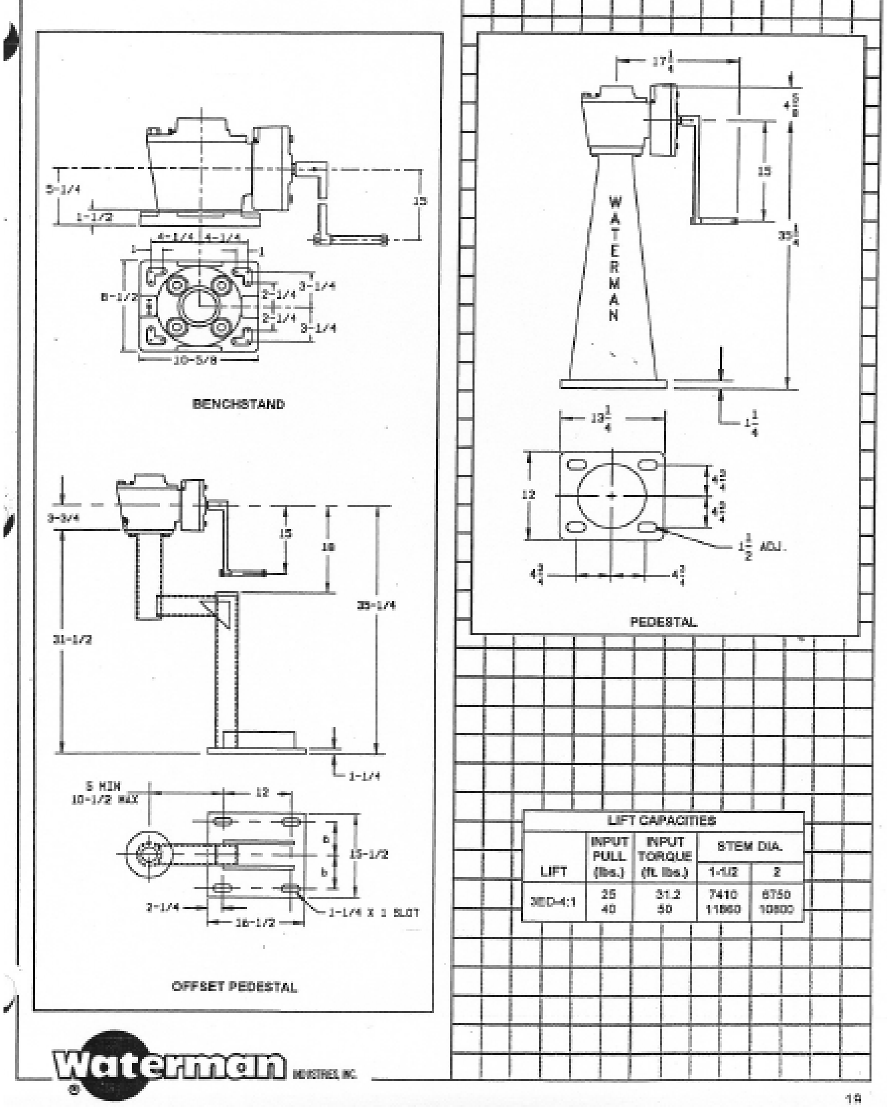
Rating Curve for Culvert S-386B: Tailwater Elevation 23.6 (from Stanley Consultants 2005)



Rating Curve for Culvert S-386C: Tailwater Elevation 26.0 (from Stanley Consultants 2005)



TYPE 3ED- 4:1 GEARED OPERATOR



LIFT CAPACITIES				
LIFT	INPUT PULL (lbs.)	INPUT TORQUE (ft. lbs.)	STEM DIA.	
			1-1/2	2
3ED-4:1	25 40	31.2 50	7410 11860	6750 10800

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SOUTH FLORIDA WATER MANAGEMENT DISTRICT

VEGETATION MANAGEMENT PLAN

NUBBIN SLOUGH

STORMWATER TREATMENT AREA

November, 2005

WETLAND CONSULTING SERVICES, INC.

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1. Introduction

The South Florida Water Management District (SFWMD), the U. S. Army Corps of Engineers (Corps), the Florida Department of Environmental Protection (FDEP), other agencies and private landowners are cooperating on efforts to improve water quality in the Lake Okeechobee watershed and throughout the south Florida ecosystem. This cooperation includes studies and capital projects composing the Lake Okeechobee Protection Program, the Comprehensive Everglades Restoration Plan (CERP), and Critical Restoration Projects. The Lake Okeechobee Water Retention / Phosphorus Removal Project consists of two shallow stormwater treatment areas – the Nubbin Slough Stormwater Treatment Area (STA) and the Taylor Creek STA – designed to remove phosphorus loads from the Nubbin Slough and Taylor Creek watersheds. High phosphorus loads have been implicated in excessive eutrophication of Lake Okeechobee that have resulted in algal blooms, high sediment oxygen demand, and loss of fisheries and recreational benefits provided by the lake.

The Nubbin Slough STA is one of the Critical Restoration Projects authorized by Congress through Section 528 of the Water Resources Development Act of 1996. The project was designed by Stanley Consultants, Inc. working under contract to the Corps, who was responsible for construction. Construction is presently underway with completion scheduled for January 2006. The SFWMD, as the project sponsor, assisted in funding the capital works and is responsible for operation and maintenance of the STA. The anticipated long-term average phosphorus reduction within the STA was estimated during the design phase to be approximately 90% of the total phosphorus concentration of Nubbin Slough at the project location.

The Nubbin Slough STA is located approximately 6.5 miles southeast of the City of Okeechobee, immediately north of State Road 710 (Beeline Highway). A gated driveway will provide access to the project site, and the water control structures can be reached by traveling along the top of the levees. The southern end of this project is approximately 1.3 miles from the edge of Lake Okeechobee. The Nubbin Slough/New Palm Dairy site originally consisted of a large dairy along with pasture, depressional marsh and cypress/forested wetland habitats. The site also contained limited native uplands that supported gopher tortoises that were relocated before construction began. Additionally, the Nubbin Slough STA site and surrounding area contains open pastures with scattered cabbage palms, considered prime foraging and nesting habitat for Audubon's crested caracara.

This document is intended to provide District vegetation management staff with the information necessary to maintain Nubbin Slough STA in a manner that provides the greatest nutrient removal from the vegetation community within the perimeter levee. Appropriate management options are provided for each phase of operations and strategies for managing adverse conditions will be discussed. While this vegetation management plan (Plan) cannot predict the full range of conditions that may affect the STA or provide comprehensive solutions for every event, the information contained within should provide sufficient guidance to enable District staff to meet the project objectives.

2. Background

2.1 STA Background

The land that the Nubbin Slough STA occupies was most recently used for dairy operations before construction of the project began. Prior to construction, most of the property consisted of wet and dry pasture, a few small depressions, excavated manure ponds, limited upland forest and some forested wetlands.

Nubbin Slough STA is an 809-acre wetland on the east side of Nubbin Slough in Okeechobee County (Figure 1). An inflow pump station lifts water from Nubbin Slough on the west side of the STA and delivers it into the treatment area via a 48-inch force main. Treatment occurs through natural biogeochemical processes as the water slowly flows by gravity westerly through 263-acre Cell 1 and subsequently through 546-acre Cell 2 before being discharged back to Nubbin Slough. Water levels and flow rates through the treatment cells are controlled by individual gated structures (S-386A-C, S-387A-C). Deep zone trenches at the inflow and outflow of each cell are designed to help distribute flow evenly throughout the cell. Several manure ponds within the project footprint were remediated by scraping out the organic sediments and backfilling them with the native soils.

2.2 Vegetation History and Existing Conditions

Based on knowledge and experience gathered from the operation and maintenance of many large STAs, it was assumed during design that cattail (*Typha* sp.) would colonize the project early and eventually become the dominant plant species within the treatment cells. Initial observations of the two treatment cells prior to construction completion (May and August, 2005) revealed the presence of cattail and a variety of other native wetland plant species, including pickerelweed, fireflag and maidencane, perhaps indicating that a viable source of seeds for these plants remains on the property. No planting activities are planned at Nubbin Slough STA; wetland vegetation will colonize the treatment cells through natural recruitment. Also observed were several notable invasive exotic plants, such as torpedo grass, that may need to be treated (depending on its nutrient uptake ability and other factors) to help ensure optimal performance of the STA. This will be discussed in further detail in section 3.1.2.

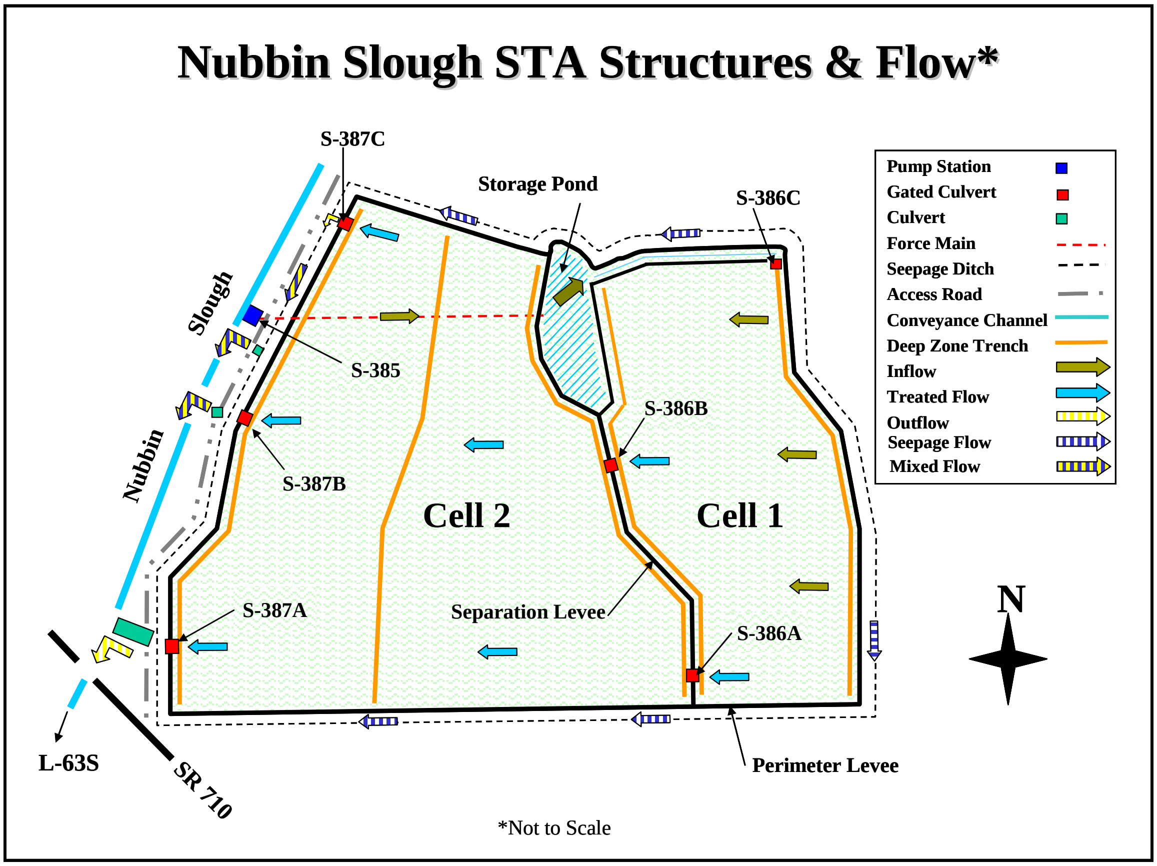

Figure 1. Schematic of Nubbin Slough STA.

2.3 Project Objectives

The goal of Nubbin Slough STA is to capture and reduce the mass of total phosphorus from the Nubbin Slough Basin prior to discharge back into Nubbin Slough and on to Lake Okeechobee. The phosphorus concentration in Nubbin Slough runoff exhibits considerable variability, with an average of approximately 500 parts per billion (ppb). This greatly exceeds the phosphorus concentration of Lake Okeechobee, which averages just over 100 ppb. Emergent wetland vegetation (cattail, pickerelweed, etc.) has already begun to colonize the treatment areas, and average depths of 2 feet or less should be conducive to sustaining these communities. The long-term phosphorus storage mechanism within the STA will be the accretion of new organic sediment, and for this reason it is important to operate the STA to avoid dry out, which could release nutrients through remineralization of these sediments. In addition to the reduction of phosphorus loads, Nubbin Slough STA will provide additional water quality and quantity benefits to downstream waters, including the removal of suspended solids, dissolved and particulate oxygen-demanding materials, total nitrogen, metals, and pesticides that would otherwise flow into the lake.

The development and successful management of vegetation plays an important role in optimizing the phosphorous reduction abilities of stormwater treatment areas. *The objectives of this Plan are to provide the methods required to successfully and cost effectively maintain the desired vegetation communities within the STA.* The District will operate and maintain the STA in accordance with the final Operation Plan and this Plan, and confer with the USACE regarding any major variations to the plans necessary to meet the goals of this project.

3. Vegetation Management Activities

3.1 Management Activities During Start-up Operations Phase

In order for an STA to perform in a manner consistent with its stated objectives, an appropriate plant community must first be established. The selection of an effective community can only result from the consideration of several factors, including the hydrology of the STA (water depths, velocity, hydroperiod), what wetland plants, if any, are/were present on the property, soil type(s), and basin water quality characteristics. Once the desired plant community has been identified, operations and maintenance activities will likely need to be concentrated during this initial grow-in phase to help ensure that it is established successfully and undesirable plants are controlled within the STA.

The Nubbin Slough STA will be managed as a shallow, emergent marsh system intended to reduce nutrient loading to Lake Okeechobee. Depths will range from 0.5 to 3.0 feet but should average approximately 2.0 feet. Based on the hydrologic analyses conducted during the design, approximately 95% of the time the STA should have flow of approximately 12 cfs (Stanley Consultants, Inc. 2003 (1)), resulting in low water velocities through the project. Periods of STA dryout are expected but will likely occur only during the dry season. Because of these hydraulic characteristics, the resulting plant community is expected to be lentic (i.e., characterized by slowly moving water) in nature.

Much of the New Palm Dairy property has historically been saturated for part of the year and supported a variety of desirable wetland plant species. It was determined that Nubbin Slough STA would not be planted with additional wetland plants, but rely on natural revegetation from internal and external sources. Previous experience with STA start-up has shown that initial vegetation growth will depend on the seed source found in STA soils and viable plants and seeds carried into the STA by wind, water and wildlife. Because of the proximity to Nubbin Slough and low elevation, portions of the former New Palm Dairy that Nubbin Slough STA now occupies contained a variety of wetland plants that would be appropriate for inclusion in an STA and could be reestablished through deliberate management of water levels.

Figure 2. Borrow area in Cell 2. Several borrow areas were created to help provide levee material and have a minimum elevation approximately 2.0 feet below the treatment cell floor.

Native soils at Nubbin Slough STA consist mainly of fine sands of the Basinger, Riviera and Immokalee Series. Fine sands provide appropriate substrate for virtually all desirable emergent wetland plants listed in Table 1 and should help resist the occurrence of floating plants and the creation of potentially damaging tussocks within the treatment cells.

In terms of water quality, the characteristics most important to the vegetation community and ultimately the performance of an STA are perhaps nutrient loading and phosphorus in particular. Total Phosphorus (TP) concentrations in the Nubbin Slough basin upstream of the STA have most recently averaged around 500 parts per billion (ppb), which will create hyper-eutrophic conditions within the STA. Plants that once naturally occurred in the area may be best suited to exist in this high-phosphorus environment, but several species of nuisance vegetation are also well-equipped to thrive here. Should additional varieties of vegetation be considered for planting in the future, they should be chosen based partly on their ability to compete with existing plants in a hyper-eutrophic setting.

3.1.1 Strategies to encourage desirable emergent vegetation

Effectively managing water levels in Cells 1 and 2 will be necessary to create a desirable emergent marsh plant community through synchronized operation of the inflow pump station (S-385) and the project water control structures, S-386A-C and S-387A-C, to regulate depths within the treatment cells. The Operations Plan prescribes activities designed to establish a water depth of ***1.0 ft*** in both treatment cells to promote seed germination and young plant growth within the emergent marsh community. If the initial depth is allowed to exceed much more than 1.0 ft, plant growth may be hindered by reduced available sunlight, particularly if the water is turbid or tannin stained.

Table 1. Desirable Plants in an Emergent Marsh

Cattail	*Typha* spp.
Sawgrass	*Cladium jamaicense*
Spikerush	*Eleocharis interstincta*, *E. baldwinii*
Soft rushes	*Juncus* spp. (esp. *J. marginatus*, *J. megacephalus*)
Bulrushes	*Scirpus* spp.(esp. *S. californicus)*
Leather fern	*Acrostichum danaeifolium*
Pickerelweed	*Pontederia cordata*
Duck potato	*Sagittaria lancifolia*
Arrowhead	*Sagittaria latifolia*
Maidencane	*Panicum hemitomon*
Switch grass	*Panicum virgatum,*
Barnyard grass	*Echinochloa* spp.
Flat Sedge	*Cyperus* spp.
Giant reed	*Phragmites australis*
Wax myrtle	*Myrica cerifera*
Elderberry	*Sambuca canadensis*
Primrose willow	*Ludwigia* spp.
Smartweed	*Polygonum* spp.
Alligator flag	*Thalia geniculata*

3.1.2 Strategies to exclude invasive or non-desirable vegetation

Should non-desirable plants become established in either treatment cell during the start-up phase, it may be necessary to apply appropriate herbicides to eliminate or control their spread. Certain exotic plants may out-compete more desirable native species, sometimes displacing them entirely over time, and are suspected of reducing system performance. Additionally, Nubbin Slough STA should be maintained in a manner that will not cause the spread of exotic plant species to downstream areas.

If undesirable plant species are observed within the treatment cells, particularly those listed in Table 2, a qualified vegetation management specialist should be consulted who can help develop an appropriate strategy for controlling the infestation. If deemed necessary, herbicides may be applied using several approved methods including aerial, vehicle, airboat or backpack based equipment. The size of the infested area will usually dictate the method of application, but in almost every case, herbicides must carry a label approving it for aquatic use to be applied within the STA. Care must be taken to reduce herbicide impacts to desirable plants while targeting potentially harmful species. *Also, if applying herbicide to a large area within the treatment cell(s), the effects that a subsequent nutrient release may have on the start-up compliance test should be carefully considered*.

Table 2. Undesirable Plants in an Emergent Marsh*

Water Lettuce	*Pista stratiotes*
Water Hyacinth	*Eichhornia crassipe*s
Torpedograss	*Panicum repen*s
Frogs-bit	*Limnobium spongia*
Old World climbing fern	*Lygodium microphyllum*
Brazilian pepper	*Schinus terebinthifoliu*s
Melaleuca tree	*Melaleuca quinquenervia*
India cupscale grass	*Sacciolepis indica*

*Due to performance considerations, exotic plants may be tolerated in some STA settings.

There are several species of non-rooted, floating plants that could retard emergent plant growth and reduce performance if they become established within the STA. The most effective management strategies to prevent this are keeping the trash rack clean and maintaining a maximum depth of ***1.0 ft*** within both treatment cells during start-up. A clean trash rack will reduce the chance of these plants entering the system and shallow cell depths will prevent their spread should some pass through the inflow pumps. Once a healthy emergent plant community is established in the STA, it will be less vulnerable to invasion by noxious floating plants.

3.2 Management Activities During Normal Operations

Upon completion of the Start-Up Operation Phase, Nubbin Slough STA will enter normal operations and be subject to a wider variety of water depths, control structure settings, and possibly research and monitoring activity. Maintaining appropriate depths within the cells will be an important part of successful management because of the variety of plant species that occur in the STA. For example, maintaining depths in excess of the targets may eventually eliminate certain plant species, creating large unvegetated areas that are vulnerable to invasion by inappropriate plants. Likewise, allowing depths to fall below the targets or below ground surface may also create large vegetation die-offs and a subsequent invasion of undesirable plants.

Table 3. Treatment Cell Size, Vegetation and Estimated Target Depths/Stages

Cell	Cell Area (acres)	Target Vegetation	Design Ground Elevation ft NGVD	Target D/S Start-up ft/NGVD	Target D/S Normal Ops Ft/NGVD
1	263	Emergent Marsh	30.2	1.0 / 31.2	2.0 / 32.2
2	546	Emergent Marsh	28.5	1.0 / 29.5	2.0 / 30.5

Note: These stages and depths are estimates and will be revised based on actual observed conditions.

3.2.1 Strategies to maintain desirable emergent vegetation

Except for unusual events, Nubbin Slough STA will always be managed in the normal operations mode. In this mode, District staff should seek to always maintain treatment cell depths within the target range to promote healthy plant communities and reduce the possibility of invasion by nuisance species. In both treatment cells, depths should range primarily between ***0.5*** and ***2.0 ft***, with higher levels during intense rainfall events.

Through experienced gained by operating other large STAs, a seasonal pattern of performance should be expected at this STA. Peak vegetation growth and system performance will likely occur during spring and summer, taper downward during autumn and reach their lowest levels during winter. As a result, the system will respond most quickly to operational changes such as varying depths and herbicide applications during the spring and summer, something to consider when planning any modifications or maintenance or research activities.

Also, physical disruption within the treatment area of the STA should be avoided to prevent damaging the plants. Appropriate airboat operation (non-recreational) will not likely have adverse impacts on the vegetation in either treatment cell, but the use of heavy equipment should be restricted to activities that are deemed necessary for operations or maintenance purposes. One possible form of impact to be avoided would be the accidental creation of furrows or ditches that could allow water to flow in a more direct fashion through the project, bypassing critical treatment area. This diversion from a sheet flow pattern is known as a 'short circuit' and can reduce STA performance.

3.2.2 Strategies to control invasive/non-desirable vegetation

Should non-desirable plants become established in either treatment cell during the normal operations phase, it may be necessary to apply appropriate herbicides to eliminate or control their spread. Again, a qualified vegetation management specialist should be consulted for their opinion on the severity of the infestation and potential treatment options.

Depending on the undesirable vegetation in question, it may be appropriate to delay treatment until hydrologic or seasonal conditions improve, particularly if an herbicide application is recommended. As discussed previously, seasonal variations can impact herbicide efficacy. Should mechanical harvest be recommended to eliminate an infestation, managers should carefully consider the compatibility of the equipment with the treatment area. For instance, to control a hypothetical water hyacinth invasion from the storage pond, it may be possible for Operations Control to temporarily raise the water level in the storage pond (particularly during the summer) to allow a mechanical harvester or tow boat access to the area. If unchecked, an infestation that reached either treatment cell would be more difficult to control with mechanical means because of much shallower water depths and may require the application of aquatic herbicides, possibly resulting in a nutrient release.

Spot treatment of undesirable vegetation has largely been considered ineffective in other STAs because of their great size. However, Nubbin Slough STA may be small enough for backpack or airboat based herbicide application, particularly for invasive shrubs and trees growing alone or in small stands. This treatment strategy may also work for undesirable herbaceous plants that are not yet spatially extensive enough for aerial applications. Again, qualified vegetation management specialists should be consulted for specific treatment remedies. Control of terrestrial invasive plants on the interior and perimeter levees should also be addressed by qualified vegetation management technicians.

3.3 Management Activities During Drought

The potential for drought conditions to impact the vegetation viability and subsequent nutrient removal performance of an STA cannot be overstated. Even a drought considered moderate in severity could cause a significant shift in the vegetation community and excessive soil oxidation within an STA, leading to a reduction in performance upon returning to normal operations. While it is possible that a drought may not cause serious long-term damage to the treatment area, operations at Nubbin Slough STA should be managed carefully during drought conditions to help ensure a prompt return to normal operations once the drought has passed. The Operations Plan describes control structure operations designed to minimize the adverse impacts of droughts.

3.3.1 Strategies to maintain native/desirable vegetation

Based on the availability of water in the Nubbin Slough basin, S-385 will be operated to maximize the flow through the treatment area. To minimize the duration and frequency of dry out, the gates at S-386 and S-387 will need to be partially closed as the number of pumps in operation decrease (see Operations Plan for specific details). The Operations plan describes gate closings to maintain a minimum depth of 0.75 feet in the dry season of the initial year to protect the vegetation community from dry-out.

Once it is suspected a drought is imminent, to the extent possible, water should be conserved within the treatment cells at higher than normal depths in anticipation of a decrease in future flows. All three S-387 structures (A-C) should be closed and S-386A-C opened as needed to allow water depths in both cells to rise up to 2 feet, and up to 3 feet if possible.

Subject to water supply conditions in the Nubbin Slough basin, there may be times when S-385 should be operated outside the normal operating range described in the Operations Plan, specifically, turning on the pumps at stages below 17-20 ft in order to prevent the STA from drying out.

If it is not possible to maintain the 0.5 ft minimum depth, sufficient water should be provided to ensure that all treatment area soils are saturated to protect some of the emergent plant species. Certain plants, like cattail, can tolerate dry soils for short to moderate periods; however others, such as bulrush, may not survive as well without some standing water. However, if all STA soils are maintained in a saturated condition through the drought, a significant portion of the vegetation should survive.

Operations Following STA Dry Out. Management activities following a dry out will vary depending on the severity of the drought and the attendant loss of vegetation. For mild to moderate loss of vegetation, the inundation regime described in Section 3 above can be followed (i.e., slowly raising depths to 1.0 ft). For severe loss of vegetation, it may be necessary to limit the initial depth to 0.5 ft to promote re-establishment of desirable emergent vegetation. The length of time to retain water in the STA before initiating flow-through should be based on achieving a net reduction in the weekly phosphorus concentrations. This recommendation should be revisited after the first year of flow-through operation to ensure it is achieving a water quality goal of annual net improvement or better.

3.3.2 Strategies to control invasive/non-desirable vegetation

Maintaining water depths as described in Section 3.3.1 during drought conditions will help prevent invasion of undesirable vegetation. The onset of drought can provide invasive or undesirable plant species an opportunity to displace desirable wetland plants and cause a long-term shift in the vegetation of an STA that could affect system performance. A severe drought could cause a loss of part of the wetland plant community and allow upland grasses or shrubs to invade the treatment cells, which would delay the re-establishment of an effective wetland plant community when the drought subsides. Staff should remain vigilant against the invasion of undesirable plants during drought conditions and qualified vegetation management specialists should be consulted for herbicide treatment options when nuisance vegetation is observed.

3.4 Management Activities During High stage/flow conditions

During periods of heavy rainfall over the Nubbin Slough basin and high water levels within the STA, impacts to the treatment cell plant communities should be carefully observed. Prolonged water depths in excess of 3.0 feet may damage certain components of the vegetation communities and reduce performance in both treatment cells.

3.4.1 Strategies to maintain native/desirable vegetation

The inflow pump and water control structure operations described in the Operations Plan should prevent prolonged periods of excessive depths. After a high stage/flow event, Nubbin Slough STA should be inspected and the condition of the emergent plants noted as well as any other areas of concern. Should the stage inside the cells exceed the crest elevation of the emergency overflow sections, water will overtop the west perimeter levee and may carry with it some floating or uprooted plant material.

In the event of a catastrophic loss of vegetation during a storm (such as occurred in STA-1W following Hurricane Jeanne in September, 2004), STA managers could consider lowering treatment cell depths to 0.5 feet at Nubbin Slough STA to help accelerate the restoration of the desired emergent marsh community. Once treatment cell vegetation is deemed to be in satisfactory condition, the operations described in Section 3.3.1 above should be followed.

Figure 3. Tailwater side of G-5 structure.

3.4.2 Strategies to control invasive/non-desirable vegetation

A high stage/flow event may carry certain species of invasive vegetation into the STA, particularly floating plants such as water hyacinth or water lettuce. Prior to these extreme events, the automatic trash rack at S-385 should be checked if possible and cleared if necessary. A mass of floating vegetation pressing against the trash rack could force plants through the bars and ultimately into the storage pond where they could spread throughout the treatment cells.

Operations staff should be aware of the possible effects of high stages and flows on the plant community at Nubbin Slough STA. Protecting the desirable plants from disruption and stress caused by storm events will also help prevent subsequent invasion by nuisance plants, which can save significant maintenance dollars. The strategy described in Section 3.4.1 to discourage encroachment by invasive plant species should be considered following high stage/flow events.

4. Long-Term Management Activities

A regular quantitative analysis of treatment cell vegetation should be performed at Nubbin Slough STA by appropriate staff to help provide some insight to prevailing trends among the plant communities within the treatment area. Monthly observations from the levees and from SFWMD helicopter overflights should be used to help manage vegetation within Nubbin Slough STA.

Observations from the STA levees should be performed monthly and include permanent monitoring stations from which to record observations and digital color photographs. These monitoring stations should be located along the perimeter and separation levees at no greater that 0.25 miles apart. The plant species observed at each station, their approximate dominance, the proportion of open water or unvegetated area, and any other important information should be recorded. To balance accuracy and simplicity, a scale from 0 to 100% that includes five ranges (0-20, 20-40, 40-60, 60-80, and 80-100) should be used to quantify vegetation coverage. Over time, this information will assist the SFWMD in managing Nubbin Slough STA successfully.

Observations by project staff from SFWMD helicopters should also be performed regularly, perhaps when seats are available on routine regulatory flights, and include digital color photographs that clearly show vegetation identifiable to the genus or species level and its distribution within the STA.

4.1 Aerial Photography

Although not specifically required to do so, SFWMD should consider purchasing aerial photography of Nubbin Slough STA each year for a general analysis of vegetation coverage and species composition within each treatment cell. A series of annual photos may provide helpful insight regarding the increase or loss of specific vegetation coverage. The best and most economical format for this photography is color infrared (CIR) and should be shot at a scale of approximately 1:6000. This aerial perspective is an additional reference point that STA managers may find helpful, rather than relying solely on brief helicopter overflights or limited views from the levees.

4.2 Vegetation Mapping

While not a specific permit requirement, a baseline vegetation coverage map for Nubbin Slough STA could be created to provide a detailed analysis of vegetation coverage and species composition within each treatment cell. The procedure involves acquiring CIR photographs, digitizing them, field verifying their contents and finally, producing a fully georeferenced vegetation map of the STA. While these maps can be potentially useful in tracking vegetation coverage statistics, they are very expensive to produce, require extensive effort to interpret and may have limited management value.

4.3 Advanced techniques

Over a period of time, an STA will mature and may eventually need additional monitoring or maintenance not yet described in this Plan. By monitoring long-term changes in the STA and planning for possible 'regenerative' maintenance, the system can be understood in greater detail, enabling more successful and cost-effective management of Nubbin Slough STA. After a period of several years to perhaps several decades, the vegetation within an STA may mature to a point where biomass becomes extremely high, sediment accretion has lowered hydraulic capacity, and/or performance significantly declines. If such a scenario arises at STA, it may be advisable to consider one or more of the 'regenerative' maintenance techniques listed below.

4.3.1 Prescribed Fire

The removal of emergent vegetation through a prescribed burn may help restore system performance in several ways. First, a controlled burn will enable new plant growth to occur where only mature and possibly senescent vegetation was found. Young vegetation grows more rapidly than mature plants and has a higher nutrient uptake rate (DeBusk, et al). Also, with more sunlight reaching the treatment cell substrate, periphyton biomass would likely be greater and capture more phosphorus. Perhaps as importantly, this technique requires no additional handling or disposal methods which make it quite cost effective to use on a large scale. While this technique has been used at the 1,220 acre Orlando Easterly Wetlands Project in Orange County, Florida to help restore project performance, the District may elect to study the effects of fire on vegetation succession and specific performance expected in this STA before proceeding, perhaps using a pilot study.

Water levels may need to be lowered in order for a prescribed burn to be successful, but not lowered so much that treatment cell soils become overly dry and lose too much organic material during the fire. Some other possible restrictions associated with prescribed burning at STA might include the proximity of State Road 710 and reduced visibility for motorists due to smoke. The surrounding property should also be assessed for its vulnerability to fire should it escape from the treatment area. Should this technique be employed, a permit will need to be acquired from the Florida Division of Forestry before proceeding.

Should performance decline significantly or the system becomes a consistent net exporter of phosphorus over several years, additional regenerative measures of a more aggressive nature could be investigated, such as vegetation or sediment harvesting. These two techniques, however, have not been attempted on the scale of a large to moderate sized STA and may not be feasible because of the scale of labor required and/or complications related to disposal of soil and plant material.

5. References

Stanley Consultants, Inc., Lake Okeechobee Water Retention / Phosphorus Removal Project, Final Design Analysis Submittal, June 2003

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South Florida Water Management District, WQ Monitoring Plan for Nubbin Slough Storm Water Treatment Area (STA), April 2005.

U. S. Army Corps of Engineers, Draft Lake Okeechobee Water Retention / Phosphorus Removal Project –Water Control Plan (June 2005).

DeBusk, Thomas A., Forrest E. Dierberg, John Juston. Phosphorus Removal in Treatment Wetlands. DB Environmental, Inc., Rockledge, FL. MS Powerpoint presentation, date unknown.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PERFORMANCE PLAN

NUBBIN SLOUGH / NEW PALM

STORMWATER TREATMENT AREA

FINAL

November 2005 ***Gary Goforth, Inc.***

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PLEASE NOTE

During the preparation of this *Performance Plan,* a potential critical hydraulic issue was identified that needs attention to ensure that maximum phosphorus removal of the STA can be achieved.

Capacity of the S-386 and S-387 structures. After review of the hydraulic properties of the S-386A-C and S-387A-C structures, it appears that the hydraulic capacity of the structures is smaller than stated in the design documents, which was to pass the peak flow with a head loss of 1.0 ft or less. For the inlet structure S-386C, the head loss is estimated at 2.6 ft or more at the peak flow of 120 cfs; for the S-386A&B structures, the head loss is estimated at 2.5 ft or more at 60 cfs; for the S-387 structures the head loss is estimated at 1.5 ft or more at 40 cfs. This reduced capacity may increase the stage at peak flow through the STA, particularly in the 30-acre storage pond, which in turn may reduce the freeboard on the levees. It is recommended that the District pursue resolution of this issue with the Corps, perhaps through flow tests after the STA is constructed, to ensure that maximum phosphorus removal of the STA can be achieved. Until this issue is resolved, the Corps and District should consider an appropriate operational remedy such as limiting the number of pumps operating at one time to three, and revising the pump shut-off set point from 37.5 to 36.5 ft NGVD in the 30-acre storage pond.

Depending upon the resolution of this critical issue, this Performance Plan may need to be revised accordingly.

1 PROJECT DESCRIPTION

1.1 BACKGROUND

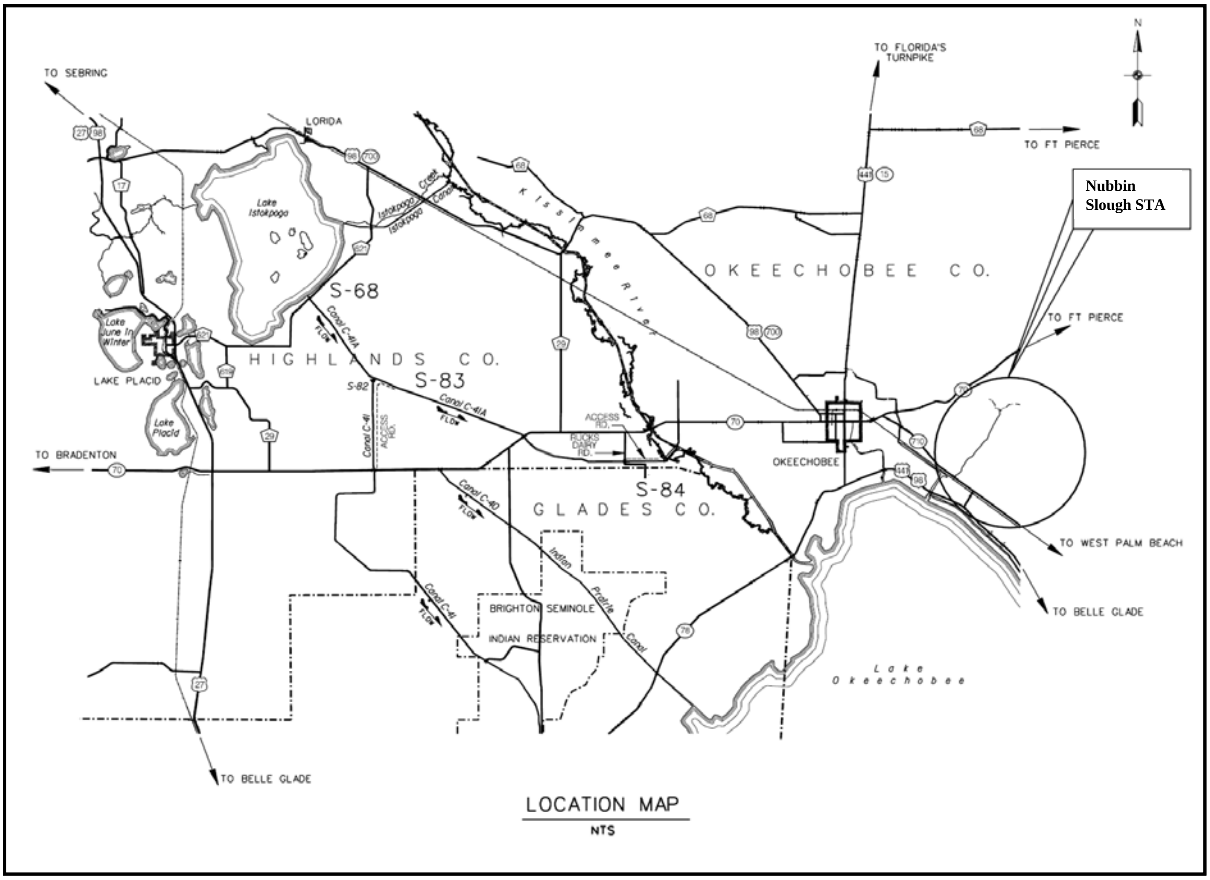
The South Florida Water Management District (SFWMD), the U. S. Army Corps of Engineers (Corps), the Florida Department of Environmental Protection (FDEP), other agencies and private landowners are cooperating on efforts to improve water quality in the Lake Okeechobee watershed, and through the south Florida ecosystem. This cooperation includes studies and capital projects composing the Lake Okeechobee Protection Program, the Comprehensive Everglades Restoration Plan (CERP), and Critical Restoration Projects. The Lake Okeechobee Water Retention Phosphorus Removal Project consists of two shallow stormwater treatment areas – the Taylor Creek Stormwater Treatment Area (STA) and the Nubbin Slough STA – designed to remove phosphorus loads from the Nubbin Slough and Nubbin Slough watersheds. High phosphorus loads have been implicated in excessive eutrophication of Lake Okeechobee that have resulted in algal blooms, high oxygen demand, and loss of fisheries and recreational benefits provided by the lake.

The Nubbin Slough / New Palm STA is one of the Critical Restoration Projects authorized by Congress through Section 528 of the Water Resources Development Act of 1996. The project was designed by Stanley Consultants, Inc. working under contract to the Corps, who was responsible for construction. Construction is presently underway with completion scheduled for early 2006. The SFWMD is the sponsor for the project and assisted in the funding of the capital works and will be responsible for operation and maintenance of the STA. The anticipated long-term average phosphorus reduction within the STA was estimated during the design phase to be greater than 90% (more than 5 tons per year), and greater than 85% of the phosphorus load of Nubbin Slough at the project location (Stanley Consultants, Inc. 2003).

The Nubbin Slough STA is approximately 6.5 miles southeast of the city of Okeechobee (Figure 1), adjacent to Nubbin Slough, immediately north of the State Road 710 and just east of the bridge that spans Nubbin Slough. The STA occupies approximately 809 acres of a 2,135-acre site purchased by the SFWMD. The southern end of this project is approximately 1.3 miles from the edge of Lake Okeechobee. The Nubbin Slough STA is located on a former dairy farm and remediation activities were completed during STA construction.

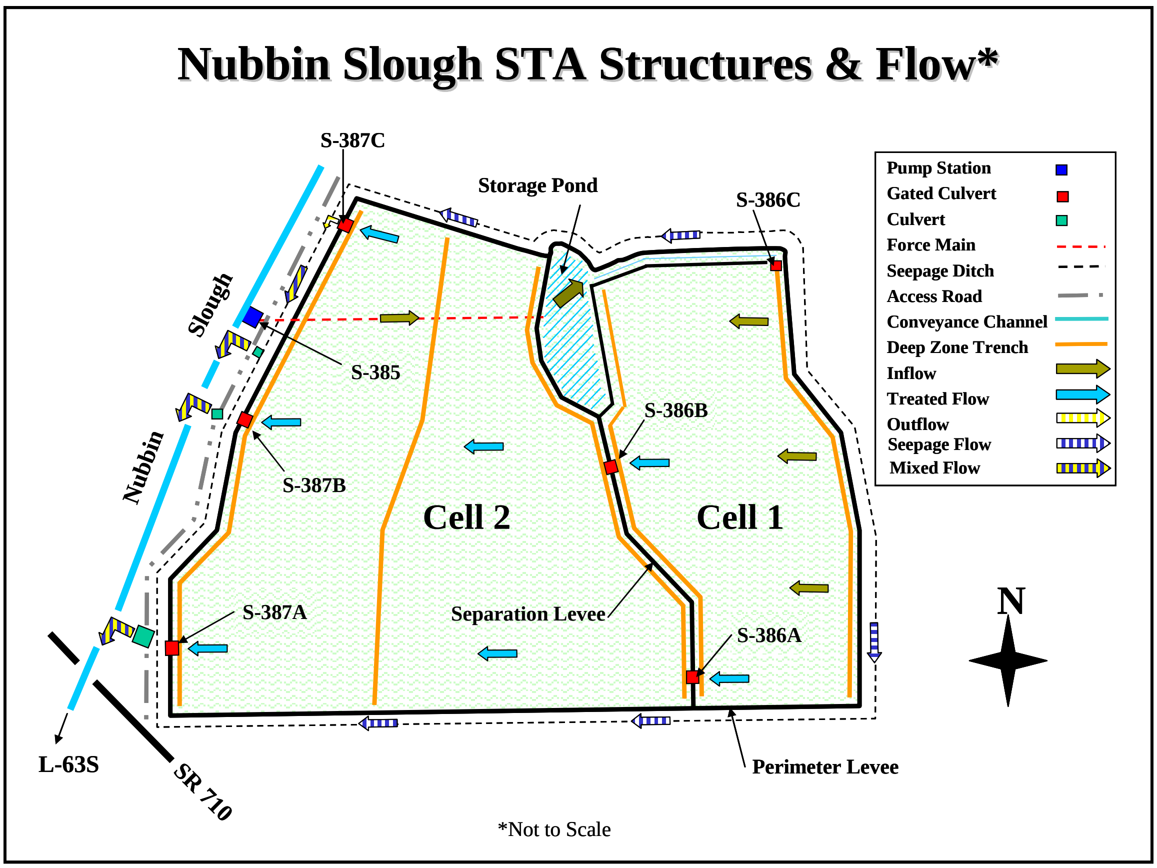
The goal of the Nubbin Slough STA is to capture and reduce the mass of total phosphorus from the Nubbin Slough Basin prior to discharge back into Nubbin Slough and on to Lake Okeechobee. The phosphorus concentration in Nubbin Slough runoff exhibits considerable variability, with an average of approximately 515 parts per billion (ppb) (Stanley Consultants, Inc. 2003). This value greatly exceeds the phosphorus concentration of Lake Okeechobee, which averages just over 100 ppb. Emergent wetland vegetation (cattail, bulrush, *sagitaria*, *pontedaria*, etc.) should begin to colonize the treatment area after construction completion, and average depths of less than 2 feet should be conducive to sustaining these communities. The long-term phosphorus storage mechanism within the STA will be through accretion of new organic sediment, and for this reason it is important to operate the STA to avoid dry out, which could release nutrient through remineralization of these sediments. Estimates of the STA water budget developed during the project design indicate that average seepage and ET losses will be greater than average surface inflows from Nubbin Slough – hence dry out will likely occur on a regular basis. The anticipated long-term average phosphorus reduction within the STA was estimated during the design phase to be greater than 90% (more than 5 tons per year), and greater than 85% of the phosphorus load of Nubbin Slough at the project location. The FDEP Lake Okeechobee Protection Act (LOPA) permit issued to the Corps for the Nubbin Slough STA indicated the design objective is to reduce the discharge concentration toward a target of 40 ppb, and the Design Analysis Report indicates the design objective is to maximize load reductions (FDEP 2003; Stanley Consultants, Inc. 2003). In addition to the reduction of phosphorus loads and concentrations, the Nubbin Slough STA will provide additional water quality and quantity benefits to downstream waters, including the removal of suspended solids, nitrogen, metals, and pesticides that would otherwise flow into the lake.

Figure 1. Nubbin Slough / New Palm STA location map.



The Nubbin Slough STA encompasses approximately 809 acres adjacent to Nubbin Slough, and has a rectangular geometry (shown in Figure 2). An inflow pump station lifts water from Nubbin Slough at the western edge of the STA and delivers it through a 48-inch diameter underground force main to a 30-acre storage pond located in the north central portion of the STA. Treatment occurs through natural biogeochemical processes as the water slowly flows by gravity south and westerly through the 263-acre Cell 1 and subsequently through the 546-acre Cell 2 before being discharged back to Nubbin Slough. Water levels and flow rates through the treatment cells are controlled by gated structures located at the western boundaries of each cell. The predominant grade within the STA creates flow from the east to the west. Deep zone trenches at the inflow and outflow of each cell, and in the center of Cell 2, are designed to help distribute flow evenly throughout the cell. Discharge of treated water to Nubbin Slough will be through three uncontrolled concrete reinforced pipes, the most southerly of which is over 1,200-ft in length in order to avoid contact of the treated discharge with the phosphorus rich soils on site.

Figure 2. Schematic of Nubbin Slough STA.



1.2 PERFORMANCE OBJECTIVES

The original performance objective was to design an STA that would produce a flow-weighted mean phosphorus concentration of approximately 50 parts per billion (ppb). However, due to limited size of the STAs that could be constructed for this Project, the revised objective is to maximize the total mass of phosphorus removal from the available treatment area. **As described below, the expected long-term phosphorus removal efficiency was estimated to be greater than 90% within the treatment area.**

Phosphorus removal performance for the Nubbin Slough STA was estimated during the design by use of the Infiltrating/Exfiltrating model by Wetland Solutions, Inc. as part of the design (Stanley Consultants, Inc. 2003). No flow gauging stations are located within the Nubbin Slough watersheds upstream of S-191. The South Florida Water Management District (SFWMD) performed a hydrologic analysis of the Nubbin Slough basin and estimated that the average annual runoff from the upstream basin at the location of the Nubbin Slough intake pump is 13.3 cfs. Although the hydrologic analysis indicates an average available flow of 13.3 cfs, daily values fluctuate widely. In order to capture a significant portion of the peak flow, the pump station was designed to produce a peak capacity of 120 cfs, using four pumps. Daily flows equal to or less than the maximum inflow pump capacity were averaged to estimate pumped inflow to the STA. Flows exceeding the maximum inflow pump capacity were averaged to estimate the amount of bypass. For the purpose of estimating phosphorus removal, it was estimated that a long-term average flow of 12.2 cfs could be supplied to the Nubbin Slough STA with the 4-pump configuration installed at S-385, with a stream bypass averaging approximately 1.1 cfs. The long-term average annual influent phosphorus concentration was estimated as approximately 515 parts per billion (ppb) at Nubbin Slough, yielding a long-term average annual phosphorus load to the STA of approximately 5,615 kg/yr. The long-term average annual outflow concentration was estimated to be approximately 43 ppb. At these average values, the long-term average phosphorus removal for the Nubbin Slough STA was estimated to be approximately 5 metric tons per year with a removal efficiency of greater than 90%. **Taking into account the balance of the Nubbin Slough flows that bypassed the STA, and assuming 50% capture and subsequent discharge of seepage, the estimated long-term average phosphorus load reduction within the STA was greater than 85%. The actual annual performance within the Nubbin Slough STA may vary significantly from these forecast long-term averages due to the variability in the flows and phosphorus levels within Nubbin Slough, as well as the inherent variability in the biological removal processes within the STA.**

With regard to performance, there are two distinct phases for the Nubbin Slough STA. In accordance with the Project Cooperation Agreement executed between the Corps and the District, prior to turnover of the project to the District, the Corps will conduct an **initial operational testing and monitoring period**. During this period, data will be collected to demonstrate that the project achieves the designated benefits. Once the District Engineer determines that the project is performing as designed, the Corps will transfer the project to the District for subsequent operations, maintenance, repair, replacement and rehabilitation, commencing the **operations phase.** The following sections describe the performance objectives specific to those two periods.

1.2.1 Initial Operational Testing and Monitoring Period

The initial operational testing and monitoring period consists of a start-up phase (pre-discharge) and a flow-through (discharge) phase. The operational goal during STA startup is to provide hydrologic conditions conducive to wetland vegetation growth, while avoiding release of total phosphorus and mercury. The performance objective during start-up is to demonstrate a net improvement in both phosphorus and mercury (see Section 2.1.1 below for details). The STA permits issued to the Corps by the FDEP preclude flow-through operations until phosphorus and mercury concentrations demonstrate a net improvement compared to the source water in Nubbin Slough. In addition, the permit requires that a pesticide sample be taken in the water column and sediment at the inflow and outflow structures before discharges are to occur from the STA.

Once the phosphorus and mercury data demonstrate a net improvement, discharges will begin, and the second phase of the initial operational testing and monitoring period will begin. During this phase, the nutrient removal performance of the STA will be monitored through extensive water quality sampling. In addition, the FDEP permit requires monitoring and assessment of numerous other water quality constituents; the project permit and the *WQ Monitoring Plan For Nubbin Slough Storm Water Treatment Area (STA)* (SFWMD 2005) contains additional details.

During the **initial operational testing and monitoring period**, data will be collected to demonstrate that the project achieves the designated benefits. Once the District Engineer determines that the project is performing as designed, the Corps will transfer the project to the SFWMD for subsequent operations, maintenance, repair, replacement and rehabilitation, commencing the **operations phase.**

1.2.2 Operations Phase

The goal of the Nubbin Slough STA is to maximize the phosphorus load reduction. The phosphorus concentration in Nubbin Slough runoff exhibits considerable variability, with a long-term average of approximately 515 ppb (Stanley Consultants, Inc.). This greatly exceeds the phosphorus concentration of Lake Okeechobee, which averages just over 100 ppb. The long-term phosphorus storage mechanism within the STA will be through accretion of new organic sediment. Analyses conducted during the design of the project suggest that the long-term phosphorus load reduction within the STA would be greater than 90%, or approximately 5 metric tons per year. A summary of the performance characteristics developed during the design of the project are summarized in Table 1. In addition to the reduction of phosphorus loads, the Nubbin Slough STA will provide additional water quality and quantity benefits to downstream waters, including the removal of suspended solids, nitrogen, metals, and pesticides that would otherwise flow into the lake.

Table 1. Summary of Nubbin Slough STA Performance Parameters

Design Parameter	Cell 1	Cell 2	Entire STA
Treatment Area			
Effective Treatment Area (acres)	251	522	773
Total Area (acres)	263	546	809
Average ground elevation (ft NGVD)	30.2 ±	28.5 ±	29.1 ±
Nominal Length (feet)	2,600	4,800	7,400
Nominal Width (feet)	4,210	4,735	4,550
Aspect Ratio (length:width)	0.6	1.0	1.6
Flow			
Average flow (cfs)	12.2	12.2	12.2
Average annual inflow (acre feet/yr)	8,838	8,838	8,838
Mean depth at design water surface (ft)	2 ±	2 ±	2 ±
Average hydraulic loading rate (ft/yr)	35.2	16.9	11.4
Average hydraulic loading rate (cm/d)	2.9	1.4	1.0
Nominal hydraulic residence time (days)	21	43	64
Average annual rainfall (inches/yr)			47.6
Average annual evapotranspiration (inches/yr)			51.6
Phosphorus			
STA			
Average inflow concentration (ppb)			515
Average inflow load at 12.2 cfs (kg/yr)			5,615
Average inflow loading rate ($g/m^2/yr$)			1.79
Average atmospheric deposition (equiv. ppb)			40
Effective settling rate (m/yr)			10.2
Estimated outflow concentration (ppb)			43
Estimated outflow load – including 50% seepage capture (kg/yr)			316
Estimated load removal (kg/yr)			5,299
Estimated STA phosphorus reduction (%)			94%
Nubbin Slough			
Base flow before STA (AF/yr)			9,635
Base load before STA (kg/yr)			6,121
Estimated total load after STA – including seepage (kg/yr)			822
Estimated concentration after STA (ppb)			164
Estimated load reduction (kg/yr)			5,299
Estimated overall load reduction (%)			87%

Note: During the preparation of this *Operation Plan,* it was determined that the hydraulic capacity of the interior and outlet water control structures was smaller than stated in the design documents, which may require a reduction in the peak, and therefore the average, flows through the STA, with an associated adjustment to the values in this table.

All ground and water surface elevations are referenced to the 1929 NGVD.

2 PERMIT INFORMATION AND REPORTING REQUIREMENTS

2.1 INITIAL OPERATIONAL TESTING AND MONITORING PHASE

On September 15, 2003, the Florida Department of Environmental Protection (FDEP) issued Lake Okeechobee Protection Act (LOPA) permit 0194483-001-GL to the Corps for the construction of the Nubbin Slough STA. For the purpose of the permit, the construction phase includes the initial operational testing and monitoring period. The phosphorus performance-related monitoring requirements of the permit are discussed below.

2.1.1 Performance Monitoring Requirements for the Start-up (pre-discharge) Period

Net improvement in phosphorus concentrations. Figure 3 identifies the monitoring locations for water levels, flow and phosphorus samples. **[Note – Figure 3 is consistent with the construction plans, however, the permit identifies the 30-acre storage pond as the location for the inflow TP sample.]** Total phosphorus will be sampled weekly at the inflow (S-385) and outflow (S-387) structures, via grab and automatic samples, respectively, for the duration of the pre-discharge period. The automatic samplers will be programmed to collect samples on a time composite basis during the period of pre-discharge.

Prior to initiating flow-through (discharge) activities, phosphorus will be monitored to demonstrate that the STA is achieving a net improvement in phosphorus. This net improvement shall be deemed to occur when the 4-week geometric mean total phosphorus concentrations collected at the outflow structure (S-387) is less than the 4-week geometric mean collected at the inflow structure (S-385). If the project has not achieved a net improvement of phosphorus within two months after beginning pre-discharge activities, reports of the 4-week geometric mean differences will be transmitted to the FDEP. If net improvement has not been demonstrated after six months, the vegetation conditions shall be evaluated and strategies to achieve the net improvement are to be identified.

Figure 4 contains a hypothetical scenario of phosphorus levels for the Nubbin Slough STA during this start-up period. Plotted in Figure 4 are hypothetical 4-week geometric mean phosphorus concentrations at the inflow (S-385) and the outlet structure (S-387). As shown in this example, net improvement of phosphorus was demonstrated from the commencement of the weekly grab sampling. While the values in Figure 4 are hypothetical, they represent potential trends, variations and relative magnitude of phosphorus levels that could be anticipated for Nubbin Slough STA.

Mercury net improvement shall be demonstrated when the concentration of total mercury and methyl mercury at the mid-point of the STA are not significantly greater than the concentration of the corresponding species at the inflow to the STA. In addition, the permit requires that a pesticide sample be taken in the water column and sediment at the inflow and outflow structures before discharges are to occur from the STA.

Once the net improvement in phosphorus and mercury has been demonstrated, the FDEP shall be notified and discharges from the STA may commence.

Figure 3. Schematic of Nubbin Slough Hydrologic and Water Quality Monitoring Sites

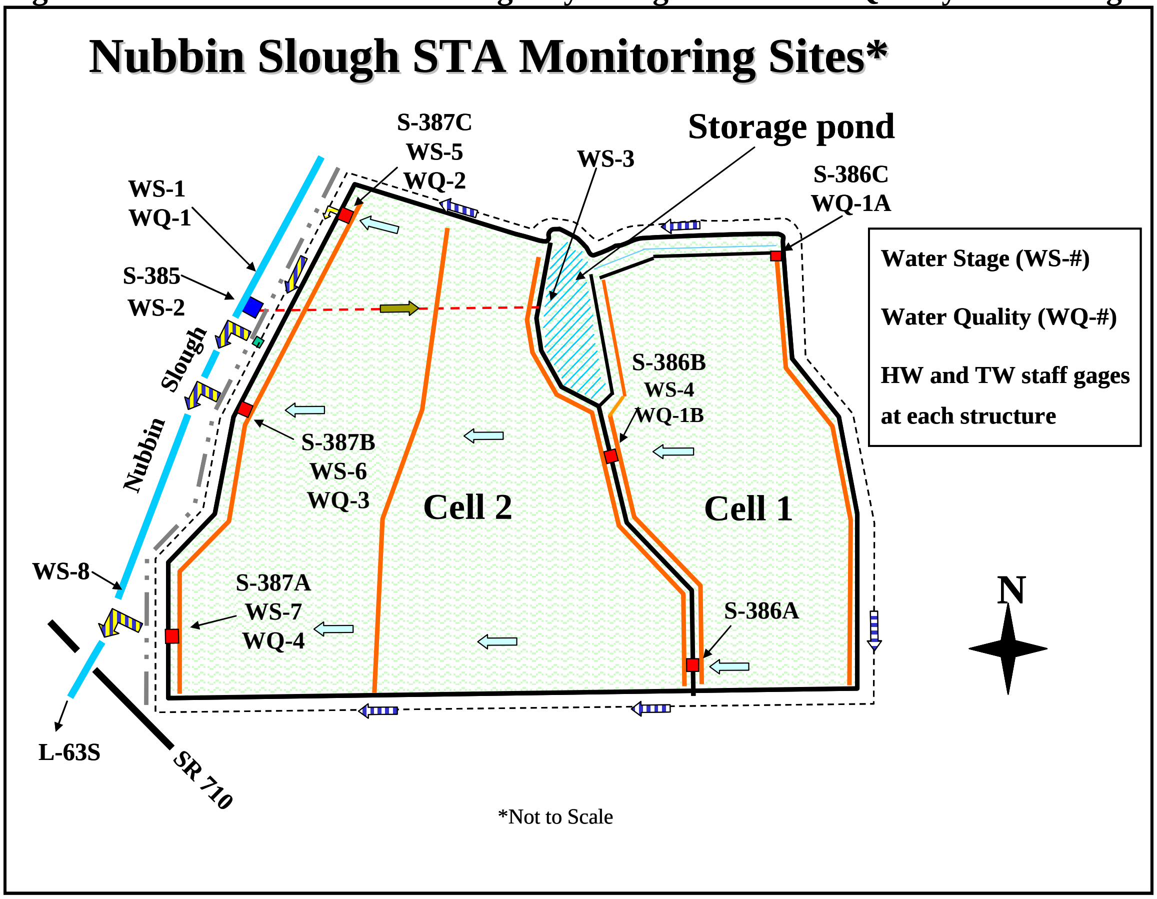
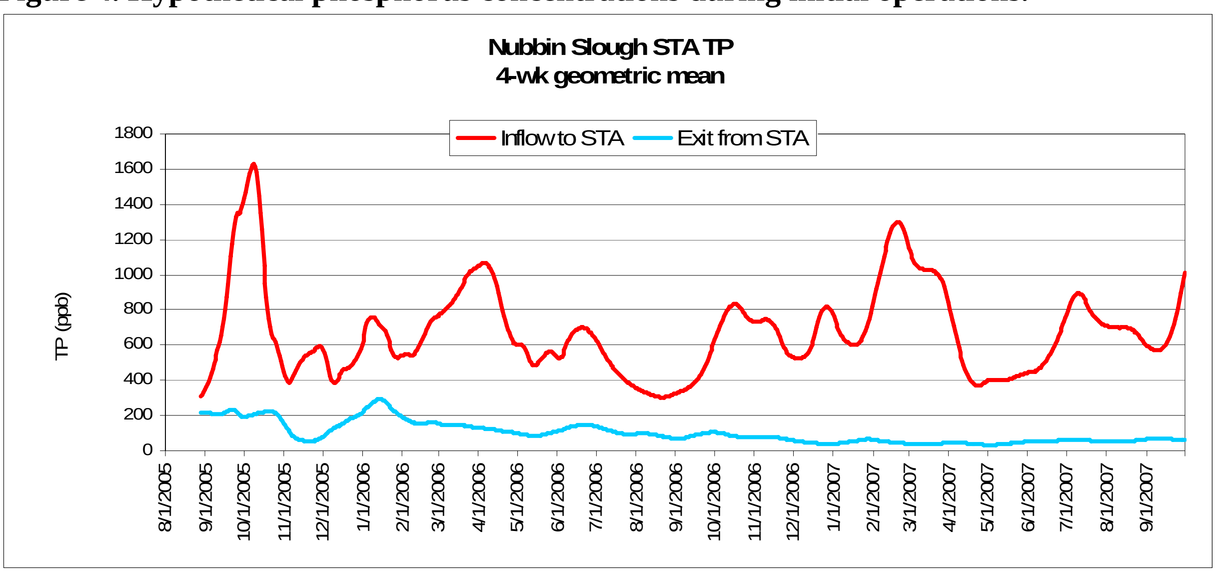


Figure 4. Hypothetical phosphorus concentrations during initial operations.



The complete set of water quality constituents being monitored at the Nubbin Slough STA is described in the *WQ Monitoring Plan For Nubbin Slough Storm Water Treatment Area (STA)* (SFWMD 2005). Although not required by the permit, the District plans to collect a grab sample for total phosphorus at the S-386C and S-386B structures to enable direct estimates of phosphorus removal performance in each treatment cell, which allow accurate mass balances in each treatment cell, and provides operational feedback to optimize removal performance.

2.1.2 Performance Monitoring Requirements for the Flow-through (discharge) Period

During the Flow-through Period, the focus of the STA performance monitoring will be on establishing flow-weighted mean concentrations and loads entering and leaving the STA. Total water column phosphorus samples will be collected weekly at the inflow and outflow structures. Water quality data at the inflow location will be collected via grab sample approximately 150 ft upstream of the S-385 pump station. Grab samples will initially be collected weekly. However, the data will be analyzed after a period of time to determine if the grab sampling frequency may be reduced.

Water quality data at the STA outlet will be obtained on the upstream side of the S-387A-C discharge structures. Samples will be collected by an automatic sampler and weekly grab samples. The S-387 structures will be instrumented to provide computed flow rates by using upstream and downstream stage in combination with gate opening information. A MOSCAD remote terminal unit will total the discharge and trigger the automatic sampler.

Data from these samples will be evaluated for the permit as follows:

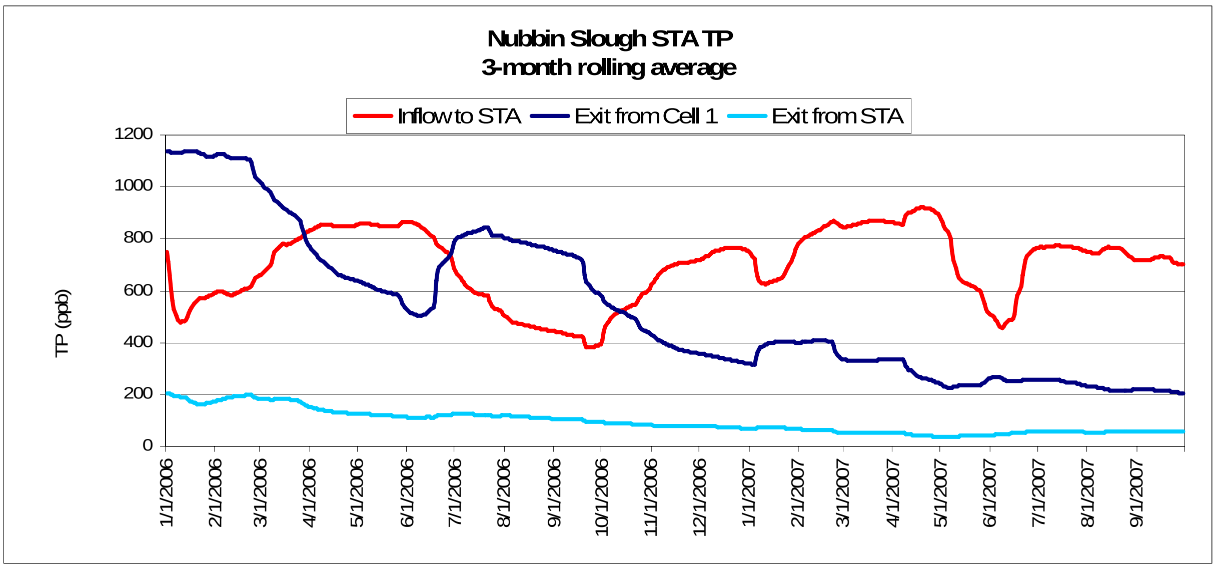
1. Rolling 3-month flow-weighted mean total phosphorus concentrations for the STA shall be calculated for the outflow and inflow structures;
2. The flow-weighted mean outflow concentrations of total phosphorus for the STA at the outflow structure shall be compared to flow-weighted mean concentrations at the inflow structure using the student’s t-test with a 95% confidence interval on log transformed data.

If the evaluation indicates that the flow-weighted mean outflow concentration is less than the flow-weighted mean inflow concentration, then the discharges from the project shall be deemed to be in compliance with Specific Condition 14A. If after six months, discharges from the STA are not achieving a net reduction in total phosphorus, the vegetation conditions shall be evaluated and strategies to achieve the net improvement are to be identified.

Figure 5 represents a hypothetical set of 3-month rolling average phosphorus concentrations during initial operations of an STA, assuming that discharge began on or about October 2005. Shown in the figure are hypothetical 3-month rolling phosphorus concentrations at the inflow (S-385), the exit from Cell 1 (S-386 A&B) and the outlet from the STA (S-387A-C). Note that the initial 3-month comparison will not be available until 3 months after initial discharge began. This scenario achieves the permit-required net reduction after approximately 6 months of flow-through. While the values in Figure 5 are hypothetical, they represent potential trends, variations and relative magnitude of phosphorus levels that could be anticipated.

In addition to phosphorus, the permit contains conditions requiring either a net improvement in concentrations, or discharges to be at or below applicable criteria. For dissolved oxygen the permit requires demonstration that the STA is not responsible for degradation of dissolved oxygen in downstream receiving waters. Although not required by the draft permit, the District plans to collect a grab sample for total phosphorus at the S-386C and S-386B structures to enable direct estimates of phosphorus removal performance in each treatment cell, which allow operational feedback to optimize removal performance.

Figure 5. Hypothetical phosphorus concentrations during initial flow-thru operations.



2.1.3 Reporting Requirements

All water quality submittals required by the FDEP construction permit shall be transmitted to the FDEP in an Annual Report. Specific Condition 18 of the FDEP permit contains the minimum information to be contained in the Annual Reports. A summary of the phosphorus-related monitoring requirements and recommendations are shown in Table 2 and Figure 3.

Table 2. Summary of Phosphorus-related Performance Monitoring

Structure	Headwater Stage	Tailwater Stage	Flow	Phosphorus
S-385	Continuous	Continuous	Based on pump curves and stage data	Weekly grab
S-386 A-C	Staff gage	Staff gage	Calculated based on HW; will likely need TW under most flow conditions	Weekly grab samples at S-386 B & C
S-387 A-C	Continuous	Staff gage	Calculated based on HW; will need TW under some flow conditions	Autosampler and weekly grab

2.2 OPERATIONS PHASE

Presently the FDEP and the SFWMD are finalizing the operations, maintenance and monitoring permit for the project (0194483-002-GL). Accordingly, the STA Operation Plan must be consistent with the requirements of those permits.

2.2.1 Performance Monitoring Requirements for the Operations Phase

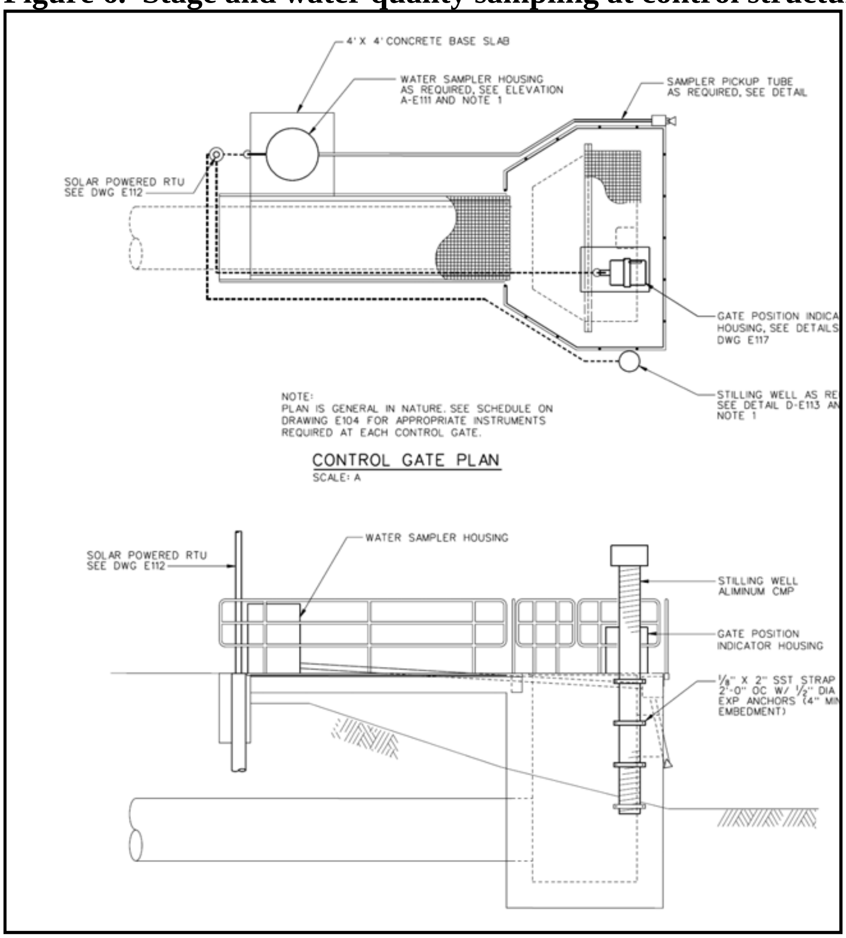
It is anticipated that the phosphorus performance-related monitoring requirements will be similar to those described in Section 2.1.2 and shown in Table 1 and Figure 3 above. The District has requested that 12-month flow-weighted mean phosphorus concentrations be evaluated annually instead of 3-month rolling means.

Data are collected to monitor flow rates and phosphorus removal rates within the STA, as well to gather other water quality information. Inflow volumes to the system are determined by the manufacturer's pump curves and system head determined from water levels transmitted from sensors upstream of the pump station and at the 30-ac storage pond. A weekly grab sample will be collected approximately 150 feet upstream of the S-385 pump station. The District is planning to collect weekly grab samples at the S-386C structure to characterize the water quality entering the treatment cells. In addition, the District is planning to collect a grab sample for total phosphorus at the S-386B structure to enable direct estimates of phosphorus removal performance in the storage pond and each treatment cell, which allow operational feedback to optimize removal performance. At S-386B, a gate level sensor, monitored in conjunction with the headwater level sensor provides discharge information from Cell 1 to Cell 2, however, due to the anticipated submerged flow conditions, tailwater levels are necessary for accurate flow measurements. A similar arrangement of water and gate level sensors at the outfall of Cell 2 provides total effluent discharge. The District is planning to install a headwater staff gage and a tailwater staff gage at each water control structure. In addition to providing operational information, these staff gages will assist flow calibration and estimation purposes, which are critical to establishing accurate water and nutrient mass balances for the treatment cells. The three flow measurements, one at the inflow, one at the separation levee, and one at the discharge end of the STA, in conjunction with local rainfall measurements, will enable the calculation of quantities of water treated and combined losses from seepage and evapotranspiration. Stage readings across the STA will also be helpful in assessing static and dynamic surface water profiles, allowing verification of estimates developed during design. A schematic of the hydraulic and water quality sampling arrangement for S-387 is shown in Figure 6.

2.2.2 Reporting Requirements

It is anticipated that all water quality submittals required by the FDEP permit shall be transmitted to the FDEP in an Annual Report; the DRAFT Operations Authorization permit requires quarterly water quality monitoring reports and annual monitoring reports, however, the District requested the final operations permit require annual reporting only. Furthermore, it is assumed that the Nubbin Slough STA performance report will be included in the South Florida Ecosystem Report, published annually by the District. The FDEP permit to be issued to the District for the STA will contain the minimum information to be contained in the Annual Reports.

Figure 6. Stage and water quality sampling at control structure S-387.



An example of an annual report that was recently prepared for STA-2 of the Everglades Construction Project is reprinted in Appendix 1 (Goforth et al. 2005). The format of that report has evolved over the last several years with valuable input from the peer-review panel that annually reviews the draft document. The report contains a summary of the annual operations, vegetation management, phosphorus performance, mercury, as well as a summary of other water quality parameters monitored at the STA, and is based on a May 1 – April 30 water year. The Nubbin Slough STA manager should review the report in Appendix 1 to identify which features may be relevant to the Nubbin Slough STA.

3 PHOSPHORUS PERFORMANCE ANALYSES

In addition to the permit-required monitoring and reporting, there is a minimal amount of analyses and reporting that the District may wish to conduct to better understand the phosphorus removal capability of the Nubbin Slough STA. This includes both a basic water budget and phosphorus mass budget information for each treatment cell and the STA as a whole. This information will be invaluable in developing appropriate adaptive management remedies should the phosphorus performance not achieve expectations. In addition, the information gained from this prototype STA can potentially be applied to many of the remaining 40,000 acres of STAs contained in the overall CERP program.

3.1.1 <u>Performance Assessment</u>

It is recommended that a weekly assessment of STA flows and phosphorus levels be performed by the Nubbin Slough STA manager. The District has many good flow and nutrient load analytical tools that facilitate frequent evaluations, e.g., the Load Program developed by Environmental Resource Assessment. The Nubbin Slough STA manager may want to discuss setting up a weekly automated batch file to generate the latest information.

In addition to the Load Program, a simple spreadsheet can be quickly created and maintained. For example, Table 3 and Figures 7-10 were developed using flows from the USGS gage near the STA site, along with phosphorus data from STA-1W, adjusted for the differences in inflow phosphorus concentrations. The table identifies the simple components of the water budget, although, estimates of rainfall, evapotranspiration and seepage could be added on an annual basis to complete the water budget. The table also outlines the basic components of the phosphorus budget for the STA, although the change in biomass and sediment storage of phosphorus, and loss through seepage, will need to be estimated through other means. Figure 7 depicts a two-year period of initial flows adjacent to the STA in Nubbin Slough, and into the STA through the S-385 pump station. Figure 8 presents a hypothetical time series of flows into, through and out of the STA, demonstrating the step function (exaggerated) resulting from the pumped inflow. Figures 9 and 10 depict hypothetical weekly and 12-month rolling mean phosphorus concentrations at the STA. Table 4 summarizes the performance of the initial two years of flow-through operation, and although the values are hypothetical, they represent potential trends and variability that may be observed at Nubbin Slough STA. An important characteristic of the STA is the variability in short-term flows, loading and performance.

Nubbin Slough STA																3					
	Nubbin Slough					Inflow to STA								Exit from Cell 1							
Date	Stage ft NGVD	Flow cfs	Flow AF	TP ppb	TP kg	# of pumps	Flow cfs	Flow AF	TP ppb	4-wk TP ppb	3-mo ppb	12-mo TP ppb	TP kg	HW	Flow AF	TP ppb	4-wk TP ppb	3-mo ppb	12-mo TP ppb	TP kg	TP Removed kg
1-Sep-07	17.57	21.8	43.2	495	26	1	21.8	43	495	598	717	718	26	31.8	32	238	206	218	245	10	17
2-Sep-07	17.56	15.4	30.6	520	20	1	15.4	31	520	592	717	718	20	31.8	23	234	208	218	245	7	13
3-Sep-07	17.48	11.8	23.4	545	16	1	11.8	23	545	586	717	717	16	31.8	18	229	210	218	245	5	11
4-Sep-07	17.42	10.4	20.7	570	15	1	10.4	21	570	582	717	717	15	31.8	16	224	211	218	244	4	10
5-Sep-07	17.44	10.0	19.8	595	15	1	10.0	20	595	578	717	717	15	31.8	15	220	213	218	244	4	11
6-Sep-07	17.38	8.2	16.2	620	12	1	8.2	16	620	575	716	717	12	31.8	12	215	214	218	244	3	9
7-Sep-07	17.32	8.2	16.2	645	13	1	8.2	16	645	573	717	717	13	31.8	12	210	215	218	244	3	10
8-Sep-07	17.28	13.2	26.1	670	22	1	13.2	26	670	572	718	717	22	31.8	20	206	216	218	244	5	17
9-Sep-07	17.24	9.1	18.0	695	15	1	9.1	18	695	571	720	717	15	31.8	14	201	217	218	244	3	12
10-Sep-07	17.42	20.4	40.5	720	36	1	20.4	41	720	571	723	717	36	31.8	30	197	218	218	244	7	29
11-Sep-07	17.83	74.0	146.8	745	135	3	74.0	147	745	571	725	717	135	31.8	110	192	218	218	243	26	109
12-Sep-07	17.86	79.5	157.7	803	156	3	79.5	158	803	574	727	718	156	31.8	118	191	218	217	243	28	128
13-Sep-07	17.86	50.9	100.9	861	107	2	50.9	101	861	578	728	719	107	31.8	76	189	218	217	242	18	90
14-Sep-07	18.03	40.9	81.1	920	92	2	40.9	81	920	585	729	720	92	31.8	61	188	218	216	242	14	78
15-Sep-07	18.03	48.6	96.4	978	116	2	48.6	96	978	594	731	721	116	31.8	72	187	218	216	241	17	100
16-Sep-07	17.92	37.7	74.8	1036	96	2	37.7	75	1036	604	733	722	96	31.8	56	186	217	216	241	13	83
17-Sep-07	17.95	26.8	53.2	1094	72	1	26.8	53	1094	617	733	724	72	31.8	40	184	216	215	241	9	63
18-Sep-07	18	29.1	57.7	1153	82	1	29.1	58	1153	632	729	725	82	31.8	43	183	215	214	240	10	72
19-Sep-07	18.06	23.2	45.9	1211	69	1	23.2	46	1211	650	728	727	69	31.8	34	182	213	214	240	8	61
20-Sep-07	18.2	23.2	45.9	1269	72	1	23.2	46	1269	670	728	728	72	31.8	34	180	212	213	240	8	64
21-Sep-07	18.12	18.2	36.0	1327	59	1	18.2	36	1327	693	726	730	59	31.8	27	179	210	213	240	6	53
22-Sep-07	18.08	14.5	28.8	1385	49	1	14.5	29	1385	718	721	731	49	31.8	22	178	208	212	240	5	45
23-Sep-07	18.13	11.4	22.5	1444	40	1	11.4	23	1444	747	715	732	40	31.8	17	177	206	210	239	4	36
24-Sep-07	18.29	9.1	18.0	1502	33	1	9.1	18	1502	779	710	733	33	31.8	14	175	203	209	239	3	30
25-Sep-07	18.25	6.8	13.5	1560	26	1	6.8	14	1560	815	706	734	26	31.8	10	174	201	208	239	2	24
26-Sep-07	18.28	5.9	11.7	1560	23	1	5.9	12	1560	854	703	735	23	31.8	9	174	198	208	239	2	21
27-Sep-07	18.35	5.5	10.8	1560	21	1	5.5	11	1560	893	702	736	21	31.8	8	174	196	207	239	2	19
28-Sep-07	18.46	4.5	9.0	1560	17	1	4.5	9	1560	932	701	736	17	31.8	7	174	193	206	239	1	16
29-Sep-07	18.37	5.5	10.8	1560	21	1	5.5	11	1560	971	701	737	21	31.8	8	174	191	206	239	2	19
30-Sep-07	18.43	5.9	11.7	1560	23	1	5.9	12	1560	1010	701	737	23	31.8	9	174	189	206	239	2	21
1-Oct-07	18.46	5.0	9.9	1560	19	1	5.0	10	1560	1049	699	738	19	31.8	7	174	187	205	239	2	17
Annual Average		13.3	9635	718	8540		12.4	8970	718				8056		6727	313				2601	5455

Table 3. Possible spreadsheet analysis for Nubbin Slough STA

Nubbin Slough STA				0.25								50%	capture of seepage		
						Exit from STA							Nubbin Slough after STA		
				adj					Cell 2	STA Total					
Date	HW	Flow	TW	TP	4-wk TP	3-mo TP	12-mo TP	TP	TP Removed	TP Removed	TP Removed	Flow	TP	TP	TP Removal
		AF		ppb	ppb	ppb	ppb	kg	kg	kg	%	AF	ppb	kg	%
1-Sep-07	29.8	13.1	17.6	73	66	60	58	1	8	25	96%	28.2	73	3	98%
2-Sep-07	29.8	9.3	17.6	72	67	60	58	1	6	19	96%	20.0	72	2	98%
3-Sep-07	29.8	7.1	17.5	71	68	60	58	1	4	15	96%	15.3	71	1	98%
4-Sep-07	29.8	6.3	17.4	70	68	60	58	1	4	14	96%	13.5	70	1	98%
5-Sep-07	29.8	6.0	17.4	68	69	60	58	1	4	14	97%	12.9	68	1	98%
6-Sep-07	29.8	4.9	17.4	67	69	60	58	0	3	12	97%	10.6	67	1	98%
7-Sep-07	29.8	4.9	17.3	66	69	60	58	0	3	13	97%	10.6	66	1	98%
8-Sep-07	29.8	7.9	17.3	65	70	60	58	1	4	21	97%	17.0	65	1	99%
9-Sep-07	29.8	5.5	17.2	64	70	60	58	0	3	15	97%	11.7	64	1	99%
10-Sep-07	29.8	12.3	17.4	63	70	60	58	1	6	35	97%	26.4	63	2	99%
11-Sep-07	29.8	44.5	17.8	62	70	60	58	3	23	132	97%	95.7	62	7	99%
12-Sep-07	29.8	47.8	17.9	61	69	60	58	4	24	153	98%	102.7	61	8	99%
13-Sep-07	29.8	30.6	17.9	60	69	60	58	2	15	105	98%	65.7	60	5	99%
14-Sep-07	29.8	24.6	18.0	59	69	60	58	2	12	90	98%	52.8	59	4	99%
15-Sep-07	29.8	29.2	18.0	59	69	60	58	2	15	114	98%	62.8	59	5	99%
16-Sep-07	29.8	22.7	17.9	58	68	60	58	2	11	94	98%	48.7	58	3	99%
17-Sep-07	29.8	16.1	18.0	57	68	60	58	1	8	71	98%	34.6	57	2	99%
18-Sep-07	29.8	17.5	18.0	56	67	60	58	1	9	81	99%	37.6	56	3	99%
19-Sep-07	29.8	13.9	18.1	56	67	60	58	1	7	68	99%	29.9	56	2	99%
20-Sep-07	29.8	13.9	18.2	55	66	60	58	1	7	71	99%	29.9	55	2	99%
21-Sep-07	29.8	10.9	18.1	54	65	60	58	1	5	58	99%	23.5	54	2	99%
22-Sep-07	29.8	8.7	18.1	53	64	60	58	1	4	49	99%	18.8	53	1	99%
23-Sep-07	29.8	6.8	18.1	53	64	60	58	0	3	40	99%	14.7	53	1	99%
24-Sep-07	29.8	5.5	18.3	52	63	60	58	0	3	33	99%	11.7	52	1	99%
25-Sep-07	29.8	4.1	18.3	51	62	59	58	0	2	26	99%	8.8	51	1	100%
26-Sep-07	29.8	3.5	18.3	51	61	59	58	0	2	22	99%	7.6	51	0	100%
27-Sep-07	29.8	3.3	18.4	51	60	59	58	0	2	21	99%	7.0	51	0	100%
28-Sep-07	29.8	2.7	18.5	51	59	59	58	0	1	17	99%	5.9	51	0	100%
29-Sep-07	29.8	3.3	18.4	51	59	59	58	0	2	21	99%	7.0	51	0	100%
30-Sep-07	29.8	3.5	18.4	51	58	59	58	0	2	22	99%	7.6	51	0	100%
1-Oct-07	29.8	3.0	18.5	51	57	59	58	0	1	19	99%	6.5	51	0	100%
Annual Average		2718		69				232	2369	7824	97%	6509	129	1040	88%

Table 3. Possible spreadsheet analysis for Nubbin Slough STA (concluded)

Figure 7. Time series of hypothetical flows in Nubbin Slough and the STA

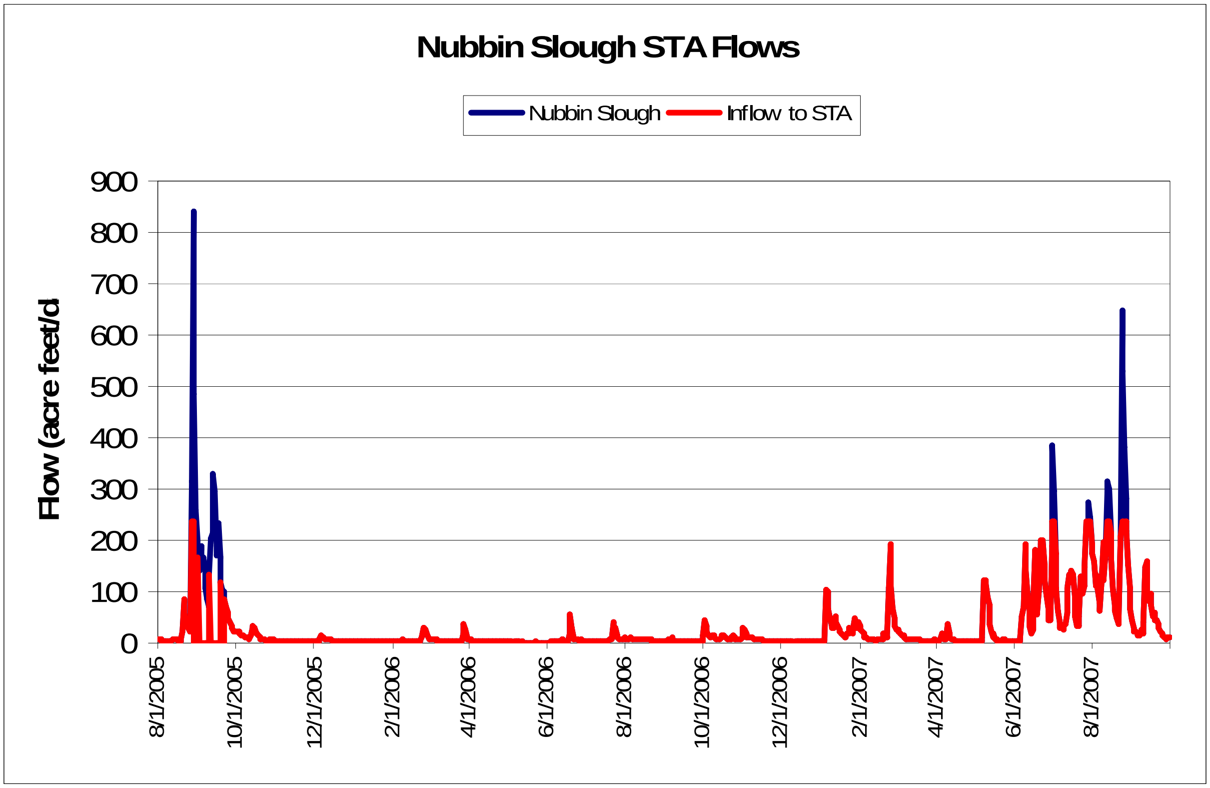


Figure 8. Time series of hypothetical flows into, through and out of the STA.

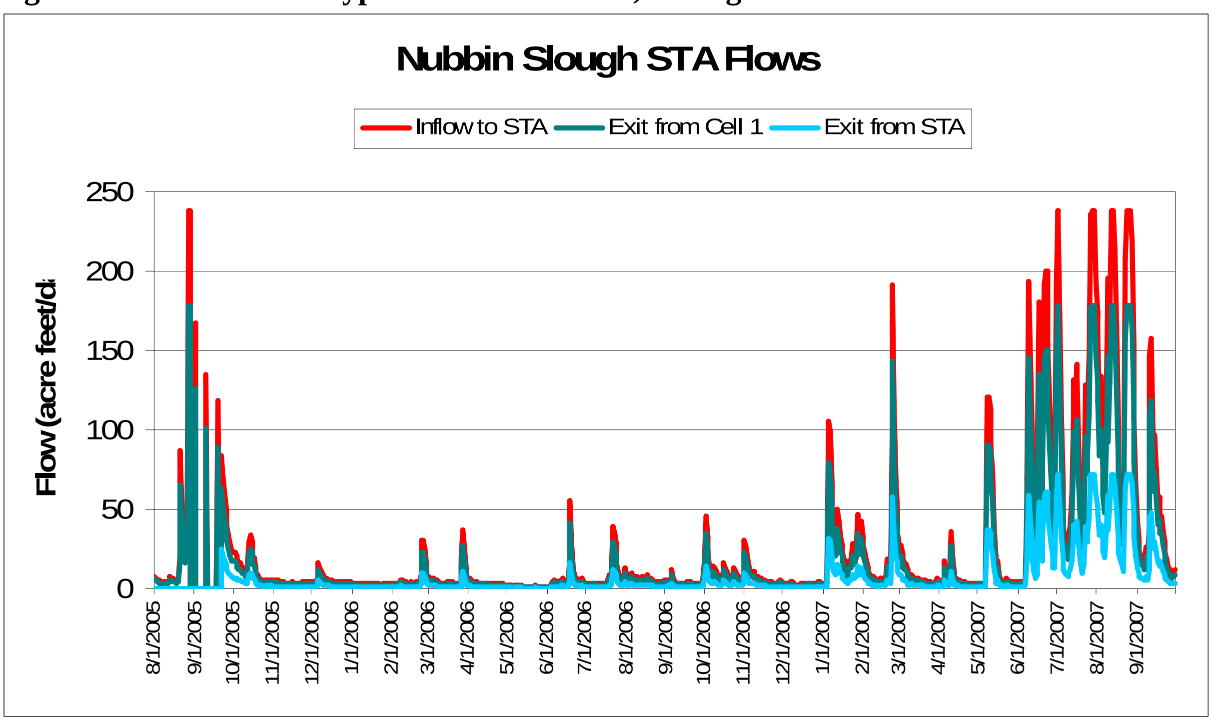


Figure 9. Hypothetical weekly phosphorus concentrations at Nubbin Slough STA.

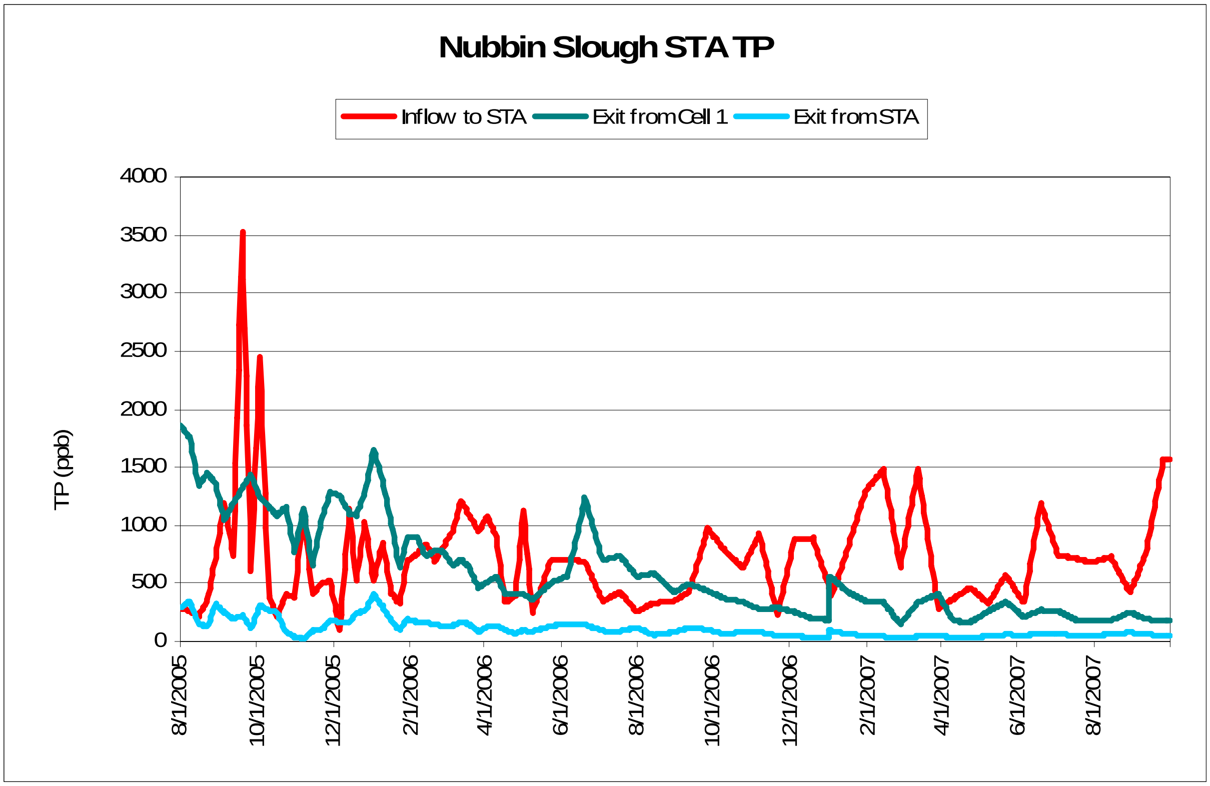


Figure 10. Hypothetical 12-month rolling phosphorus concentrations at Nubbin Slough STA.

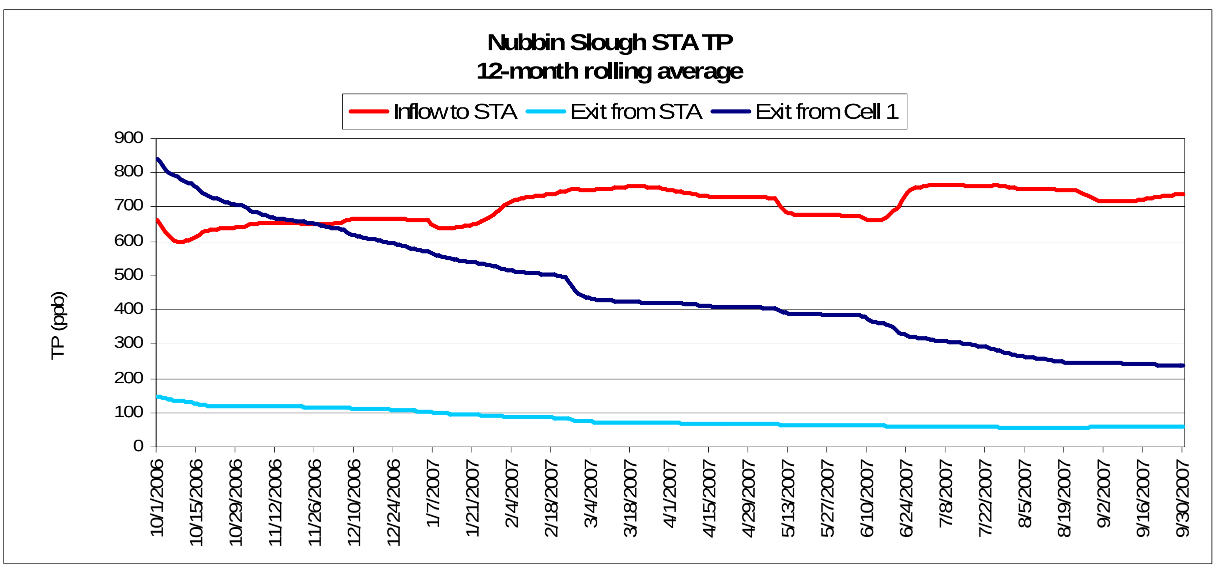


Table 4. Hypothetical
Summary of First Two Years of Performance of Nubbin Slough STA

	Oct 2005 - Sep 2006	Oct 2006 - Sep 2007	Average of 2-Year Period
Inflow to STA			
Flow (AF/yr)	2,229	15,711	8,970
Percent of Taylor Creek	100%	92%	93%
TP Load (kg/yr)	1,818	14,295	8,056
TP Conc (ppb)	661	738	728
Cell 1			
Discharge (AF/yr)	1,671	11,783	6,727
TP Load (kg/yr)	1,733	3,469	2,601
TP Conc (ppb)	840	239	313
Cell 2			
Discharge (AF/yr)	675	4,760	2,718
TP Load (kg/yr)	123	342	232
TP Conc (ppb)	148	58	69
STA Reduction			
TP Load (kg/yr)	1,695	13,953	7,824
Removal Efficiency	93%	98%	97%
TP Conc (ppb)	513	679	659
Seepage Return to Nubbin Slough (assume 50%)			
Flow (A/yr)	777	5,475	3,126
Load (kg/yr)	142	393	267
TP Conc (ppb)	148	58	69
Nubbin Slough After STA			
Flow (A/yr)	1,452	10,235	5,844
Load (kg/yr)	265	735	500
TP Conc (ppb)	148	58	69
Nubbin Slough Reduction			
TP Load (kg/yr)	1,553	13,560	7,557
Removal Efficiency	85%	95%	94%
TP Conc (ppb)	513	679	659

4 COORDINATION

As with most large water resource projects, effective coordination within the agency and among the various agencies will be critical to ensure the STA performance objectives are achieved. The nature of this coordination will change as the project goes through the initial operational and testing period, and is then transferred to the District by the Corps.

4.1 Initial Operational Testing and Monitoring Period

In accordance with the Project Cooperation Agreement executed between the Corps and the District, prior to turnover of the project to the District, the Corps will conduct an **initial operational testing and monitoring period**. During this period, data will be collected to demonstrate that the project achieves the designated benefits. Once the District Engineer determines that the project is performing as designed, the Corps will transfer the project to the District for subsequent operations, maintenance, repair, replacement and rehabilitation, commencing the **operations phase.** This **initial operational testing and monitoring period** is further divided into two phases – a start-up phase (no discharge) and a flow-through phase once discharge commences. Prior to initiating flow-through (discharge) activities, phosphorus and mercury will be monitored to demonstrate that the STA is achieving a net improvement in both constituents. In addition, pesticide sampling will occur as a condition for moving into the flow-through phase.

4.1.1 <u>On-going data review and operational feedback</u>

In accordance with the project PCA, the District will conduct the phosphorus, mercury and pesticide samples during the **initial operational testing and monitoring period**. A **Project Coordination Team** was established in accordance with the Project Cooperation Agreement, and this team will establish a protocol for communicating the start up operations between the District and Corps prior to the initiation of start up. Key aspects are to identify who will be the respective tactical contact points, and the appropriate type and frequency of start up communication. The frequency of telephone conferences and meetings will likely be weekly at first as issues surrounding structure operations may arise; experience in other new systems suggests that the frequency will likely decrease to approximately once per month by the end of the start-up phase. During this start-up phase, the format, data extraction and distribution list of the STA performance worksheets should be finalized

Once flow-through operations begin, the weekly/monthly communications will include operational feedback (pump operations, gate openings, flow rates and water levels) in addition to the performance discussion. By that time, the criteria for project transfer from the Corps to the District should be finalized.

4.1.2 Interagency coordination (District, FDEP, Corps, DACS)

In addition to the day-to-day project coordination, by virtue of the fact that the Nubbin Slough STA is a feature of an integrative set of water quality protection projects, project staff will necessarily be communicating and coordinating with other District staff (e.g., Lake Okeechobee Division), FDEP (for permitting and other wetland protection purposes), the Corps (CERP and related activities) and DACS (e.g., for implementation of watershed BMPs).

An initial list of potential contact persons from these agencies is presented below.

STA Project Manager: Lisa Kreiger, Staff Environmental Scientist, (863) 462-5280 x 3026 lkreiger@sfwmd.gov; South Florida Water Management District, Okeechobee Service Center, 205 N Parrott Ave, Suite 201, Okeechobee, FL 34972.

Program Manager: Dave Unsell, Lead Project Manager, (561) 686-8800 x 6888; dunsell@sfwmd.gov; South Florida Water Management District; 3301 Gun Club Road; West Palm Beach, FL 33406

Okeechobee Field Station: Terry Peters, Interim Director, 863-462-5280 x 3102; rpeters@sfwmd.gov; and Bruce Chesser, Interim Director of Field Operations, x 3114; bchesser@sfwmd.gov; Okeechobee Field Station, Okeechobee, FL

Operations Department: Tom Kosier, Environmental Operations Section (561) 682-6533; tkosier@sfwmd.gov; South Florida Water Management District; 3301 Gun Club Road; West Palm Beach, FL 33406

Water quality monitoring: W. Patrick Davis **Field Project Manager** (863) 462-5280 x 3171; wpdavis@sfwmd.gov; Okeechobee Water Quality Field Section, 1000 NE 40 Avenue, Okeechobee, FL 34972.

U. S. Army Corps of Engineers: Stephanie Jenkins; Hydraulic Engineer (904) 232-1612; Stephanie.L.Jenkins@saj02.usace.army.mil; US Army Corps of Engineers, Jacksonville District, ENHW, 701 San Marco Blvd, Jacksonville, Florida 32207 and Chuck Wilburn, Civil Engineer (863) 471-1741; Charles.R.Wilburn@usace.army.mil; Sebring Project Office, 6406 U.S. Hwy 27 S, Sebring, Florida 33876

Florida Department of Environmental Protection: Kim Shugar, Program Administrator, (561) 681-6706; kimberly.shugar@dep.state.fl.us; FDEP-Southeast District, 400 N. Congress Avenue, Suite 200, West Palm Beach, Florida 33401

Florida Department of Agricultural and Consumer Services: Bo Griffin, Environmental Manager, (863) 462-5883; griffid@doacs.state.fl.us; 305 E.N. Park Street, Suite C, Okeechobee, Florida 34972.

4.2 Operations Phase

Once the Corps transfers the project over to the District, the **Operations Phase** commences. Most, if not all, of the same degree of communication and coordination that began in the **initial operational testing and monitoring period** will continue.

4.2.1 On-going data review and operational feedback

The frequency and type of the weekly/monthly meetings during the Operations Phase may not differ from the earlier phases, depending on the status of the STA and whether or not there are significant refinements to the permit requirements. During the summer, the performance evaluation for the previous water year should be drafted for including in the draft of the annual South Florida Environmental Report.

4.2.2 Interagency coordination (District, FDEP, Corps, DACS)

Depending on the Corps continued role and responsibilities after the project is turned over to the District, their involvement in the weekly/monthly coordination conferences may change in the Operations Phase. There may or may not be a shift in the other agency contacts shown in section 4.1.2 above, depending on the status of the STA and other needs.

5 REFERENCES

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APPENDIX 1. EXCERPT FROM 2005 SOUTH FLORIDA ENVIRONMENTAL REPORT